Investigating the contribution of mountain-block recharge to springs in northeast Salt Lake Valley using environmental tracers and noble gas thermometry

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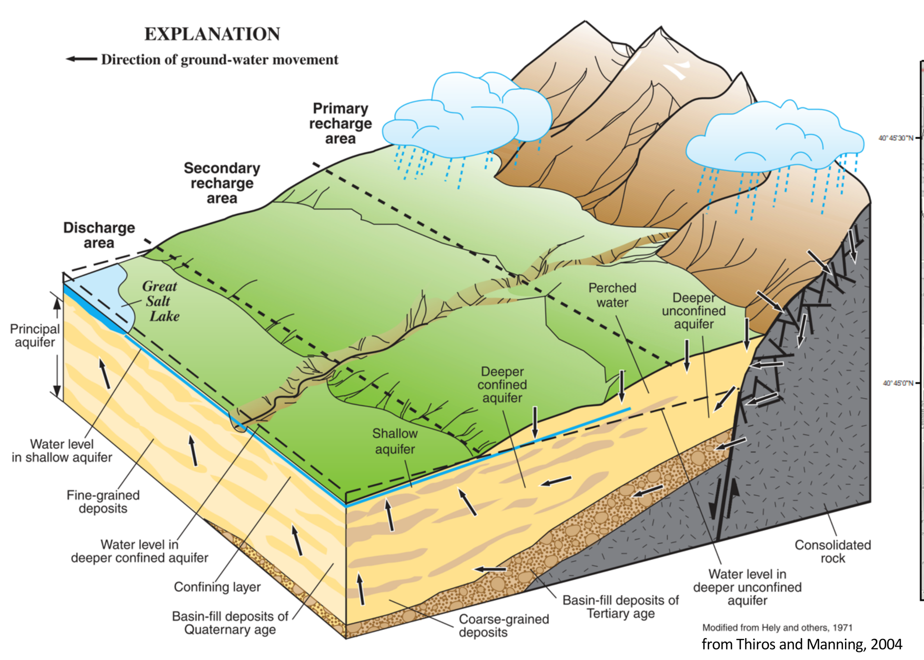
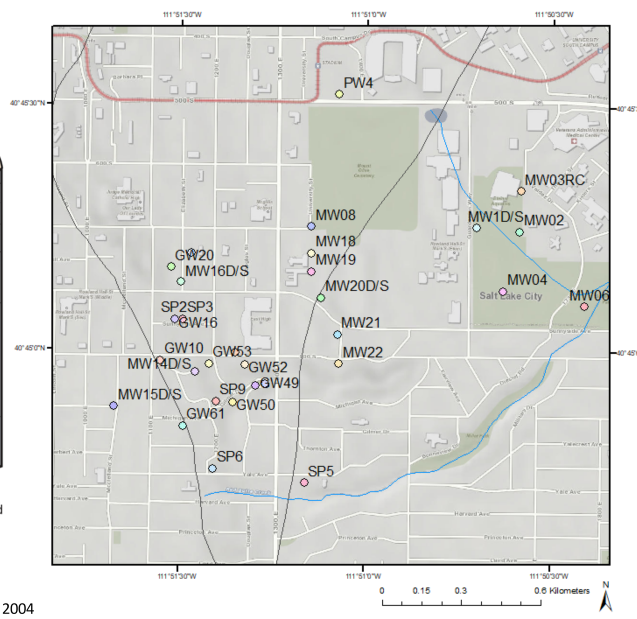
BACKGROUND & RESEARCH Q'S

- **Groundwater accounts for one-third of Salt Lake City's water supply**, with groundwater use being highest in the summer.
- There is an **ongoing Superfund investigation** into the extent of a PCE plume in shallow groundwater in northeast Salt Lake Valley.
- The Salt Lake Valley groundwater system includes a **deep, regional aquifer,** which supplies much of the valley's groundwater resources, and a **shallow unconfined aquifer** atop the deep aquifer's confining layer that is more susceptible to contamination from the land surface and can contribute to the deeper aquifer in areas where there is a downward head gradient or where the confining layers are absent.





