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Mapping river recharge rates with stable isotopes and tritium-helium groundwater ages

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While climate change will challenge the future of California's water resources, groundwater can buffer variability in precipitation and streamflow, if managed sustainably. Enhanced river recharge is an important tool to reach sustainable groundwater management in the California Central Valley (USA). Understanding and predicting recharge rates of river water, either natural river bank infiltration or managed aquifer recharge (MAR) during floods (Flood-MAR) or on agricultural land (Ag-MAR) is essential to evaluate the sustainability of groundwater management plans. Groundwater ages, combined with other isotopic and noble gas evidence, can elucidate surface water-groundwater interactions and support river recharge rates calculations over longer time periods.

Our study is focused on the recharge from the Cosumnes River in the California Central Valley. The Cosumnes River forms the boundary between the Sacramento Valley groundwater basin to the north and the San Joaquin Valley groundwater basin to the south. For this study, 28 new samples were collected for the analysis of 3H/3He age, noble gases, and stable isotopes. 25 additional samples from the California Waterboards Groundwater Ambient Monitoring and Assessment (GAMA) Shallow Aquifer Assessment program were included, which were collected and analyzed by the USGS California Water Science Center in 2017.

We find that 28% of groundwater in the San Joaquin – Cosumnes groundwater subbasin originated as river water recharge, based on the interpolated mean $\delta^{18}O$ (7.7 ‰), compared with river water (-9 ‰) and local precipitation recharge (-7 ‰) end-members. River water is a source of modern recharge, resulting in high tritium concentrations close to the Cosumnes River. In contrast, ambient groundwater from local precipitation recharge is predominantly pre-modern or fossil, containing less than 1 pCi/L tritium. Combining groundwater ages with the distance to the river, aquifer thickness, and porosity, estimates of river water recharge rate vary between 0.02 km^3/yr and 0.035 km^3/yr. These quantitative estimates of river water recharge will constrain the numerical groundwater flow model for this basin and aid groundwater managers in developing sustainability plans to balance groundwater pumping with recharge rates.