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APPENDIX E
SOIL TREATMENT CAPACITY

This appendix has seven sections:

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APPENDIX E-1
EFFECTS OF THE PHASE IV LDRs ON SOIL TREATMENT CAPACITY

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Effects of the Phase IV LDRs on Soil Treatment Capacity

This section presents a brief analysis of the effects of the Phase IV Land Disposal Restrictions (LDRs) alternative soil treatment standards on soil remediation and soil treatment capacity. This analysis was conducted as follows.

1. Evaluate how the Phase IV rule may affect selected remedies for the universe of on-going soil remediation projects. This step involved evaluating how current LDRs impact soil remediation and what would differ under Phase IV.

2. For sites where Phase IV requires soil treatment modifications, this step involved describing how Phase IV will affect the treatment selected. This step also addressed whether innovative treatment technologies can meet the new treatment requirements and whether the greater demand can be met by technology venders.

Background

This analysis is based on the following applicability of the LDRs currently in effect and the changes required by the Phase IV rulemaking.

<u>Applicability of LDRs</u>

Soil classified as RCRA hazardous is considered to be generated, for RCRA purposes, when it is excavated. Conversely, contaminated soil left in place is not subject to any RCRA requirements, assuming that the contamination is not subject to spill cleanup or clean closure requirements. LDRs often apply to hazardous soils generated during site remediation. The general rule is that if contaminated soil is RCRA hazardous and is destined for land disposal, the LDR regulations apply to the waste at the point of generation. There are several significant exceptions to this rule.

- Remediation wastes at sites cleaned under the RCRA corrective action program are not subject to LDRs when they are managed in corrective action management units (CAMUs). A CAMU is defined as a designated area within a facility that is utilized to manage wastes generated in corrective actions at either permitted or interim status RCRA TSD facilities.

- Contaminated soils excavated at CERCLA sites are eligible for reduced regulatory requirements under the area of contamination (AOC) concept, the CAMU provisions, or one of several variances. When either a treatability variance or the new site-specific, risk-based variance is approved, the soils can be treated to meet alternative treatment levels and then land disposed. A case-by-case capacity variance also could be used.

For CERCLA remediation sites, certain discreet areas of generally dispersed, contiguous (not necessarily uniform) contamination are identified as AOCs. Movement of hazardous soils within the AOC is not considered land disposal or placement (for LDR purposes) and do not trigger LDRs. Agency guidance notes that consolidation of soils within the AOC or in-situ treatment of soils is not assumed to be placement. However, moving wastes from one AOC to another or actively managing soils (e.g., ex-situ treatment in a tank or portable incinerator) within or outside the AOC and then redepositing the soils in the AOC is assumed to be placement and will trigger LDRs.

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Phase IV LDR Changes

Summarized below are the differences in treatment requirements between the current LDRs and the Phase IV rule.

- *Characteristic ignitable, corrosive, or reactive (ICR) or toxicity characteristic (TC) organic soils.* Currently, prior to the Phase IV rule, all wastes exhibiting ICR or TC for organics must be treated for all underlying hazardous constituents (UHCs) UTS levels. The alternative standards relax the soil treatment standard levels to 10 times UTS or 90 percent reduction. Thus, less treatment is needed for these wastes.

- *TC metal-only soils*. Prior to today's rule, LDR treatment standards for soils exhibiting TC for metals were set at TC levels; all UHCs were not required to be treated. The Phase IV rule revises the UTS levels for 12 metal constituents and requires that TC metal soils be treated for all UHCs to the alternative standards. Soils exhibiting TC for metals-only can, and often do, contain organic UHCs at less than TC levels. Thus, for most TC-metal only soils, more treatment is needed.

- *Soils contaminated with listed waste*. Soils contaminated with listed wastes are currently required to treat regulated hazardous constituents identified in 40 CFR 268.40 for the relevant listed wastes. The Phase IV rule requires soils contaminated with listed wastes be treated for all UTS to the alternative standards. Additional treatment may be needed for some soils to address all UHCs, but less treatment for other soils because the alternative treatment standards relax required treatment levels from UTS to 10 times UTS or to 90 percent reduction.

Effect of LDRs on Remediation

Site remediation goals for soils may be derived from health-based levels specific to conditions at a site, "applicable or relevant and appropriate requirements" (ARARs), or other criteria such as State-required cleanup levels. The goals define what concentration of contaminants may remain in soils on-site, and are often used as the basis for identifying areas of soil for which treatment should be considered. Soil contaminant reduction or immobilization may be achieved by containment, in-situ treatment, or by removal and ex-situ treatment. After ex-situ treatment the soils are either disposed on-site or off-site.

