

# **Integrated Use of Geology, Shallow Geophysics, and Geochemistry for Environmental Site Characterization and Remediation Performance**

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## **Abstract**

Surface and downhole geophysical methods have been used in the petroleum industry since the 1920's. The use of geophysics methods for environmental and water resource studies has also been steadily increasing over the past few decades. Pioneer Natural Resources (PNR) uses the integrated collection and interpretation of geological and geophysical data on environmental sites to increase the understanding of the subsurface hydrostratigraphy which controls ground water flow and migration of contamination. The geophysical investigation techniques used can basically be grouped into three categories: (1) airborne, (2) surface, and (3) borehole or downhole methods. These geophysical methods can be used for a number of purposes in soil and ground-water contamination studies:

- Geologic characterization, including assessing types and thicknesses of strata and the topography of the bedrock surface below unconsolidated material, and for mapping subsurface paleochannels.
- Aquifer characterization, including depth to water table, water quality, and hydraulic conductivity.
- Contaminant plume identification, both vertical and horizontal distribution including monitoring changes over time.

In addition to the geological mapping of the subsurface, PNR routinely collects natural-gamma, SP, SPR and induction log data to provide additional information about the lithology and resistivity/conductivity of the matrix of soil, rock, and water adjacent to and within the wells.

The integrated data is used to provide an improved understanding of the geological framework of an area particularly in regard to hydrostratigraphy and variations in water quality. Well logs are also being used to provide subsurface controls for the interpretation of a helicopter electromagnetic survey flown over portions of the East Poplar oil field, in eastern Montana.

PNR also conducts ground electromagnetic magnetic (EM34) geophysical surveys for produced water, brine impact investigations. One unique aspect of ground geophysical surveys conducted by PNR has been the use of annually repeated (since 2006) EM34 surveys of a brine mitigation system which shows the spatial and temporal decreases in an area of high subsurface conductivity that correlates with a decrease in the area of the brine plume geometry as determined by monitoring wells geochemistry and geophysical induction logs.