Treatment of 1,4-Dioxane by Extreme Soil Vapor Extraction

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Background/Objectives. Conventional soil vapor extraction (SVE) systems target the removal of volatile organic compounds (VOCs) from vadose zone soil through extraction of vapors. While recovery of 1,4-dioxane is possible with SVE, the solubility of 1,4-dioxane results in its preferential partitioning into pore water, which minimizes recovery through the vapor phase. Recently, a modified SVE approach, referred to as extreme soil vapor extraction (XSVE), has been suggested to specifically address 1,4-dioxane. XSVE relies on increased pore volume exchanges (higher vacuum and air flow rate) in the vadose zone and may include the addition of heat. These adjustments to conventional SVE result in drier soil and increased partitioning of 1,4-dioxane into the vapor phase for recovery by the XSVE system. This allows for better recovery and treatment of 1,4-dioxane.

Approach/Activities. Arcadis conducted an XSVE pilot test for 1,4-dioxane treatment in February 2018. The pilot test was designed to collect critical pre-design data to allow full-scale scale-up of the XSVE technology. Four SVE wells were installed at depths ranging from 12.5 meters below ground surface (m bgs) to 19.5 m bgs, which were intended to target multiple depth horizons due to the vertical thickness of impacts. The wells were clustered in pairs (one deep and one shallow in each pair). Four observation wells were installed to 15 m bgs and 19.5 m bgs (two in each interval). Three vapor extraction step tests were completed at each XSVE well to determine extraction rates from each well that can be used to design the full-scale equipment.

Results/Lessons Learned. The results of the pilot test will be used to design the full-scale XSVE system. The vacuum applied at each SVE well reached all of the observation wells, indicating that a radius of influence of at least 6 meters is reasonable. The maximum flow rates at each well varied from 1.81 to 2.69 standard cubic meters per minute. The pore volume exchange rate varied from 23 to 35 pore volumes per day (typical SVE includes 1-2 pore volume exchanges per day), resulting in a 1,4-dioxane mass removal rate of 0.66 to 1.01 kilograms per day.

The initial results were very promising. Full-scale design will seek to maximize applied vacuum and pore volume exchange rate, likely accomplished via a combination of more closely spaced wells and increased vacuum. Coupled air injection is also being considered to supplement these design changes in order increase the pore volume exchange rate. Finally, waste heat from the blower also serves as a sustainable option to heat the injected air to further enhance 1,4-dioxane removal.