SOIL VAPOR EXTRACTION (SVE) TREATMENT TECHNOLOGY RESOURCE GUIDE

Office of Solid Waste and Emergency Response
Technology Innovation Office
Washington, DC 20460

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ABSTRACTS OF SOIL VAPOR EXTRACTION TREATMENT TECHNOLOGY RESOURCES

GUIDANCE/POLICY AND REFERENCE DOCUMENTS

Air/Superfund National Technical Guidance Study Series: Emission Factors for Superfund Remediation Technologies.
Thompson, P.; Inglis, A.; and Eklund, B., Radian Corp., Austin, TX, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Washington, DC, March 1991

EPA Document Number: EPA/450/1-91/001

NTIS Document Number: PB91-190975/XAB

The report contains procedures and example calculations for estimating air emissions that occur from treating contaminated material at Superfund sites. Emission factors for six treatment technologies are presented. These are: (1) thermal treatment, (2) air stripping, (3) soil vapor extraction, (4) solidification and stabilization, (5) physical and chemical treatment, and (6) biotreatment and land treatment. For each of the six technologies, a literature review was conducted to develop a flow diagram and identify emission points, as well as to analyze available air emissions data. For most of the technologies examined, emission factors were based on available data as well as assumed "typical" operating conditions. Where possible, however, emission factors were presented on actual operating data from the site studies. Emission factors are presented for volatile organic compounds (VOCs), metals, particulate matter, SO2, NOx, CO, HCl, and HF. The report also contains an extensive bibliography related to waste treatment technologies.

Air/Superfund National Technical Guidance Study Series: Estimation of Air Impacts for Soil Vapor Extraction (SVE) Systems.
Eklund, B.; Smith, S.; Thompson, P.; and Malik, A. S., Radian Corp., Austin, TX, U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1992

EPA Document Number: EPA/450/1-92/001

NTIS Document Number: PB92-143676/XAB

The U.S. Environmental Protection Agency's Office of Air Quality Planning and Standards and the Regional air offices have been given the responsibility of evaluating air impacts from Superfund sites. The report provides procedures for roughly estimating the ambient air concentrations associated with soil vapor extraction (SVE). The procedures for SVE systems are analogous to procedures for air strippers that have previously been published. SVE is also known as soil venting, vacuum extraction, aeration, or in situ volatilization. It is a widely used technique for removing volatile organic compound (VOC) vapors from

contaminated soil. Procedures are given to evaluate the effect of the concentration of the contaminants in the soil-gas and the extraction rate on the emission rates and on the ambient air concentrations at selected distances from the SVE system.

Air/Superfund National Technical Guidance Study Series: Models for Estimating Air Emission Rates from Superfund Remedial Actions.
Eklund, B. and Albert, C., Radian Corp., Austin, TX, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Washington, DC, March 1993

EPA Document Number: EPA/451/R-93/001

NTIS Document Number: PB93-186807/XAB

The report is a compendium of models (equations) for estimating air emissions from Superfund sites undergoing remediation. These models predict emission rates of volatile organic compounds (VOCs) and particulate matter from both area and point sources. The following remedial processes are covered: air stripping, soil vapor extraction, thermal desorption, thermal destruction (incineration), excavation, dredging, solidification/stabilization, and bioremediation. Emission estimation methods are also presented for landfills, lagoons, and spills/leaks/open waste pits. The models contained in the compendium may not accurately predict emissions for all possible scenarios.

Engineering Bulletin: Technology Preselection Data Requirements.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Washington, DC, October 1992

EPA Document Number: EPA/540/S-92/009

NTIS Document Number: PB93-105591/XAB

The bulletin provides a listing of soil, water, and contaminant data elements needed to evaluate the potential applicability of technologies for treating contaminated soils and water. This base set of data should permit preselection of applicable treatment methods and the direct elimination of others. This bulletin emphasizes the site physical and chemical soil and water characteristics for which observations and measurements should be compiled. Gathering and analyzing the information called for in this bulletin prior to extensive field investigations will facilitate streamlining and targeting the sampling and analytical objectives of the overall program.

Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction, Interim Guidance.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Washington, DC, September 1991

EPA Document Number: EPA/540/2-91/019A

NTIS Document Number: PB92-227271/XAB

Section 121(b) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) mandates the U.S. Environmental Protection Agency (EPA) to select remedies that "utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable." Treatability studies conducted during the RI/FS phase indicate whether a given technology can meet the expected cleanup goals for the site. The document refers to three levels or tiers of treatability studies: remedy screening, remedy selection, and remedy design. Summary information on planning and executing soil vapor extraction (SVE) remedy screening and remedy selection treatability studies is provided in "Guide for Conducting Treatability Studies

Under CERCLA: Soil Vapor Extraction," Quick Reference Fact Sheet, EPA/540/2-91/019B.

Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction, Quick Reference Fact Sheet.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC, September 1991

EPA Document Number: EPA/540/2-91/019B

NTIS Document Number: PB92-224401/XAB

The fact sheet provides a summary of information to facilitate the planning and execution of soil vapor extraction (SVE) remedy screening and remedy selection treatability studies in support of the remedial investigation/feasibility study (RI/FS) and the remedial design/remedial action (RD/RA) processes. Detailed information on designing and implementing remedy screening and remedy selection treatability studies for SVE is provided in "Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction," Interim Guidance, EPA/540/2-91/019A, September 1991.

Handbook on In Situ Treatment of Hazardous Waste-Contaminated Soils.
Chamber, C. D.; Willis, J.; Giti-Pour, S.; Zieleniewski, J. L.; Richabaugh, J. S., U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, January 1990

EPA Document Number: EPA/540/2-90/002

NTIS Document Number: PB90-155607/XAB

This publication discusses various alternatives for in situ treatment of hazardous waste in contaminated soils. In situ technologies discussed include: soil flushing; solidification/stabilization; chemical and biological degradation and photolysis; control of volatile materials, including soil vapor extraction; and chemical and physical separation techniques. Delivery and recovery systems are also discussed. For each technology, the document includes a description of the process and its advantages and disadvantages. An extensive list of references is included.

NPL Construction Completion Definition at Bioremediation and Soil Vapor Extraction Sites.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC, June 1993

EPA Document Number: EPA/ 540/F-93/019, OSWER-9320.2-06

NTIS Document Number: PB93-963327/XAB

The report discusses EPA's policy for categorizing bioremediation and soil vapor extraction sites as Construction Completions. Technologies addressed are: in situ soil vapor extraction, in situ bioremediation, and ex situ bioremediation.

Procuring Innovative Technologies at Remedial Sites: Q's and A's and Case Studies.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC, April 1992

EPA Document Number: EPA/542/F-92/012

NTIS Document Number: PB92-232388/XAB

The fact sheet is designed to assist EPA Remedial Project Managers (RPMs) and

Contracting Officers (COs) with the procurement of innovative treatment technologies. RPMs, COs, and U.S. Army Corps of Engineers (COE) personnel were interviewed to obtain information on their experiences in procuring innovative technologies. EPA's Technology Innovation Office (TIO) has documented case histories of experiences with acquiring innovative technologies in the Superfund program. Remedial sites chosen for inclusion in the review were Fund-lead sites that had started or completed the procurement of an innovative technology, including bioremediation, thermal desorption, vacuum extraction, chemical treatment, chemical extraction, and in situ soil flushing. The results of these interviews are presented in a question and answer format. In addition, specific detailed information on each site is presented in tabular form.

OVERVIEW/PROGRAM DOCUMENTS

An Overview of Underground Storage Tank Remediation Options.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Underground Storage Tanks, October 1993

EPA Document Number: EPA/510/F-93/029

EPA developed a series of fact sheets to answer basic questions about selected alternative cleanup technologies and to provide an easy way to compare technologies. The fact sheets related to soil vapor extraction technologies include those pertaining to in situ soil vapor extraction, in situ bioremediation and bioventing, and on-site low-temperature thermal desorption.

Citizen's Guide to Air Sparging, Fact Sheet.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC, March 1992

EPA Document Number: EPA/542/F-92/010

NTIS Document Number: PB92-235597/XAB

The fact sheet contains a description of air sparging; how it works; why use this treatment method; will it always work; where air sparging is being used; and how to get more information on this treatment.

Cleaning Up the Nation's Waste Sites: Markets and Technology Trends.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovative Office, Washington, DC, April 1993

EPA Document Number: EPA/542/R-92/012

This report captures information on the future demand for remediation services for all major cleanup programs in the U.S., including Superfund, Resource Conservation and Recovery Act (RCRA) corrective action, underground storage tanks, state programs, and federal agencies such as the Department of Defense and Energy. This report contains market information on the innovative technologies used to remediate sites contaminated with volatile organic compounds (VOCs), semi-volatile organic compounds (semi-VOCs), and other contaminants. This market information should help innovative technology vendors, developers, and investors direct their research, development, and commercialization effort towards pertinent waste programs and problems.

Engineering Issue: Considerations in Deciding to Treat Contaminated Soils In Situ.
U.S. Environmental Protection Agency, December 1993

EPA Document Number: EPA/540/S-94/500

NTIS Document Number: PB94-177771/XAB

The purpose of this issue paper is to assist in deciding whether consideration of in situ treatment of contaminated soil is worthwhile and to assist in the process of selection and review of in situ technologies. This document addresses issues associated with assessing the feasibility of in situ treatment and selecting appropriate in situ technologies which include an understanding of the characteristics of the contaminants, the site, the technologies, and how these factors and conditions interact to allow for effective delivery, control, and recovery of treatment agents and/or the contaminants. The document focuses on established and innovative in situ treatment technologies that are already available or should be available for full-scale application within 2 years. Technologies discussed include in situ solidification/stabilization, soil vapor extraction, biotreatment, bioventing, in situ vitrification, radio frequency heating, soil flushing, steam / hot air injection and extraction, and delivery and recovery systems. This document is intended to assist in the identification of applicable alternatives early in the technology screening process and is not a source for final determinations.

