Improving Soil Vapor Extraction In Loess Deposits

David Nelson (dnelson@ch2m.com), Mike Perlmutter (CH2M HILL, Atlanta, Georgia), and Mark Strong (CH2M HILL, Charlotte, North Carolina),

Soil vapor extraction (SVE) was selected by the Defense Logistics Agency (DLA), EPA, and the State of Tennessee Department of Environment and Conservation (TDEC) as the remedy for chlorinated volatile organic compounds (CVOCs) in subsurface soil at Dunn Field of the former Memphis Depot, in Memphis, Tennessee. As this technology is commonly applied, contaminant removal is induced by applying a vacuum to SVE wells and inducing air flow through the contaminated soil. The contaminants migrate as soil vapor to the extraction wells, then collected and treated aboveground. Unfortunately, Dunn Field is underlain by loess deposits that overlie fluvial sands. Because of the high silt and clay composition and high vertical conductivity in the loess, use of a standard SVE design might not be effective. Therefore, CH2M HILL conducted a four-phase SVE Treatability Study with numerical modeling to optimize application of the technology. The principal purpose of the study was to examine the possibility of using pneumatic fracturing and injection of proppants to improve horizontal vapor flow within the loess.

The Phase I study was conducted in December/ January 2001/2002 to determine whether a standard SVE system could be implemented at Dunn Field. Separate vacuum response tests were conducted for the loess and the underlying fluvial sands. Phase II of the SVE treatability study was conducted in August 2004 to assess the effect of various engineered amendments on vacuum performance in the loess. These amendments were intended to enhance the distribution and magnitude of flow near the vapor recovery wells. Phase II activities included the (1) installation of a polyethylene liner to mitigate atmospheric leakage, (2) installation and pneumatic fracturing of two boreholes in the loess deposits, and (3) injection of proppant within pneumatic fractures of one of the boreholes. The third phase of the SVE treatability study was conducted in January 2005, in an effort to optimize proppant delivery during pneumatic fracturing. The goal of Phase III was to qualitatively evaluate (1) a modified proppant injection procedure and (2) proppant effectiveness under vacuum. The fourth phase of the SVE treatability study was conducted in February 2005 to evaluate air injection (sparging) in the loess as an alternative to vapor extraction (assuming the vapor produced by the injection process could be controlled or captured). The objective of Phase IV was to evaluate the effectiveness of air injection relative to vapor extraction to remove contaminants.

Numerical modeling was performed to analyze the potential impacts of vacuum and sparging under a range of different vapor flow rates and well configurations. A multi-layer finite element model was developed using the finite element model MicroFEM (Hemker, 2004) with appropriate corrections for air properties. The model was calibrated using data from the SVE treatability study. After calibration, the model was used to evaluate subsurface pressure distribution, subsurface horizontal and vertical flux, and optimum well spacing and screen configuration.

Based on observations and data from all four phases of the SVE treatability study and the modeling results, air injection via pneumatic fractures represents the best method for removing contaminants in the loess deposits at Dunn Field. The final system will use a thermal oxidation system with granular activated carbon to collect contaminants in the offgas. Conventional SVE will be used to remediate the underlying fluvial sands.