The **apparent ages and recharge temperatures** (determined using ^{3}H-^{3}He age-dating and noble gas thermometry, respectively) were determined for groundwater from **valley, mountain-front, and headwater springs**, and **monitoring and production wells** of varying depths to address the following questions:

- What is the source of groundwater discharging from the East Side Springs in Salt Lake City, UT?
- What can be said about the contribution of groundwater from the shallow groundwater system to the deeper aquifer in this area?

INTERPRETIVE FRAMEWORK

If groundwater from seeps, springs, and shallow wells is sourced from...	We would expect to see...
Mountain-block recharge	Old apparent ages, cold recharge temperatures
Valley recharge	Young apparent ages (< 22 years), warm recharge temperatures, urban-influenced chemistry (high chloride and nitrate concentrations)
A point (or line) source within the valley, such as Red Butte Creek	Age of groundwater increases with distance from source (piston-flow model)
A diffuse source within the valley, such as seepage of irrigation or precipitation	Age of groundwater increases with depth (exponential mixing model)

RESULTS

Valley vs. mountain source

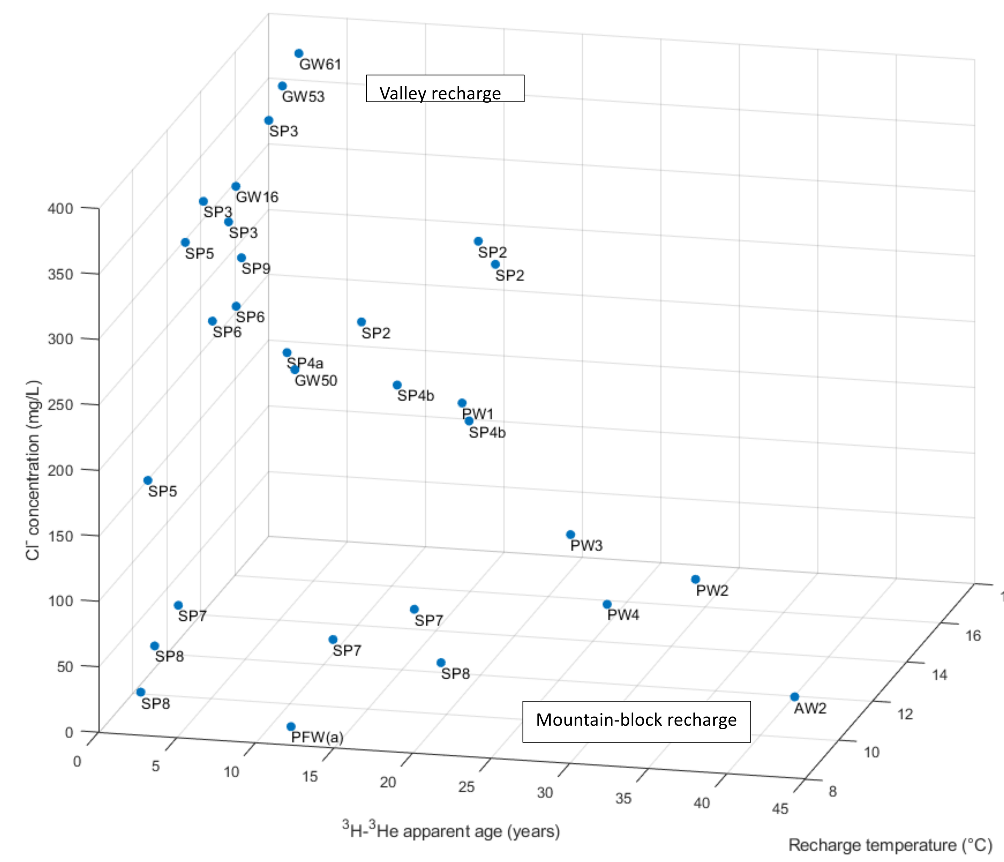


Figure 1. Recharge temperatures, apparent ages, and chloride concentrations of collected samples. Samples with warm recharge temperatures, young apparent ages, and high chloride concentrations are considered valley recharge, and samples with cold recharge temperatures, old apparent ages, and low chloride concentrations are considered mountain-block recharge.

