Using High-Resolution Data to Evaluate Distribution and Effectiveness of In Situ Injectates

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Background/Objectives. Membrane interface probes and electrical conductivity/resistance detectors can be effective, qualitative screening tools to evaluate the presence of injectates in the subsurface, but discrete samples are often needed to confirm actual distribution of treatment reagents. Obtaining high-resolution, quantitative data can be essential to characterize solute distribution in soil and groundwater and to map the slurries delivered to chase and destroy those solutes. The objective is to know “are we where we need to be?” and “how effective was the treatment?” and/or “do we need to treat some more?” Successful remediation programs need to be flexible and supported by robust reagent-distribution intel and performance monitoring that allows using “where you have been” to adjust for “where you need to go”.

A high-resolution approach was implemented at a large, urban industrial facility where trichloroethene (TCE) was used extensively. The site was underlain by river deposits and sedimentary bedrock. The selected remedy was BOS 100®, an immiscible, activated carbon solid injectate impregnated with elemental iron. Impacted alluvium consisted of well-graded, fine- to coarse-grained sand. The source area was underlain by an aquitard of clayey silt where dense non-aqueous phase liquid (DNAPL) pooled at the sand-silt interface (up to 25,477,000 micrograms per kilogram TCE in soil and 1,280,000 micrograms per liter TCE in groundwater). Subtle facies changes resulted in concentrations that varied by orders-of-magnitude in distances of only several millimeters. This inherent complexity made it essential to have quantitative, high-resolution data to demonstrate remedy delivery and performance.

Approach/Activities. Once an accurate conceptual site model was constructed and treatment was underway, the high-resolution program was tailored to map the distribution of BOS 100® and to quantify solute mass reduction. The BOS 100® was injected in Cartesian and radial grids throughout the plume area. To address remedy delivery, design conformity was evaluated to determine whether grid spacing was appropriate to achieve targeted horizontal and vertical treatment coverage. Methods to map the reagent included completing forensic borings between grid nodes using continuous-sampling equipment. Sample cores were inspected for the presence of BOS 100® using visual and/or mechanical methods, e.g. magnets were used to attract the iron-infused granules. Hydraulic-head changes were also monitored in nearby wells during injection activities to evaluate radius of influence as an indicator of reagent distribution.

Since BOS 100® was not always visible, confirmatory borings were drilled to collect soil and/or groundwater samples to serve as *de facto* evidence of injectate distribution, via observed solute concentrations. In total, 186 borings were completed to observe for BOS 100® and 1,291 soil samples were analyzed to quantify mass reduction. Additionally, 5,515 groundwater samples were analyzed from 1,349 temporary monitoring wells to further document remedy distribution and treatment effectiveness.

Results/Lessons Learned. The project was successful because the distribution of BOS 100® was optimized by monitoring injectate placement throughout the injection program. This led to treatment-performance confirmation as even the DNAPL portion of the plume was reduced from percent-level concentrations to closure levels. The dissolved-phase plume was also mitigated and site-closure monitoring began in 2015. A No Action Determination was granted by the State in 2016 for unrestricted, residential land use redevelopment.