Willard Bay Project Proposal Form

Applicant Name: Dr. Bethany T. Neilson

Project Title: Impact of beaver dams on stream temperature, hydrology, and contaminant transport

Agency: Utah State University, Utah Water Research Laboratory

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☐ Individual ☐ Non-Profit ☐ Govt. Agency ■ Academic ☐ Commercial ☐ Other

1. **Estimated Project Costs:**

Labor	$ 48,496
Materials	$ 600
Equipment	$ 0
Administration	$ 0
Miscellaneous	$ 23,234 ($3,000 travel, $20,234 IDC)
TOTAL	$ 72,330

Other sources of project funding:

Utah Water Research Laboratory	$ 5,675
Source	Amount

Total project cost including other sources of funding: $ 78,005

2. **Describe the purpose and need of the project:**

Beavers are beginning to be recognized as a potential tool to mitigate environmental disasters, improve water quality and restore degraded stream ecosystems. However, there is minimal data regarding the influence of beaver activity on local hydrology and the fate and transport of constituents in streams. Some studies exist regarding the influence of beaver dams on the local hydrology and temperature regimes, as well as on the changes in stream and riparian habitats. However, the majority of these studies lack sufficient quantitative field measurements from various spatial and temporal scales. Further, there is no information that characterizes these influences over the lifecycle of individual dams or entire beaver complexes.

We do know that beaver dams and beaver ponds created behind the dams generally increase surface water storage, water residence time, increase base flow, and create depositional areas for sediments (Nyssen et al. 2011). We also know that water infiltration through banks influences local groundwater elevations in the riparian zone (Hill and Duval 2009), alters hydraulic gradients, and increases the potential for hyporheic exchange (Lautz and Siegel 2006). Finally, there is

documentation that these changes in channel morphology and hydrology create conditions that influence stream temperature regimes (Briggs et al., 2012, Lautz and Siegel, 2006). Regardless, these data provide an incomplete understanding of the long term influences on the local hydrology and contaminant transport as dams are newly built, throughout the period where the bulk of the sedimentation occurs, over the period of variable dam height due to significant dam maintenance, and post abandonment.

We have collected much of the hydrologic and temperature data over the past 6 years to characterize conditions that represent the stream before beaver colonization, throughout dam construction, and even the early stages of dam abandonment in Curtis Creek. These data cover a variety of spatial and temporal scales and are the foundation needed to bridge the existing knowledge gap (e.g., Majerova et al., in review). However, additional funding sources are necessary to continue data collection that span the entire lifecycle of this continually evolving dam complex. Without a more complete understanding of the influence of beaver activity, the implications of introducing beavers into certain areas to remediate or restore streams remains highly uncertain.

Background

The Curtis Creek field site was initially instrumented in 2007 with pressure transducers, temperature sensors, and shallow groundwater observation wells to investigate interactions between ground and surface water (funded by Utah Water Research Laboratory (UWRL)). However, after one year of data collection, beaver colonization occurred in the study reach and presented an opportunity to gather a unique data set. Since then, we have captured changes in flow and temperature conditions, groundwater levels, as well as geomorphic changes in Curtis Creek over different spatial and temporal scales (Table 1). This data spans a period prior to and during the establishment of beaver dams in the study reach. To date, the UWRL has invested over $250,000 to collect and analyze these data while furthering our understanding of how beaver colonization and beaver dams influence Utah streams. Current data collected within this study are summarized in Table 1. A list of relevant research products (e.g., peer reviewed publications, conference presentations, theses, etc.) can be made available on request.

Currently, the beaver colony continues changing the physical template of the Curtis Creek study reach. Existing beaver dams are being maintained at different levels of intensity (some are not maintained at all) and new beaver dams are consistently being built. Given the limited amount of data to understand beaver dam colonization influences on streams and the important links to aquatic and riparian habitat, there is still great uncertainty regarding the use of beavers as a mitigation and/or restoration tool. We need to understand the effects of beaver dams during different dam life stages, as well as the longevity of these impacts. The continuation of data collection in this portion of Curtis Creek presents a unique opportunity to build on the existing data set (pre- and post-beaver colonization) and capture the longer term influences of the highly dynamic beaver activity in streams.

