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Adapting Truckee River Reservoir Operations for a Warmer Climate

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*This fact sheet reports results from **Water for the Seasons**, a collaborative modeling research program that partners researchers with water managers representing the diverse water-use communities in the Truckee-Carson River System in California and Nevada. Through systematic and iterative interactions, key water managers and researchers work together to assess climate resiliency and examine strategies to adapt to climate-induced water supply variability. The alternative water management strategies explored herein are not recommendations, but rather exemplify applied climate research that utilizes modeling tools to examine local strategies and provide useful information. This five-year (2014-2019) research program is funded by a Water Sustainability and Climate program grant from the National Science Foundation (#1360506) and the U.S. Department of Agriculture (#2014-67003-22105).*

Why might Truckee River Basin water supply be at risk under a warmer climate?

Across many river basins in the arid western United States, substantial water supply originates as mountain snowpack that typically accumulates over the winter and melts during the spring. Snowmelt runoff generates streamflow that is then stored in upstream surface water reservoirs and released later in the year to meet downstream demand (Barnhart et al., 2016; Li et al., 2017).

In the Truckee River Basin (Figure 1), seven upstream reservoirs capture Sierra Nevada snowmelt. Releases are managed to supply water to downstream communities in northwestern Nevada for municipal and industrial use and irrigated agriculture, and to sustain environmental instream flows for fisheries and riparian health.

