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# Engineering Forum Issue Paper:

## Thermal Desorption Implementation Issues

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Office of Emergency and Remedial Response
Quick Reference Fact Sheet

This issue paper identifies issues and summarizes experiences with thermal desorption as a remedy for volatile organic compounds (VOCs) in soils. The issues presented here reflect discussions with over 15 Remedial Project Managers (RPMs) and technical experts. This fact sheet has been developed jointly by the Engineering Forum and Office of Emergency and Remedial Response, with assistance from the Office of Research and Development. EPA's Engineering Forum is a group of professionals, representing EPA Regional Offices, who are committed to identifying and resolving the engineering issues related to remediation of Superfund and hazardous waste sites. The Forum is sponsored by the Technical Support Project. The information presented here is advisory in nature, should be verified for its applicability to a given site, and is not intended to establish Agency policy. RPMs should consult their regional management before applying the recommendations cited in this paper for appropriateness at their site.

Thermal desorption (TD) is a commonly used separation process that EPA has selected as a "presumptive remedy" for VOCs, in which contaminated soils, sludge, or other wastes are heated so that volatile and semivolatile organic compounds are driven off as gases (Superfund Directive 9355.0-FS; EPA 540-F-93-048; PB93-963346). The TD process is designed to separate organics from the matrix, but not to destroy them (although some thermal destruction may occur). Air, combustion gas, or inert gas (such as nitrogen, which may be introduced to impede combustion) is introduced to the waste stream, and carries the volatilized contaminants to air pollution control equipment. The volatilized contaminants generally are condensed onto cooled surfaces or adsorbed on activated carbon beds for subsequent treatment, reuse, or ultimate disposal. After cleaning, the off gas is vented to the atmosphere. Consult the bibliography at the end of this fact sheet for additional details. In addition to volatilizing constituents in the waste medium, the thermal desorption process may also result in the partial breakdown of compounds and reformation of new compounds, which can form new contaminants of concern (dioxins, furans) in the treatment residuals.

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### Site Characterization and Remedy Selection

Before remedial technologies for soil treatment can be evaluated for a site, investigations should be conducted to identify the contaminants present, the soil type and structure, and other site features. Key soil and constituent parameters are discussed in the Implementation and System Performance section of this fact sheet.

Treatability testing is often used at the remedy screening level to provide a quick and relatively inexpensive indication of the appropriateness of TD as a remedial technology. Treatability studies (TS) will indicate if heating the medium to a specific temperature for a specific period of time results in meeting VOC soil remediation goals for contaminant removal. There is disagreement among experts as to the necessity of treatability testing at the TD design level. A vendor may be in the best position to decide if a TS is required after considering soil matrix,

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contaminant level, and treatment standard variables. To supplement site characterization data, some RPMs have stated that treatability tests should be performed during the Remedial Investigation (RI). The availability of site-specific treatability test results would allow more accurate treatment cost quotes for the Feasibility Study (FS).

**Record of Decision (ROD) and Applicable or Relevant and Appropriate Regulations (ARARs)**

Many factors can affect the time and cost required to implement TD as a treatment technology. As one way to streamline the process, an RPM suggested that RODs explicitly permit more flexibility with thermal treatment technologies. For example, the language in the ROD for one site stated that “thermal treatment” was the remedy, thus allowing either thermal desorption or incineration.

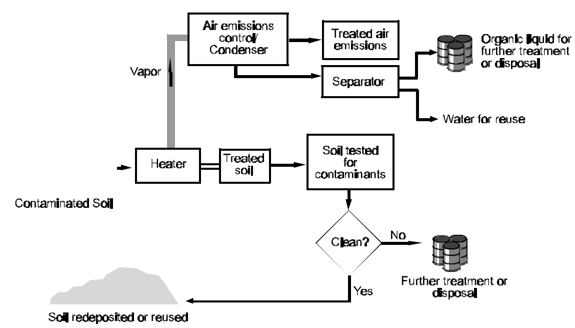
The movement and preparation of soils for *ex situ* treatment presents many issues. Reducing the soil aggregate size to meet the feed system requirements and reducing soil or sludge moisture content by blending or de-watering are specific concerns. *Ex situ* TD also has the potential for generating nuisance odors and dust, as well as other more serious emissions resulting from on-site excavation.

