Characterization and In Situ Remediation in a Complex Fracture-Flow Regime

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Background/Objectives. Since 2007, TDEC-UST instituted a standardized program to accelerate response to releases and shorten the time required for investigation and cleanup. This included purchase and use of approximately 200 DPE systems, which resulted in a closure success rate of 95% with an average time to closure of about 2 years. Some sites have conditions which limit the effectiveness or use of traditional mechanical systems and TDEC has been evaluating effective alternative technologies. One such site in rural east Tennessee has numerous drinking water well receptors. The site is underlain by relatively shallow clay soils weathered in place from limestone and dolomite. Bedrock is part of the Pine Mountain Thrust Sequence with deformed and fractured geologic units striking southwest-northeast and dipping steeply to the southeast. Groundwater occurs within the secondary fracture and solution porosity of the bedrock. A release prompted free product recovery and remediation using various mechanical systems from 1993 through 2017 with limited success. Free product and contaminant rebound would occur when the treatment system was turned off.

Approach/Activities. Alternative technologies considered for effective remediation of low concentration dissolved phase constituents and LNAPL in a fractured bedrock groundwater flow regime included in-situ chemical oxidation, enhanced bioremediation, liquid activated carbon injection, and Trap & Treat® BOS 200® (BOS). BOS was selected by TDEC for its comprehensive methodology consisting of a high resolution remedial design characterization (RDC) using surface resistivity and downhole geophysical investigations, high density soil sampling and analysis, rock coring, and aquifer characterization (AqCh). The RDC was used to develop a detailed conceptual site model (CSM) which then supported a surgical and aggressive in situ remedial plan. BOS injection was specifically selected because it demonstrated the ability to address and remediate LNAPL, could effectively be installed into a fracture-flow bedrock regime, could provide long-term degradation of contaminants, and had a reduced time to closure compared to other considered technologies. The virgin coal-based carbon used in BOS has a larger adsorption capacity than the carbons used in other products. This is important when discussing degradation kinetics. A linear relationship between adsorption capacity and kinetic rate of contaminant degradation exists. For instance, it requires four times more wood-based carbon to achieve the same rate as that of BOS. BOS is also combined with supplements (terminal electron acceptors and nutrients) and inoculated with facultative microbes prior to injection into the subsurface. All of this provides the perfect environment for contaminant adsorption and the ability to regenerate the carbon in situ by degrading adsorbed contaminants and allowing further adsorption. This is how BOS can remediate LNAPL.

Results/Lessons Learned. AqCh (pumping tests and discrete interval sampling/analysis) and in-situ injection were conducted across the study area using a custom straddle packer with a discrete 18-inch interval between elements. Surrounding wells were monitored continuously using pressure transducers for hydraulic response. A hydraulic connection within a 4 ft vertical interval across the treatment area and a vertical concentration gradient in the source wells was identified during aquifer characterization and in situ remediation. Supporting data provided at the time of presentation will include analytical data summary tables, trend analysis graphs, site figures, and contaminant mass calculation comparison. Post-injection performance groundwater monitoring has indicated an immediate and sustained reduction of all COCs to below the cleanup levels and elimination of LNAPL. Case closure is anticipated in December 2017.