Innovative Treatment of a Large, Dilute, and Commingled Plume Using a Solar-Powered In Situ Bioremediation and Phytoremediation System

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Background/Objectives. A chlorinated solvent and 1,4-dioxane plume is present in groundwater beneath a former municipal solid waste facility located in a remote area with no access to on-site water or electricity. A solar-powered groundwater extraction system (GWES) operated at the site between 2010 and 2015 to recover mass and mitigate groundwater impacts. Extracted groundwater was pumped to an aboveground storage tank and transported 10 miles to the local water treatment plant using approximately four 5,000-gallon tankers per day. Remediation efforts were supplemented using aerobic in situ bioremediation and in situ chemical oxidation. In late 2015, Trihydro was retained by the project owner to evaluate current conditions and potential modifications to the remediation strategy. The evaluation documented that: 1) natural attenuation processes were robust; 2) site geochemistry was favorable for combined remedies; 3) chlorinated solvent attenuation rates in the source area could be enhanced using extracted groundwater for anaerobic in situ bioremediation (ISB) injection; and 4) 1,4-dioxane impacts at the property boundary could be captured and treated using phytoremediation. This presentation will detail the utilization of existing GWES infrastructure to combine remedies for efficient and effective treatment of a large chlorinated ethene and 1,4-dioxane plume.

Approach/Activities. A detailed evaluation of current conditions, including fate and transport, attenuation rates, geochemistry, and performance results of previous remedies suggested that anaerobic reductive dechlorination processes were already robust in the source area, and could be further enhanced using ISB. An effective and efficient delivery process was implemented by leveraging existing GWES infrastructure including extraction wells and solar-powered pumping equipment. Impacted source area groundwater was extracted, mixed with emulsified vegetable oil (EVO), and injected into permanent injection wells upgradient of extraction wells in more highly impacted areas. Continuous operation of the injection system allowed for a widely-spaced injection well network due to the large injection volumes per well.

Geochemical conditions in the source area were not favorable for 1,4-dioxane degradation. Therefore, an alternate treatment strategy was implemented downgradient of the source area. The 1,4-dioxane plume dives as it moves downgradient and becomes too deep for conventional phytoremediation, so the GWES infrastructure was strategically modified to extract and capture groundwater from wells in select downgradient areas. Groundwater is pumped to a phytoremediation tree stand in the source area and used in a subsurface irrigation system for 4,025 poplar and willow species.

Results/Lessons Learned. The solar-powered ISB system was installed in late summer 2016, with construction consisting of injection well installation and retrofitting of solar pumping infrastructure and piping. Approximately 650,000 gallons of mixed EVO was injected and chlorinated compounds were reduced by 99%. The solar-powered phytoremediation irrigation system was installed in June 2019 and in the first growing season captured and treated over 600,000 gallons of impacted water with a 4,000-tree phytoremediation plantation. The system was expanded in 2020 to increase the volumetric capture. This project has been successful in several respects. Concentrations of target compounds in groundwater have been reduced from near parts per million concentrations to below detection limits within the source area. Groundwater extraction at the downgradient property boundary appears to achieve capture across the dilute 1,4-dioxane plume transect. The phytoremediation system will be optimized as more data are collected. Costs and emissions associated with trucking have been eliminated and replaced with phytoremediation technology that sequesters carbon.