The RPM should always consider the requirements and costs of materials handling when evaluating any remedy. For a site heavily contaminated with VOCs, and where excessive materials handling is required, *in situ* treatment technologies, such as soil vapor extraction, may be more appropriate and less costly.

Experts have noted that on a typical thermal desorption project, the requisite review by state regulatory agencies can be lengthy. Reducing the number of times that a regulatory agency must review the design would shorten the schedule. In the experience of one RPM, the most difficult task was determining the state’s requirements or other Applicable or Relevant and Appropriate Requirements (ARARs) that would be imposed on the system. Most EPA Regions try to meet substantive state requirements rather than obtain state permits. The best advice for keeping a project on schedule is to meet early and often with state air and hazardous waste permitting personnel.

Thermal desorption is a physical separation technology, not a destruction technology. A variety of TD systems may be used to separate (vaporize) VOCs and semivolatile organic compounds (SVOCs) from soil. The vaporized organics are then collected by condensation or carbon adsorption. Please note, however, that TD systems that vaporize and then burn organic contaminants are considered incinerators for the purpose of RCRA regulation—thermal desorbers may well meet RCRA definitions for incinerator, boiler, industrial furnace, or miscellaneous unit regardless of the operator’s intentions.

**Thermal Desorption Process**




To compare costs of operating a specific TD system with those of other *ex situ* technologies, one expert recommends considering only those costs associated with operations from the time the soil is removed from a screened pile until the time the processed soil is placed in the discharge pile. The costs involved in transporting and screening soil prior to treatment and removing or backfilling the treated discharge pile are common to all types of *ex situ* technologies at sites and should be costed and compared separately.

Direct-fired thermal desorbers operating at high temperatures and thermal desorbers equipped with afterburners (or other types of oxidizers) also are considered to be incinerators, and must meet the more stringent RCRA Subpart O incinerator emission requirements rather than RCRA Subpart X requirements for thermal desorbers.

**Remedial Design (RD)**

Some experts have suggested that after remedy selection, but before or during remedy design, specific vendors or contractors should be offered the opportunity to perform remedy treatability studies to demonstrate that their product will meet the goals of the project. The vendors should be allowed some flexibility in how the tests will be conducted because the vendor knows best what data are needed to evaluate their systems. A treatability study performed by the contractor who will remediate the site would prevent selecting an unsuitable system, limit unforeseen problems associated with site-specific soils and contaminants, and thereby reduce the overall costs of site remediation. The RPM should verify that the contracting strategy used for the project will allow this.

The tendency of dry, clayey soils to agglomerate can slow treatment processes and lower the efficiency of the thermal desorption process. The problem can be resolved by retrofitting the soil feeding system with a shredder that breaks up the clay balls to the proper diameter, and a screener, which removes oversized objects. The problems associated with saturated clays are far more difficult to overcome, since wet, plastic clays cannot be screened and tend to smear when handled. Chemical de-watering agents or drying can be used in certain cases, depending upon clay mineralogy; it is best to consult with the vendors or contractors for the specific TD systems being considered, for their experience and recommendations.