As described above, LDRs do not affect soil remediations that are conducted in a CAMU or an AOC. In addition, soil remediations involving in-situ treatment or containment without treatment also are not subject to LDRs because soil removal and placement does not occur. Thus, the only remediation sites affected by the Phase IV rule are those using ex-situ treatment strategies. Some of these ex-situ treatment sites may have cleanup goals that are more stringent than the Phase IV alternative soil treatment standards, while others may be less stringent. The need for additional treatment to meet the Phase IV rule may be influenced by the relationship between the site soil cleanup goals and the soil alternative treatment standards.

At many remediation sites, the exact source of soil contamination is not definitively known. Abandoned sites or landfills may contain numerous waste streams. Industrial and commercial facilities also may use and handle a number of hazardous materials and wastes. Which hazardous waste or substance contaminated the soils and is contained in the soils is often not known. This situation makes the assignment of a waste code to contaminated soils problematic. However, whether the soils are co-contaminated with more than one hazardous waste stream or with one waste stream with a number of UHCs does not affect the goals of remediation. The site goals are often risk-based for all contaminants, considering the conditions of

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the site, surrounding areas, and potential receptors. Remediation usually addresses those contaminants identified by a risk assessment as above a threshold concentration of acceptable risk. Remediation strategies focus on addressing the specific site contaminants of concern. Thus for example, a site with TC metal-only contaminated soils containing UHCs above cleanup goal limits would have to be remediated to reduce the risk of all contaminants above the goal. If the remediation strategy involved soil removal, treatment, and on-site disposal, then treatment would have to meet the LDRs for TC metals (currently only requiring treatment of metal contaminants above TC) or health-based goals (which may include other constituents), whichever limit is more stringent.[1] However, if, after removal, the TC metal contaminated soils are disposed off-site, only treatment of the TC metal contaminants to LDR levels generally is required.

To understand how Phase IV will influence treatment capacity, EPA evaluated its effect on ex-situ remediations in-progress (the type of remediation expected to be most immediately affected by Phase IV in terms of capacity issues). Two main scenarios were identified based on the relationship of cleanup goals to soil treatment standards.

Scenario 1. Sites with less stringent cleanup goals than soil alternative treatment standards.

- Soils contaminated with TC metals and/or some listed wastes.
  - Because all UHCs now must be treated, more treatment might be required to reduce UHCs for off-site disposal and on-site disposal.
- Soils contaminated with ICR or TC organic wastes and/or some listed wastes.
  - Because UHCs must now be treated to 10 times UTS or 90 percent reduction, less treatment is required to reduce UHCs for off-site disposal and on-site disposal.

Scenario 2. Sites with more stringent cleanup goals than soil alternative treatment standards.

- Soils contaminated with TC metals and/or some listed wastes.
  - Because all UHCs now must be treated, more treatment might be required to reduce UHCs for off-site disposal.
  - No change in treatment required for on-site disposal without containment because the soil cleanup goals, which are more stringent than the alternative standard, are setting treatment levels.

[1] In the case where the health-based goals are more stringent than the LDRs, containment with institutional controls could be used to avoid treatment to a levels more stringent than the LDRs. This strategy may not be suitable for sites with conditions that make containment impracticable, or where site use may potentially lead to contact or release of contaminated soil.

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- Because all UHCs now must be treated, more treatment might be required to reduce UHCs for on-site disposal with containment. (Even with containment, LDRs must be met for on-site disposal. Containment immobilizes contaminants remaining after treatment to LDRs at concentrations above cleanup goals.)

- Soils contaminated with ICR or TC organic wastes and/or some listed wastes.

  - Because UHCs must now be treated to 10 times UTS or 90 percent reduction, less treatment is required to reduce UHCs for off-site disposal.

  - No change in treatment required for on-site disposal without containment because the soil cleanup goals, which are more stringent than the alternative standard, are setting treatment levels.

  - Because all UHCs now must be treated, more treatment might be required to reduce UHCs for on-site disposal with containment. (Even with containment, LDRs must be met for on-site disposal. Containment immobilizes contaminants remaining after treatment to LDRs at concentrations above cleanup goals.)

Exhibit E-1 summarizes the anticipated effects of Phase IV described above on in-progress remediation programs.

