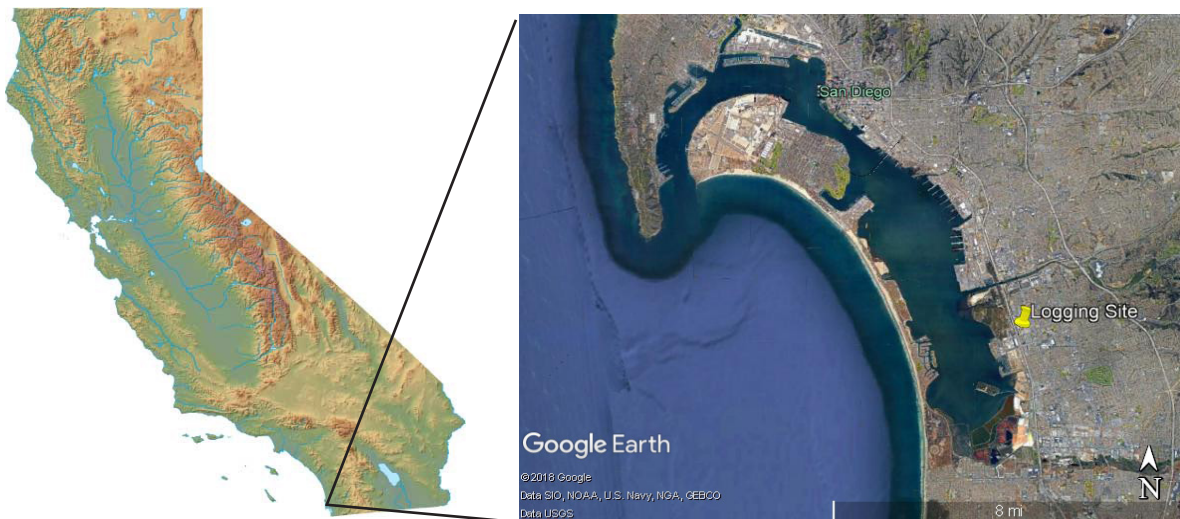




## Motivation

The US Geological Survey and water managers in California required improved understanding of saltwater intrusion in deep, coastal Southern California aquifers. In San Diego, the groundwater managers needed unambiguous, high-resolution information on the hydrologic

properties of water-bearing formations beneath San Diego Harbor, to depths of up to 3000 feet, to identify and assess the vertical distribution of and connections between critical salt water intrusion pathways into the city's groundwater aquifers.



## Technical Approach

NMR logging measurements were acquired immediately after drilling, in an open mud-filled exploration well borehole using a Javelin® Wireline NMR logging tool with 4-frequency, 3.5 inch diameter NMR logging probe. The well was drilled with a nominal 8.5 inch diameter bit, which enabled collection of useful data in all four of the tool's sensitive shells, which range from 10.5 inches to 15

inches in diameter. A rapid, low-resolution NMR log was acquired at a rate of 600 m/hr while the tool was deploying to the bottom of the borehole. A high-resolution NMR log was acquired at a rate of 60 m/hr logging from the bottom of the well to the surface.