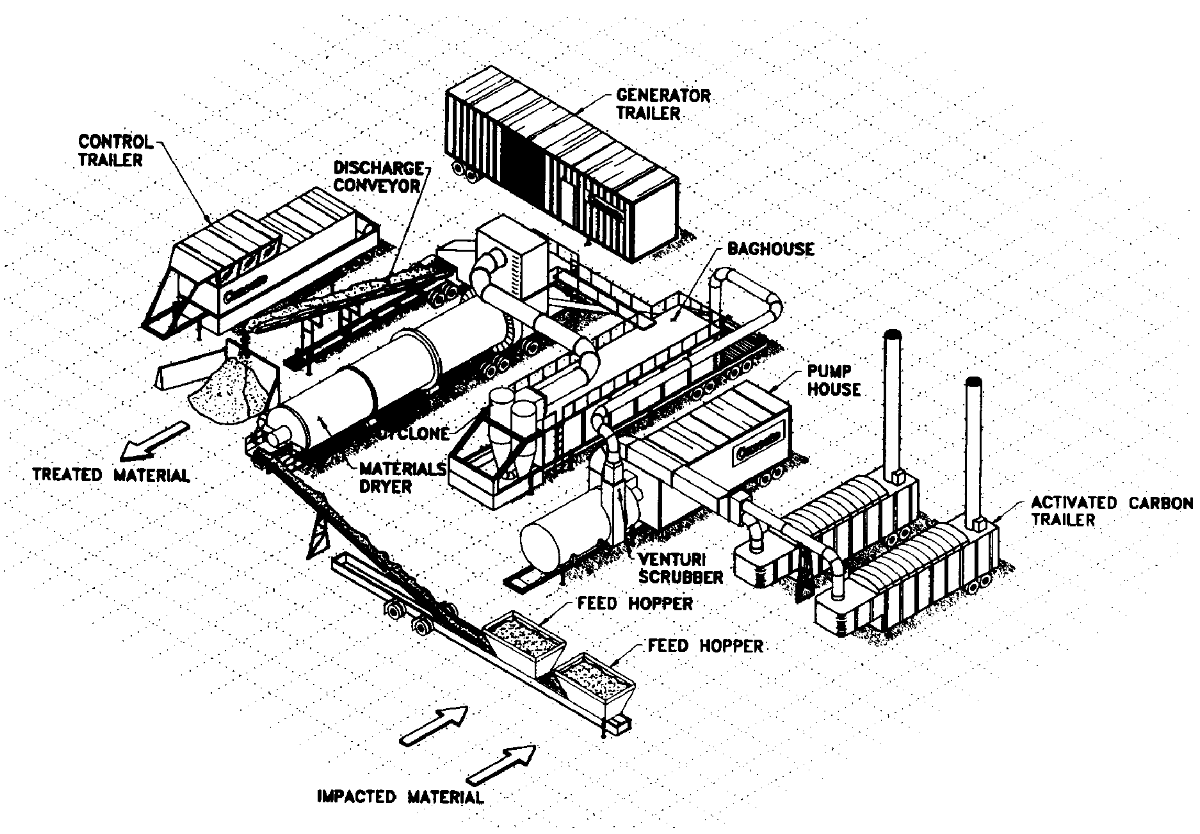
Several RPMs believe that noise pollution issues do not receive enough attention during the planning and design phases. Some TD systems produce high decibel levels and operate 24 hours per day. Possible solutions include adding mufflers or housing the desorber in a pre-engineered building.

**Implementation and System Performance**

Key soil characteristics influencing TD effectiveness at a given site include soil plasticity, particle size distribution, heat capacity, concentration of humic material, metals concentration, and bulk density. Key constituent characteristics include concentrations, boiling point range, vapor pressure, octanol/water partition coefficient, aqueous solubility, thermal stability, and dioxin formation.

Other factors affecting TD performance are the maximum bed temperature, total residence time, organic and moisture content, and feedstock properties. Since the basis of the process is physical removal from the medium by volatilization, bed temperature is a primary factor in determining endpoint concentrations. Soils having a high proportion of

**Schematic Layout of Typical Thermal Desorption Facility**



sand and gravel are easier to handle and treat than finer, more cohesive silts and clays. Processing rates for the finer soils generally are lower and therefore per unit costs are higher.

Experts have stated that most TD units easily can handle feedstock moisture content as high as 15 percent. With moisture content at 15 to 25 percent, there is some reduction in throughput, but with only inconsequential impacts on cost. When moisture content is higher than 20 percent, impacts on cost can become significant. Moisture in the material acts as a heat sink because it must be evaporated from the soil along with the organic contaminants. However, there is no upper limit on acceptable feed soil moisture content as long as it can be reduced to economically reasonable levels before treatment. Soils having high moisture content can be de-watered (by filter press or other means) or mixed and blended with dry materials before they are fed into to the TD system.

Experts have stated that the mixing of soil and sweep gas (sweep gas is used to transfer the volatilized organics and water to the off gas treatment system) within the TD unit is crucial for promoting efficient contaminant removal. However, excessive mixing also may lead to undesirable carryover of soil to the to the air pollution control equipment (APCE) system.

Almost all thermal desorption systems are designed to accept materials no larger than 1 to 2 inches in diameter. Although TD can be used for all types of contaminated soils, clays must be shredded and mixed with sand to be able to move through the feed processor. At one site, excavation uncovered cobbles that required separation from the feedstock. The cobbles were steam-cleaned and returned to the treated soil. The wastewater generated from this steam cleaning was used to wet the feedstock to the optimum moisture level for treatment. At another site, the volume of soil remaining after treatment was roughly two-thirds of that originally estimated because of the significant amounts of oversized material.