Experimental Examination of Integrated Soil Vapor Extraction Techniques: Published in Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Restoration, p. 441-452, November 1992.
Johnson, R. L.; Bagby, W.; Perrott, M.; and Chen, C. T., Oregon Graduate Institute of Science and Technology, Beaverton, OR, Department of Environmental Science and Engineering, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, 1992

EPA Document Number: EPA/600/J-92/280

NTIS Document Number: PB93-131738/XAB

Soil vapor extraction (SVE) has been shown to be effective at removing hydrocarbons from the unsaturated zone. However, at many spill sites significant fractions of the mass are at or below the water table, in which case SVE is far less effective. To improve its efficiency in cases where gasoline is trapped below the water table, SVE can be used in conjunction with other techniques to get at that trapped mass. In the last few years the direct injection of air into the formation below the water table (i.e., in situ sparging) has become a popular technique. Another approach is to lower the water table to improve air flow in the vicinity of the trapped product. This can be accomplished either in the localized area of a ground water draw down cone or as the result of larger scale dewatering. In experiments conducted at the Oregon Graduate Institute (OGI), hydrocarbon spills into a large three-dimensional physical model filled with sand are being used to study the efficiencies of SVE combined with other techniques. Experiments to date have examined SVE operating as a stand-alone technique, as well as in conjunction with air sparging below the water table, dewatering of the "smear zone" (i.e., where product is trapped as residual below the water table), and air injection into the dewatered smear zone.

Innovative Technology Demonstrations.
Anderson, D.B.; Hartley, J.N.; and Luttrell, S.P., Battelle Pacific Northwest Laboratories, Richland, WA, U.S. Department of Energy, Washington, DC, April 1992

NTIS Document Number: DE92-015617/XAB

This document discusses the several innovative technologies that are currently being demonstrated at Tenker Air Force Base (TAFB) to address specific problems associated with remediating two contaminated test sites at the base. Cone penetrometer testing (CPT) is a form of testing that can rapidly characterize a site. This technology was selected to evaluate its applicability in the tight clay soils and consolidated sandstone sediments found at TAFB. Directionally drilled horizontal wells have been successfully installed at the U.S. Department

of Energy's (DOE) Savannah River Site to test new methods of in situ remediation of soils and ground water. This emerging technology was selected as a method that may be effective in accessing contamination beneath a building at the site without disrupting the mission of the building, and in enhancing the extraction of contamination both in ground water and in soil. A soil gas extraction (SGE) demonstration, also known as soil vapor extraction, will evaluate the effectiveness of SGE in remediating fuels and TCE contamination contained in the tight clay soil formations surrounding the abandoned underground fuel storage vault located at the SW Tanks Site. In site sensors have recently received much acclaim as a technology that can be effective in remediating hazardous waste sites. Sensors can be useful for determining real-time, in situ contaminant concentrations during the remediation process for performance monitoring and in providing feedback for controlling the remediation process. A demonstration of two in situ sensor systems capable of providing real-time data on contamination levels will be conducted and evaluated concurrently with the SGE demonstration activities. Following the SGE demonstration, the SGE system and SW Tanks test site will be modified to demonstrate bioremediation as an effective means of degrading the remaining contaminants in situ.

Innovative Treatment Technologies: Annual Status Report, Fifth Edition. Fiedler, L., U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, Washington, DC, September 1993

EPA Document Number: EPA/542/R-93/003

NTIS Document Number: PB93-133387/XAB

This yearly report (formerly published semi-annually) documents and analyzes the selection and use of innovative treatment technologies at Superfund sites and some non-Superfund sites under the jurisdiction of DOD and DOE. The information will allow better communication between experienced technology users and those who are considering innovative technologies to clean up contaminated sites. In addition, the information will enable technology vendors to evaluate the market for innovative technologies in Superfund for the next several years. It also will be used by the Technology Innovation Office to track progress in the application of innovative treatment technologies. Alternative technologies are defined as alternatives to land disposal; innovative technologies are alternative technologies for which there is a lack of data on cost and performance.

Innovative Treatment Technologies: Overview and Guide to Information Sources. Quander, J. and Kingscott, J., U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, Washington, DC, October 1991

EPA Document Number: EPA/540/9-91/002

NTIS Document Number: PB92-179001/XAB

This document is a compilation of information on innovative treatment technologies being used in the Superfund program and is intended to assist site project managers, consultants, responsible parties, and owner/operators in their efforts to identify current literature on innovative treatment technologies for hazardous waste remediation on corrective action. The technologies addressed in the guide include the following: incineration, thermal desorption, soil washing, solvent extraction, dechlorination, bioremediation, vacuum extraction, vitrification, and ground water treatment. Also included in the guide for the user's reference are summary statistics of EPA's selection and application of innovative treatment technologies between 1982 and 1990. In addition, the guide provides for each technology a detailed description, status of development and application, strengths, weaknesses, and materials handling considerations. A comprehensive bibliography for each technology can be found within each chapter.

In Situ Soil Vapor Extraction Treatment, Engineering Bulletin.
Science Applications International Corp., Cincinnati, OH, FW Energy Applications, Inc., Livingston, NJ, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response, Washington, DC, May 1991

EPA Document Number: EPA/540/2-91/006

NTIS Document Number: PB91-228072/XAB

Soil vapor extraction (SVE) is designed to physically remove volatile compounds, generally from the vadose or unsaturated zone. It is an in situ process employing vapor extraction wells alone or in combination with air injection wells. Vacuum blowers supply the motive force, inducing air flow through the soil matrix. The air strips the volatile compounds from the soil and carries them to the screened extraction well. Air emissions from the systems are typically controlled by adsorption of the volatiles onto activated carbon, thermal destruction (incineration or catalytic oxidation), or condensation by refrigeration. SVE is a developed technology that has been used in commercial operations for several years. The final determination of the lowest cost alternative will be more site-specific than process equipment-dominated. The bulletin provides information on the technology applicability, the limitations of the technology, the technology description, the types of residuals produced, the site requirements, the latest performance data, the status of the technology, and sources for further information.

Potential for Joint Research Between EPA and the U.S. Army, Symposium Paper.
Sullivan, D.; Farlow, J.; and Freestone, F., U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, 1992

EPA Document Number: EPA/600/A-93/007

NTIS Document Number: PB93-149227/XAB

The environmental problems being faced by the U.S. Environmental Protection Agency (EPA) and the U.S. Army are closely related, and the research needed to address them overlaps in many areas. The paper presents an overview of the hazardous waste site remediation research programs being conducted by EPA's Risk Reduction Engineering Laboratory (RREL) and proposes a number of areas where joint efforts between the two agencies could be mutually beneficial. EPA has established a policy of encouraging the use of innovative technologies that both reduce the quantity of contaminant to be handled and also destroy harmful contaminants. Several technologies, including soil washing, soil vapor extraction, thermal desorption, solvent extraction and soil flushing are of special interest. The RREL has established capabilities for treatability studies and other research endeavors at a number of its locations. EPA also continues to foster the use of innovative technologies through its Superfund Innovative Technology Evaluation (SITE) program. In addition, EPA has established a technology transfer program available to other agencies involving both manuals/documents and training personnel. The authors welcome future contacts by Army personnel interested in sharing environmental projects.

Soil-Air Permeability Method Evaluation, Symposium Paper.
Sellers, K. L.; Pederson, T. A.; and Fan, C. Y., Camp Dresser & McKee, Inc., Cambridge, MA, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, 1991

EPA Document Number: EPA/600/D-91/273

NTIS Document Number: PB92-212439/XAB

The feasibility of soil vapor extraction (SVE) is, in part, based on vadose zone soil-air permeability. Field, laboratory, and empirical correlation methods for

estimating soil-air permeability have been reviewed for their appropriateness in determining SVE feasibility and the development of SVE system design criteria. To better understand the available air permeability test methods, a review of their theoretical development is provided. Empirical correlation methods are available to derive estimates of soil-air permeabilities from soil grain size distributions, hydraulic conductivity measurements, or pump test drawdown data. Although these techniques provide data that are of value in determining if the use of SVE at a specific site should be excluded from further consideration, they do not provide adequate data for system design criteria development. Laboratory soil-air permeability tests are also inappropriate for SVE system design because they do not take into account field variability and the non-representative nature of soil cores collected in the field. Most field techniques employed for determining soil-air permeability for surficial soils are likewise inappropriate for the evaluation of contaminant releases that have migrated to depths of greater than one meter. The in situ field borehole permeability techniques used by petroleum engineers, and subsequently modified for use at relatively shallow soil depths, hold the most promise for application to SVE design.

Soil Vapor Extraction Technology: Reference Handbook, Final Report.
Pederson, T. A. and Curtis, J. T., Camp Dresser & McKee, Inc., Cambridge, MA, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, February 1991

EPA Document Number: EPA/540/2-91/003

NTIS Document Number: PB91-168476/XAB

Soil vapor extraction (SVE) systems are being used in increasing numbers due to many advantages these systems hold over other soil treatment technologies. SVE systems appear to be simple in design and operation, yet the fundamentals governing subsurface vapor transport are quite complex. In view of the complexity, an expert workshop was held to discuss the state-of-the-art technology, the best approach to optimize systems application, and process efficiency and limitations. As a result of the workshop, an SVE Technology Assessment report was produced. The report discusses the basic science of the subsurface environment and subsurface monitoring, emission control, and costs. The report also serves as the proceedings of the expert workshop. Additional research activities being conducted include a field demonstration of a structured SVE system design approach, a laboratory column study to determine and characterize residuals following vapor extraction, an assessment of secondary emissions and regulations governing releases from SVE systems, cost of SVE implementation and operation, and a survey of techniques to enhance vapor removal.

