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Fortuitous Volatilization and Steam-Enhanced Biodegradation of VOC-TPH NAPL Mixture, 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 incudes 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 [currently being remediated with a horizontal soil vapor extraction well at 10 feet bgs]. Recent gauging of NAPL wells indicated shrinkage in the NAPL footprint by over 30%. Further investigation determined that the areas where NAPL decreased coincides with a subsurface steam line, and that NAPL temperatures are elevated proximal to the steam line (as high as 43 ^{o}C). The Navy has initiated a project with the objective of evaluating the effect of steam on NAPL volatilization and biodegradation - specifically the cVOCs. The results were used to optimize an active steam injection project (intended to mobilize NAPL recovery, with the possible added benefit of enhanced volatilization and biodegradation).

Approach/Activities. Analyses of the NAPL composition in 1998, 2015, and 2016 indicate that TCE concentrations have decreased and cis-1,2-dichlorothene (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 ^{o}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. In 2016, at a number of locations, a black layer was observed between the NAPL and groundwater, which may also be indicative of biodegradation (at the NAPL-water interface). It is hypothesized that the hydrocarbons serve as donor, and that biodegradation is likely occurring at the NAPL-water interface. Microbiological testing is being conducted at two types of locations: close to steam line with elevated temperatures, and away from steam line at lower temperatures. This will allow establishment of metrics for performance monitoring during injection (in terms of temperature). 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 the petroleum hydrocarbons serving as a continuous source electron donor. Active injection of steam can further increase temperatures within the NAPL plume, resulting in additional fortuitous biodegradation of cVOCs.