High-Resolution Investigation and MIP Visualization to Optimize In Situ Bioremediation of VOCs in Groundwater and Aquifer Sediments

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Background/Objectives. A former laundry located in Davis, California (“Site”), historically operated as a dry-cleaning facility using tetrachloroethene (PCE). A 1994 investigation conducted for an adjacent former gas station led to the discovery of potential PCE contamination at the Site. Early investigations were limited in scope and did not result in full characterization of the source area. Extended litigation amongst responsible parties and lack of funding further limited the scope of investigations. A change in approach in 2016 led to funding of one comprehensive investigation to support remedial design and costing to allow settlement to proceed. High-resolution investigation methods and data visualization were critical for a successful investigation and remedial design.

Approach/Activities. Past investigations included the installation of groundwater monitoring wells, soil and vapor sampling, and focused membrane interface probe (MIP) testing. The comprehensive investigation goals were to place existing data in context within a more uniform array of MIP, soil conductivity probe (SCP), and groundwater grab sampling borings across the source area. Nineteen MIP borings were advanced to 85 feet bgs on a grid spacing of 30 to 40 feet across the estimated source area. The continuous data from the sensors supported direct input into a database. Grab-groundwater samples were also collected from each boring to update the general understanding of volatile organic compound (VOC) distribution in the water-bearing zones.

The SCP and MIP data were processed and input into a three-dimensional (3-D) visualization model to depict the qualitative concentrations of VOCs as it related to soil/sediment permeability and stratigraphy. Manipulation of the visual output supported an updated conceptual model of VOC fate and transport across the wide range of sediment types.

Utilizing the 3-D model, a bioremediation program was designed to reduce the mass of chlorinated volatile organic compounds (CVOCs) in the source area. The bioaugmentation program utilized specialized jet injection techniques to inject liquid amendments into the saturated interbedded low- and high-permeability units between 25 and 80 feet bgs within the source area and down gradient. Working with FRx, Inc., which specializes in specialty subsurface injection for environmental remediation, 10 injection locations with 5-foot vertical injection intervals were selected to maximize the extent and distribution of injected liquid amendments. Additionally, air-permeability enhancement injections were completed in the vadose zone to increase the performance of existing soil-vapor extraction (SVE) wells by decreasing the required SVE vacuum and increasing SVE flow rates. Nine vadose zone locations were hydraulically fractured with a guar gum slurry containing a sand proppant.

Results/Lessons Learned. Data collected following bioaugmentation injections and SVE enhancement work demonstrated that the remedial approach mostly met the intended goal of reducing the mass of VOCs in the source area. The visualization model is proving useful for designing a supplemental round of injections to complete the remediation program.