

Attenuation and Biostimulation of Perchloroethylene Following In Situ Chemical Oxidation

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Perchloroethylene (PCE) was used by a drycleaner at a leased facility in the Southeast from 1973 until 1993. In 2002, studies by the owner's consultant showed subsurface impacts in soil and groundwater, particularly related to PCE, with lesser concentrations of trichloroethylene (TCE), cis-1,2-dichloroethylene, (cis-1,2-DCE), and vinyl chloride (VC). These four constituents are considered to be the constituents of concern (COCs). Initial corrective action consisting of potassium permanganate injections was performed in 2004 to attempt to chemically oxidize COCs in soil and groundwater. However, subsequent monitoring events showed rebound of the COCs and concentrations significantly greater than maximum contaminant levels (MCLs) remained in Site groundwater at some locations. Brown and Caldwell (BC) was retained to further evaluate this site, finding that migration of COCs has likely been constrained by the low permeability clays beneath the property. Subsequent to the incomplete results of the in situ chemical oxidation (ISCO), degradation products of PCE started to consistently be detected at relatively high concentrations in 2 of the 5 locations of concern, indicating that natural attenuation by reductive dechlorination is occurring. Additionally, groundwater chemistry data indicate that subsurface conditions are conducive for this biodegradation. The groundwater monitoring location that best exemplifies this series of events contained the following concentrations of PCE: 8,300 µg/L prior to chemical oxidation, 860 µg/L immediately after ISCO, rebound to 4,200 µg/L within 3 months, and then reductive dechlorination to 500 µg/L. BC developed a Corrective Action Plan (CAP) to address impacted groundwater at the Site. The objective of the CAP was to identify corrective action alternatives and then recommend one that could effectively reduce COCs in groundwater to concentrations less than MCLs, thereby ultimately allowing for future unrestricted use of the property. Biostimulation through injection of the electron donors Hydrogen Release Compound (HRC™) and Hydrogen Release Compound Extended Release Formula (HRC-X™) into the subsurface was considered to offer the most suitable combination of practicability, logistics, safety, time, and cost parameters, and these materials were selected for the corrective action. Prior to implementation of this corrective action, samples were collected from two of the on-site groundwater monitoring wells for vinyl chloride reductase enzyme testing. This proof-of-concept testing was needed to verify the presence of adequate strains of *Dehalococcoides* (Dhc) microbes that degrade vinyl chloride to ethene. The samples were also subjected to DNA testing to verify that the VC reductase (*vcrA*) gene is present. If the results had been negative, then bioaugmentation or another alternative corrective action would have been proposed. Based on acceptable Dhc and *vcrA* results, in May 2008, 3,450 pounds of HRC™ and 1,740 pounds of HRC-X™ were injected into the subsurface under pressure using direct-push methods and closely spaced points, to help provide adequate distribution within the treatment zone. More specifically, the material was be injected into approximately 143 soil borings located on an 8-foot center-to-center grid. A closer spacing was be used in the vicinity of MW-4, which is where the highest COC values were measured. Results for the first 2 monitoring events after electron donor injection are available. The observed trend of declining COC concentrations and the presence of degradation products demonstrate that biodegradation is occurring and is somewhat enhanced at this point. The bioparameters corroborate this conclusion by showing the existence of geochemical conditions