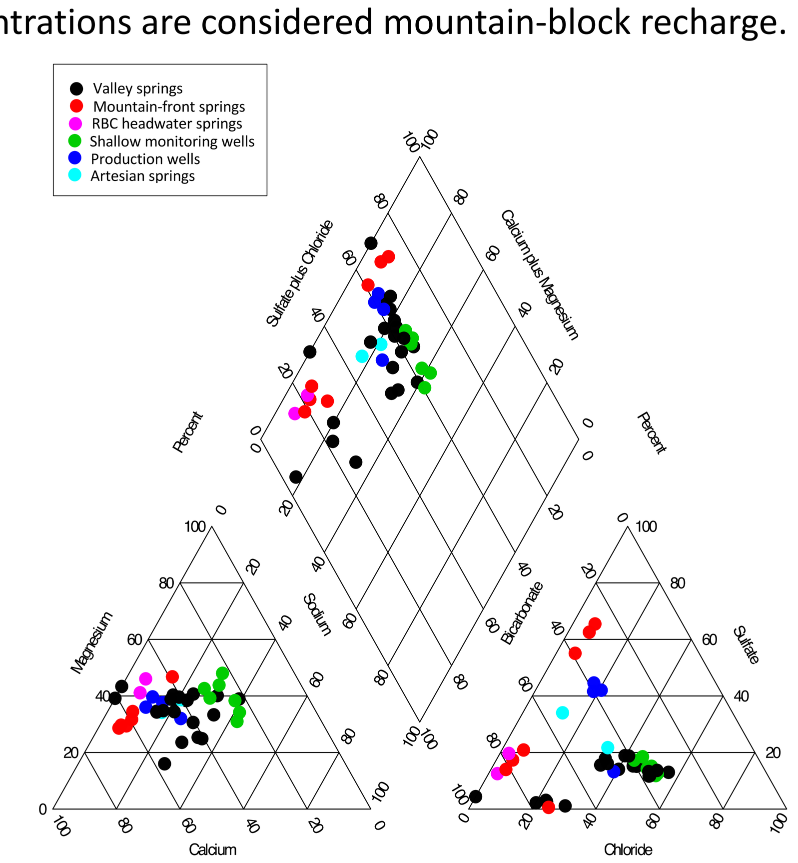


Figure 2. Piper diagram illustrating the major ion chemistry of collected samples. Mountain-front springs generally plot with Red Butte Creek headwater springs, suggesting they are mountain-sourced. Most of the valley springs, shallow monitoring wells, production wells, and artesian springs have high chloride concentrations, a signature of urban-influenced, valley recharge.