Quantification of Waste Affected by Phase IV

To assess the impact of the Phase IV rule on treatment capacity, EPA estimated the quantity of soils that may require additional treatment. Estimates are based on data developed for USEPA's *Application of the Phase IV Land Disposal Restrictions to Contaminated Media: Costs, Cost Savings, and Economic Impacts*[2] (Phase IV RIA) and on the analysis assumptions discussed in the previous section. According to the Phase IV RIA, approximately 1,805 site equivalents per year are remediated.[3] A subset of this total includes approximately 1,458 site equivalents per year with soil treatment. Based on the number of site equivalents per year with soil treatment and the average tons treated per site by program area, the Phase IV RIA estimates that the approximately 2,680,000 annual tons of soils are treated. Based on the CAMU Regulatory Impact Analysis,[4] about 72 percent of the quantity of CERCLA remedial action soils, and RCRA corrective action and closure soils are assumed to be treated in CAMUs or AOCs that are not subject to LDRs. Assuming that the same ratio of sites in other programs are managed in either a CAMU or AOC, the Phase IV RIA estimates that approximately 1,210,000 tons of

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[2] USEPA, *Application of the Phase IV Land Disposal Restrictions to Contaminated Media: Costs, Cost Savings, and Economic Impacts*, February 23, 1998.

[3] The term site "equivalent" recognizes that soil may be treated at a site over a period of several years. For example, if six sites of equal size were cleaned up over a two-year period, the pace of cleanup would be three site equivalents per year.

[4] U.S. EPA, Office of Solid Waste, *Regulatory Impact Analysis for the Final Rulemaking on Corrective Action Units and Temporary Units*, January 11, 1993.

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Exhibit E-1. Anticipated Effect of Phase IV Alternative Soil Treatment Standards on In-progress Soil Remediation

Waste Group	Selected Remediation Plan[a]	Cleanup Goal Relative to Phase IV Standard[b]	More Treatment Required to Stay with Remediation Plan?
TC Metals-only with UHCs	Ex-situ treatment/on-site disposal w/o containment	Less stringent	Yes
	Ex-situ treatment/on-site disposal w/o containment	More stringent	No
	Ex-situ treatment/on-site disposal w/ containment	Less stringent	Yes
	Ex-situ treatment/on-site disposal w/ containment	More stringent	No
	Ex-situ treatment/off-site disposal	Less stringent	Yes
	Ex-situ treatment/off-site disposal	More stringent	Yes
Listed with UHCs	Ex-situ treatment/on-site disposal w/o containment	Less stringent	Possibly
	Ex-situ treatment/on-site disposal w/o containment	More stringent	No
	Ex-situ treatment/on-site disposal w/ containment	Less stringent	Possibly
	Ex-situ treatment/on-site disposal w/ containment	More stringent	Possibly
	Ex-situ treatment/off-site disposal	Less stringent	Possibly
	Ex-situ treatment/off-site disposal	More stringent	Possibly
ICR or TC Organics with UHCs	Ex-situ treatment/on-site disposal w/o containment	Less stringent	No
	Ex-situ treatment/on-site disposal w/o containment	More stringent	No
	Ex-situ treatment/on-site disposal w/ containment	Less stringent	No
	Ex-situ treatment/on-site disposal w/ containment	More stringent	No
	Ex-situ treatment/off-site disposal	More stringent	No
	Ex-situ treatment off-site disposal	Less stringent	No

[a] The "Selected Remediation Plan" for a site describes three basic categories of ex-situ treatment remedies for remediations in-progress: ex-situ treatment and on-site disposal without containment; ex-situ treatment and on-site disposal with containment; and ex-situ treatment and off-site disposal**.**

[b] Soil "Cleanup Goals" established for a site may be site-specific risk-based, ARARs, etc. Less stringent means that the site cleanup goals for soil are greater than the Phase IV alternative soil treatment standards. More stringent means that the site cleanup goals for soil are less than the Phase IV alternative soil treatment standards.

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soils annually are treated outside of CAMUs and AOCs. Exhibit E-2 presents the estimates of site equivalents and tons treated annually developed for the Phase IV RIA. The quantity estimate for soils treated outside CAMUs or AOCs includes soils treated in-situ, which are not subject to LDRs, and therefore are not affected by Phase IV. According to EPA's analysis of treatment technology trends (see Appendix E-5), 26 percent of National Priorities List (NPL) site with Records of Decision (RODs) use in-situ treatment technologies (in-situ soil vapor extraction, bioremediation or soil flushing) for source control. The actual percentage is likely to be higher if sites using in-situ solidification/stabilization are included (data not available). Thus, assuming 74 percent of sites treat ex-situ, a high-end estimate of the annual volume of soils treated ex-situ outside of CAMUs or AOCs is 890,000 tons.