3. **Estimated time frame of the project with significant milestones:**

July 2014 - July 2016

4. **Describe the location of the project:**

The Curtis Creek study area is located about 15 miles east of Hyrum, Utah at Hardware Ranch (an elk refuge operated by the Utah Division of Wildlife Resources (UDWR)). The Curtis Creek study reach is divided into a Lower, beaver impacted reach and an Upper, non-impacted reach. The Upper Reach represents reference conditions because no beaver activity has occurred in this area. The Lower and Upper Reach are approximately 750 m and 535 m long, respectively. These reaches cover about 18.8 acres of land, out of which 10 acres consist of riparian zone and floodplain within the lower, beaver impacted reach (Figure 1).

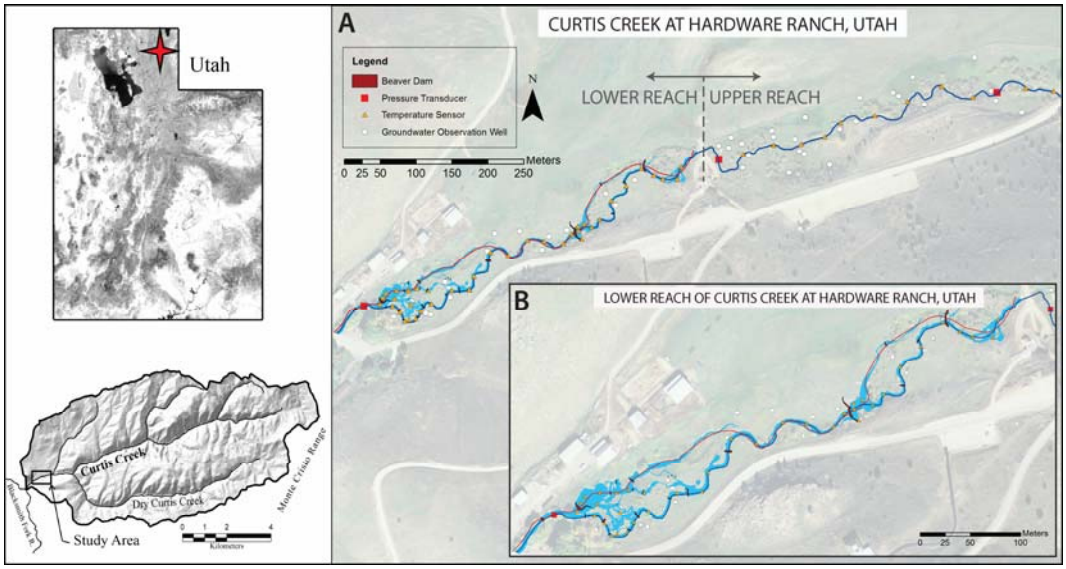

Figure 1. Map of Curtis Creek study area at Hardware Ranch, Utah. Blue line indicates the present channel and the red line the old original channel. The location of instruments is also shown. Flow is from right to left. B) Locations of beaver dams with ponded areas in the lower reach.

5. **Describe how the project will specifically enhance and protect waterways affected by the Willard Bay diesel release and improve the conditions of one or more of the following: wildlife, habitat, natural vegetation, water quality or emergency response:**

Although, the project is not located directly in the Willard Bay watershed, it provides significant information regarding the role of beaver activity on the hydrology and stream temperature dynamics that are directly influencing the health of stream ecosystem. Further, this fundamental understanding of the physical system is necessary to understand the instream water quality or contaminant transport. For example, when using beaver as a mitigation tool or in cases of environmental emergencies, it is requisite to understand surface and subsurface water flow paths, flow residence times, potential surface and subsurface storage, and the overall complexity of the beaver impacted stream. The past and continued data collection provide the foundational information necessary to quantify how these responses change throughout the lifespan of the beaver dams.