Contributions of Red Butte Creek

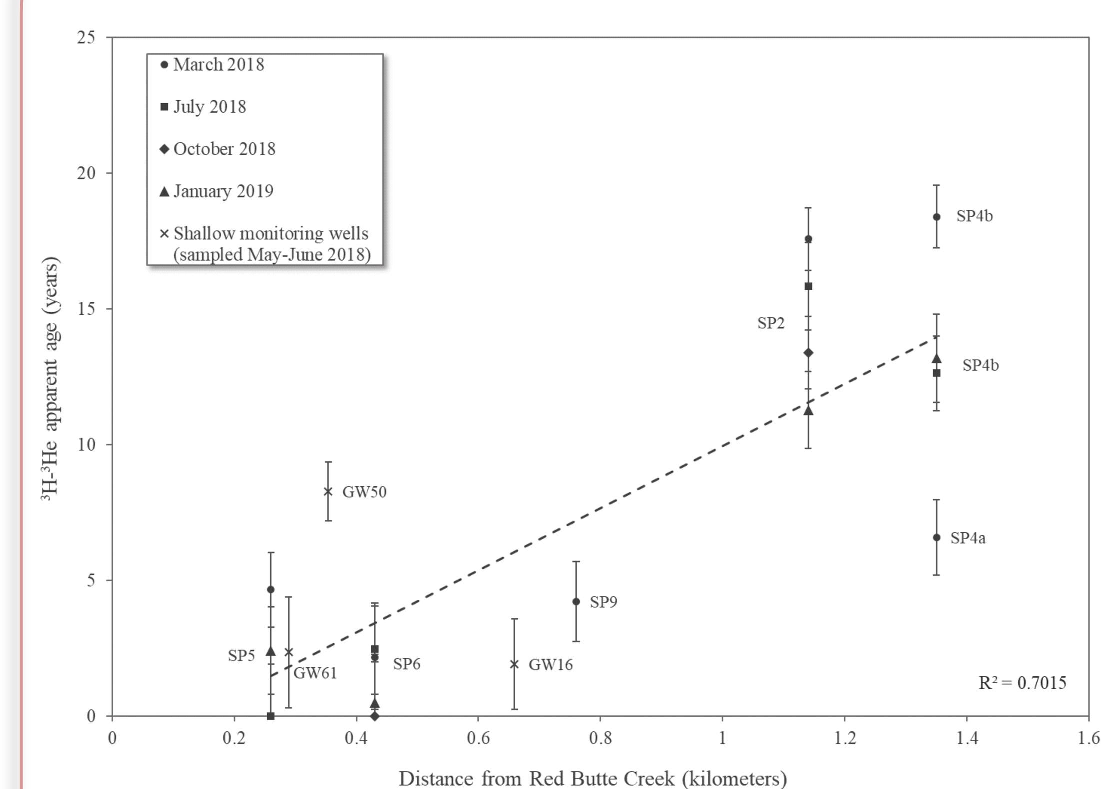


Figure 3. ^{3}H-^{3}He apparent ages of valley springs and shallow monitoring wells increase with distance from Red Butte Creek, suggesting that Red Butte Creek acts as a line source of groundwater for these springs and wells. Error bars represent measurement uncertainty in calculating ^{3}H-^{3}He apparent ages.

