Specialty Electrical Resistivity Imaging at NAPL-Impacted Site in Brazil: Key Contributions to the Conceptual Site Model

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Background/Objectives. Past operations at an industrial facility in Brazil have resulted in the presence of a complex mixture of constituents of concern (COCs) in soil and groundwater. Non-aqueous phase liquid (NAPL) has been observed in groundwater monitoring wells, soil samples and investigation trenches; primary COCs include dichlorobenzenes and dichloronitrobenzenes, among others. Site geology consists of interbedded layers of sands and clays, with evidence of a clay aquitard at a depth of approximately 50 meters below ground surface (mbgs). The water table is encountered at a depth of approximately 7 mbgs. While the site is no longer active, much of the industrial infrastructure is still present making access to source areas difficult. Due to drilling challenges in the area, most of the investigations conducted prior to 2016 were to a depth of approximately 12 to 20 mbgs. To help screen a large portion of the 14-hectare site with multiple potential source areas, a specialty electrical resistivity imaging (ERI) technology (Aestus GeoTrax Survey™) was used as an additional line of evidence to evaluate the extent of NAPL (horizontal and vertical), and hydrogeologic conditions to depths of 50+ mbgs.

Approach/Activities. Twenty-four (24) ERI transects were performed with lengths of 110 m and 385 m, and corresponding 2D image depths ranging from 22 mbgs to 77 mbgs, respectively. Shallow and deep transects were colocated to evaluate the sensitivity of the method relative to imaging depth (anticipated resolution was ~1 m for shallow images and ~3.5-m for deeper images). Existing lithologic data from site soil borings, regional geologic data, and downhole natural gamma logs were integrated to assess whether the ER data were able to identify the clay aquitard anticipated to be present at 50 mbgs. Existing groundwater and soil COC data and Membrane Interface Probe/Hydraulic Profiling Tool (MiHPT) data, along with historic observations of NAPL, were compared to the ER data to support interpretation. A focused confirmatory investigation was performed to assess significant resistive and conductive anomalies, both shallow and deep, including additional MiHPT logging, continuous coring and soil sampling, monitoring well installation, groundwater sampling, and analysis for COCs, DNA, redox conditions, and compound specific isotopes.

Results/Lessons Learned. Site resistivity values ranged over six orders of magnitude (< 0.1 ohm-m to > 20,000 ohm-m), with the 15^{th} and 85^{th} percentiles at 11 ohm-m and 760 ohm-m, respectively. Sands at the site demonstrated resistivity values of ~100 ohm-m. ERI successfully delineated the unconformity between the shallow and deep portions of the site aquifer (~24 mbgs), which represents an important stratigraphic control of groundwater flow and solute transport. Integrated data sets indicate that the clayey aquitard anticipated at 50 mbgs is not contiguous across the site. Vertically-oriented, highly resistive anomalies (> 5000 ohm-m) were observed near multiple source areas with some transport appearing to be affected by lithology. At depth (i.e., 30-50 mbgs), highly conductive anomalies (< 1 ohm-m) were observed, primarily on the eastern half of the site. Shallow and deep transects produced similar interpretations. This presentation will provide a detailed discussion of what the confirmatory investigation revealed about the highly resistive and conductive anomalies, and how these results were utilized to enhance the conceptual site model.