State of Technology Review: Soil Vapor Extraction Systems, Final Report.
Hutzler, N. J.; Murphy, B. E.; and Gierke, J. S., Michigan Technological University, Houghton, MI, U.S. Department of Civil Engineering, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, June 1989

EPA Document Number: EPA/600/2-89/024

NTIS Document Number: PB89-195184/XAB

Soil vapor extraction is a cost-effective technique for the removal of volatile organic compounds (VOCs) from contaminated soils. Among the advantages of the soil air extraction processes are that they create a minimal disturbance of the contaminated soil, they can be constructed from standard equipment, there is demonstrated experience with soil vapor extraction at pilot- and field-scale, they can be used to treat larger volumes of soil than can be practically excavated, and there is a potential for product recovery. The experience with existing extraction systems has been reviewed and information about each system is briefly summarized.

Superfund Innovative Technology Evaluation (SITE) Program: Innovation Making a Difference.
U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, May 1994

EPA Document Number: EPA/540/F-94/505

The Superfund Innovative Technology Demonstration (SITE) Program encourages commercialization of innovative technologies for characterizing and remediating hazardous waste site contamination through four components: Demonstration; Emerging Technology; Monitoring and Measurement Programs; and Technology Transfer Activities. The information presented in this brochure addresses the demonstration segment of the program. The demonstration component evaluates promising innovative remedial technologies on site and provides reliable performance, cost, and applicability information for making cleanup decisions. This document lists the advantages of the SITE Program, as well as statistics such as the percentage of RODs using innovative technology, cost savings with innovative technologies for 17 sites, and market activities as reported by SITE vendors.

Synopses of Federal Demonstrations of Innovative Site Remediation Technologies, Third Edition.
U.S. Environmental Protection Agency, Office of Solid and Waste Emergency Response, Technology Innovation Office, U.S. Department of Defense, U.S. Department of Energy, U.S. Department of the Interior, October 1993

EPA Document Number: EPA/542/B-93/009

This collection of abstracts describes field demonstrations of innovative technologies used to treat hazardous waste. Ninety-one demonstrations in six different technology categories (bioremediation, chemical treatment, thermal treatment, vapor extraction, soil washing, and other physical treatment) are described. This publication is intended to be an information resource for hazardous waste site project managers for assessing the availability and viability of innovative technologies for treating contaminated ground water, soils, and sludge. It is also intended to assist government agencies in coordinating ongoing hazardous waste remediation technology research initiatives. Innovative technologies, for the purposes of this compendium, are defined as those technologies for which detailed performance and cost data are not readily available.

Technology Assessment of Soil Vapor Extraction and Air Sparging.
Loden, M. E., Camp Dresser & McKee, Inc., Cambridge, MA, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, September 1992

EPA Document Number: EPA/600/R-92/173

NTIS Document Number: PB93-100154/XAB

Air sparging, also called "in situ air stripping" and "in situ volatilization" injects air into the saturated zone to strip away volatile organic compounds (VOCs) dissolved in ground water and adsorbed to soil. These volatile contaminants transfer in a vapor phase to the unsaturated zone where soil vapor extraction (SVE) can then capture and remove them. In addition to removing VOCs via mass transfer, the oxygen in the injected air enhances subsurface biodegradation of contaminants. Air sparging is a relatively new treatment technology. Research efforts have not yet fully elucidated the scientific basis (or limitations) of the system, nor completely defined the associated engineering aspects. However, a substantial body of available information describes the effectiveness and characteristics of air sparging systems. This document summarizes the available literature and addresses case studies of practical air

sparging applications. It also identifies needs for further research.

STUDIES AND DEMONSTRATIONS
Documents Focusing on Test Design

Column Vapor Extraction Experiments on Gasoline Contaminated Soil: Published in Hydrocarbon Contaminated Soils Proceedings, ch26v11, p. 437-449, September 1991.
Miller, M. E.; Pederson, T. A.; Kaslick, C. A.; and Fan, C. Y., Camp Dresser & McKee, Inc., Cambridge, MA, U.S. Environmental Protection Agency, Cincinnati, OH, Office of Research and Development, Risk Reduction Engineering Laboratory, 1991

EPA Document Number: EPA/600/A-92/254

NTIS Document Number: PB93-131514/XAB

Soil vapor extraction (SVE) is a technique that is used to remove volatile organic compounds from unsaturated soils. Air is pumped from the contaminated area and the chemicals are removed from the resulting vapor stream. In the work laboratory, soil column experiments were conducted using a gasoline residually saturated sandy soil to evaluate the performance of SVE under controlled conditions. Both vapor extraction and aqueous leaching of the soil columns were conducted. The progress of the vapor extraction event was continuously monitored by an in-line total hydrocarbon analyzer. Performance of vapor extraction was evaluated by a series of soil chemical analyses including total petroleum, hydrocarbons, headspace measurements, and extraction techniques with quantification by GC/FID and GC/MS.

Feasibility of Hydraulic Fracturing of Soil to Improve Remedial Actions.
Murdoch, L. C.; Losonsky, G.; Cluxton, P.; Patterson, B.; and Klich, I., University of Cincinnati, OH, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, April 1991

EPA Document Number: EPA/600/2-91/012

NTIS Document Number: PB91-181818/XAB

Hydraulic fracturing, a method of increasing fluid flow within the subsurface, should improve the effectiveness of several remedial techniques, including pump and treat, vapor extraction, bio-remediation, and soil-flushing. The technique is widely used to increase the yields of oil wells, but is untested under conditions typical of contaminated sites. The project consisted of laboratory experiments, where hydraulic fractures were created in a triaxial pressure cell, and two field tests, where fractures were created at shallow depths in soil. The lab tests showed that hydraulic fractures are readily created in clayey silt, even when it is saturated and loosely-consolidated. Many of the lab observations can be explained using parameters and analyses based on linear elastic fracture mechanics. Following the field tests, the vicinity of the boreholes was excavated to reveal details of the hydraulic fractures. Maximum lengths of the fractures, as measured from the borehold to the leading edge, averaged 4.0 m, and the average area was 19 sq m. Maximum thickness of sand ranged from 2 to 20 mm, averaging 11 mm. As many as four fractures were created from a single borehold, stacked one over the other at vertical spacing of 15 to 30 cm.

Innovative Technology Demonstrations.
Anderson, D. B.; Luttrell, S. P.; Hartley, J. N.; and Hinchee, R., Battelle Pacific Northwest Laboratories, Richland, WA, U.S. Department of Energy, Washington, DC, August 1992

NTIS Document Number: DE92-015617/XAB

Environmental Management Operations (EMO) is conducting an Innovative Technology Demonstration Program for Tinker Air Force Base (TAFB). Several innovative technologies are being demonstrated to address specific problems associated with remediating two contaminated test sites at the base. Cone penetrometer testing (CPT) is a form of testing that can rapidly characterize a site. This technology was selected to evaluate its applicability in the tight clay soils and consolidated sandstone sediments found at TAFB. Directionally drilled horizontal wells were selected as a method that may be effective in accessing contamination beneath Building 3001 without disrupting the mission of the building, and in enhancing the extraction of contamination both in ground water and in soil. A soil gas extraction (SGE) demonstration, also known as soil vapor extraction, will evaluate the effectiveness of SGE in remediating fuels and TCE contamination contained in the tight clay soil formations surrounding the abandoned underground fuel storage vault located at the SW Tanks Site. In situ sensors have recently received much acclaim as a technology that can be effective in remediating hazardous waste sites. Sensors can be useful for determining real-time, in situ contaminant concentration during the remediation process for performance monitoring and in providing feedback for controlling the remediation process. Following the SGE demonstration, the SGE system and SW Tanks test site will be modified to demonstrate bioremediation as an effective means of degrading the remaining contaminants in situ. The bioremediation demonstration will evaluate a bioventing process in which the naturally occurring consortium of soil bacteria will be stimulated to aerobically degrade soil contaminants, including fuel and TCE, in situ.

McClellan Air Force Base: Health and Safety Plan, Soil Vapor Extraction Treatability Investigation, Site S Within Operable Unit D, McClellan Air Force Base, Draft Final Report.
CH2M/Hill, U.S. Air Force, Sacramento, CA, July 1991

NTIS Document Number: AD-A239 407/0/XAB

The health and safety program for personnel working at McClellan Air Force Base (McAFB), California, consists of a base site safety plan (SSP) and task-specific amendments. The base SSP contains general information that applies to all or most areas of the site. The base SSP contains: the project description, personnel responsibilities, site hazards, personal protective equipment (PPE), air monitoring guidelines, site control, decontamination procedures, and an emergency response plan. Predominant functions at McAFB have been to manage, maintain, and repair aircrafts, missiles, space vehicles, electronics, and communication equipment. These operations have required the use of toxic and hazardous materials. Some of the hazardous materials that have been used or generated on the base include: industrial solvents and caustic cleaners, electroplating waste, heavy metals, oils contaminated with polychlorinated biphenyls, contaminated jet fuels, low-level radioactive wastes, unused chemicals, oils, and lubricants. Characterization, recovery, and remediation of areas affected by waste disposal practices are ongoing. Contaminated drill cuttings and purge water will be generated during field activities. Purge water will be disposed of at the industrial waste water treatment plant (IWTP) or ground water treatment plant. Drill cuttings and contaminated soils will be handled in accordance with the McAFB Soils Management Plan.