Under the Phase IV rule, ICR and TC organic soil volumes will require less treatment, thus freeing treatment capacity for other soils. In addition, some quantities of soils contaminated with listed wastes will require more treatment, while other quantities of soils will require less treatment. Therefore, under the Phase IV rule, the demand for additional treatment for some soils contaminated with listed wastes is off-set by the freeing of treatment capacity from other soils contaminated with listed wastes requiring less treatment. The overall demand for additional treatment of TC metals soils to meet the Phase IV rule will increase the required treatment capacity. Thus, the increased demand for additional treatment under the Phase IV rule is generated mainly by additional treatment requirements from TC metal soils. However, most sites contain more than one source of wastes.[5] For sites where soils are contaminated by TC metals and either ICR TC organics, or listed waste with organic regulated hazardous constituents, required treatment of the organics in the TC organic, or listed wastes could also address organic UHCs from the TC metal waste. Therefore, the quanitity of soils requiring additional treatment under the Phase IV rule can be refined further by limiting the estimate to soils contaminated by TC metals-only.

The Phase IV RIA estimates that TC metals-only soils comprise 20 percent of CERCLA soils and 7 percent of RCRA soils. Assuming that the portion of State and voluntary cleanup soils contaminated with TC metals only is similar to CERCLA soils, approximately 55,000 annual tons of TC metal soils will require additional treatment to meet the Phase IV rule (see Exhibit E-3). This quantity of soil is equivalent to the volume of soil treated annually at two additional CERCLA remediation sites (based on the Phase IV RIA estimate of 28,000 tons treated per CERCLA site). The actual quantity requiring alternative treatment likely is less than this given the results of Appendix E-3, which shows very little soil not meeting the new treatment standards. Furthermore, this estimate of regulated soil capacity is likely an overestimate of soil contaminated with newly identified wastes (i.e., TC metal wastes that would not fail EP).

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[5] EPA, *Cleaning Up the Nation's Waste Sites: Markets and Technology Trends, 1996 Edition*, EPA 542-R-96-005, April 1997.

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Exhibit E-2. Contaminated Soils Treated Annually[a]

Remediation Category	Site Equivalents/Year Remediated	Site Equivalents/Year with Soil Treatment	Average Tons Treated/Site	Annual Tons Treated	Annual Tons Treated Outside of CAMUs and AOCs
CERCLA Remedial Action Soils	70	30	28,000	840,000[b]	240,000[b]
RCRA Corrective Action Soils	115	111	7,400	820,000[b]	230,000[b]
RCRA Closures Soils (Landfills)	40	40	3,900	160,000	40,000
RCRA Closure Soils; (Treatment and Storage Facilities)	240	199	1,100	220,000	60,000
State Superfund Soils	510	464	280	130,000	130,000
Voluntary Cleanup Soils	830	614	830	510,000	510,000
TOTALS	1,805	1,458	NA	2,680,000	1,210,000

[a] From USEPA, *Application of the Phase IV Land Disposal Restrictions to Contaminated Media: Costs, Cost Savings, and Economic Impacts*, February 23, 1998.

[b] Includes volumes treated in-situ, which are not subject to LDRs.

Exhibit E-3. Annual Tons Requiring Additional Treatment to Meet the Phase IV Rule

Remediation Category	Annual Tons Treated Outside of CAMUs and AOCs	Annual Tons Treated Ex-Situ Outside of CAMU and AOCs[b]	Annual Tons TC Metal Soils Treated Ex-situ Outside of CAMUs and AOCs[c]
CERCLA Remedial Action Soils	240,000	62,400	12,480
RCRA Corrective Action Soils	230,000	67,600	4,732
RCRA Closures Soils (Landfills)	40,000	40,400	2,828
RCRA Closures Soils; (Treatment and Storage Facilities)	60,000	15,600	1,092
State Superfund Soils	130,000	33,800	6,760
Voluntary Cleanup Soils	510,000	132,600	26,520
TOTALS	1,210,000	352,400	54,412

[a] Includes soil treated in-situ, which are not subject to LDRs.
[b] Assumes that treatment occurs ex-situ at 74 percent of sites.
[c] Assumes that 20 percent of CERCLA, State and Voluntary remediation soils are TC metal-only, and that 7 percent of RCRA remediation soils are TC metal-only.

Effect of Phase IV on Choice of Treatment Technology

The following discussion focuses on the effect of Phase IV on the capacity of organic treatment technologies for those remediations that will require more treatment for Phase IV soils with organic UHCs. A later section of this appendix addresses treatment for Phase IV soils without organic UHCs. That analysis identified solidification/stabilization as a technology capable of meeting the Phase IV soil treatment standards.

Organic contaminants can be separated into three major treatment groups: volatile organic compounds (VOCs); semi-volatile organic compounds (SVOCs); and aromatic halogenated compounds and halogenated pesticides and herbicides (AHCs). If present as UHCs in Phase IV soils, the contaminants would generally be addressed using more than one technology often together in a treatment train consisting of organic treatment technologies followed by metals treatment technologies. There are a number of innovative treatment technologies that are gaining acceptance to treat such organics. Listed below are innovative technologies that are gaining in acceptance based on their ability to achieve reductions to meet site cleanup goals:

- Bioremediation
- Soil washing
- Thermal desorption
- Soil vapor extraction
- Dehalogenation

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Although several of these technologies are generally performed in-situ, they are included because they may be used to eliminate or reduce organics to meet the alternative soil treatment standards before the soils are treated for metals ex-situ. Although in-situ treatment alone is not subject to LDRs, it may have to meet the alternative treatment standards if the soils are later excavated for further ex-situ treatment. Exhibit E-4 presents the list of the organic treatment groups and the innovative technologies that have been demonstrated to be effective in reducing concentrations of organics.