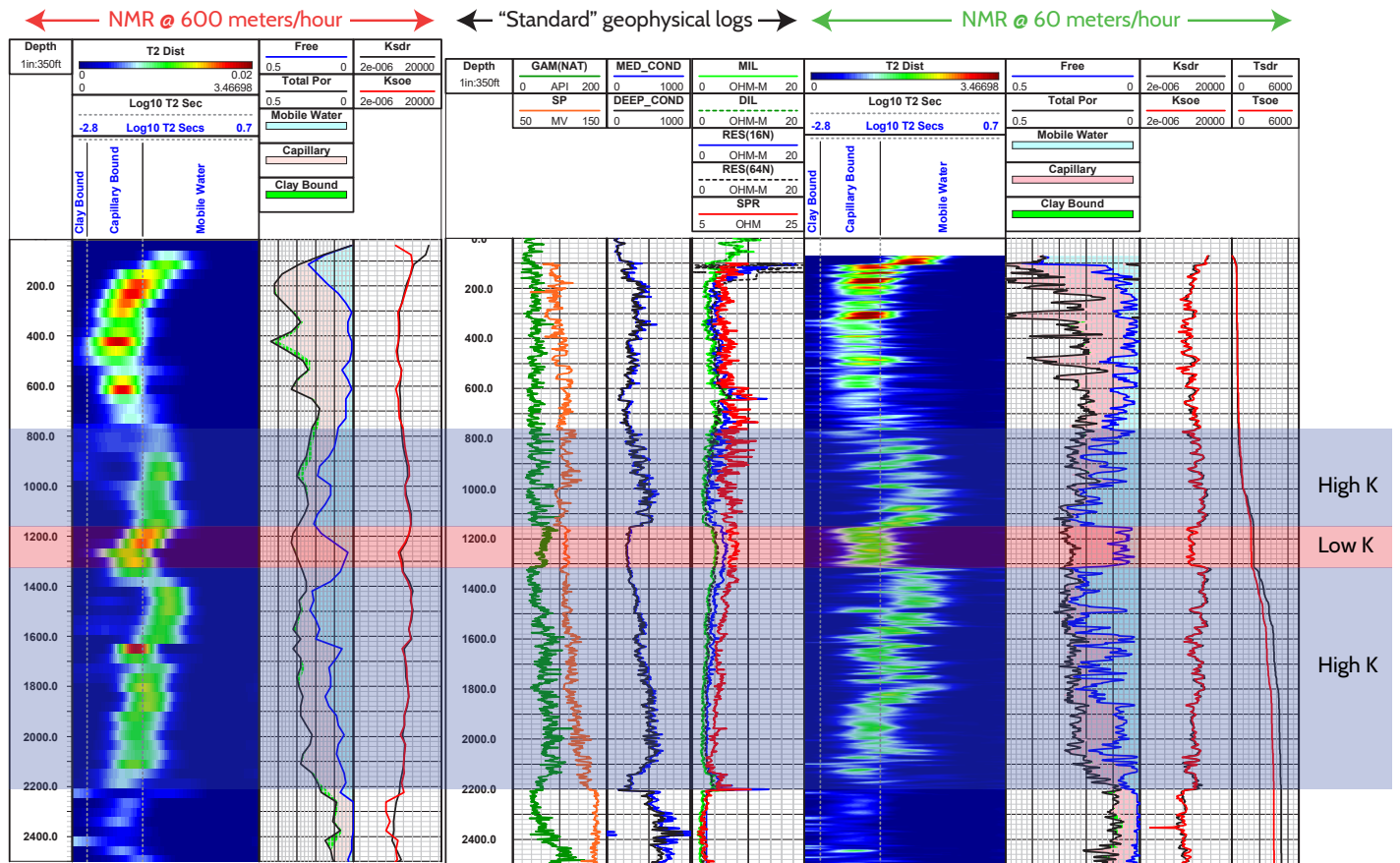
**Javelin® NMR**  
**Wireline Logging Tool**



# Results

The NMR log acquired at 600m/hr (left) provided a fast, real-time view of the structure of aquifers and aquitards. The high-resolution NMR log acquired at 60 m/hr (right) provided greater detail on the variability of bound and mobile porosity and hydraulic conductivity.

NMR clearly delineated permeable coarse-grained aquifers and low-permeability fine-grained formations, while electrical resistivity, gamma, and SP logs produced conflicting indications of permeability due to the influence of saltwater, particularly in the low-permeability formation between 1150 and 1300 ft.



## “Takeaway”

This application of NMR logging by the USGS demonstrates its value for characterization of deep groundwater resources, and for enabling improved management of these resources. NMR logging provides continuous, quantified measurement and estimation of hydrological

properties, at sub-meter resolution – invaluable data that cannot be obtained by any other combination of hydrological or geophysical measurements.

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