Low Temperature Heat Injection for 1,4-Dioxane Source Zone Remediation

Gordon Alexander, PE (gordonalexander@kennedyjenks.com), Robert Logan, PG (boblogan@kennedyjenks.com), and Ryan Strandberg, PG (ryanstrandberg@kennedyjenks.com) (Kennedy/Jenks Consultants, Irvine, CA, USA)
Scott Crawford, PE (crawford@xdd-llc.com) and Dennis Keane, PE (XDD Environmental, Stratham, NH, CA, USA)

Background/Objectives. 1,4-Dioxane use as a chlorinated-solvent stabilizer has resulted in impacts to unsaturated soil at a former industrial facility (Site) in Commerce, California. Defining a cleanup goal for 1,4-dioxane in the vadose zone is problematic because:

1. Little has been done in the industry to address such impacts to heterogeneous soils typical of southern California, and
2. The vertical extent of impact depth greater than 100 feet.

Kennedy/Jenks reviewed options for removal of 1,4-dioxane and performed a cost-benefit analysis, concluding that reduction of the unsaturated zone concentrations would be costly and impractical given the minimal risk posed by 1,4-dioxane to groundwater at this Site. It was agreed with the oversight agency that the most appropriate way to confirm this analysis would be to perform a pilot test of 1,4-dioxane removal to assess effectiveness and economic feasibility.

Approach/Activities. A subsection of the main 1,4-dioxane source area has been identified as the location where a pilot cell will be established to test low-temperature heat injection. The test will use of heated-air injection to enhance the removal of volatile organic compounds (VOCs) and soil moisture within this cell, so the 1,4-dioxane can partition to the vapor phase for soil vapor extraction (SVE) removal. The pilot configuration was tested using the HypeVent^{tm} model to predict 1,4-dioxane removal rates, soil heating performance, and define the optimal pilot test layout. Pre-test soil and soil vapor samples were collected to establish baseline conditions. Soil probes were installed to measure temperature, soil moisture, and vapor humidity; nested soil vapor wells were used to allow for repeated vapor sampling to track the test progress. The existing vapor extraction system was expanded to focus extraction, prior to heated-air injection, to reduce pilot cell VOC mass. Reducing vapor VOC concentrations were important to monitoring the progress of the test because VOCs elevate the reporting limit for 1,4-dioxane, masking its removal. The presentation will focus on the modeling, pre-test operations, and progress monitoring in comparison to the Hype-Vent^{tm} modeling results. If available, initial results of the low-temperature heat injection will also be discussed.

Results/Lessons Learned. Modeling of the planned test cell indicated that the heated air injection process is highly sensitive to the temperature of the injected air. The economics of the technology will likely depend on well spacing, anticipated to be 15 to 30 feet.