In terms of enhancements to the ecosystem, we have observed raised surface and groundwater levels, significant decreases in bank erosion, and a stabilization of the channel due to the influences of beaver dams in the Lower Reach of Curtis Creek. Fine sediment has also been stored

in the beaver ponds and beaver activity has influenced riparian vegetation through a transition from invasive plant species to primarily wetland species. Further, significant willow harvesting (used in beaver dam construction and as a food source) and regrowth in the riparian zone has resulted in a significant shift in herbaceous plant composition in the flood plain thus improving wildlife habitat in the area. The native fish population (e.g., Bonneville Cutthroat Trout) also qualitatively appears more abundant in the Lower Reach. We have also seen neotropical birds, sandhill cranes, blue herons, greater sage-grouse, and moose in the Lower Reach.

6. **Describe project's connectivity to other natural areas or projects that further enhance wildlife, habitat, natural vegetation, water quality or emergency response:**

The findings of this project would be unique in that the results would provide the only comprehensive data describing the long term impacts of beaver dam complex development on the local hydrology and instream temperatures. These findings would be foundational to understanding the use of beaver in stream restoration or to prevent or mitigate potential disasters throughout the state of Utah. We have quantified the impacts of beaver activity to some extent and expect our findings to be transferable to similar streams. For example, based on data and modeling efforts in this high gradient system, we have found an increase in hydrologic and thermal variability within beaver ponds that will not be detected in looking at the pond inflow and outflow temperature differences. However, at the reach scale, we found that a series of dams will result in longitudinal temperature differences. Using these initial data, we have begun to disentangle the conflicting literature regarding the impacts of beaver complexes on stream hydrology and temperature (e.g., Majerova et al., 2014, In Review; Snow 2014). In the context of ecosystem impacts and potentially using beaver as a restoration tool, this increase in hydrologic and thermal variability results in greater habitat heterogeneity and biodiversity (Pollock et al,. 2004; Billman et al., 2013; Kemp et al., 2012). When it comes to understanding instream water quality, it is imperative to understand the local hydrology, flow paths, residence times, and surface and subsurface storage in a stream reach. Our abilities to understand these influences in streams not influenced by beaver has advanced significantly. However, our understanding of beaver impacted reaches is extremely limited, but key to anticipating the utility of beavers in sensitive areas as a means to prevent the impacts of environmental disasters (e.g., Willard Creek at Willard Bay State Park, March 2013).

7. **Describe any additional social benefits of implementing this project:**

The results from our study will demonstrate the role of beavers in Utah's ecosystems and will be valuable in achieving the Outreach and Education objective of increasing awareness and appreciation of the role of beaver in Utah (Utah Beaver management Plan 2010-2020). Utah DWR has also expressed interest in using this portion of Curtis Creek to establish a beaver management area showcase at Hardware Ranch (Outreach and Education section, Utah Beaver Management Plan 2010-2020).

8. **Project plans and details, including rights to work on specified piece of land:**

Our primary plans will be to continue the existing data collection effort which includes the monitoring of flow and temperature conditions within the Curtis Creek study area. We will also continue to monitor the groundwater levels near the stream and within the floodplain and document

changes in stream topography due to beaver dam breach, failure, or new construction. We will not need to purchase any new equipment.

Beyond data collection, we will also analyze data to assist in quantifying the impacts of beaver dams on Curtis Creek. We will work with DEQ and Division of Wildlife Resources (DWR) to determine how best to use this information in the context of other streams throughout Utah.

The letter of permission to work on Hardware Ranch Wildlife Management Area from Department of Natural Resources, Division of Wildlife Resources is attached.