Appendix E-3 contains case study summaries of sites that use innovative technologies to treat organic constituents. These case studies demonstrate that the innovative technologies presented in Exhibit E-4 are readily available (see the next section for further discussion of this point) and able to meet the alternative soil treatment standards under certain site conditions. The optimum treatment conditions for the listed innovative treatment technologies are described in detail in Appendix E-2. Moreover, most of the sites reviewed are meeting soil cleanup goals that are below the alternative soil standards, and consequently are currently in compliance with the Phase IV rule.

Availability of Additional Treatment Capacity

An estimated 55,000 tons of TC metals-only soils may require additional treatment to meet the Phase IV rule. Additional treatment may also be required for some soils containing other characteristic or listed wastes, but this new demand for treatment will be off-set by the treatment capacity made available by other soils containing wastes that will require less treatment. The quantity of TC metals-only soils requiring additional treatment may actually be less than the 55,000 tons estimate because some of the sites currently are treating organic constituents found in soils. That is, no additional treatment may be required at these sites if site cleanup goals for organics are more stringent than the alternative soil treatment standards. Furthermore, only the portion of the waste that would pass the EP, and thus, be newly identified, or that would be considered a newly identified mineral processing waste is eligible for a capacity variance. On the other hand, adjustments to selected treatment technologies may have to be made for sites treating organics to cleanup goals less stringent than the alternative soil treatment standards.

One way for many on the innovative technologies to achieve greater contaminant reduction is to increase the length of treatment time. For example, for soil vapor extraction, bioremediation and thermal desorption higher reductions can be achieved by operating longer. Many of these technologies may reach a point in time when the rate of reduction is so small that operation and maintenance costs outweigh the costs of more costly modifications that can reduce the overall treatment time. Modifications such as the installation of additional soil vapor extraction wells, or increasing desorption temperatures for thermal desorption can be made with little delay in operation. Bioremediation modifications may involve adjustments to nutrient content that do not impede the treatment process. Most of these adjustments do not involve long shutdowns. Generally, the existing treatment system can continue to operate while additional bench-scale studies are performed to evaluate modifications prior to implementation. Because soil treatment is generally a long-term process, measurement of the reduction and compliance with LDRs may not be done until years after the start of treatment. The increased demand for treatment capacity is not likely to be felt immediately, but be felt over years as sites come closer to meeting the alternative treatment standards and evaluate the treatment system's ability to achieve the standards. This time gap will provide vendors with the opportunity to adjust to increases in demand.

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Exhibit E-4. Technology Assignments for Treatment Groups

Treatment Groups	**Treatment Technology**
One Contaminant Treatment Group	
VOCs	
	Bioremediation
	Soil Vapor Extraction
	Thermal Desorption
SVOCs	
	Thermal Desorption
	Bioremediation
	Soil Vapor Extraction
AHCs	
	Soil Washing
	Thermal Desorption
Two-Contaminant-Treatment Group	
VOCs/SVOCs	
	Thermal Desorption
	Bioremediation
	Soil Vapor Extraction
VOCs/AHCs	
	Soil Vapor Extraction
	Soil Washing
	Thermal Desorption
SVOCs/AHCs	
	Soil Vapor Extraction/Stabilization
	Thermal Desorption/Stabilization
Three Contaminant Treatment Groups	
VOCs/SVOCs/AHCs	
	Soil Vapor Extraction/Dehalogenation
	Thermal Desorption
	Soil Washing/Dehalogenation

VOC: volatile organic compound
SVOC: semi-volatile organic compound
AHC: aromatic halogenated compound and halogenated pesticide and herbicide

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APPENDIX E-2
DESCRIPTION OF INNOVATIVE TREATMENT TECHNOLOGIES*

* All information presented in this appendix was obtained from *Contaminated Soil Treatment Technologies—Analysis of Treatability Data (Revised Draft)* prepared by ICF, Inc. for USEPA, Office of Solid Waste, April 1997.

SOIL VAPOR EXTRACTION

Soil Vapor Extraction (SVE) uses a vacuum to remove VOCs from the vadose (unsaturated) zone of soil. It can be performed both in-situ and ex-situ.

