Long-Term Soil Vapor Extraction (SVE) Monitoring and Effectiveness in Two Adjoining Low-Permeability Soil Horizons

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Background/Objectives. Chlorinated volatile organic compounds (VOCs) were present in low permeability fractured sandy siltstone (generally >8 feet deep) and an overlying and even lower permeability clayey silt soil unit (generally <8 feet deep) at the SLAC National Accelerator Laboratory, Menlo Park, California. Soil vapor extraction (SVE) pilot testing of the fractured silty sandstone unit in 2002 indicated a low effective soil permeability from 2 to 7 x 10^{-9} cm^2 in the unit. Despite low permeability, pilot testing suggested potential effectiveness and other remedial alternatives were less favorable, so SVE was selected for remediation with plans to actively monitor VOCs in soil vapor in situ to determine effectiveness. The remedial objective was to reduce VOC concentrations and vapor intrusion risks to levels protective of potential future unrestricted land use, including residential.

Approach/Activities. Full-scale SVE was implemented in 2006 using 19 vertical wells as part of a dual-phase extraction (DPE) system that also included groundwater extraction from the underlying groundwater. The DPE wells were screened in the lower silty sandstone unit to remediate that zone and also draw airflow for remediation downward from the surface through the thin and shallower clayey silt soil unit which was too shallow and thin to target by individual wells. It was planned to assess SVE effectiveness and remediation progress by routinely collecting soil vapor samples from multiple fixed soil vapor probes (SVPs) designed specifically for sampling from low permeability soil.

Results/Lessons Learned. VOC monitoring over time at the fixed SVPs was highly effective for resolving uncertainties in SVE effectiveness and guiding remediation decisions. SVE remediation was slow, steady, and ultimately effective in reducing VOC concentrations in the deeper low permeability sandy siltstone unit, meeting remedial goals for vapor intrusion risk after six years and sustaining low VOC concentrations during rebound testing. In the thin and shallow (<8 feet deep) clayey silt unit, the SVP monitoring showed the SVE system created high induced vacuum in the soil (up to 5 in-Hg) but indicated little to no remediation progress over 10 years of SVE due to extremely low effective permeability to air flow.

Additional SVPs were installed in the clayey soil to target and define the risk-based area of concern in the unit and to allow development of alternative remedial options, such as pneumatic fracturing to enhance permeability and SVE effectiveness, in situ thermal treatment, and soil excavation. Soil excavation was selected since the soil unit was relatively shallow. The required depth, volume, and cost of soil excavation were substantially reduced by effective SVE in the deeper low permeability sandy siltstone soil horizon, and by targeted low permeability soil vapor monitoring to effectively delineate the soil zone where VOCs remained.

It was learned that soil vapor monitoring can be performed effectively in very low permeability soil and can provide consistent results or trends over time to monitor SVE progress and delineate risk-based areas of concern. Such monitoring can be used to regularly assess SVE effectiveness in differing soil types and adjust remediation plans accordingly.