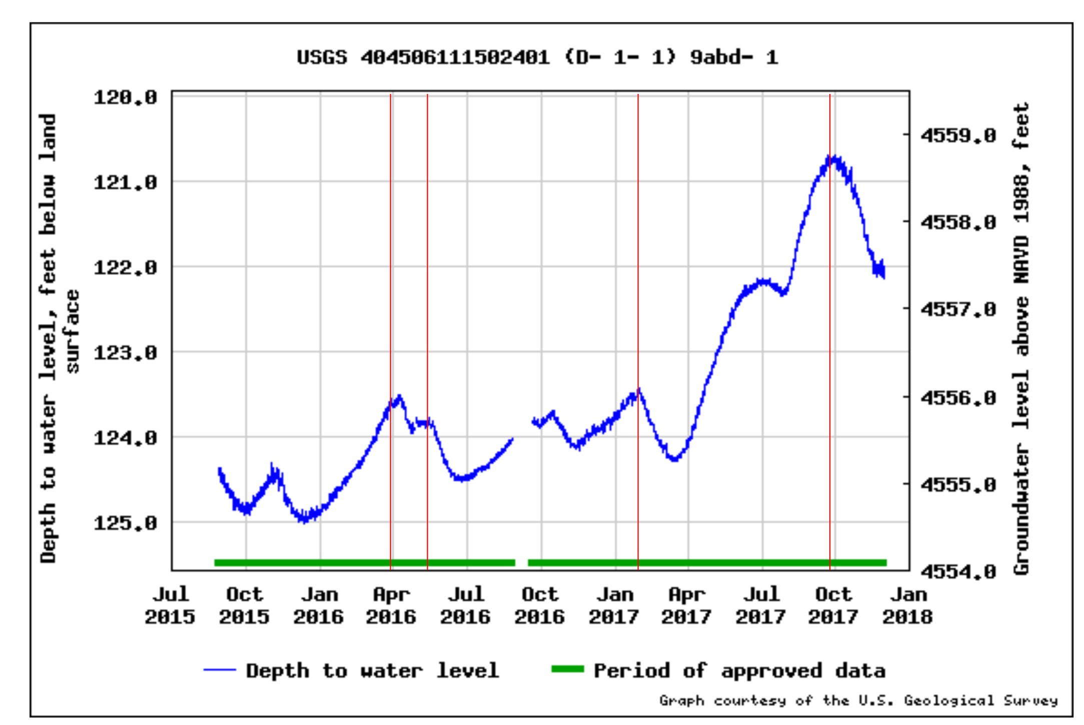


Figure 4. Water level in a monitoring well (depth = 40.8 meters) located near Red Butte Creek. Red lines indicate periods of time when Red Butte Creek was diverted from its channel. Water levels in this well are observed to decline following diversion, suggesting a hydraulic connection between this well and Red Butte Creek. There are at least three other monitoring wells of the same depth in this area that show the same hydraulic response.

Deeper groundwater system

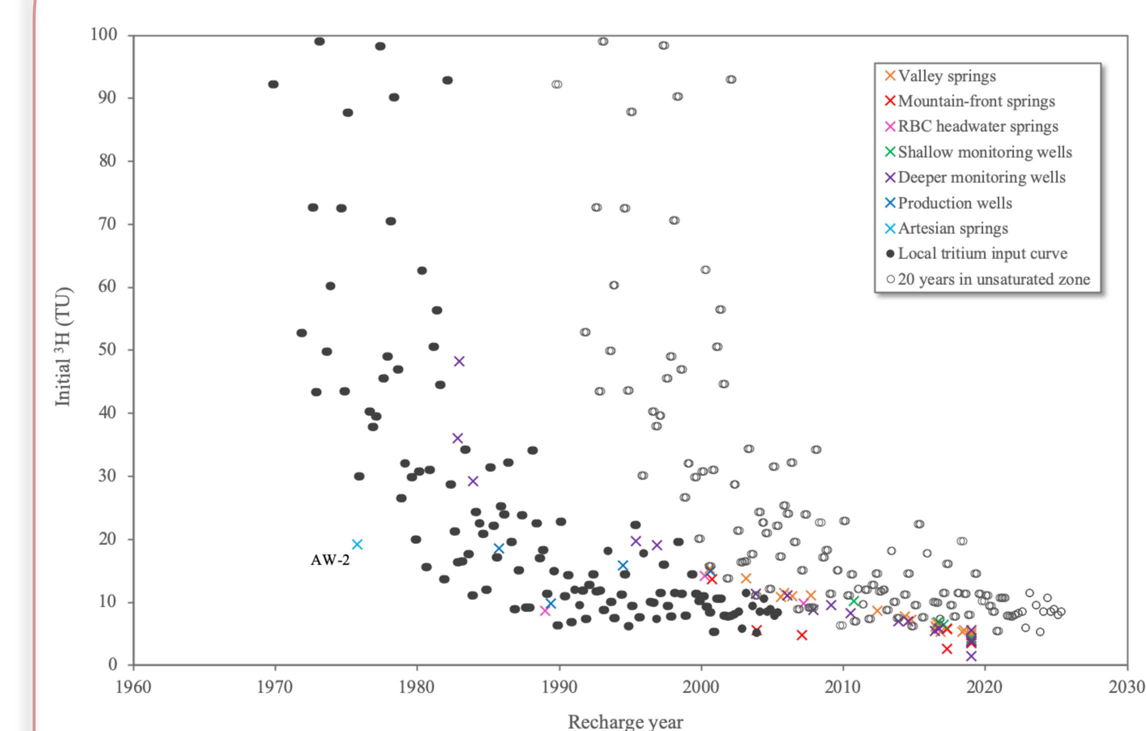


Figure 5. Atmospheric tritium curve for Salt Lake Valley, and the tritium curve shifted 20 years to represent 20 years of unsaturated zone transport, which would reset the ^{3}H-^{3}He clock. Samples that plot underneath the atmospheric tritium curve have some component of old (premodern) groundwater. An artesian well in the valley (AW2) is the only sample that plots below the curve, suggesting that it contains a mixture of old and modern water. All of the other samples are interpreted to contain entirely modern water.