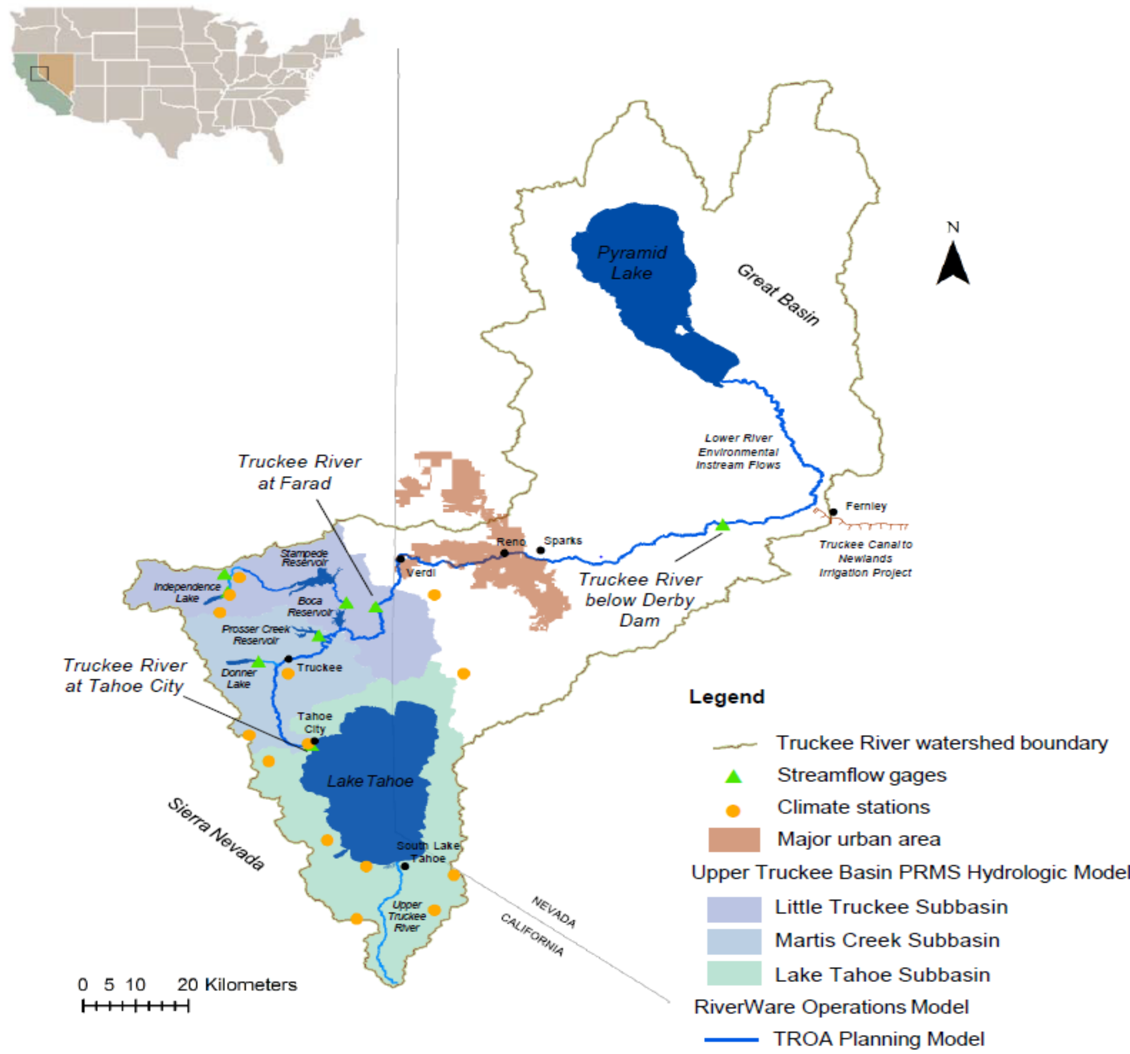

Figure 1. Key features of the Truckee River Basin, including upstream reservoirs and hydrologic and operations model boundaries.

Recently observed changes to Sierra Nevada snowpack, including less snow accumulation, more rain than snow, and earlier snowmelt runoff, alter streamflow timing (Hatchett et al., 2017; McCabe, Wolock, & Valentin, 2018; Mote et al., 2018). These changes can translate water management challenges particularly when policies and operations are tied to historical climate patterns (Milly et al., 2008).

For example, Stampede, Boca and Prosser Creek reservoirs in the Upper Truckee River Basin (see Figure 1) are operated by the Bureau of Reclamation according to storage dates set by the U.S. Army Corps of Engineers flood-control criteria. These criteria ensure sufficient storage exists during the winter and spring to capture potential floodwaters and mitigate downstream flood risk. The reservoirs begin storing water April 10, a date set based on historical peak streamflow and the assumption that significant snowmelt does not begin earlier (Berris, Hess, & Bohman, 1998; USACE, 1985).

Under projected warming, shifts in peak streamflow timing before the April 10 fill date has the potential to reduce reservoir storage (Dettinger, Udall, & Georgakakos, 2015; Gergel et al., 2017). As mentioned, releases are managed to meet particular river basin policy including the Floriston rate, the most fundamental operational policy in the basin that defines a target rate of flow at the Farad gage at the California and Nevada state line (see Figure 1) (USBOR, 2016). The ability to meet this rate during summer has implications for water right allocations for municipal and agricultural water-use communities. Another demand includes instream environmental flows that support fish spawning and riparian health in the lower reach of the Truckee River from Derby Dam to Pyramid Lake (USFWS 2003).

What research activities can support an understanding of future water management challenges?

As part of a collaborative modeling research program underway in the Truckee River Basin (Singletary & Sterle, 2017), local water managers and researchers work together to assess water management challenges and explore strategies to enhance water supply. Through hydrologic and operations modeling activities, researchers are able to simulate alternative management strategies and quantify their potential impacts under climate change.[1]

Figure 2 illustrates how face-to-face interviews and iterative workshops identified the research presented here. That is, local water managers requested

