Sandia National Laboratories

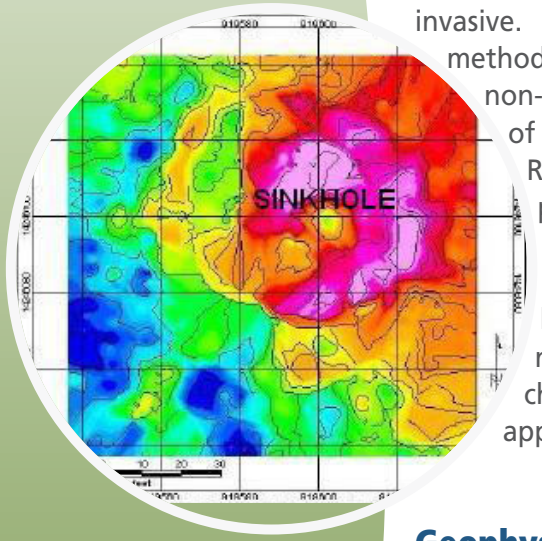
Energy, Climate, & Infrastructure Security

Hydrogeophysical Capabilities

Sandia National Laboratories' Defense Waste Management Programs' advances in physical understanding of the coupling between geophysics and hydrology have led to novel hydrogeophysical characterization approaches.

Description

Water is a critical component of the Earth's ecosystem, particularly in the desert Southwest. Drilling, pumping, and maintaining water wells is expensive and invasive. Indirect geophysical methods allow inexpensive non-invasive exploration of the Earth's subsurface. Recent advances in our physical understanding of the coupling between geophysics and hydrology have led to novel hydrogeophysical characterization approaches.



Sinkhole Located with EM and GPS

Remote Sensing Equipment for Detection of Water Movement

Geophysical Characterization Methods

Geophysical characterization methods (e.g., seismic, electrical resistivity, and electromagnetic methods) have long been used to delineate geologic layering, locate faults, and explore for water and hydrocarbon resources. Many geophysical methods are indirectly able to monitor the presence of subsurface water or water quality. Hydrogeophysics includes the subset of geophysical methods physically coupled to the hydrologic problem of interest. Streaming potentials, micro-gravity, and temporal electrical resistivity are some hydrogeophysical techniques used by Defense Waste Management Programs to investigate subsurface flow.

Streaming Potential

When water flows through a porous medium, a pore-scale electric current (i.e., the streaming potential) is generated, which can be measured at the surface as a time-variable direct current signal.

This hydrogeophysical method sees the movement of water, rather than just its presence or change through time. This makes the approach uniquely suited to characterizing aquifers while pumping wells, or detecting unwanted channeling through the foundation of a dam. We have developed several useful analytical solutions, which can be used to estimate aquifer flow parameter (i.e., permeability, storage properties, and unsaturated flow properties) without additional monitoring wells, only using surface voltage measurements.

U.S. DEPARTMENT OF ENERGY

Temporal Micro-gravity & Electrical Resistivity

Micro-gravity observations detect subtle differences in the Earth's gravitational field, due to differences in the distribution of mass surrounding the sensor. Changes in the gravitational field through time have been successfully connected with movement of water into (i.e., recharge due to infiltration) or out of (i.e., drainage due to pumping) the region of interest. Micro-gravity observations during unconfined pumping tests can provide distinct between dropping of piezometric pressure and actual water table declines.

Electrical resistivity surveys measure electric potential differences (i.e., voltage) in response to subsurface current injection at other locations. Different soil and rock formations have different intrinsic resistivities, which are important in geologic characterization. In hydrogeophysics, we are interested in the difference in apparent resistivity between dry and wet materials. Observing changes in resistivity through time using a semi-permanent survey arrangement, we observe effects of precipitation, infiltration, and drying on the otherwise-constant backdrop of geologic variation.

Remote Sensing Equipment for Detection of Water Movement

Publications

Estimation of the electrokinetic coupling coefficient and hydraulic conductivity from streaming potential measurements in a falling-head permeameter. 2012. B. Malama. Sandia National Laboratories, Albuquerque, NM. SAND2012-2994C.

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