

Steam-Enhanced Biodegradation of VOC-TPH LNAPL Mixture under an Active Building Using Horizontal Wells at Naval Air Station North Island

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Background/Objectives. Building 379 at Naval Air Station North Island has a footprint of 172,000 square feet and overlies a light non-aqueous phase liquid (LNAPL) plume comprised of jet fuel and Stoddard solvent mixed with trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA). Estimates of NAPL volumes range from tens to hundreds of thousands of gallons. Approximately 40 percent of the NAPL footprint includes cVOCs. The depth to the top of LNAPL is approximately 23 feet below ground surface, and thickness exceeds 1 foot. Volatilization of cVOCs from the LNAPL has created a significant cVOC vapor plume underneath the building. NAPL temperatures are elevated proximal to the steam line (as high as 43 °C). Levels of cis-1,2-DCE in soil gas near the steam line are much higher than TCE; whereas TCE is much higher away from the steam line. Volatilization of cVOCs from the LNAPL has created a significant cVOC vapor plume underneath the building with initial VOC levels > 10,000,000 µg/m³. A soil vapor extraction (SVE) system has been in operation since May 2016, with recovery of >30,000 lbs of VOCs (allowing re-located female personnel to return to the building due to decreases in indoor air VOCs to acceptable levels). Three steam injection wells (screened below NAPL) have been in operation to enhance NAPL volatilization and biodegradation, specifically the cVOCs. In addition, two horizontal NAPL recovery wells were installed to recover mobilized NAPL (due to steam injection).

Approach/Activities. Analyses of the NAPL composition in 1998, 2015, and 2016 indicate that TCE concentrations have decreased and cis-1,2-dichloroethene (cDCE) concentrations have increased over time. Decreases in NAPL thickness were also observed. Temperature data for the NAPL collected in 2016 indicate temperatures over 30 °C at a number of locations. Significant levels of cDCE were detected in soil gas, both in sub-slab and at depth. Low levels of methane have also been detected in the vicinity of the NAPL. Laboratory microcosm tests using site aquifer material and NAPL, incubated without amendments for one year at room temperature, showed dechlorination of TCE to cDCE, with concentration of cDCE increasing in the NAPL. Levels of cDCE in NAPL after steam injection will be compared to historical data to determine the effect of steam on biodegradation, if any. The composition of cVOCs and TPH in extracted vapor and soil gas will be evaluated as a secondary indicator of biodegradation. This will be coupled with measurement of carbon dioxide and methane (and oxygen) in vapor monitoring probes located above the NAPL plume.

Results/Lessons Learned. Biodegradation of cVOCs in NAPL is not commonly reported, possibly due to difficulty in measuring daughter products. However, given the right conditions (presence of electron donor and elevated temperatures), biodegradation is possible. Elevated temperatures are promoting biodegradation of TCE at the NAPL-water interface, with TPH serving as a continuous/limitless source of electron donor. Active injection of steam further increased temperatures within the NAPL plume, resulting in biodegradation of cVOCs. The compositional makeup of cVOC/TPH in extracted vapor and soil gas with and without steam injection shows a significant increase in concentrations and monthly removal rates.