In Situ Treatment of a Commingled Carbon Tetrachloride and Trichloroethene Groundwater Plume in Fractured Bedrock

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Background/Objectives. Hunters Point Naval Shipyard (HPNS) Parcel C in San Francisco, California, Remedial Unit (RU)-C2-3, contains a commingled trichloroethene (TCE), carbon tetrachloride (CT) and chloroform (CF) groundwater plume, derived from releases during historical pipe manufacturing, pickling, and degreasing operations. Concentrations within the plume range from 30 to 1500 micrograms per liter (µg/L) TCE and 10 to 140 µg/L CT and are present within a low-permeability water-bearing unit of Franciscan fractured bedrock. The RUC2-3 cleanup requires chemicals of concern (COC) be reduced to 2.9 µg/L for TCE, 0.5 µg/L for CT, and 0.7 µg/L for CF based on future use. In situ treatment using hydraulic fracturing to emplace a combination of in situ chemical reduction (ISCR) using zero valent iron and in situ bioremediation (ISB) using emulsified vegetable oil will be used to treat this complex plume. The objectives of remedial action at RU-C2-3 are to: 1) design a robust strategy for in situ treatment of TCE and CT to overcome limitations of inhibition, geochemistry, and bedrock matrix, and 2) achieve site-specific remediation goals.

Approach/Activities. A robust decision process was implemented to evaluate ISB and ISCR remedial technologies alone and in combination with a hydraulic and/or pneumatic fracturing for emplacement. ISB and ISCR involve the addition of amendments and microorganisms to produce biogeochemical conditions in the aquifer that promote destructive abiotic and biotic processes for the removal of COCs. However, the dynamics of combined technologies with comingled COCs are complex. The remedial design must consider: abiotic and biotic degradation pathways for all COCs, biotic inhibition (e.g., TCE degradation is inhibited by CT and CF), buildup of undesirable daughter products (e.g., vinyl chloride and CF), geochemistry and impact by amendments (e.g., reducing potential), and inter-amendment effects (e.g., prevention of zero-valent iron [ZVI] passivation). The design targeted enhancing CT abiotic degradation with concomitant abiotic and biotic degradation of TCE for the complete destruction of all COCs to nontoxic end products.

Results/Lessons Learned. The remedial strategy combines ISB and ISCR with amendment dosing adjusted based on mass and distribution of COCs. For high concentrations, high-dose (0.4% weight percent ZVI/soil) will be emplaced compared to low-dose ZVI (0.25% ZVI/soil). All treatment volumes will receive 2.5% by volume emulsified vegetable oil and lactate along with bioaugmentation cultures. Two- and three-dimensional visualization of plume extent, injections and treatment in the context of site hydrogeology will be presented using ArcGIS™ and Leapfrog®. Inhibition is not often discussed or addressed in remediation design for co-contaminated sites, where traditional ISB methods should be complemented after thorough understanding of co-contaminant impacts.