In-Situ SVE. With in-situ SVE, vapor extraction wells are placed at contaminated depths in the soil, and the resulting air flow strips the soil of contaminants. For contamination deep within the soil, in low permeability or in saturated soils, air injection can facilitate contaminant extraction. After the air containing the contaminants is extracted from the soil, it must be treated. This is often done through carbon adsorption, thermal destruction (e.g., flare), and condensation through refrigeration. In-situ SVE requires complex design, operation, and monitoring of the system.

Waste Applicability

VOCs in the vadose zone are the main contaminants removed through in-situ SVE, although SVOCs are sometimes removed as well. Site considerations include soil moisture content, organic carbon content and groundwater depth, SVE works best on drier soil with low carbon content.

Thermally Enhanced SVE. Thermally Enhanced SVE (TE-SVE) is almost identical in process to in-situ SVE; steam, hot air injection, or electric/radio frequency heating is used in addition to SVE to increase semi-volatile contaminant mobility and facilitate extraction. As excess water within the soil is driven off, VOC mobility increases.

Waste Applicability

TE-SVE is intended for use with SVOCs, including some pesticides and fuels. VOCs, especially those in contaminated soils with high water content, low air permeability, or highly bound contaminants, can also be remediated with this method. TE-SVE is commonly used as part of a treatment train, with biodegradation used to treat any residual contaminants.

Ex-Situ SVE. Ex-Situ SVE (ES-SVE) involves placing excavated soils over a network of piping, onto which a vacuum is applied. ES-SVE has several advantages over in-situ SVE. Because of an increased number of passageways in the soil, ES-SVE encourages more organic volatilization than in-situ SVE. ES-SVE can also be monitored for system operation and performance. Leachates can be collected, and the presence of groundwater does not interfere with the process.

Waste Applicability

Both VOCs and SVOCs can be remediated with ES-SVE.

SOLVENT EXTRACTION

Solvent extraction is an ex-situ treatment process where the contaminants are physically removed from the soil matrix. Excavated soil is mixed with an organic chemical solvent in an extractor. The drained contaminated solvent is then sent to a separator; the solvent is recycled to the extractor. Solvent extraction is often used along with other treatment techniques.

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Waste Applicability

Solvent extraction is often used for remediation of organic wastes, such as VOCs, PCBs, halogenated solvents, and petroleum wastes. Treatability tests should be employed before performing solvent extraction to determine the type or combination of solvent(s) necessary to extract the contaminants found in the soil.

DECHLORINATION

Dechlorination (or dehalogenation) is an ex-situ treatment which remediates toxic, halogenated contaminants. Soils are mixed with an alkaline polyethylene glycol (APEG), such as potassium polyethylene glycol (KPEG), and heated in a reactor for up to several hours. The reactor may be heated to temperatures of 100° to 180°C. The reaction usually produces a glycol ether and/or a hydroxylated compound and an alkali metal salt, which are generally non-toxic. While the wastewater and residual vapor may need to be treated, dechlorination is generally considered to be a stand alone technology.

Waste Applicability

Halogenated SVOCs and pesticides are remediated through this technology, as are PCBs.

SOIL WASHING

Soil washing is an ex-situ process, similar to solvent extraction, that removes contaminants from the soil matrix with water. It can be used as a stand alone process, or in a treatment train. Contaminants dissolve in the water which is then treated by conventional wastewater procedures. Another method of soil washing is to use particle size separation, gravity separation, or attrition scrubbing to concentrate contaminants into a smaller volume of soil. Water is then used to separate the contaminated finer particles (i.e., silt, clay) which are then treated by other techniques (i.e., stabilization/solidification).

Waste Applicability

Soil washing is used to treat SVOCs, inorganics, metals, and fuel products, as well as VOCs. Soil flushing acids and chelating agents can be added to enhance remediation in less water-soluble metals and pesticides.

SOIL FLUSHING

Soil flushing is an in-situ treatment technique that uses water or other solutions to remove contaminants. The solution is applied to the contaminated soil by spraying, injection, or infiltration and recovered with extraction wells in the underlying aquifer. The solution is treated before being recycled to the flushing system or released to a public water treatment system.

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Waste Applicability

Soil flushing is used primarily for inorganic metals, including radioactive contaminants. Although it may not be the most cost effective method, soil flushing can also be used to treat organic contaminants.

THERMAL DESORPTION

Thermal desorption is an ex-situ remediation process in which contaminants are vaporized and removed from the soil matrix. The volatility of the contaminants determines the temperature range appropriate for thermal desorption. Volatile contaminants are appropriate candidates for low temperature thermal desorption (LTTD), whereas materials with high boiling points and volatile metals are candidates for high temperature thermal desorption (HTDD).

