

Adaptive Site Management to Demonstrate Remedial Success of Chlorinated Ethenes in Groundwater at a New Jersey Site

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Background/Objectives. Voluntary adaptive site management was used at a New Jersey site with chlorinated volatile organic compounds (CVOCs) in groundwater to modify and improve a modestly-performing groundwater in situ bioremediation recirculation system with soluble substrate into a well-performing system with a slow-release carbon substrate and bioaugmentation. The in situ bioremediation recirculation system operated between 2015 and 2018. Water from extraction wells was amended with a fast-acting soluble substrate and reinjected at injection wells to remediate the CVOCs, primarily trichloroethene (TCE), with total concentrations on the order of 40,000 micrograms per liter (µg/L) in source area site monitoring wells. A remediation performance evaluation completed in 2018 found that while TCE was being reduced to cis-1,2-dichloroethene (cis-1,2-DCE), degradation to final non-toxic end products was not achieved. Key limitations to system effectiveness included a limited radius of influence of the carbon substrate and an absence of key microbial populations responsible for complete reductive dechlorination. Furthermore, re-injection of CVOc-impacted groundwater led to increased CVOc concentrations in areas of the site with historically low concentrations. Using an adaptive management approach with a flexible remediation system, strategic modifications were employed to resolve the stalled remediation, demonstrate remedy success, and meet a statutory deadline.

Approach/Activities. The adaptive management strategy focused on modifications to the remediation system to quickly and cost-effectively promote complete reductive dechlorination of CVOcs. Modifications included: 1) cessation of recirculation of groundwater; 2) conversion of existing extraction wells to injection wells to increase the injection footprint; 3) installation of additional injection wells in identified source areas; 4) transition from a quick-release to a slow-release emulsified vegetable oil substrate to provide a longer-lasting carbon source; and 5) bioaugmentation with a *Dehalococcoides* microbial consortium to support microbial degradation of CVOcs. A pilot test was completed in June 2018 and confirmed that enhanced bioremediation including bioaugmentation could be effective at full scale. Full-scale injections were completed in fall 2019 summer 2021.

Results/Lessons Learned. Quarterly groundwater monitoring following injections has shown favorable geochemical conditions for reductive dechlorination, with increased carbon availability and microbial cell counts. TCE (the primary contaminant on site) decreased from greater than 21,000 microgram/L to less than 25 microgram/L in the source area well with decreasing concentrations of daughter products observed as well. CVOc concentrations in several downgradient (property boundary) monitoring wells were reduced by over 99 percent (from approximately 1 milligram/L to 0.01 milligram/L), again with evidence demonstrating complete degradation to non-toxic end products. The adaptive site management approach allowed for relatively quick implementation of a flexible remediation system, which can continue to be adjusted as site conditions are monitored, resulting in improve remedial performance at a lower cost.