# Harnessing the Power of Electromagnetic Imaging to Recharge California's Groundwater

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**ABSTRACT**

In California's Central Valley legislation now mandates that groundwater be sustainably managed after over a century of depletion of this critical resource. Managed aquifer recharge (MAR) is one vital component of many plans to reach this sustainability goal. MAR involves deliberately directing surface water into aquifers during periods of abundance, to store for later use. MAR operations can be classified into two broad categories; infiltration MAR, wherein the surface water percolates through an unsaturated zone before reaching the water table, and injection MAR, where water is directly injected into the saturated zone. Of these two, infiltration MAR is the most popular in California.

There are many factors that must be considered to effectively implement an infiltration MAR project, one of which is whether the site under consideration has subsurface conditions suitable for efficient recharge. The best sites are ones with interconnected pathways of sediments with high hydraulic conductivity. We refer to these pathways, which efficiently transport infiltrated water from the surface layer to the water table, as "fast paths". Often, the suitability of the subsurface represents a major data gap, due to limited depth coverage in traditional soil sampling approaches and low spatial density of drilling/coring data (e.g., driller's logs). The airborne electromagnetic (AEM) method, which rapidly maps out the subsurface resistivity, can play an important role in filling in this data gap. With the state-wide AEM project led by the California Department of Water Resources, there are now AEM data available throughout the valley (about 20,000 line-km) as well as resistivity profiles obtained from the inversion of these AEM data.

Motivated by the availability of these valley-wide AEM data, our study focused on creating valley-wide recharge metric maps that can be used to identify areas most suitable for recharge, based on their subsurface characteristics. To extract relevant information about fast paths from the AEM data, we designed a comprehensive approach that can create 2D recharge metric maps from input data including: (a) resistivity profiles from AEM; (b) sediment type profiles (from driller's logs); (c) water level measurements; (d) water quality measurements. Our approach was an expansion of previous approaches outlined in Knight et al., (2018) and Goebel and Knight, (2020) for constructing the relationship between resistivity and sediment type and in Pepin et al., (2022) for creating recharge metric maps from a sediment type model.

To maximize the potential for harnessing the power of AEM imaging for recharging California's groundwater, we have publicly released all AEM and in-situ data used in this study through our online database and made research software publicly available through the Python Package Index. In addition, by developing a web-based application providing a user interface to access the database and research software in a cloud computing platform, we aim to advance widespread adoption of AEM data to support the planning and implementation of recharge operations. (https://fastpath.stanford.edu).

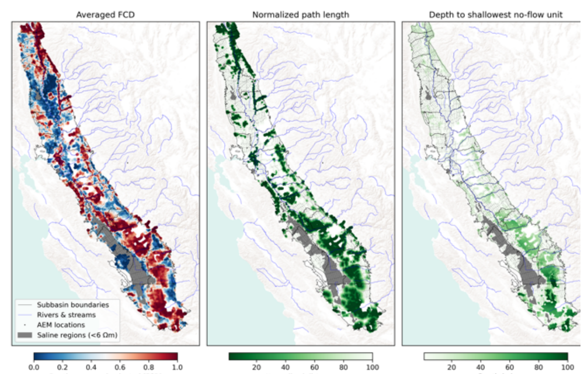


Figure 1: Valley-wide recharge metric maps derived from the AEM data. Left: vertically averaged fraction coarse-dominated (FCD); regions with red color indicate locations with high recharge potential. Middle: path length between the surface and the water table through the flow unit. Right: depth of the shallowest no-flow unit. Greener regions are better for recharge sites.

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