Low Temperature Thermal Desorption. LTTD takes place at temperatures between 90°F and 300°F in units such as rotary dryers, thermal screws, and belt conveyer systems. Organic gases are collected or destroyed in a secondary treatment. LTTD consists of a treatment system which includes soil preparation and pre-treatment, soil treatment, and solid, gas, and residuals post-treatment.

Waste Applicability

VOCs, SVOCs, PCBs, pesticides and herbicides can all be remediated with LTTD. Volatile metals and inorganics are not effectively treated with LTTD.

High Temperature Thermal Desorption. HTTD heats wastes to temperatures of 320°F to 560°F in order to volatize organics and water, and the volatized water and organic contaminants are treated in a gas treatment system. This process is often used with other remediation methods, such as incineration, solidification/stabilization, or dechlorination.

Waste Applicability

SVOCs, PAHs, PCBs, and pesticides are successfully treated with HTTD. Separate organics from refinery wastes, coal tar wastes, wood-treating wastes, creosote-contaminated soils, hydrocarbon contaminated soils, mixed radioactive wastes, synthetic rubber processing wastes, and paint wastes have all been remediated with this process.

BIOREMEDIATION

Bioremediation uses microorganisms, such as fungi and bacteria, to degrade organic chemicals. The microorganisms convert organic contaminants into carbon dioxide, water, and microbial cell mass under aerobic conditions, or into methane and carbon dioxide under anaerobic conditions. Bioremediation treatment can be either in-situ or ex-situ.

Biodegradation. Biodegradation utilizes microorganisms present in contaminated soil in order to metabolize organic contaminants. Groundwater or uncontaminated water treated with nutrients and oxygen is injected into the soil in order to increase the microorganisms' metabolic rates. Water is applied either via spray irrigation (best for shallow soil

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contamination) or via injection wells (for deeper contamination). As this treatment is used generally used to treat saturated soils, groundwater bioremediation is often performed concurrently.

Bioventing. Bioventing stimulates existing microorganisms by providing oxygen through low-flow air injection. Sub-terrain air flow may be increased by applying vacuum extraction at the surface.

Waste Applicability

Biodegradation and bioventing are used to remediate VOCs and SVOCs such as petroleum hydrocarbons, solvents, pesticides, wood preservatives, and other organic chemicals. Soils, sludges, and groundwater have all been remediated successfully through biodegradation and bioventing.

Composting. Composting techniques involve using indigenous microorganisms to degrade organic contaminants in excavated soil. The treatment is performed at elevated temperatures (i.e., 120°F to 130°F) which are naturally generated by the microorganisms. The soil is mixed with bulking agents (e.g., wood chips, straw) and nutrients (e.g., animal wastes) and composted in one of three methods: aerated static pile (soil mixture placed in piles that are aerated with pumps or blowers), mechanically agitated in-vessel (composting takes place in a reactor), and windrow composting (piles of soil are aerated by power tillers).

Waste Applicability

Composting is applicable to VOCs and other organic compounds. The technique has also been developed for remediation of explosives, such as TNT, RDX, and HMX, due to the tendency for these materials to be spread over large areas.

Slurry Phase Biodegradation. Slurry Phase Biodegradation (SPB) improves mass transfer between microorganisms and contaminants through mixing contaminated soils with water in a contained reactor. Either native or introduced microorganisms can be used. The slurry is dewatered and backfilled after treatment, although further treatment, such as stabilization may be necessary. By-products (i.e., water, off-gas) may require treatment before release as well, and volatiles may be released into the air during excavation of the soil.

Waste Applicability

SPB effectively treats soils, sludges, and groundwater that are contaminated with explosives, petroleum hydrocarbons, solvents, pesticides, wood preservatives, and other organic compounds. Proprietary vendor nutrient/bacteria formulations remediate a range of contaminants with concentrations from 2,500 to 250,000 ppm; however, treatability tests should be used to determine if a given formulation will accomplish treatment goals.

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APPENDIX E-3
CASE STUDIES

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Case Studies for Soil Treatment Analysis

Treatment performance data were compiled and reviewed estimates of required capacity developed in Appendix E-1 to assess the availability of treatment technologies that can achieve the alternative treatment standards for soil. The treatment performance data were categorized into two groups: metals and organics. This section of Appendix E outlines the approach taken to identify, compile, and analyze contaminated soil treatment performance data. This information demonstrates the ability of existing soil treatment technologies to achieve the alternative treatment standards.

Metal Contaminated Soil (Exhibit 1)

The following data collection steps were conducted to compile the case studies for metal contaminated soil presented in Exhibit E-5.

1. The CERCLA Records of Decision (ROD) Database was reviewed by first searching through ROD database for keywords. These keywords included: solidification, stabilization, metals, and individual metals. Sites with RODs containing appropriate keywords were reviewed for appropriate/sample data.

