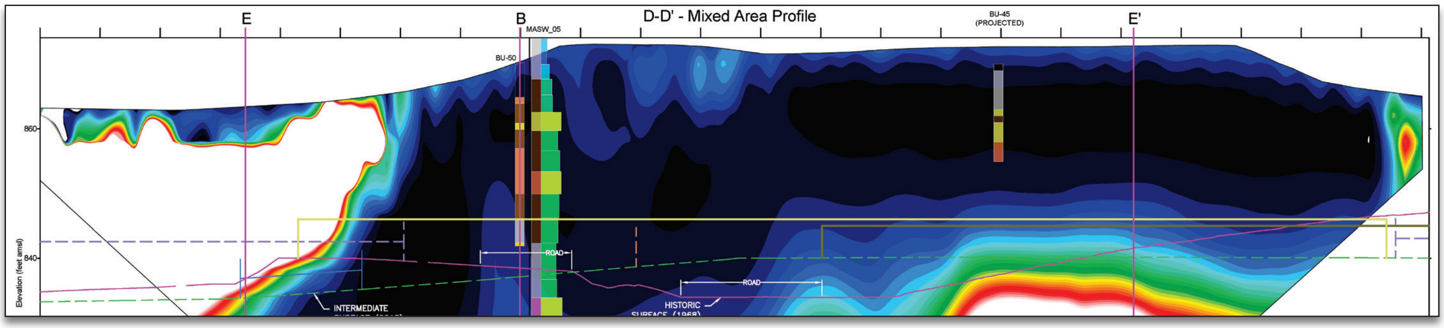
Geophysics

Alternative Subsurface Investigations



KEY provides geophysical services for subsurface environmental and geological characterization.

When traditional borehole programs are infeasible, KEY has experience using geophysical methods to characterize subsurface material using electromagnetic and seismic data. Project consideration should include ease of data collection, depth and size of target, and magnitude of material contrast based on method. Collection, processing, and correlation is essential as artifacts can arise from interferences, short-circuiting, poor signal-to-noise ratios, or modeling. These unintrusive options provide the ability to quickly and cost-effectively supplement existing information to fill gaps in data, complete site characterization, and plan material development.

Electrical Resistivity Imaging (ERI)

ERI is a common method for mapping subsurface material resistivity by sequentially applying an electrical current at induction nodes and recording the signal at receiver nodes along an array. ERI imaging depth is typically 1/3 the array length (often 100-feet or more) and resolution is dependent on survey configuration. ERI is commonly used for mapping bedrock, groundwater plumes, underground storage tanks, and investigating landfill material. It can be used on its own or combined with other geophysical methods.

Transient Electromagnetic (TEM)

TEM is a less common method that is used to map electrical resistivity by emitting a pulsed current through a loop to generate a magnetic field and secondary eddy currents, the decay of which provide a vertical profile of subsurface structure. TEM methods have the ability to image beyond 100-feet in material with moderate to high conductivities. The TEM methods do not require direct contact with the ground surface and can be used for delineating high conductivity solid or liquid material, and characterizing subsurface structure. It is often paired with ERI for improved interpretation.

Multi-channel Analysis of Surface Wave (MASW)

MASW is a seismic method of determining subsurface geomechanical properties (shear wave velocities) from the analysis of Rayleigh surface waves collected along an array of geophones. MASW is best used to image the upper 30-meters of the subsurface using hammer-drop methods, while passive MASW has the ability to image to greater depths, albeit at a lower resolution. MASW is often used for site characterization, bedrock mapping, and void and hazard detection. It can be combined with refraction tomography for enhanced subsurface models.

Geophysical Method Comparison

	ERI	TEM	MASW
What it Measures	Subsurface electrical resistivity distribution by injecting current and measuring voltages between electrodes	Subsurface electrical conductivity/resistivity by inducing EM fields with transient current pulses and measuring the decay response	Shear-wave velocity of near-surface layers by analyzing dispersive surface waves (Rayleigh waves) generated by a source
Resolution	Moderate (horizontal and vertical)	Lowest (horizontal and vertical)	Highest (vertical)
Collection	Deploy array with contact pins, apply and test current signal, and collect entire profile	Transmitter loop creates a pulsed EM field; receiver coils measure changing magnetic field over time. No galvanic contact required	Geophone array planted along a profile; a seismic source (e.g., hammer) generates surface waves recorded across the spread array
Typical Depth of Investigation	Shallow to moderate	Moderate	Shallow
Effort Collection: Processing	2 1:1	3 1:2	4 2:2
Cost-effort/Value	Low and Moderate	Low and Low	Moderate and High
Pros/Cons	+ High resolution + Direct contrast in resistivity - Needs good electrode contact - Short circuit potential	+ No need for direct contact electrodes + Can penetrate deeper electrical features - Limited shallow resolution detail - Sensitive to noise	+ Great for shear-wave (Vs) velocity profiles + Geomechanical properties - Moderate processing - Doesn't image contacts; models best fit curve
Typical Output	2D resistivity cross-sections or 3D volumes of resistivity (ohm-m)	1D resistivity profile or stitched 2-D cross-sections of conductivity/resistivity vs depth	1D Vs profiles or stitched 2D cross-sections
How Features are Interpeted	Changes in resistivity gradients correlated to lithology, porposity, or pore-fluid	Changes in bulk conductivity between layers	Changes in stiffness (Vs), not necessarily lithology
Best Used For	Delineating groundwater, bedrock, clay, voids, inorganic-contaminant plumes, and electrical stratigraphy	Deep resistivity contrasts such as mineral exploration, bedrock mapping, deeper groundwater detection, regional conductivity mapping, and environmental surveys	Shear-wave velocity profiling for geotechnical parameters, stiffness mapping, strategraphic modeling, and geohazard assessment