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Project Summary

Assessing UST Corrective Action Technologies: *In Situ* SVE-Based Systems for Free Product Recovery and Residual Hydrocarbon Removal

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The objective of the report summarized recovery and soil-vapor-extraction (SVE)-based systems. The SVE-based systems examined include soil vapor extraction, bioventing, and air sparging. In addition, an overview of natural attenuation/biodegradation is also provided. The full report is intended to provide assistance in developing a conceptual understanding of the factors influencing hydrocarbon migration and retention in the subsurface and to identify key process parameters that are used to select, design, and monitor corrective action systems. A common approach to corrective action may involve the use of a favored technology, which alone does not fully achieve the remedial goals. When corrective action options are evaluated, the different contaminants present in different matrices and in different physical states must be considered along with their location, amount, and mobility. Therefore, the use of multiple corrective action technologies in an integrated system may be needed to effectively remove these contaminants from locations of concern.

This Project Summary was developed by EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Over the past several years, since promulgation of the final underground storage tank (UST) regulations by the U.S. Environmental Protection Agency (EPA), the number of sites with confirmed releases from USTs has far exceeded the resources of both industry and regulatory agencies to clean up and close them out. Delays in initiating corrective action allow mobile contaminants to migrate further from the source, thereby increasing the likelihood of more severe environmental impacts and ultimately higher cleanup costs.

A variety of conventional and emerging technologies are being proposed to address sites with confirmed releases. A common approach to corrective action typically involves implementing one or two technologies during a particular stage of the cleanup. For example, the use of free product "pump-and-treat" systems has traditionally been a favored conventional corrective action technology. At many sites, a properly designed pump-and-treat system may in fact be the most effective technology. After the recovery of free product is completed, soil vapor extraction (SVE) is sometimes installed as a supplementary technology. Biodegradation occurs as part of the SVE process but is often not considered in the overall design and operation of SVE systems. More recently, SVE has been used in combination with *in situ* air sparging.

The purpose of the full report is to provide information for evaluating several corrective action technologies that can be used either individually or in combination. It is intended as a resource document that can serve as a starting point in understanding the appropriate selection and use of the technologies discussed. The manual provides the following:

- A conceptual understanding of the factors influencing hydrocarbon migration and retention in the subsurface.
- Identification of process parameters that are used in the selection and design of nonaqueous phase liquid (NAPL) and SVE-based corrective action systems.
- An overview of approaches and tools used in system design for these technologies.
- An example of the types of monitoring requirements that may be needed to determine system effectiveness.
- An example of cost estimates for selected corrective action technologies.

Methodology

The full report focuses on (1) site characterization, approaches, and techniques for obtaining the data needed for making corrective action decisions; (2) the fundamental considerations for free product migration and recovery; (3) the remediation of residual organics using soil vapor extraction; (4) bioventing and intrinsic bioremediation; (5) *in situ* air sparging; and (6) relative cost comparison between product recovery, SVE, and air sparging-SVE systems. Chemical properties of organic contaminants typically encountered are also provided.

Results

The approach for examining the technologies in this manual is based on an understanding of the characteristics of the porous media and the contaminants, and the distribution of the contaminant phases at various locations in the subsurface. Hydrocarbon contaminant releases from leaking USTs into a porous media will be distributed among four phases: (1) NAPLs or the "immiscible phase," (2) the soil moisture or "dissolved phase" in interstitial water, (3) the "adsorbed phase," and (4) the "vapor phase." The distribution of contaminants into the different phases is dependent on the chemical and physical characteristics of the hydrocarbon, the degree of weathering that has occurred, and the characteristics of the porous media. The contaminant distribution will change as the contaminant moves from the unsaturated zone to the saturated porous and fractured media.

At many sites where NAPL is present, the initial cleanup efforts are removing the NAPL sources, if possible. For NAPLs that cannot be removed directly or that remain as residuals, the contaminant mass may be partly removed by volatilization and dissolution into groundwater. Biodegradation processes may be a cost-effective option for attenuation of groundwater plumes, or for decreasing contaminant concentrations to acceptable levels in both the saturated and unsaturated zones.

The remedial action will use a corrective action technology based on the subsurface properties and contaminant mass, phases, locations, and mobility. Once a technology is selected, designed, and implemented, the performance of the system is monitored to determine if remediation goals can be met by using the selected technology. If the goals are not met, then a reassessment of the remedial system, site condition, and remedial goals (if necessary) may be needed.

Conclusions

Sites with subsurface contamination vary greatly in terms of complexity, physical and chemical characteristics, and in the risk that they may pose to human health and environmental resources. In determining appropriate action for addressing petroleum releases, three-dimensional site characterization is required to provide a sufficient contaminant definition of behavior and to support corrective action decisions. Based on an understanding of the phase locations and the mechanisms affecting the movement and disposition of the contaminants, appropriate technologies can be identified and selected as part of a corrective action strategy.

For larger spill volumes or shallower water tables, light nonaqueous phase liquid (LNAPL) may reach the groundwater, where it will spread laterally. Initial remediation steps involve controlling and removing free product by pumping it from trenches or wells to limit the spread. Pumping rates should be selected to maintain hydraulic gradient control. Higher rates will lead to lower overall product recovery as NAPLs are smeared over a larger cone of depression in the water table and become trapped by capillary forces as residual hydrocarbons. Careful placement and design of free product recovery systems can have a major impact on recovery efficiency.

Soil vapor extraction (SVE) based technology primarily includes soil vapor extraction, bioventing, and a combination of soil vapor extraction and air sparging. This technology removes volatile contaminants and to a lesser extent semivolatile contaminants from the vadose zone and upper part of the saturated interval (primarily in the case of air sparging). SVE can be used to biovent the soil and to deliver oxygen for enhanced biodegradation.

Bioventing is an emerging technology that combines features of SVE and *in situ* bioremediation. The technology permits the *in situ* treatment of vadose zone soil impacted with any biodegradable contaminant. An attractive treatment strategy for contaminated vadose zone soil and groundwater involves bioventing and intrinsic bioremediation. Bioventing in source areas can be an effective approach to eliminate the dissolution, diffusion, and leaching of contaminants into the groundwater. Without a constant recharge of contaminants, intrinsic bioremediation in the groundwater can limit plume migration and ultimately reduce contaminant levels to acceptable or even nondetectable levels. A combined treatment strategy has the potential to be expedient and cost-effective.

In situ air sparging is a recently introduced technology that utilizes *in situ* volatilization to remove volatile components from residual NAPL or dissolved-phase contaminants present below the water table. As with SVE, air sparing has broad appeal because it is simple to implement and capital costs are moderate. Air sparging technology is still in its infancy, however. A limited number of air sparging operations and pilot tests have been evaluated; some of these were effective, while several were not.

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The complete report, entitled "Assessing UST Corrective Action Technologies: In Situ *SVE-Based Systems for Free Product Recovery and Residual Hydrocarbon Removal," (Order No. PB96-163605; Cost:$49.00, subject to change) will be available only from:*

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