McClellan Air Force Base: Sampling and Analysis Plan, Soil Vapor Extraction Treatability Investigation, Site S Within Operable Unit D, McClellan Air Force Base, Draft Final Report.
CH2M/Hill, U.S. Air Force, Sacramento, CA, July 1991

NTIS Document Number: AD-A239 406/2/XAB

This sampling and analysis plan (SAP) describes procedures developed for the treatability investigation of soil vapor extraction (SVE) at Site S at the

McClellan Air Force Base near Sacramento, California. The purpose of the treatability investigation is to develop sufficient field and operational data to assess the applicability of SVE technology in removing site-specific contaminants at the base. Site S is one of 12 waste disposal sites identified as a former fuel and solvent disposal pit. Primary objectives of the sampling and analysis efforts are to: (1) assess the nature and extent of vadose zone soil contamination; (2) evaluate the in situ permeability of vadose zone soils; (3) obtain site-specific field data for design of the pilot-scale SVE system; and (4) evaluate the effectiveness and implementability of SVE for site remediation and recovery.

Radioactive Waste Management Complex: Health and Safety Plan for Operations Performed for the Environmental Restoration Program, Task: Vapor Vacuum Extraction.
Lugar, R. M., EG&G Idaho, Inc., Idaho Falls, ID, U.S. Department of Energy, Washington, DC, July 1991

NTIS Document Number: DE91-018758/XAB

This document constitutes the generic health and safety plan for the Environmental Restoration Program (ERP). It addresses the health and safety requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120 standard; and EG&G Idaho, Inc. This plan is a guide to individuals who must complete a health and safety plan for a task performed for the ERP. It contains a task-specific addendum that, when completed, specifically addresses task-specific health and safety issues. This health and safety plan reduces the time it takes to write a task-specific health and safety plan by providing discussions of requirements, guidance on where specific information is located, and specific topics in the addendum that must be discussed at a task level. This format encourages a complete task-specific health and safety plan and provides a standard for all health and safety plans written for ERP. This plan also incorporates the "Health and Safety Plan for Operations Performed for the Environmental Restoration Program" (EGG-WM-8771, Rev. 1) with an addendum completed for vapor vacuum extraction (VVE). The VVE project includes: sampling and analyzing of gas concentrations in monitors and open wells; measuring pressures in monitoring wells; measuring extraction well gas and system operational parameters in support of characterizing the volatile organic compounds (VOC) contamination beneath the subsurface disposal area (SDA) of the Radioactive Waste Management Complex (RWMC); and calibrating the organic transport model and prevailing engineering data for a final remedial action.

Radioactive Waste Management Complex: Report of Results of the Vapor Vacuum Extraction Test at the Radioactive Waste Management Complex (RWMC) on the Idaho National Engineering Laboratory (INEL) in the State of Idaho.
Chatwin, T. D.; Miyasaki, D. H.; Sisson, J. B.; and Sondrup, A. J., EG&G Idaho, Inc., Idaho Falls, U.S. Department of Energy, Washington, DC, 1992

NTIS Document Number: DE92-017920/XAB

A test-scale vapor vacuum extraction (VVE) system was installed and operated at the Radioactive Waste Management Complex (RWMC) on the Idaho National Engineering Laboratory (INEL), which is west of Idaho Falls, Idaho and is managed by the U.S. Department of Energy Idaho Field Office. The system was constructed for the purpose of demonstrating the feasibility of VVE or vapor venting technology to abate a volatile organic compound (VOC) plume located in the vadose zone below the subsurface disposal area at the complex. To date, the system has been operated for two periods, a two-week test and a four-month test. The purpose of the two-week test was to determine what would be extracted from the borehole and to verify the design of the system to handle what would be extracted. The original prediction for the removal of VOCs from the vadose zone was after three months of operation there should be a very noticeable decrease in the gas concentration upwards to 200 ft. in a radial direction from the extraction well.

However, the test data indicated very little change in concentration at the monitoring well at 82 ft. The modeling parameters required to be adjusted in the model cannot be determined from the test data. Information for design of a remediation facility is also lacking and further testing is required.

Remediation Cleanup Options for the Hoe Creek UCG Site.
Nordin, J.; Griffin, W.; Chatwin, T.; Lindblom, S.; and Crader, S., University of Wyoming Research Corp., Laramie, WY, Western Research Institute, U.S. Department of Energy, Washington, DC, March 1990

NTIS Document Number: DE91-002003/XAB

The U.S. Department of Energy must restore ground water quality at the Hoe Creek, Wyoming, underground coal gasification site using the best proven practicable technology. Six alternative remediation methods are evaluated in this project: (1) excavation, (2) three variations of ground water plume containment, (3) in situ vacuum extraction, (4) pump and treat using a defined pattern of pumping wells to obtain an effective matrix sweep, (5) in situ flushing using a surfactant, and (6) in situ bioremediation. Available site characterization data is insufficient to accurately project the cost of remediation. Several alternative hypothetical examples and associated costs are described in the text and in the appendices. However, not enough information is available to use these examples as a basis for comparison purposes. Before a cleanup method is selected, core borings should be taken to define the areal extent and depth of contaminated matrix material. Segments of these core borings should be analyzed for organic contaminants in the soil (e.g., benzene) and their relationship to the ground water contamination. These analyses and subsequent treatability studies will show whether or not the contaminants can be effectively removed by surface or in situ volatilization, leached from the matrix using washing solutions, or removed by bioremediation. After this information is obtained, each technology should be evaluated with respect to cost and probability of success. A decision tree for implementing remediation at the Hoe Creek site is presented in this report.

Subsurface Interim Measures/Interim Remedial Action Plan and Decision Document for the 903 Pad, Mound, and East Trenches Areas (Operable Unit No. 2), Public Comment, Responsiveness Summary: Final.
EG&G Rocky Flats, Inc., Golden, CO, Rocky Flats Plant, U.S. Department of Energy, Washington, DC, September 1992

NTIS Document Number: DE93-002251/XAB

The Department of Energy (DOE) is pursuing an Interim Measure/Interim Remedial Action (IM/IRA) at the 903 Pad, Mound, and East Trenches Areas (Operable Unit No. 2) at the Rocky Flats Plant (RFP). This IM/IRA is to be conducted to provide information that will aid in the selection and design of final remedial actions at OU2 that will address removal of suspected free-phase volatile organic compound (VOC) contamination. The plan involves investigating the removal of residual free-phase VOCs by in situ vacuum-enhanced vapor extraction technology at three suspected VOC source areas within OU2. VOC-contaminated vapors extracted from the subsurface would be treated by granular activated carbon (GAC) adsorption and discharged. The plan also includes water table depression, when applicable at the test sites, to investigate the performance of vapor extraction technology in the saturated zone. The plan provides for treatment of any contaminated ground water recovered during the IM/IRA at existing RFP treatment facilities. The proposed IM/IRA plan is presented in the document entitled "Proposed Subsurface Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2," dated March 20, 1992. Information concerning the proposed Subsurface IM/IRA was presented during a DOE Quarterly Review meeting held on April 7, 1992 and a public meeting held on May 7, 1992, at the Marriott Hotel in Golden, Colorado. The Responsiveness Summary presents DOE's response to all comments received at the public meeting, as well as those mailed to date to DOE

during the public comment period.

Superfund Innovative Technology Evaluation Program: Technology Profiles, Sixth Edition.
U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, November 1993

EPA Document Number: EPA/540/R-93/526

The Superfund Innovative Technology Evaluation (SITE) Program evaluates new and promising treatment and monitoring and measurement technologies for cleanup of hazardous waste sites. The program was created to encourage the development and routine use of innovative treatment technologies. As a result, the SITE Program provides environmental decisionmakers with data on new, viable treatment technologies that may have performance or cost advantages compared to traditional treatment technologies. Each technology profile presented in this document contains (1) a technology developer and process name, (2) a technology description, including a schematic diagram or photograph of the process, (3) a discussion of waste applicability, (4) a project status report, and (5) EPA project manager and technology developer contacts. The profiles also include summaries of demonstration results if available. The technology description and waste applicability sections are written by the developer. EPA prepares the status and demonstration results if available.

Technologies of Delivery or Recovery for the Remediation of Hazardous Waste Sites.
Murdoch, L.; Patterson, B.; Losonsky, G.; and Harrar, W., University of Cincinnati, Cincinnati, OH, U.S. Department of Civil and Environmental Engineering, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, January 1990

EPA Document Number: EPA/600/2-89/066

NTIS Document Number: PB90-156225/XAB

Techniques to recover contaminants or deliver treating material at contaminated sites are described in the report. Few of the 17 described delivery or recovery techniques are in use today. New technologies, used in other industries such as petroleum extraction or mining, show promise for remediation of contaminated sites but require investigation to confirm their suitability for in situ remediation. The following 17 technologies are described: colloidal gas aphrons, hydraulic fracturing, radial drilling, ultrasonic methods, kerfing, electro-kinetics, jet slurrying, CO2 injection, polymer injection, vapor extraction, steam stripping, hot brine injection, in situ combustion, radio frequency heating, cyclic pumping, soil flushing, and ground freezing. Each description of a technology includes an explanation of the basic processes involved, the optimal site conditions for use, the current status of research, the personnel currently involved in research, and a list of references.