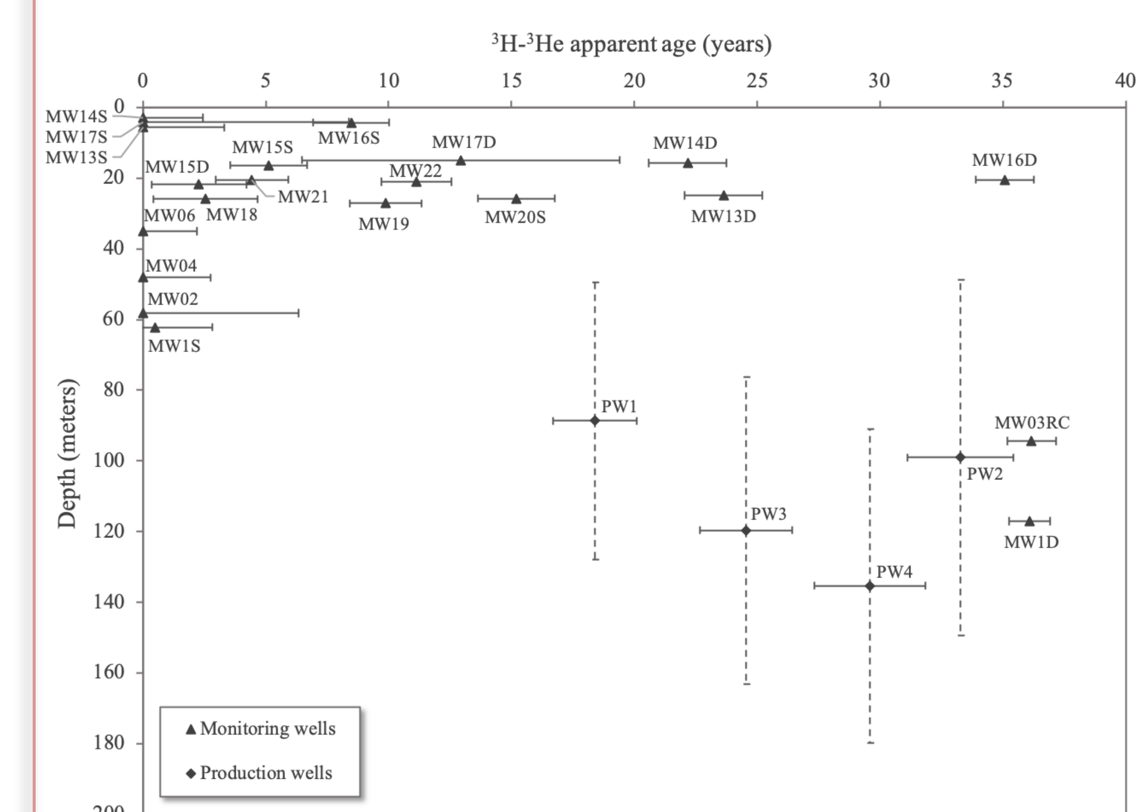


Figure 6. Relationship between ^{3}H-^{3}He apparent ages and depth for the deeper monitoring wells and production wells. Ages generally increase exponentially with depth, suggesting that groundwater transport can be described using an exponential mixing model. The vertical error bars on the samples collected from production wells represent the depths of the shallowest and deepest well screens.

CONCLUSIONS

- The seeps, springs, and shallow wells in this region primarily receive urban-influenced valley recharge as opposed to mountain-block recharge, as evidenced by their young apparent ages, high recharge temperatures, and relatively high chloride concentrations.
- A likely source of this water is losses from Red Butte Creek, as supported by the direct relationship between age and distance from Red Butte Creek and the hydraulic connection between Red Butte Creek and monitoring wells in the area.
- Deeper production and monitoring wells also have relatively high recharge temperatures and young apparent ages compared to production wells in the southern portion of the valley and display signals of urban-influence, including high chloride and nitrate concentrations, suggesting contribution of water from the shallow groundwater system.

I would like to acknowledge the CERCLA team at the VASLCHCS for allowing me to collect samples from the monitoring wells installed as part of their investigation. I would also like to thank Wil Mace and Jens Ammon for their help with sample collection and analysis, as well as my advisor Kip Solomon for his support throughout my master's.