Table 1. Relevant Curtis Creek data collected since 2007

Data Collection	Location/Spatial Scale	Data Type/Collection Interval
Water Surface Level	At three pressure transducers	Continuous (since 2008, 5min)
Discharge Measurements	At three pressure transducers	Instantaneous (since 2008)
Stream Temperature	At three pressure transducers	Continuous (since 2008, 5min)
	Longitudinally (39+11 sensors)	Continuous (since 2012,10min)
	Longitudinally above and below beaver dams	Sept - October 2010
	Beaver pond in detail	May 2012, Sept 2013
Groundwater Level	Observation wells	Instantaneous (since 2008)
Dilution Gauging/ Groundwater Gains and Losses	Upper and Lower Reach	2008, 2010, 2013
Channel Centerline Survey	Upper and Lower Reach	2007 (pre-beaver activity period)
High Resolution Topographic Survey	Upper and Lower Reach	Summer 2012, Summer 2013, as needed when changes occur
Geomorphic and Habitat Mapping	Lower Reach	Summer 2012, Summer 2013
Substrate Size	Longitudinally in Lower and Upper Reach (34)	Summer-Fall 2013
Aerial Imagery (Aggie Air)	Upper and Lower Reach	Sept 2010 (NIR, RGB), April 2011 (NIR, RGB),
		June 2011 (NIR, RGB), May 2012 (NIR, RGB, Thermal),
		October 2012 (NIR, RGB, Thermal), March 2013 (NIR, RGB)
		March 2014 (NIR, RGB)

9. **Describe your experience in implementing projects of similar scope and magnitude:**
   The proposed project is a continuation of an existing project.

10. **Describe how ongoing maintenance of the project will be funded and carried out:**
    N/A

11. **List consultants or agency partners that have participated in project development:**

Scott Walker/ Utah Division of Wildlife Resources (UDWR)	515 East 5300 South Ogden, UT 84401	(801)476-2776
Name/Company	Address	Phone
Brad Hunt/Hardware Ranch Wildlife Management Area		(435)753-6168
Name/Company	Address	Phone

Signature _____ Norma "Nan" Buxton Contract Administrator Date 5/1/14
Applicant usu# 140777

Signature _____ Date _____
Co-Applicant (if applicable)

Literature References

Briggs MA, Lautz LK, and McKenzie JM. 2012. A comparison of fibre-optic distributed temperature sensing to traditional methods of evaluating groundwater inflow to streams. *Hydrological Processes* 26 (9):1277-1290.

Hill AR, and Duval TP. 2009. Beaver dams along an agricultural stream in southern Ontario, Canada: their impact on riparian zone hydrology and nitrogen chemistry. *Hydrological Processes* 23 (9):1324-1336.

Lautz LK, and Siegel DI. 2006. Modeling surface and ground water mixing in the hyporheic zone using MODFLOW and MT3D. *Advances in Water Resources* 29 (11):1618-1633.

Majerova M, Neilson BT, Schmadel MN, Wheaton JM, and Snow CJ. 2014. Impacts of beaver dams on hydrologic and temperature regimes. *Journal of Ecohydrology*. In Review.

Nyssen J, Pontzeele J, and Billi P. 2011. Effect of beaver dams on the hydrology of small mountain streams: Example from the Chevral in the Ourthe Orientale basin, Ardennes, Belgium. *Journal of Hydrology* 402 (1-2):92-102.

Snow CJ. 2014. The effect of beaver on stream temperature and the fate of solar radiation in the water column. Master Thesis. Civil and Environmental Engineering. Utah State University. Logan, UT.

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State of Utah
DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of Wildlife Resources
GREGORY SHEEHAN
Division Director

March 4, 2014

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To Whom It May Concern:

Dr. Bethany Neilson and her students have permission to work on Hardware Ranch WMA.

Sincerely,

Bradley P. Hunt
Hardware Ranch WMA Manager

bph