Comparison of In Situ Bioremediation of Perchlorate and Chlorinated Solvents at Three Sites in Close Proximity: Challenges and Lessons Learned

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Background/Objectives. At a former Army Ammunition Plant in northeast Texas, in situ bioremediation (ISB) was proposed to address elevated perchlorate concentrations in groundwater at one site (Site A), and perchlorate and chlorinated solvents in groundwater at two other sites (Sites B and C) under a fixed price performance-based remediation contract. The plume sizes ranged from approximately 1/2 to 12 acres. The plumes are present in shallow and intermediate depth saturated units that range from 10 feet below ground surface to 60 feet below ground surface with a leaky aquitard between the units ranging in thickness from a few feet to approximately 20 feet. Vadose zone source area contamination was addressed at Sites A and C via excavation, while Site B is located downgradient from a landfill that is acting as an ongoing source of contamination. Each of the sites was in a different stage of the remediation process prior to the ISB injections, with Site A at the remedial design step, Site B with an interim groundwater extraction/capture remedy in place and a remedial design already published, and Site C with a monitored natural attenuation (MNA) remedy in place that was determined to be inadequate to address the site contamination. The objective at all three sites was to develop a remedy (or contingency remedy) that would accelerate the degradation of the contaminants of concern (COC) and would ultimately result in site conditions that were protective of human health and the environment, allowing the sites to be turned over to the U.S. Fish and Wildlife Service for incorporation into a National Wildlife Refuge.

Approach/Activities. At Site A, the small size of the plume (limited to the shallow zone) allowed injection across the entire plume area exceeding five times the protective concentration limit. At Site B, the length of the plume and ongoing nature of the source dictated a combination of biobarriers and grid areas to attempt to reduce the highest levels of contamination while protecting the nearby bayou. Site C had two high concentration areas that were targeted with injections to attempt to reduce the plume source and allow MNA to be more successful. Injections were performed at all three sites between September 2019 and March 2020.

Results/Lessons Learned. Ideal reducing conditions were generated at Site A. Perchlorate concentrations at Site A dropped below the cleanup goal in all wells with 6 months of the injections and have remained there for over two years. At Site B, reducing conditions have been generated with varying degrees of success within the injection areas, but widespread reductions in COC concentrations have been slow to develop. Seasonal fluctuations in groundwater elevation and flow direction have made evaluation of the remedy's overall success challenging and it is likely that the remedial design was inadequate in some areas. At Site C, the injections did not result in widespread or long duration reducing conditions, and the injected carbon source was consumed rapidly, contributing to the short duration of the reducing conditions. The seasonal groundwater fluctuations and a recent sustained increasing trend in the groundwater elevation have coincided with significant increases in COC concentrations, suggesting that shallow source material or a significant smear zone may be present and contributing to the concentration fluctuations. Additional investigation and remedial action will be required at Sites B and C to meet remedial goals. The lessons learned from these three sites include the need for better predesign evaluations (particularly in performance based remedial contracts) to

properly place bio-barriers, to develop a more realistic radius of influence estimate for injections, and to predict the carbon source loading necessary for sustained remedial performance.