Performance of Combined Bioremediation and ZVI Emplacement Remedy for Chlorinated Solvent Source Treatment

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Background/Objectives. The Bountiful/Woods Cross Operable Unit 1 Site (referred herein as the Site) is located in southern Davis County, Utah, roughly 10 miles north of Salt Lake City. The several acre source area is impacted with elevated trichloroethene (TCE) concentrations including residual dense, non-aqueous phase liquid (DNAPL) from past industrial activities. While the majority of the groundwater in the vicinity of the source has been remediated using in situ bioremediation with emulsified oil amendments, a localized recalcitrant source zone containing heterogeneous deposits of dense, well-graded sand and gravel alternating with layers of sandy, silty clay continues to contain residual DNAPL, and conventional amendment injections have not substantially reduced concentrations of contaminants. An aggressive remedy for targeted source treatment was implemented, combining enhanced anaerobic bioremediation with emplacement of zero-valent iron (ZVI) via environmental hydraulic fracturing to target residual TCE mass present within low-permeability lithologic units.

Approach/Activities. ZVI emplacement occurred within an area where enhanced anaerobic bioremediation was well established following several rounds of electron donor (Wilclear Plus®) injection. Following delineation of the high-concentration source area using membrane interface probe and development of a 3-D visualization model to aid in source delineation and selection of treatment locations, nearly 20,000 pounds of micro-scale ZVI was emplaced at targeted locations and depth intervals in the source area using environmental hydraulic fracturing. Following ZVI emplacement, hydraulic characterization of the source area was completed using pumping and injection tests, and a MODFLOW model was developed based on the 3-D visualization to model recirculation scenarios to enhance biodegradation of VOC source mass following ZVI emplacement. Performance monitoring was conducted at wells within and downgradient of the targeted treatment area.

Results/Lessons Learned. The permeability enhancement approach using hydraulic fracturing was effective at delivering ZVI throughout a network of fractures within the high-concentration source area, as confirmed using tilt meter analysis and through confirmation borings. Evaluation of tiltmeter data indicate that the emplacement created a network of overlapping and interconnected fractures throughout the target treatment area. A greater than 99 percent reduction in VOC concentrations was observed in source area monitoring wells within one month after emplacement of the ZVI, and this reduction has been sustained through seven months of monitoring after ZVI emplacement. Continued generation of degradation compounds and ethene indicate that biological degradation is occurring in addition to abiotic degradation. Sustained reductions in VOC compounds following ZVI emplacement has indicated that biorecirculation is not necessary at this time to enhance source mass reduction.