Technology Evaluation Report: SITE Program Demonstration Test, Accutech Pneumatic Fracturing Extraction and Hot Gas Injection, Phase 1, Volume 1.
Science Applications International Corporation, Hackensack, NJ, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, July 1993

EPA Document Number: EPA/540/R-93/509

NTIS Document Number: PB93-216596/XAB

The Pneumatic Fracturing Extraction (PFE) process developed by Accutech Remedial Systems, Inc., makes it possible to use vapor extraction to remove volatile organics at increased rates from a broader range of vadose zones. The low

permeability of silts, clays, shales, etc. would otherwise make such formations unsuitable for cost-effective vapor extraction and require more costly approaches. Pneumatic fracturing provides an innovative means of increasing the permeability of a formation and thus extending the radius of influence so that contaminants can be effectively extracted. In the PFE process, fracture wells are drilled in the contaminated vadose zone and left open bore (uncased) for most of their depth. A packer system is used to isolate small (2 ft.) intervals so that short bursts (< 20 sec.) of compressed air (less than 500 psig) can be injected into the interval to fracture the formation. The process is repeated for each interval. The fracturing extends and enlarges existing fissures and/or introduces new fractures, primarily in the horizontal direction. When fracturing has been completed, the formations then are subjected to vapor extraction.

STUDIES AND DEMONSTRATIONS (CONT'D)

Documents Focusing on Study Results

AWD Technologies Integrated AquaDetox (Trade Name)/SVE Technology: Applications Analysis Report.
U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, October 1991

EPA Document Number: EPA/540/A5-91/002

NTIS Document Number: PB92-218379/XAB

In support of the U.S. Environmental Protection Agency's (EPA) Superfund Innovative Technology Evaluation (SITE) Program, the report evaluates the AWD Technologies, Inc., integrated AquaDetox/SVE treatment system for simultaneous on-site treatment of contaminated ground water and soil-gas. The AWD technology uses an AquaDetox moderate vacuum steam stripping system to treat contaminated ground water and a SVE system that uses granular activated carbon (GAC) beds to treat soil-gas. The two systems are looped together to form a closed system with no emissions. The report evaluates both the treatment efficiency and economic data based on results from the SITE demonstration and describes several case studies.

Demonstration of Remedial Action Technologies for Contaminated Land and Ground Water, Volume 1, Final Report, November 1986 - November 1991.
Olfenbuttel, R.F.; Dahl, T.O.; Hinsenveld, M.; James, S.C.; Lewis, N., U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, NATO Committee on the Challenges of Modern Society, Washington, DC, 1991

EPA Document Number: EPA/600/R-93/012A

NTIS Document Number: PB93-218238/XAB

This publication reports the results of the NATO Committee on the Challenges of Modern Society (NATO/CCMS) Pilot Study, which was conducted from 1986-1991. The Pilot Study was designed to identify and evaluate innovative, emerging, and alternative remediation technologies and to transfer technical performance and information to potential users. Technologies included are: thermal, stabilization/solidification, soil vapor extraction (SVE), physical/chemical extraction, pump-and-treat, chemical treatment of contaminated soils, and microbial. The chapter on SVE discusses the NATO/CCMS pilot studies and related studies implemented in the U.S. The case studies were chosen to illustrate how SVE has been applied to a wide range of site and soil conditions, as well as to various contaminant types and concentrations. Commercially available processes for destruction of the vented air emissions are also discussed.

Demonstration of Waste Treatment Technologies.
Martin, J. F., U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, 1991

EPA Document Number: EPA/600/A-92/091

NTIS Document Number: PB92-179670/XAB

The need for long-term, permanent treatment schemes as alternatives to land disposal has been highlighted by legislation such as the Hazardous and Solid Waste Amendments of the Resource Conservation and Recovery Act (RCRA) and the Superfund Amendments and Reauthorization Act (SARA) of 1986. SARA directed the U.S. Environmental Protection Agency to establish an "Alternative or Innovative Treatment Technology Research and Demonstration Program" to identify promising waste treatment technologies, assist with their evaluation, and promote their use at Superfund sites. In response to this directive, the Superfund Innovative Technology Evaluation (SITE) Program was formed. Twenty technology demonstrations have been completed in the SITE Program to date. Those completed within the past year include microfiltration (DuPont and the Oberlin Filter Company), waste excavation and emissions control (EPA Region 9), integrated vapor extraction and steam vacuum stripping (AWD Technologies), solidification of contaminated soil (Silicate Technology Corporation), and flame reactor recovery of lead (Horsehead Resource Development Company).

Evaluation of Vapor Extraction of Vadose Zone Contamination.
Crotwell, A. T.; Waehner, M. J.; MacInnis, J. M.; Travis, C. C.; and Lyon, B. F., Oak Ridge National Laboratory, TN, U.S. Department of Energy, Washington, DC, May 1992

NTIS Document Number: DE92-019065/XAB

An in-depth analysis of vapor extraction for remediation of soils contaminated with volatile organic compounds (VOCs) was conducted at 13 sites. The effectiveness of the vapor extraction system (VES) in removing organic contaminants from soil was evaluated using two methods. Soil sampling, the first method, is the best method of characterizing the concentration and location of contaminant within the substance. The second method, soil gas sampling, is the more common but less accurate method of evaluating the effectiveness of VES. The range of effectiveness was found to be 64 percent to 99 percent effective in removing organic contaminants from soil. At 9 of the 13 sites studied in this report, vapor extraction was found to be effective in reducing VOC concentrations by at least 90 percent. At the remaining four sites studied, vapor extraction was found to reduce VOC concentrations by less than 90 percent. Vapor extraction is ongoing at two of these sites. At a third, the ineffectiveness of the vapor extraction is attributed to the presence of "hot spots" of contamination. At the fourth site, where performance was found to be relatively poor, the presence of geological tar deposits at the site is thought to be a major factor in the ineffectiveness.

Forced Air Ventilation for Remediation of Unsaturated Soils Contaminated by VOCs.
Cho, J. S., Robert S. Kerr Environmental Research Laboratory, Ada, OK, U.S. Environmental Protection Agency, Washington, DC, May 1991

EPA Document Number: EPA/600/2-91/016

NTIS Document Number: PB91-181750/XAB

Parameters that were expected to control the removal process of VOCs from contaminated soil during the SVE operation were studied by means of numerical simulations and laboratory experiments in the project. Experimental results

of SVE with soil columns in the laboratory indicated that the removal efficiency of VOCs from soil columns was a complicated function of air flow and the hydrogeometry inside. The partition process between air and the immobile liquid was not an equilibrium one, and the interfacial mass transfer varied with the residual amount of VOCs in the soil. Additional experiments under various conditions should be conducted to obtain further insight into SVE process. Two computer models were developed to study soil air and VOC movement during the SVE process. The first one was an analytical approximate model that could be used for the simulation of air movement in the SVE operation with multiple wells in homogeneous soil media. The second one was a numerical model in three-dimensional geometry that used a finite difference solution scheme. A simple pneumatic pump test was conducted, and part of test data were used for the validation of the simple analytical model.

Groveland, Massachusetts: EPA Site Demonstration of the Terra Vac In situ Vacuum Extraction Process in Groveland, Massachusetts, SITE Program Update: Part VII, Journal Article: Published in Journal of the Air Pollution Control Association, v39n8, p. 1054-1062, August 1989.
Stinson, M. K., U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, 1989

EPA Document Number: EPA/600/J-89/520

NTIS Document Number: PB91-182097/XAB

The paper presents an EPA evaluation of the in situ vacuum extraction process patented by Terra Vac, Inc. that was field-demonstrated on trichloroethylene (TCE)-contaminated soil in Groveland, Massachusetts, under the EPA Superfund Innovative Technology Evaluation (SITE) program. The Terra Vac process employs vacuum for removal and venting of volatile organic compounds (VOCs), such as TCE, from the subsurface soil without excavation. The demonstration site was a machine shop operating in Groveland. The site was contaminated with VOCs, mainly TCE, which had been used as a degreasing solvent. The Terra Vac system was designed, installed, and operated by Terra Vac, Inc. Evaluation of the process was performed by EPA based on the results from an extensive sampling and analytical program and on daily observation of the operations.

Groveland, Massachusetts: Technology Evaluation Report: SITE (Superfund Innovative Technology Evaluation) Program Demonstration Test, Terra Vac In situ Vacuum Extraction System, Groveland, Massachusetts, Volume 1.
Michaels, P. A., Foster Wheeler Enviresponse, Inc., Livingston, NJ, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, April 1989

EPA Document Number: EPA/540/5-89/003A

NTIS Document Number: PB89-192025/XAB

An evaluation was made of Terra Vac, Inc.'s vacuum extraction system during a 56-day demonstration test run at Valley Manufactured Product Company's site in Groveland, Massachusetts. This site is part of the Groveland Wells Superfund site and is contaminated mainly by trichloroethylene. The report, one of three volumes, includes a detailed discussion of the operations of the vacuum extraction unit, a process description and diagram of the system, and a summary of the sampling and analytical protocols. The final sampling and analytical report and the quality assurance project plan are included. An overall evaluation of the process cost and its applicability to other Superfund sites across the country is included. Both shallow soil gas and soil VOC concentrations showed a decline with time that was correlatable. The process worked well in soils of both high and low permeability. The system operation was very reliable during the 56-day demonstration test run and the only attention required was to replace the spent activated carbon canisters

with fresh canisters.