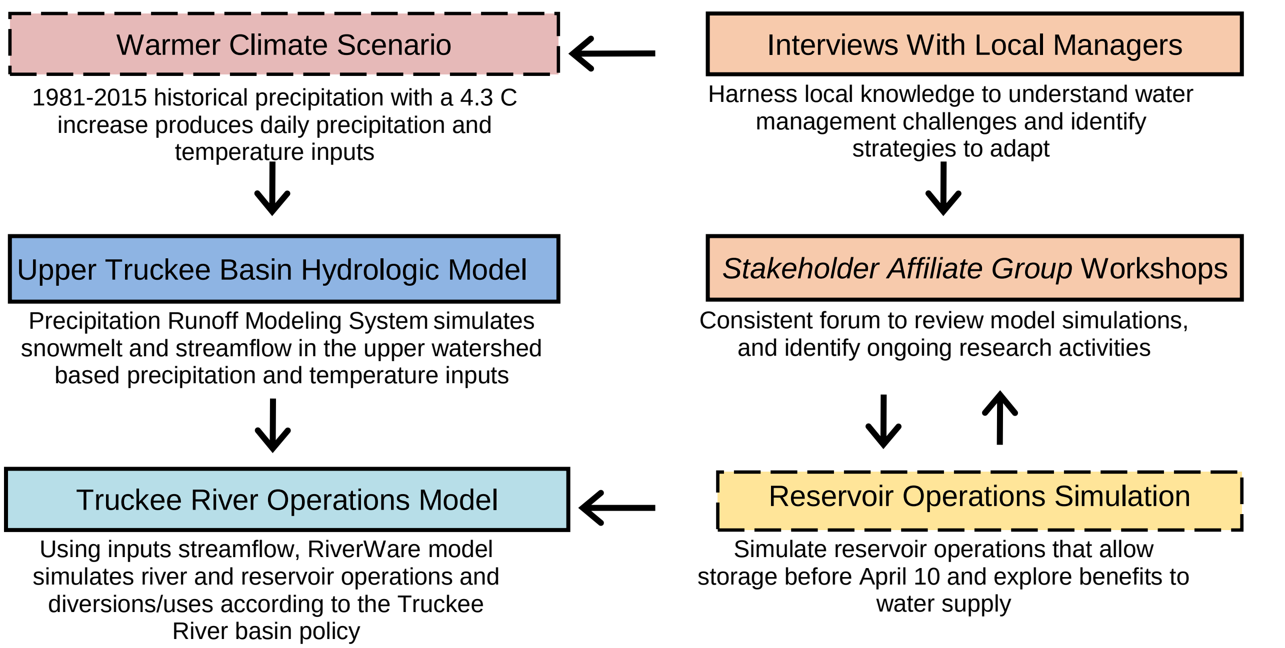

Figure 2. Research and modeling activities identified through collaborative modeling. Solid-line components represent primary data collection methods and the hydrologic and operations model. Dashed-line components represent the scenario and simulation requested by local water managers.

[1] For a summary of the hydrologic and operation models, see Extension publication *Collaboratively Modeling Water Resources in the Truckee-Carson River System (SP-17-04)* (Sterle, Singletary, & Pohll, 2017).

that researchers examine reservoir operations more closely to determine if allowing reservoirs to store water earlier, or before April 10, increases storage under a warmer climate. Simulating this strategy required researchers to:

1. Develop a plausible warmer climate scenario to determine shifts in streamflow timing
2. Simulate reservoir operations that allow for earlier reservoir storage
3. Present results as a function of local metrics to ensure results are useful to managers

A warmer climate scenario was generated and downscaled to the basin scale to simulate streamflow change in the river using the Precipitation Runoff Modeling System (PRMS) (Markstrom et al., 2015) that simulates snowmelt and streamflow in the Upper Truckee River Basin (see Figure 1). Streamflow at seven streamflow gages was then passed to the Truckee River Operations Model developed in RiverWare, a river and reservoir operations model that operates the system based on existing policies (Zagona et al., 2001). The reservoir operations in the model were simulated so as to allow for reservoir storage before April 10, thus exploring whether climate-induced changes to the river could be absorbed through alternative water management practices. Note, this simulation looked only at reservoir storage and did not address flood control operations and flood risk.

Do the model simulations suggest that earlier reservoir storage enhances water supply?

When the historical record (water years 1981-2015) warms by 4.3 degrees Celsius (Dettinger et al., 2016), peak streamflow into the reservoir occurs roughly 45 days earlier, from mid-March to early February. Note this is just one possible climate scenario for the region (Dettinger et al., 2017). Figure 3 presents simulation results for a) current operations under a historical climate (i.e., “as-is”), b) current operations under a warmer climate, and c) operations that allow the reservoir to store approximately one month earlier under a warmer a climate. As illustrated, under current reservoir operations, earlier streamflow results in less water stored, or 46 percent of the reservoir’s capacity versus 76 percent historically. Allowing the reservoir to fill approximately one month earlier (or as early as Feb 1) captures earlier streamflow, thereby increasing upstream reservoir storage to 76 percent of capacity.

