

Evaluating groundwater inflow to Great Salt Lake, USA

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The Great Salt Lake (GSL) is a saline terminal lake located on the eastern margin of the Great Basin, USA. Since the mid 1980's lake levels have been declining and reached a record low in 2022, and this resulted in record high salinity levels (up to 180 g/L) and elevated area of dry lakebed that produces hazardous dust. As one of the most ecologically important water bodies in North America and responsible for more than 2 billion USD annually to the local economy, understanding the lake's water budget is critically important. While most inflow comes from direct precipitation and surface water, the role of direct groundwater discharge has been poorly constrained. Early estimates attributed about 3% of the total water budget to direct groundwater discharge, but more recent chemical mass balance methods suggest up to 12%. Remarkably, very little was known conceptually about the how groundwater discharges into the lake as the freshwater/saltwater interface on the margins or beneath the lake was unknown.

A collaborative study of groundwater occurrence and discharge involving nested piezometers, seepage meters, salinity profiles, resistivity surveys, permeability measurements, and environmental tracer data (noble gases, ^3H , SF_6 , ^{14}C) is providing conceptual and quantitative insights. Fresh water has been observed beneath the lake at depths of about 6 m with a wedge of salt water (up to 100 g/L) above. Upward hydraulic gradients appear to limit the downward migration of salty porewaters, but low vertical permeability results in long transit times with this fresh water being ^3H free, having elevated ^4He (up to 1000 times air-equilibrated water) and low ^{14}C (down to 5 pmc). Adjacent to the lake, noble gas thermometry suggests high-elevation recharge derived from the nearby Wasatch Mountains (more than 3000 m in elevation) with apparent $^3\text{H}/^3\text{He}$ and SF_6 ages ranging from about 0 near the mountain block to more than 70 years near the margin of GSL. Horizontal gradients in both $^3\text{H}/^3\text{He}$ and SF_6 ages are in relatively good agreement and are being used to estimate groundwater flow and rates of recharge.