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Combined In-Situ Chemical Reduction and Enhanced Bioremediation to Treat Chlorinated Solvents in Unsaturated Soils at a Former Chlorinated Solvents Manufacturing Plant

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Background/Objectives. A former chlorinated solvent manufacturing facility undergoing remediation at a Solid Waste Management Unit (SWMU) #77 which was formerly a production area (Area of Concern [AOC] E). The site is managed under the RCRA Corrective Action program with oversight by the Louisiana Department of Environmental Quality (LDEQ). Various chlorinated volatile organic compounds (CVOCs) are present in the unsaturated soils at concentrations greater than 100 parts per million (ppm) at multiple locations. The unsaturated soil impacts range from ground surface to approximately 15 feet below ground surface. The chlorinated solvents originated from storage and transfer of solvent products in this former production area (Per/Tri Area). These COCs include carbon tetrachloride (CT), chloroform, 1,2 dichloroethane (DCE),1,1,2 trichloroethane (1,1,2 TCA), tetrachloroethylene (PCE), trichloroethene (TCE). Heterogeneous, tight, depositional soils in the target area, along with buried debris from former operations and proximity to a tenant's active pilot plant operations make this a challenging area to remediate.

Approach/Activities. A technology feasibility study was conducted at the site between December 2015 and April 2016 to determine the effectiveness of injecting, via direct push technology, chemical reductants for direct chemical dehalogenation of the targeted chlorinated compounds, as well as co-injection of electron donor, nutrients and enriched bacteria culture to enhance both abiotic and biotic dechlorination. Pre-injection base-line sampling and analysis of CVOC concentration were performed at three target depths (3-5 ft, 8-10 ft, and 12-15 ft bgs) over the 15-foot injection horizon. In addition, microbiological/genomic testing was conducted on soil samples to determine the presence or absence of dechlorinating bacteria, and thereby determine the biotic and abiotic degradation pathways. Two injection locations were selected as representative of the overall AOC and injections of all chemical and biological amendments were conducted over a two-day period. Injection volumes, flow-rates and pressures were measured at each injection location and depth. Post-injection soil sampling was conducted approximately 120 days after the initial injection event to determine the effectiveness of the feasibility testing program to destroy and/or degrade the targeted CVOCs present in soil. Follow-up genomic testing was also performed to determine the effects of the injected chemistry on the biological communities present in the subsurface soils.

Results/Lessons Learned. The reduction in CVOC concentrations and the genomic data indicate that both reductive biotic and abiotic pathways are likely occurring with abiotic sulfate reduction being the predominant pathway. The feasibility testing was most successful in achieving reductions in chlorinated ethenes (e.g., PCE, TCE) and carbon tetrachloride. Reductions from 99% for carbon tetrachloride across all depths to a low of 13% for Ccloroform (3-5') were observed. Chloroform being a direct daughter product of CT, it is not surprising that it did not decrease significantly. An increase in 1,2-DCA and 1,1,2-TCA at the 3-5 ft bgs depth was

likely due to very low initial concentrations and a variability in sampling location. The success of this feasibility testing indicates that a full-scale application of these technologies is likely to achieve meaningful reductions of the targeted CVOC's at the site and is currently planned for Q1 2017.