As a result, downstream municipal and agricultural water users benefit as indicated by an additional 14 days of Floriston rate water being met. Additionally, earlier storage increases the amount of water available for releases that sustain environmental instream flows, benefiting fish species and riparian habitat in the lower river.[2]

What’s next?

Simulation results suggest that under a warmer climate, current upstream reservoir operations compromise the

[2] For detailed explanation of research findings, see Sterle et al., in revision.

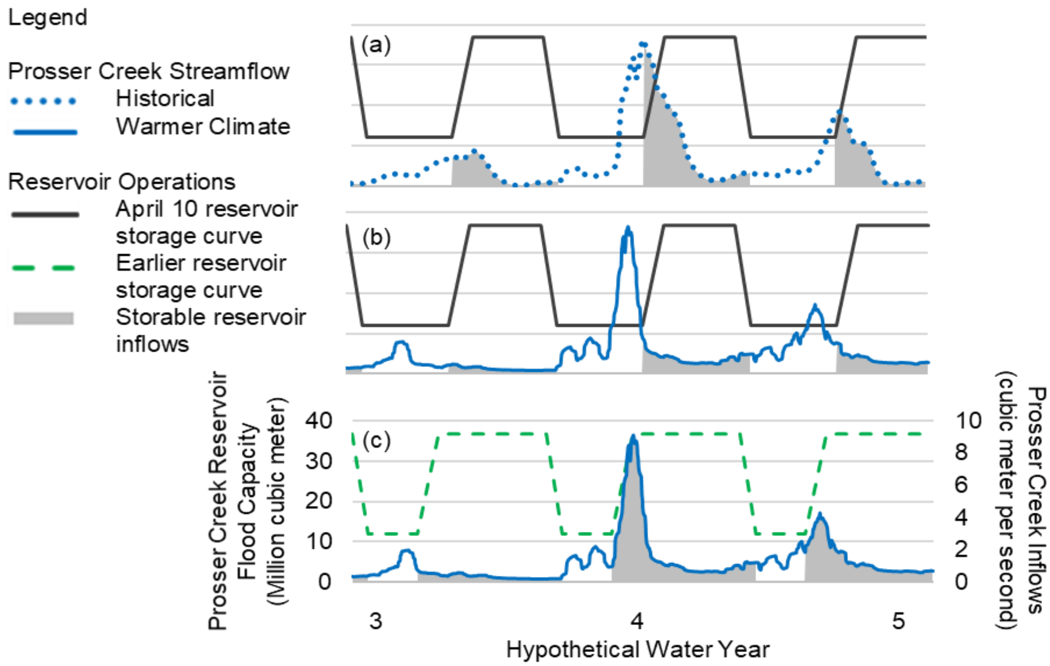

Figure 3. Simulation results for Prosser Creek Reservoir over three hypothetical water years. Light grey shading illustrates (a) inflows stored under current reservoir operations (dark gray line) based on historical streamflow record (dotted blue line), (b) inflows stored under current operations (dark gray line) and a warmer climate (solid blue line), and (c) inflows under operations that allow for earlier storage (green dashed line) and a warmer climate (solid blue line).

amount of water stored in the reservoir, reducing water supply for downstream water-use communities dependent on reservoir storage and releases to meet summer water demand. Additional modeling tools are required to more thoroughly assess reservoir operations under climate change. For example, while the Upper Truckee Basin Hydrologic Model provides insight as to how warmer climate shifts streamflow timing, it is not set up to accurately predict flood magnitude and timing likely to increase under a warmer climate. This is an important piece to assess both climate change impacts on the river and the feasibility of alternative reservoir management, as the reservoirs are managed not only to meet downstream water demand but also to mitigate flood risk. These tools should explore how earlier storage operations perform under a range of climate scenarios, including variable precipitation in addition to temperature.

Ongoing collaboration among local water managers and researchers continues to guide research and modeling activities to ensure results are useful. Given managers' continued requests to assess climate change impacts to Truckee River water supply and management, researchers continue to simulate possible future climate scenarios for the Truckee River Basin and present implications accordingly to key indicators of water supply.

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