Sludges at one site were found to be full of large debris and required de-watering and screening prior to treatment. The screened debris was transported to a RCRA landfill for disposal. Placement of chemical additives in the sludge also should be considered carefully, because additives can affect the load-bearing potential of the treated soil and result in material unsuitable for backfill intended to support pavement or an overlying structure.

Dust control is another important consideration in the implementation of TD. At one site, dust was generated by the convection of hot air across the end of the TD unit as treated solids were discharged. To address this type of problem, contractors have installed dust control systems which include a quenching water spray at the point where dry treated soil leaves the TD oven. At one site, a dust control shed was constructed to house both the water-quenched soil awaiting treatment and the dust discharge pile. An 18-inch diameter pipe was installed in the shed and a vacuum truck was used to collect fugitive dust from the air within the shed. It should be noted that TD processing of sandy sediments does not create a significant dust problem since the relatively large particles that remain after processing do not become airborne.

RPMs have stressed that more obscure parameters should be considered when evaluating or designing a TD system. For example, media that are highly basic or acidic may corrode the processing system components. Also, high levels of sulfur in the untreated soil can form sulfuric acid in the TD system and cause significant corrosion.

Several RPMs have recommended that greater emphasis be placed on the adherence to process drawings, specifications, and descriptions developed during the RD phase and on oversight during the RA phase to reduce the occurrence of technical problems (*e.g.*, equipment failure) during implementation of the remedy.

Proof-of-Process (POP) performance tests typically are conducted to verify that the TD system is achieving soil treatment goals, and that air emissions are below allowable limits. One issue concerning POP tests centered on the representativeness of TD test conditions, which are governed by the representativeness of the soil tested. If POP tests are conducted with blends of soils collected from various locations at the site, it becomes critical to ensure that any contaminant “hot spots” are properly recognized and tested.

RPMs have recommended that TD systems be shut down following the performance test until EPA has reviewed and approved the data. To facilitate the review process, the RPMs recommend that the chemical analysis of samples be expedited even if additional costs are incurred. Any potential benefits (economic or otherwise) from continuing operation during the review period may be outweighed by the risks associated with continuing operation without better knowledge of how well the system is performing.

**Air Emissions Control**

Several APCE systems have been evaluated by RPMs under field conditions. RPMs state that a system that removes particulates, cools and condenses vapors, and adsorbs residual vapors on carbon beds typically is recommended over thermal oxidation (which must meet the more stringent requirements of an incinerator) and a scrubber to eliminate the products of incomplete combustion. However, there are possible drawbacks to the condenser/adsorption system. Contaminant concentrations in the vapor may be too high to be treated effectively, and therefore would not meet the cleanup goals. In such a case, the thermal oxidation process may be more appropriate.

Experts have noted that at most sites contaminated with chlorinated aromatics there is a strong possibility that dioxins or furans also are present, and would be removed from the soils and sediments during TD treatment. The APCE must be designed to deal with this possibility, and the POP test should include measurements to detect and quantify dioxin in exhaust emissions.

Soils at one site contained a significant amount of wood chips. During the first performance test, embers from the wood chips burned holes in the walls of the dust collection bags. A cyclone collector (centrifuge) was added to remove the embers. However, the cyclone was not effective in removing the fine dust from the gas stream prior to the afterburner and stack. The feed rate had to be reduced to less than 60 percent of capacity to prevent excessive emissions of particulate matter.

Operation of the desorption system in a way that increases heat transfer to the contaminated soil usually increases carryover of dust to the APCE and creates problems. As an example, off-gas may burn holes in the baghouse filter media, and cause the induction fan to fail. The holes would then allow particulate matter to pass through the bag walls and clog the carbon adsorption bed. The bed would then have to be regenerated more often during the cleanup process.

**Community Involvement**

The focus and level of community interest varies at each site. Community relations efforts should begin early, include risk communication in nontechnical terms, and afford numerous opportunities for the public to view the process. Members of the community should be encouraged to visit the site and observe as much of the actual system as possible without compromising their safety. The community should be shown how air emissions will be controlled to safe levels, both in a fact sheet and further at public meetings.

Public acceptance of thermal desorption may be adversely affected by confusion with incineration technologies, which do not enjoy public confidence. When presenting TD to the public, the differences in air emissions from alternative remedial technologies and APCE should be compared and explained. The public should be made aware of the safeguards that will prevent atmospheric releases of toxic gases.