Groveland, Massachusetts: Technology Evaluation Report: SITE (Superfund Innovative Technology Evaluation) Program Demonstration Test, Terra Vac In Situ Vacuum Extraction System, Groveland, Massachusetts, Volume 2.
Michaels, P. A., Foster Wheeler Enviresponse, Inc., Livingston, NJ, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, April 1989

EPA Document Number: EPA/540/5-89/003B

NTIS Document Number: PB89-192033/XAB

Sampling and analysis were conducted during the Terra Vac in situ vacuum extraction project in Groveland, Massachusetts. The Terra Vac process was demonstrated and tested under the U.S. Environmental Protection Agency's (EPA's) Superfund Innovative Technology Evaluation (SITE) program. The major objectives of the demonstration were: (1) to determine the ability of the technology to reach an acceptable low level of contaminant concentration in the soil, (2) to assess the effectiveness in various soil types, (3) to gather capital and operating costs, and (4) to gain performance and reliability information. A secondary objective was to establish a correlation between volatile organic concentrations in soils and concentration in extracted vapor. The report has been organized into three volumes. Volume II, Field Data Sheets, contains copies of the original daily sample data sheets that were used to record process conditions and sampling information. Copies of the chain-of-custody sheets used during the project are also included.

Groveland, Massachusetts: Terra Vac In Situ Vacuum Extraction System: Applications Analysis Report.
Stinson, M., Foster Wheeler Enviresponse, Inc., Edison, NJ, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, July 1989

EPA Document Number: EPA/540/A5-89/003

NTIS Document Number: PB90-119744/XAB

The document is an evaluation of the Terra Vac in situ vacuum extraction system and its applicability as a treatment method for waste site cleanup. The report analyzes the results from the Superfund Innovative Technology Evaluation (SITE) Program's 56-day demonstration at the Valley Manufactured Product Company's site in Groveland, Massachusetts and data from other applications. Conclusions were reached concerning the technology's suitability for use in remediations involving both similar and different materials at other sites. Operational data and sampling and analysis information were monitored carefully to establish a database against which the vendor's claims for the technology could be evaluated. The conclusions from the results of the Groveland demonstration test and from other available data are: (1) the process can be used to remediate a site contaminated with VOCs; (2) the process can remove VOCs from soils with permeabilities as low as 10-8 cm/s; (3) the process operates well in all weather conditions; and (4) the process implementation costs can be as low as $10/ton, depending on various site-specific conditions.

Hanford Site: Field Observations of Variability of Soil Gas Measurements.
Fancher, J. D., Westinghouse Hanford Co., Richland, WA, U.S. Department of Energy, Washington, DC, December 1992

NTIS Document Number: DE93-006904/XAB

A baseline monitoring survey is being performed at the U. S. Department of

Energy's Hanford Site located in southeast Washington State. Monitoring is in support of the carbon tetrachloride Expedited Response Action (ERA) vapor extraction system (VES) operations. Since late 1991, soil-gas probes and wellheads have been routinely monitored for volatile organic concentrations. The monitoring network now encompasses 59 locations. These include 46 wellhead locations, 11 shallow soil-gas probes (1.2 m (4 ft.) deep), and 2 deep soil-gas probes (11 and 22 m (37 and 73 ft.) deep). The project site is an area where carbon tetrachloride (CCl4) and co-contaminants were discharged to the soil between 1955 and 1973. There are three separate CCl4 disposal areas at the project site. This contamination is linked to past liquid waste disposal practices resulting from operation of the Plutonium Finishing Plant at the Hanford Site. The contamination caused an extensive vapor plume in the vadose zone and a ground water contamination plume that covers over 12 km2. The following are the objectives of this baseline monitoring survey: (1) to measure the existing concentrations of CCl4 in the subsurface prior to initiation of the vacuum extraction; (2) to investigate how the existing concentrations of CCl4, vary with time; (3) to evaluate the impact of vapor extraction on the distribution and concentrations of CCl4, in the subsurface; and (4) to provide data to help maintain a safe working environment.

Hanford Site: Soil Vapor Extraction Test in a Radiologically Contaminated Site.
Swanson, L. C.; Moak, D. J.; Coffman, R. T.; Gale, S. J.; and Wilder, J., Westinghouse Hanford Co., Richland, WA, U.S. Department of Energy, Washington, DC, September 1991

NTIS Document Number: DE93-002241/XAB

A pilot test was conducted at the Hanford site in Washington State using soil vapor extraction technology, to test the vapor extraction technology under Hanford site conditions, and to provide data for designing a large-scale vapor extraction system that will be used to stabilize an existing vadose zone CCl4 vapor plume. Testing was performed at the 216-Z-lA tile field where over 5 million liters of water, 245 metric tons of CCl4, and 58 kilograms of plutonium and americium were disposed in the 1960s. The test objectives were to determine the distribution of CCl4 beneath the tile field, estimate soil permeabilities, observe trends in CCl4 concentrations during soil vapor extraction, and determine the behavior of radionuclides during the extraction process. The presence of the radionuclides required the use of a high efficiency particulate filter mounded in-line with the conventional vapor extraction equipment. Gas and filter samples were collected for laboratory analysis using a gas chromatograph/mass spectrometer. Real-time monitoring was performed using on-line flame-ionization and photo-ionization detectors for CCl4 and continuous alpha-radiation and beta-radiation air monitors for radionuclides. The test results showed that CCl4 concentrations generally increased with depth with significant concentrations of CCl4 detected outside the tile field boundaries; air permeabilities were in the range of a sand; large amounts of CCl4 were produced; plutonium and americium were not detected during the test or later on any of the test equipment; and unexpectedly high volumes of radon can be produced. The test also demonstrated that the soil vapor technology is a viable method for removing CCl4 at the tile field, with the ability to separate CCl4 from the plutonium and americium soil contamination.

Innovative Operational Treatment Technologies for Application to Superfund Site: Nine Case Studies, Final Report.
Young, C.; Schmoyer, B.; Edison, J.; Roeck, D.; and Ball, J., U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC, April 1990

EPA Document Number: EPA/540/2-90/006

NTIS Document Number: PB90-202656/XAB

Nine case studies are presented in a report that was designed to identify and obtain operational data from ongoing and completed remediation efforts. The case studies are presented as appendices and provide process descriptions plus performance, operational, and cost data. The nine appendices present case studies on the following topics: incineration of explosives and contaminated soils; ground water extraction with air stripping; ground water biodegradation treatment system; ground water extraction and treatment; ground water extraction with air stripping and soil vacuum extraction; ground water extraction with physical, chemical, and biological, treatment; and chemical treatment of ground water and soil flushing.

In Situ Soil Venting - Full Scale Test, Hill AFB, Volume 2, Guidance Document, Final Report.
Depaoli, D. W.; Herbes, S. E.; Wilson, J. H.; Solomon, D. K.; and Jennings, H. L., Oak Ridge National Laboratory, TN, U.S. Department of Energy, Washington, DC, National Oceanic and Atmospheric Administration, Earth Sciences Laboratories, Boulder, CO, August 1991

NTIS Document Number: AD-A254 888/1/XAB

The purpose of this project was to demonstrate a full-scale in situ soil venting technology and to carefully document the design, operation, and performance of this system so that it could be applied at other Air Force contaminated sites. Although this technology is now commercially available, its ability to fully remediate jet fuel spills had never been proven, nor had the full-scale costs ever been validated when catalytic incineration is used as an emission control method. ESL Technical Report 90-21 is in three volumes. Volume 1 is a complete literature review of previous soil venting research and field work. Volume 2 is a guidance manual that provides important design information and describes methods of pilot testing this technology prior to full-scale application. Volume 3 includes results of the Hill AFB test. These publications will provide valuable information to Air Force engineers responsible for cleaning up chemically contaminated sites. See also Volume 1 (NTIS Document Number: AD-A254 924/4/XAB) and Volume 3 (NTIS Document Number: AD-A261 179/6/XAB).

McClellan Air Force Base: Data Summary Report for Area D Soil Gas Sampling and Analysis, McClellan Air Force Base, Volume 1, Data Summary, Final Report.
CH2M/Hill, U.S. Air Force, Sacramento, CA, January 1992

NTIS Document Number: AD-A246 266/1/XAB

The task order for which this report was prepared required sampling and analysis of soil gas extracted from vent risers through a low permeability cover over hazardous waste sites in Area D and from soil gas migration wells around the perimeter of the cover. The objectives of sampling and analyses were to provide data for comparison of the various sampling media used, determine the concentrations of target analytes in subsurface gases, evaluate the change in subsurface gas concentrations over time during vapor extraction, evaluate recovery of gas concentrations during non-extraction periods, evaluate sampling and analytical methods for future use in determining the nature and extent of contamination at the site, and recommended routine sampling and analytical protocols for soil gas monitoring at McClellan. This report is organized into a data interpretation volume (Volume 1), a second volume (Volume 2) containing data both condensed and as received, and quality control reports.

McClellan Air Force Base: Soil Vapor Extraction Treatability Investigation, Site S Within Operable Unit D, McClellan Air Force Base, Addendum to the Quality Assurance Project Plan, Draft Final Report.
CH2M/Hill, U.S. Air Force, Sacramento, CA, July 1991

NTIS Document Number: AD-A239 345/2/XAB

The United States Air Force (USAF) is conducting a study at the McClellan Air Force Base to assess the nature and extent of contamination resulting from past practices and spills on the base and to plan for the remediation of identified areas of contamination. This project discusses activities related to the treatability investigation to assess the viability and effectiveness of in situ soil vapor extraction (SVE) as a tool for remediation and recovery at the McClellan AFB. The treatability investigation will include a site characterization study, an in situ air permeability test, and an SVE pilot test. Sampling includes soil borings samples, air permeability testing, and SVE pilot testing. Analytical methodology includes identification of volatile organic compounds from canister air sampling.

