Editors Choice: Remediation

HYDROGEOLOGIC CONSIDERATIONS FOR IN-SITU SVE DESIGN

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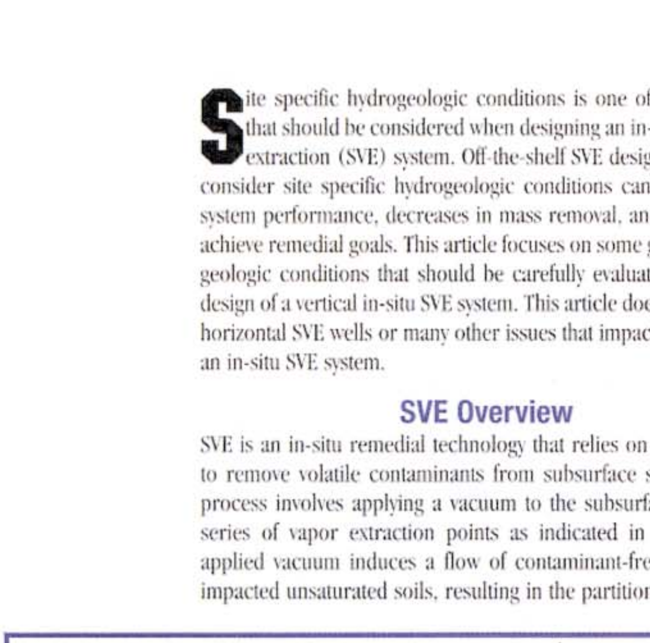
Soil-Vapor-Extraction is an in-situ remedial technology that relies on mass transfer to remove volatile contaminants from subsurface soils.

Site specific hydrogeologic conditions is one of many factors that should be considered when designing an in-situ soil vapor extraction (SVE) system. Off-the-shelf SVE designs that do not consider site specific hydrogeologic conditions can lead to poor system performance, decreases in mass removal, and/or failure to achieve remedial goals. This article focuses on some general hydrogeologic conditions that should be carefully evaluated during the design of a vertical in-situ SVE system. This article does not focus on horizontal SVE wells or many other issues that impact the design of an in-situ SVE system.

SVE Overview

SVE is an in-situ remedial technology that relies on mass transfer to remove volatile contaminants from subsurface soils. The SVE process involves applying a vacuum to the subsurface through a series of vapor extraction points as indicated in Figure 1. An applied vacuum induces a flow of contaminant-free air through impacted unsaturated soils, resulting in the partitioning of volatile organic compounds (VOCs) to the vapor phase to be captured by the SVE extraction wells. Captured SVE vapors are transported to the surface for treatment via SVE transport piping.

FIGURE 1
SVE WELL DETAIL



In addition to accomplishing a mass transfer of contaminants to the surface for treatment, SVE also enhances biostimulation of the naturally occurring microbial populations. By creating a subsurface aerobic environment, microbial populations can flourish and increase biodegradation rates for volatile, semivolatile and non-volatile organic compounds within the unsaturated zone. The following equation demonstrates this mineralization process:

$$C_6H_{14} + 9.5\ O_2 = 6\ CO_2 + 7\ H_2O$$

Unsaturated Zone

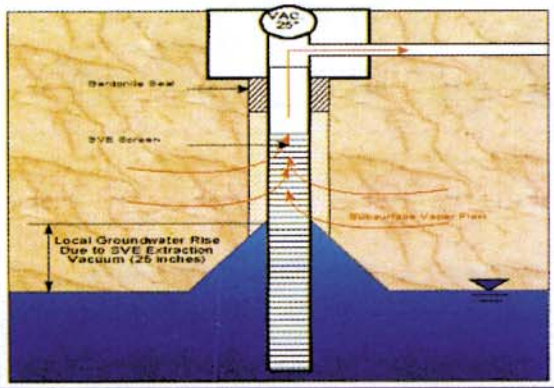
SVE technology remediates contaminants within the unsaturated zone. A shallow groundwater condition is of concern due to the potential to submerge the vertical in-situ SVE well screens into groundwater which would reduce or eliminate the well's ability to effectively extract subsurface air and ultimately decrease mass removal of contaminants. When designing a SVE remedial system for sites where groundwater is less than five feet (1.5 meters) below grade, one should consider the potential installation of horizontal in-situ SVE wells.