**Selected Bibliography**

**Remediation Case Studies: Thermal Desorption, Soil Washing, and In Situ Vitrification.**
U.S. EPA, Office of Solid Waste and Emergency Response, Technology Innovation Office. March 1995
EPA-542-R-95-005, PB95-182945.

This report contains six case studies on thermal desorption at Superfund sites, and describes contaminants treated, media and quantities, project durations, costs, and performance. The report is a publication of the Federal Remediation Technologies Roundtable.

**A Citizen’s Guide to Thermal Desorption.**
U.S. EPA, Office of Solid Waste and Emergency Response, Technology Innovation Office. July 1996
EPA/542/F-92/0036, PB92-232396.

This fact sheet presents in lay terms the technologies, processes, and applicability of thermal desorption technology. It may be a useful handout to communities associated with possible thermal desorption systems.

**VISITT Database (Version 5.0) — Vendor Information System for Innovative Treatment Technologies**
U.S. EPA, Office of Solid Waste and Emergency Response, Technology Innovation Office. July 1994
EPA/542/R-94/003, PB94-213634.

This database provides current information on innovative treatment technologies for the remediation

of contaminated sites. VISITT contains technology information submitted by developers, manufacturers, and suppliers of innovative treatment technology equipment and services.

**Combustion Emissions Technical Resource Document (CETRED). Draft.**
U.S. EPA, Office of Solid Waste and Emergency Response, Washington, DC, May 1994
EPA 530/R94/014

This text contained the initial technical analysis by the U.S. EPA concerning potential emissions of dioxins/furans and particulate matter (PM). CETRED represents the current state of analysis of EPA technical staff in the Office of Solid Waste as regards the emission levels of PM and dioxins/furans achievable by the best controlled sources. Approx. 330 pp.

**Estimation of Air Impacts for Thermal Desorption Units Used at Superfund Sites. Air/Superfund National Technical Guidance Study Series**
U.S. EPA, Office of Emergency and Remedial Response, Washington, DC, April 1993. 54 pp.
EPA/451/R-93/005, PB93-215630

The report provides procedures for estimating the ambient air concentrations associated with thermal desorption. Procedures are given to evaluate the effect of the treatment rate and contaminant concentrations on the emission rates and on the ambient air concentrations at selected distances from the treatment area. Health-based ambient air action levels are also provided for comparison to the estimated ambient concentrations.

**XTRAX Model 200 Thermal Desorption System, OHM Remediation Services Corporation: SITE Demonstration Bulletin.**
U.S. EPA, Office of Solid Waste and Emergency Response, Washington, DC, May 1993
EPA 540-MR-93-502

EPA and Environment Canada both have programs that support emerging innovative technology development and technical evaluation demonstrations. EPA's Superfund Innovative Technology Evaluation (SITE) Program and Environment Canada's Development and Demonstration of Site Remediation Technologies (DESRT) Program present an evaluation of cost and performance based on a demonstration of the XTRAX technology. The X*TRAX™ Model 200 thermal desorption System developed by Chemical Waste Management, Inc., is a low-temperature process designed to separate organic contaminants from soils, sludges, and other solid media.

**Innovative Site Remediation Technology, Vol. 6, Thermal Desorption.**
Office of Solid Waste and Emergency Response, Technology Innovation Office. November 1993
EPA/542/B-93/011, PB94-181716

The monograph on thermal desorption is one of a series of eight on innovative site and waste remediation technologies that are the culmination of a multi-organization effort involving more than 100 experts over a two-year period. The thermal desorption processes addressed in this monograph use heat, either direct or indirect, *ex situ*, as the principal means to physically separate and transfer contaminants from soil, sediment, sludge, filter cakes, or other media. Thermal desorption is part of a treatment train; some pre- and post-processing is necessary.

**Contaminants and Remedial Options at Wood Preserving Sites**
U.S. EPA, Office of Research & Development, Cincinnati, OH. October 1992. 178 pp.
EPA/600/R-92/182, PB92-232222

The report provides information that facilitates the selection of treatment technologies and services at wood preserving sites, in order to meet acceptable levels of cleanliness. It identifies the sources and types of wood preserving contaminants, characterizes them, and defines their behavior in the environment. It addresses the goals in technology selection and describes the principal remedial options for contaminated wood preserving sites. It also considers ways to combine these options to increase treatment efficiency. Finally, this remedial aid provides a comprehensive bibliography, organized by its relevance to each section, to complement the information offered in these pages.