McClellan Air Force Base: Steam Injection/Vacuum Extraction, Phase 2, Treatability Investigation, Site Characterization and Design, Final Report.
Heglie, J.; Koster, R.; Pexton, R.; and Stewart, L., CH2M/Hill, U.S. Air Force, Sacramento, CA, December 1991

NTIS Document Number: AD-A243 745/7/XAB

The United States Air Force is planning to conduct a pilot test of steam injection and vapor extraction remediation technology at McClellan AFB. This innovative technology, under development by Kent Udell at the University of California at Berkeley, combines in situ steam injection into soil in both the vadose (unsaturated) and saturated zones, with vacuum extraction of volatile and semi-volatile organic contaminants from the soil. Results of the composite soil samples received to date show the presence of dioxins and dibenzofurans, petroleum hydrocarbons, volatile organics, semi-volatile organics, and polychlorinated biphenyls in the waste fill material. Results of the treatability testing indicate that: (1) low concentrations of dioxins and furans were mobilized by the steam condensate, (2) high concentrations of hydrocarbons were reduced by one order-of-magnitude by the steam, and (3) dioxins and furans appear to be dissolved mainly in the hydrocarbon nonaqueous phase liquid (NAPL) phase. Petroleum hydrocarbon and dioxin concentrations are not high enough to preclude a pilot scale test.

Model for the Future: Innovative Combination of Technologies for Soil and Ground Water VOC (Volatile Organic Compound) Remediation.
Reeme, T. L.; Hartnett, S. L.; and Miller, S. F., Argonne National Laboratory, IL, U.S. Department of Energy, Washington, DC, July 1989

NTIS Document Number: DE90-001767/XAB

Elevated levels of carbon tetrachloride and chloroform were detected in 4hlN/2 in a public water supply serving a small agricultural community in the Midwest. The U.S. Environmental Protection Agency subsequently initiated an "expedited response action" and identified the contaminant source as a former grain storage facility where carbon tetrachloride had been used as a fumigant from 1955 to 1965. An innovative remedial system, operating at the facility site since early 1988, simultaneously removes volatile organic compounds from extracted ground water by air stripping and reduces subsoil source contamination by in situ vapor extraction. This paper presents a case history of the contamination and the remedial action and discusses plans to expedite cleanup operations and increase their cost-effectiveness.

Performance Evaluation of a Ground Water and Soil Gas Remedial Action.
Hansen, M.C.; and Hartnett, S. L., Argonne National Laboratory, IL, U.S. Department of Energy, Washington, DC, July 1990

NTIS Document Number: DE90-017659/XAB

Volatile organic compounds (VOCs) continue to be remediated by a ground water extraction system and an in situ vapor extraction system at a Midwest agricultural site. Carbon tetrachloride (CCl4) and chloroform (CHCl3) contamination levels were detected at maximum concentrations of 4,000 parts per billion (ppb) and 360 ppb, respectively, for on-site groundwater samples and 6,000 ppb and 1,800 ppb, respectively, for on-site gas samples. Groundwater from a domestic well and a monitoring well located at least 2,300 ft. downgradient from the site also had CCl4 and CHCl3 contamination. Furthermore, a public water supply well, located downgradient of the site, was found to have groundwater contaminated with CCl4. During two years of operations of the remedial action, groundwater and soil gas samples have been analyzed to monitor potential migration of contaminants from the site and to track the overall progress toward cleanup. Results demonstrate a decrease in groundwater contamination in both on- and off-site monitoring wells and a decrease in soil gas air emissions from the site. This paper presents the sampling results for the site over the last two years and discusses trends indicating the effectiveness of the remedial action system in controlling contaminant migration and overall progress toward reducing the source of contamination in the unsaturated subsoils.

Pneumatic Pumping Test for Soil Vacuum Extraction, Journal Article: Published in Environmental Progress, v11n3, p. 228-233, August 1992.
Cho, J. S. and DiGiulio, D. C., Robert S. Kerr Environmental Research Laboratory, Ada, OK, U.S. Environmental Protection Agency, Washington, DC, August 1992

EPA Document Number: EPA/600/J-92/391

NTIS Document Number: PB93-121234/XAB

In situ pneumatic pumping tests were performed to estimate the pneumatic permeability at a site containing soils contaminated with aviation gasoline. Determination of pneumatic permeability was necessary to evaluate soil-air discharge or pore volume exchange rates. Pressure propagation was measured in clustered vapor probes during the application of vacuum and positive pressure. An analytical solution for soil-air pressure distribution with a non-linear data fitting algorithm was adopted to obtain the pneumatic permeability from soil-air pressure distribution. Pneumatic pumping tests indicated substantially higher air discharge rates in the immediate vicinity of wells. The air discharge rate dissipated rapidly as distance from the wells increased. Application of increased vacuum or injection pressure resulted in substantially increased air flow in the immediate vicinity with small changes at a distance. This fact indicates that effective design should be based on air flow fields near wells, and the site specific design criteria should be determined with carefully conducted tests.

Portsmouth Gaseous Diffusion: Technology Demonstration Assessment Report for X-231B (Part 1) and Summary of Closure Activities (Part 2).
Portsmouth Gaseous Diffusion Plant, OH, Theta Technologies, Inc., Oak Ridge, TN, U.S. Department of Energy, Washington, DC, July 1992

NTIS Document Number: DE93-004610/XAB

This Technology Demonstration Assessment Report (TDAR) was developed to evaluate and recommend the most feasible approach for cleanup of contaminated Minford soil in the vadose zone and to summarize closure activities at the Portsmouth Gaseous Diffusion Plant X-231B Oil Biodegradation Plot (X-231B). The X-231B site, consisting of a north and south area, is oriented on a north-south axis. The north and south areas measure 265 ft. by 10 ft. and 100 ft. by 70 ft., respectively. The X-231B Technology Demonstration (TD) Project was initiated during Fall 1990 to identify and evaluate emerging technologies that could provide cost effective and feasible in situ soil treatment. The four technologies plus the contingent design evaluated were: in situ soil mixing

with solidification/stabilization, in situ soil mixing with isothermal vapor extraction, in situ soil mixing with thermally enhanced vapor extraction, in situ soil mixing with peroxidation destruction, and center-line trench drain-contingent design.

Portsmouth Gaseous Diffusion: Technology Demonstration Assessment Report for X-701B Holding Pond.
Portsmouth Gaseous Diffusion Plant, OH, Theta Technologies, Inc., Oak Ridge, TN, U.S. Department of Energy, Washington, DC, July 1992

NTIS Document Number: DE93004608/XAB

This Technology Demonstration Assessment Report (TDAR) was developed to evaluate and recommend the most feasible approach for cleanup of contaminated Minford soils below the X 701B Holding Pond and to summarize closure activities at the Portsmouth Gaseous Diffusion Plant X-701B Holding Pond (X-701B) site. In this TDAR, the recommended alternative and the activities for closure of the X-701B site are discussed. Four treatment technologies chosen for the TD, along with a Contingent Design, were evaluated to determine which approach would be appropriate for final closure of X-701B. These technologies address removal of soil contamination from the vadose zone and the saturated zone. The four technologies plus the Contingent Design evaluated were: in situ soil mixing with solidification/stabilization, in situ soil mixing with isothermal vapor extraction, in situ soil mixing with thermally enhanced vapor extraction, in situ soil mixing with peroxidation destruction, and contingent closure. These technologies were evaluated according to their performance, reliability, implementability, safety, waste minimization, cost, and implementation time. Based on these criteria, a preferred treatment approach was recommended. The goal of the treatment approach is to apply the most appropriate technology demonstrated at X-231B in order to reduce Volatile Organic Compounds (VOCs) in the saturated Minford soils directly beneath the X-701B Holding Pond. The closure schedule will include bidding and awarding of two construction contracts, mobilization and demobilization, soil treatment, cap design, and cap construction. The total time required for soil treatment will be established based on actual performance of the soil treatment approach in the field.

Remediation of a Gasoline Spill by Soil Vapor Extraction.
Cook, G. E.; Oberdorfer, J. A.; and Orloff, S. P., Lawrence Livermore National Laboratory, Livermore, CA, U.S. Department of Energy, Washington, DC, September 1991

NTIS Document Number: DE92-000488/XAB

Lawrence Livermore National Laboratory (LLNL) is located approximately 40 miles east of San Francisco in the southeastern portion of the Livermore Valley near Livermore, California. In 1979, an underground gasoline tank was found to be leaking. The spill occurred near Building 403 in the southeast corner of LLNL. The initial investigation confirmed the presence of gasoline contamination in both the soil and ground water. The water table is at a depth of approximately 100 feet. A pilot study on the use of soil vapor extraction in heterogeneous deposits was begun in August 1988. Fieldwork to assess the efficacy of the vapor extraction, including soil sampling and installation of three vadose zone monitoring devices, began in October 1990. The soil vapor extraction system at LLNL was found to be effective in removing BTEX from the soil. It is also noted as being more effective in areas of high concentrations of volatile compounds.

