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Treatment of Multiple TCE Plumes in Shallow Aquifer by Sequencing SVE, Chemical Oxidation, and Enhanced Reductive Dechlorination

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Background/Objectives. In 2007 aggressive remediation began at this manufacturing facility to manage potential risks posed by TCE source areas in shallow groundwater in silty alluvial soils overlying deeply weathered basalt (WB). Remedial objectives included 1) decrease volatile organic compound (VOC) mass in shallow source media to reduce ongoing horizontal migration in shallow groundwater; and 2) decrease shallow groundwater VOC mass to protect against downward plume spreading into the WB.

Approach/Activities. The treatment volume is approximately 30,000 cubic yards, in an area of approximately 100,000 square feet. The technologies that were combined to reach these objectives are:

1. Soil Vapor Extraction (SVE) to decrease vadose zone VOC mass at the source (implemented summer 2013);
2. In situ chemical oxidation (ISCO) using 93,000 gallons of injected sodium permanganate (target in situ concentration of 18 to 22 mg/L) to treat high-strength TCE concentrations (>10,000 µg/L) in the source areas (implemented 2014-15); and
3. Enhanced Reductive Dechlorination (ERD) for the dissolved-phase plumes extending from the sources. In 2015-16, ERD was implemented by injecting 430,000 gallons of EVO solution (target in situ concentration of 4,000 to 8,000 mg/L) in five cross-plume transects, supplemented locally by bacterial amendment, in areas containing TCE concentrations exceeding Oregon risk-based concentrations (RBCs) for excavation workers (430 µg/L).

Among the methods used to evaluate progress of ISCO and ERD injections were pre-design investigations before each technology application, careful monitoring of injectant delivery and persistence, and compound specific isotope analysis (CSIA) for corroborating chloroethene treatment.

Results/Lessons Learned. The initial ISCO applications (Rounds 1 and 2) diminished dissolved TCE concentrations 50 to 90 percent, with an estimated cumulative TCE mass removal of 95 percent (sorbed plus dissolved) in the shallow saturated soil and the groundwater. An additional ISCO application (Round 3 in July 2016) targeted newly found residual areas of elevated concentration scattered around the edges Rounds 1 and 2 injection locations - data from Round 3 is currently being evaluated. Four post-ERD injection sampling events have been conducted as of October 2016. Results indicate a 60 to 90 percent decrease in TCE mass. The EVO has been successful in converting TCE to daughter products and decreasing total aqueous concentrations of chloroethenes in the aquifer. The SVE and ISCO are treating the high strength sources, and the ERD is treating the dissolved phase material emanating from the sources. Thus, the stepwise application of the three technologies is approaching the goal of source removal, driving the system toward meeting risk based concentrations, and decreasing contaminant mass to prevent potential longer term downward flux into WB.