**Thermal Desorption Treatment: Engineering Bulletin**
U.S. EPA, Office of Research & Development, Cincinnati, OH. February 1994. 11 pp.
EPA 540-S-94-501, PB94-160603

The bulletin discusses various aspects of the thermal desorption technology including applicability, limitations of its use, residuals produced, performance data, site requirements, status of the technology, and sources of further information. The document is an update of the original bulletin published in May 1991.

**Thermal Desorption Remedy Selection Guide for Conducting Treatability Studies under CERCLA**
U.S. EPA, Office of Emergency and Remedial Response, Washington, DC. September 1992. 47 pp.
EPA 540-R-92-074A, PB93-126597

The manual focuses on thermal desorption treatability studies conducted in support of remedy selection prior to the Record of Decision (ROD). It is a standard guide for designing and implementing a treatability study to evaluate the effectiveness of thermal desorption on a site-specific basis. The manual describes, discusses, and defines the prescreening and field measurement data needed to determine if treatability testing is required. It also presents an overview of the process for conducting treatability tests, and discusses the applicability of tiered treatability testing for evaluation of thermal desorption technologies. The elements of a treatability study work plan also are defined, and detailed information on the design and execution of the remedy screening treatability study are provided.

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Thermal desorption has been selected as the remedy for VOCs or SVOCs in soils at the sites or operable units listed below. Some sites are currently operating, and some are in the design phase. This list has been adapted from the “Innovative Treatment Technologies: Annual Status Report (Eighth Edition),” September 1996 (EPA 542-R-96-010). This list is not comprehensive.

Aberdeen Pesticide Dumps, OU 1 & OU 4, NC
Acme Solvent Reclaiming, Inc., OU 3, IL
American Chemical Services, IN
American Thermostat (Phase 1), NY
American Thermostat (Phase 2), NY
Anderson Development (ROD Amendment), MI
Arlington Blending and Packaging Co., OU 1, TN
Cannon Engineering/Bridgewater, MA
Ciba-Geigy (MacIntosh Plant), OU 2, AL
Ciba-Geigy (MacIntosh Plant), OU 4, AL
Clare Water Supply, MI
Claremont Polychemical, NY
Drexler - RAMCOR, WA
Duell-Gardner Landfill, MI
FCX-Washington Site, NC
Fort Lewis Military Reservation, Solvent Refined Coal Plant, WA
Fulton Terminals, Soil Treatment , NY
GCL Tie and Treating, NY
General Motors/Central Foundry Division, OU 1 & OU 2, NY
Harbor Island, WA
Industrial Latex, OU 1, NJ
Jacksonville Naval Air Station, OU 2, FL
Lipari Landfill Marsh Sediment, NJ
Lockheed Shipyard Facility/Harbor Island, OU 3, WA
Lockheed/Martin (Denver Aerospace), CO
Martin Marietta Corp., W C Astronautics Facility, CO
Marzone Inc./Chevron Co. Superfund Site, OU 1, GA
McKin, ME
Metaltec/Aerosystems, OU 1, NJ
Naval Air Station, Cecil Field Site 17, OU 2, FL
Ott/Story/Cordova Chemical, MI
Ottati & Goss, NH
Outboard Marine/Waukegan Harbor, OU 3, IL
Potter's Septic Tank Service Pits, NC
Pristine (ROD Amendment), OH
Re-Solve, MA
Reich Farms, NJ
Reilly Tar and Chemical, IN

Rentokil, VA
Reynolds Metals Company Study Area Site, (RMC), NY
Sand Creek Industrial, OU 5, CO
Sangamo/Twelve-Mile/Hartwell PCB, OU 1, SC
Sarney Farm, NY
Saunders Supply Co, OU 1, VA
Sherwood Medical, NE
Smith's Farm Brooks, OU 1, KY
Solvent Savers, NY
South Andover Salvage Yards, OU 2, MN
U.S.A. Letterkenny SE Area, OU 1, PA
Universal Oil Products, NJ
Valley Park TCE Site, Wainwright OU, MO
Waldick Aerospace Devices, OU 1, NJ
Wamchem, SC
William Dick Lagoons, OU 3, PA