Savannah River Site: Pilot Test of a Vacuum Extraction System for Environmental Remediation of Chlorinated Solvents at the Savannah River Site.
Looney, B. B.; Pickett, J. B.; and Malot, J. J., Westinghouse Savannah River

Co., Aiken, SC, U.S. Department of Energy, Washington, DC, December 1991

NTIS Document Number: DE93-006165/XAB

Vacuum extraction is an environmental restoration technique that is currently being applied to the remediation of soils and shallow segments that are contaminated with volatile constituents. In 1987, a study was performed to evaluate the performance and potential applicability of this technology at the Savannah River Site (SRS). Vacuum extraction is useful when volatile constituents are present in the vadose zone. The technology has been used to remediate a number of sites across the country, including leaking underground storage tanks, spill sites, landfills, and production facilities. The primary objective of the pilot study was to test the performance of the technology under the conditions specific to many of the potential areas of application at SRS. There is only a limited body of literature documenting field studies in similar environments within sands and clayey zones and a relatively thick vadose zone. Careful studies of this type are needed to develop full scale designs at SRS. The vacuum extraction pilot study at SRS was performed by a group consisting of technical representatives of the Environmental Sciences Section in the Savannah River Laboratory (SRL), the Raw Materials Engineering and Technology Section of SRS, and TerraVac, Inc., a subcontractor with experience in this field. The pilot study yielded promising results. The concentrations of contaminants in the extracted gas decreased significantly during the test. Modeling of the pressures in the vicinity of the test indicate that the gas flow in this interbedded vadose system is similar to water flow in a leaky confined aquifer system; a shallow clay zone at 30 to 40 ft. deep acts as an "aquitard" overlying a relatively thick zone of higher permeability. The data from the pilot study indicate that vacuum extraction will be an effective tool for cleaning up volatile contaminants in the vadose zone at SRS.

Savannah River Site: Status of In Situ Air Stripping Tests and Proposed Modifications: Horizontal Wells AMH-1 and AMH-2, Savannah River Site.
Kaback, D. S. and Looney, B. B., Westinghouse Savannah River Co., Aiken, SC, U.S. Department of Energy, Washington, DC, August 1989

NTIS Document Number: DE90-000652/XAB

A project to drill and install two horizontal vapor extraction/air injection wells at the Savannah River Site (SRS), Aiken, South Carolina, was performed in September and October of 1988. The project was performed to test the feasibility of horizontal drilling technologies in shallow unconsolidated sediments. Additional study to evaluate the effectiveness of in situ air stripping of volatile organics from the ground water and unsaturated soils is planned. This status report contains (1) a short summary of the construction details of the two horizontal wells and (2) proposed modifications to the original program plan. The modifications include added pressure monitoring and use of an inert tracer gas (helium) to better evaluate system performance. This paper contains sections that provide information requested by the South Carolina Department Health and Environmental Control as part of the underground injection well permitting process.

Savannah River Site: Well Completion Report on Installation of Horizontal Wells for In Situ Remediation Tests.
Kaback, D. S.; Looney, B. B.; Corey, J. C.; and Wright, L. M., Westinghouse Savannah River Co., Aiken, SC, U.S. Department of Energy, Washington, DC, August 1989

NTIS Document Number: DE93-008615/XAB

A project to drill and install two horizontal vapor extraction/air-injection wells at the Savannah River Site (SRS), Aiken, South Carolina, was performed in September and October of 1988. This study was performed to test the

feasibility of horizontal drilling technologies in unconsolidated sediments and to evaluate the effectiveness of in situ air stripping of volatile organics from the ground water and unsaturated soils. A tremendous amount of knowledge was obtained during the drilling and installation of the two test wells. Factors of importance to be considered during design of another horizontal well drilling program include the following: (1) trips in and out of the borehole should be minimized to maintain hole stability, and no reaming to enlarge the hole should be attempted; (2) drilling fluid performance should be maximized by utilizing a low solids, low weight, moderate viscosity, high lubricity fluid, and interruption of drilling fluid circulation should be minimized; (3) well materials should possess adequate flexibility to negotiate the curve, and a flexible guide should be attached to the front of the well screen to guide the screen downhole; and (4) sands containing a minor amount of clay are recommended for completion targets, as better drilling control in the laterals was obtained in these sections.

Soil Vapor Extraction Column Experiments on Gasoline Contaminated Soil, Final Report.
Miller, M. E.; Pederson, T. A.; Kaslick, C. A.; Hoag, G. E.; and Fan, C. Y., Camp Dresser & McKee, Inc., Cambridge, MA, University of Connecticut, U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, September 1992

EPA Document Number: EPA/600/R-92/170

NTIS Document Number: PB92-226430/XAB

Soil vapor extraction (SVE) is a technique that is used to remove volatile organic compounds from unsaturated soils. Air is pumped through and from the contaminated zone to remove vapor phase constituents. In the work, laboratory soil column experiments were conducted using a gasoline residually saturated sandy soil to evaluate the performance of SVE under controlled conditions. Both vapor extraction and aqueous leaching of the soil columns were conducted. The progress of the vapor extraction event was continuously monitored by an in-line total hydrocarbon analyzer. Performance of vapor extraction was evaluated by a series of soil chemical analyses including total petroleum hydrocarbons, headspace measurements, and extraction techniques with quantification by GC/FID and GC/MS.

Soil Vapor Extraction VOC Control Technology Assessment, Final Report.
Pacific Environmental Services, Inc., Durham, NC, U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 1989

EPA Document Number: EPA/450/4-89/017

NTIS Document Number: PB90-216995/XAB

Soil vapor extraction (SVE) is an emerging technology in which volatile organic compounds (VOCs) are extracted from soil through use of a vacuum system. The decision to employ a VOC control system treatment is largely dependent upon VOC concentrations and applicable regulations. The selection of a particular VOC treatment option may be somewhat more complicated and based upon individual site characteristics. Pacific Environmental Services, Inc. (PES), was contracted by the U.S. EPA to investigate and evaluate potential VOC control techniques for use at SVE sites. The purpose of the investigation is to gain insight into the operation of SVE systems in general and to develop and summarize information on the factors associated with determining applicable VOC control systems. These factors include the feasibility, relative cost, and performance of various air pollution control techniques.

Summary Report of Results of the Vapor Vacuum Extraction Test at the RWMC.
Sisson, J. B. and Ellis, G. C., EG&G Idaho, Inc., Idaho Falls, ID, U.S. Department of Energy, Washington, DC, November 1990

NTIS Document Number: DE91-006145/XAB

A test scale vapor vacuum extraction system was operated for four months at the Radioactive Waste Management Complex. The extraction system removed more than 65 million ft.3 of soil gas containing 429 kg of carbon tetrachloride and 164 kg of TCE. Hydraulic properties of the basalts were estimated and inputted into a numerical transport model. The model simulations indicated that a rubble zone at 190 ft. dominated the soil gas flow pattern. Refined calibration of transport models will allow enhancement of the production system design to increase operational efficiency and effectiveness.

Thermal Enhanced Vapor Extraction System.
Phelan, J. M., Sandia National Laboratories, Albuquerque, NM, U.S. Department of Energy, Washington, DC, 1992

NTIS Document Number: DE93-005343/XAB

At some landfills, hazardous wastes were placed into disposal pits with other waste oils. Volatile organic wastes, such as cleaning solvents, when combined with oil are much more difficult to remove from the soils because the oil makes the volatile organic chemical evaporate much slower. The typical vacuum extraction remediation method could become a lengthy campaign. Since all chemicals evaporate faster when they are heated, if the contaminated soil could be heated, the chemicals would be easier to remove from the soil. By using heating techniques developed by the oil and gas industry to enhance the removal of oil and gas resources from the soil, the problem of removing contamination from the soils could be solved. The Thermal Enhanced Vapor Extraction System (TEVES) demonstration will combine vacuum vapor extraction technology with powerline frequency soil heating and radiofrequency soil heating to accelerate the soil decontamination process. The premise that soil heating technology can actually reduce the costs of soil decontamination is complicated by the high capital costs of the soil heating equipment and the cost of electrode installation. By performing this field demonstration, Sandia will be able to collect the information needed to see if this new technology will improve the decontamination of soils.

U.S. EPA Site Demonstration of AWD Technologies' AquaDetox/SVE System, Journal Article: Published in Journal of Air and Waste Management Association, v41n11, p. 1519-1523, November 1991.
Evans, G. M., U.S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, OH, 1991

EPA Document Number: EPA/600/J-91/300

NTIS Document Number: PB92-124387/XAB

The report covers the results of the Superfund Innovative Technology Evaluation Program's demonstration of the AWD Technologies' AquaDetox/SVE. The system combines a vacuum assisted steam stripping unit and a soil vapor gas extraction system into an integrated unit. The demonstration was conducted during September 1990 at the Lockheed Aeronautical System Corporation in Burbank, California. The results of a 2-week demonstration confirmed the ability of the system to meet regulatory discharge requirements for the contaminants of concern, TCE and PCE.

OTHER RESOURCE GUIDES

Bioremediation Resource Guide.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, Washington, DC, September 1993 (see abstract below)

EPA Document Number: EPA/542/B-93/004

Ground Water Treatment Technology Resource Guide.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, Washington, DC, September 1994 (see abstract below)

EPA Document Number: EPA/542/B-94/009

Physical/Chemical Treatment Technology Resource Guide.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, Washington, DC, September 1994

EPA Document Number: EPA/542/B-94/008

These documents are intended to support decision-making by Regional and State Corrective Action permit writers, Remedial Project Managers (RPMs), On-Scene Coordinators, contractors, and others responsible for the evaluation of innovative treatment technologies. These guides will direct managers of sites being remediated under RCRA, UST, and CERCLA to bioremediation, ground water, physical/chemical, and soil vapor extraction treatment technology resource documents, databases, hotlines, and dockets, and will identify regulatory mechanisms (e.g., Research Development and Demonstration Permits) that have the potential to ease the implementation of these technologies at hazardous waste sites. Collectively, the guides provide abstracts of over 330 guidance/workshop reports, overview/program documents, studies and demonstrations, and other resource guides, as well as easy-to-use Resource Matrices which identify the technology and contaminants discussed in each abstracted document.