The length of in-situ SVE well screens vary depending upon site specific hydrogeologic conditions. In general, the well screen length varies from 5 to 10 ft (1.5 to 3.0 m) or more, depending upon the objective of the remedial effort. Whether horizontal or vertical in-situ SVE wells are installed, seasonal fluctuation to groundwater elevations combined with localized increases in groundwater elevation due to induced vacuum within the SVE extraction well must be evaluated to ensure optimal mass removal at the wellhead. The impact of fluctuating groundwater elevations and induced vacuum on in-situ SVE well design is described below.

Hydrogeologic Conditions

Site specific groundwater elevation and groundwater flow direction are two of the many site specific design parameters to be considered when determining the optimal location of in-situ SVE wells. Groundwater elevations can fluctuate due to seasonal trends, tidal influence and rainfall events, and the evaluation of depth to groundwater data requires consideration of historical trends and the time of year in which data is collected. For example, groundwater elevations collected at a site in the northeast U.S. during late summer and early fall would typically be representative of the lowest groundwater elevations of the year. If regional groundwater fluctuation data is available, groundwater elevations can then be predicted for other periods of the year. Unusual weather patterns, such as drought and flood conditions, should also be considered in predicting groundwater elevations.

FIGURE 2
GROUNDWATER TABLE RISEDETAIL



Understanding site specific groundwater elevation changes is critical to properly positioning in-situ SVE well screens in the subsurface. If the in-situ SVE well screens are positioned based on depth to groundwater during low groundwater periods, the screened interval could be partially submerged during high groundwater periods. This scenario is compounded when the SVE extraction vacuum artificially increases the elevation of the local water table surrounding the SVE well. Once the SVE well screen is submerged, it is literally cut off from the subsurface and can no longer effectively perform.

Other natural and manmade phenomenon can impact groundwater elevations, depending upon the location of the site. Sites located adjacent to tidally influenced surface water bodies should consider the influence of tidal changes on groundwater elevations. Groundwater elevations under tidal influence can vary from a few inches to several feet daily. The length and position of an in-situ SVE well screen must be considered or the well screen may be fully or partially submerged periodically throughout a 24-hour period.

Man-made phenomena include groundwater production wells for commercial or drinking water supply that may be located on site or adjacent to a site with production volumes sufficient to impact groundwater elevations. Injection of sanitary or industrial wastewater to the subsurface via dry wells, or leaching fields can also impact groundwater elevations. Daily or periodic fluctuations to groundwater elevations that are not attributed to seasonal conditions, rainfall events or tidal conditions may be a result of nearby extraction or injection processes.

Design

Upon completion of the assessment of the daily or seasonal fluctuation to groundwater elevations, the depth of the in-situ SVE well screen can be selected. The final depth should be selected to ensure that the SVE well screens are not submerged under static groundwater conditions. As a general rule, the bottom of an in-situ SVE well should be placed at depth equal to the lowest historical groundwater elevation with an SVE screen length equal to the range of historical groundwater fluctuations plus two times the proposed SVE extraction vacuum in feet of water. For instance, if a site specific design requires 48 in. (122 cm) of vacuum, groundwater will rise 48 in. (122 cm) or 4 feet (1.2 m) within the well. If 4 ft (1.2 m) of well screen is not available then potentially the SVE well screen will be completely submerged, as indicated in Figure 2.

Submerged or partially submerged well screens results in little or no mass removal. A partially submerged well screen will impact the radius of influence of the in-situ SVE well. These conditions can be misinterpreted as evidence that cleanup has been achieved, since no volatiles or significantly reduced concentrations of volatiles are detected in the vapor removed from an in-situ SVE well.

Conclusion

Fluctuation of groundwater elevations, as well as the impact of the induced vacuum on static groundwater elevations must be carefully considered when determining the depth and/or length of an in-situ SVE well screen. Neglecting to account for these factors in the design process can impact mass removal and significantly reduce system performance. The reduction of VOC concentrations due to submerged or partially submerged in-situ SVE wells can lead to a misinterpretation that cleanup levels have been achieved. Once groundwater elevations drop to previous levels, mass transfer concentrations will increase rapidly (much to the surprise of the unwary engineer or geologist). If the fluctuation of groundwater elevation is not considered during the design phase of the in-situ SVE remedial system, significant performance, cost and schedule overruns can occur.

For more information, contact the authors at RAM Environmental, 508-747-7900.