2. The Innovative Treatment Technology Database was searched for sites where: a ROD was signed in the past 5 years; the project status was either installed, operational, or complete; and the technology used was innovative (i.e., bioremediation, dechlorination, soil vapor extraction, soil washing, thermal desorption).

3. Site visit reports were reviewed for records having complete information.

4. Data from the "Contaminated Solid Treatment Technologies Analysis of Treatability Data" report were reviewed and selected, if applicable.

All treatment performance data were evaluated and screened to ensure their applicability and quality. For each case study presented in Exhibit E-5, the following information is included:

- site identity;
- vendor (if known);
- study type;
    - Treatability study - Small to medium size waste treatment study to assess the applicability for use on a site.
    - Treatability analysis - similar to treatability study but for a waste stream.
    - Bench-scale study - similar to treatability study except typically incorporates mroe site conditions.
        - Full-scale study.

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    - Fully operational treatment system at a site.

- treatment technology used;
- contaminants;
- treatment performance;
- waste volume;
- contaminant source;
- treatment duration (if available); and
- management site.

Most of the data fields are self explanatory. All of the contaminants at a particular site may not be listed; generally, however, major contaminants are listed. The management on- or off-site indicates if the treated soil was disposed of on- or off-site.

Technology performance is determined by several factors. "Before concentrations" of individual constituents are given in total constituent concentration, except where footnoted (in which case they are TCLP results). "After concentrations" for metals are given as TCLP results, except where footnoted (in which case they are total constituent concentrations). When comparable before and after treatment data was available, the percent reduction is listed for the constituent. The value of 10 times the Universal Treatment Standard (UTS) is also listed for each constituent, if applicable. If the treatment efficiency for a given constituent is greater or equal to 90%, or if the after treatment concentration of a constituent is less than 10 times the UTS, these constituents are recognized as meeting the LDR.

Organic Contaminated Soil (Exhibit E-6)

The case summaries presented in Exhibit E-6 were taken exclusively from "Contaminated Solid Treatment Technologies Analysis of Treatability Data," prepared by ICF, Inc. for U.S. EPA Office of Solid Waste. In this document, the following data collection approach was followed:

1. all relevant documents in the HWIR-Media docket were reviewed;
2. EPA representatives in the Office of Research and Development (SITE program), Technology Innovation Office, and the Office of Solid Waste and Emergency Response were contacted;
3. an Internet search was conducted to obtain information on innovative soil remediation treatment technologies; and

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4. an online literature search was conducted to identify other commercially available and pilot-scale remediation technologies, with particular emphasis on treatment technologies applicable to semivolatile organic compounds (SVOCs) and mixed constituents.

Treatment performance data presented in the document were evaluated and screened for applicability and quality. Required data included: constituent-specific concentrations in untreated and treated waste, soil matrix, source of contamination, soil volume, treatment duration, commercial status of the technology, and treatment cost. Commercially demonstrated remediation technologies' performance data were the highest priority; pilot scale demonstration data were used only when commercial demonstration data were not available. Case studies were omitted if they lacked treatment performance data or had inadequate performance data. Case studies with adequate data for all but a few constituents were included. If removal efficiency for a case study was less than or equal to zero, the study was not included.

For each case study presented in Exhibit 2, the following information is included:

- site name;
- vendor name;
- treatment technology used;
- contaminants;
- treatment performance;
- contaminant source;
- treatment duration; and
- data source.

Most of the data fields are self explanatory. The "contaminants" field includes the major contaminants of the site, but may not contain all contaminants.

Several factors are used to determine technology performance. Before and after concentrations of individual constituents are given in total constituent concentration. When treatment efficiency was available, the percent reduction is listed for the constituent. The value of 10 times the UTS was listed for each constituent, if applicable. Some of the constituents are not listed individually, but as constituent groups. UTS generally have been developed for individual constituents rather than for constituent groups, and thus comparisons with UTS could not be made for some constituents reported as a constituent group. If the treatment efficiencies for a given constituent is greater or equal to 90%, or if the after concentration of a constituent is less than ten times the UTS, these constituents are recognized as meeting the LDR.

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Exhibit E-5. Case Summaries of Metal Contaminated Soil

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	Technology Performance: After (mg/L unless noted)	Technology Performance: % Re-duced	Technology Performance: 10x UTS	Technology Performance: Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
Sapp Battery Site, Jackson Co. FL	Treatability study	Solidification/ Fly ash cement	Lead	7,100	<0.067-76 ppm	99	7.5	yes	Slag	Recycled lead battery wastes	NA	2	NA
			Lead	7,100	<0.06-0.085 ppm	>99	7.5	yes					
United Chrome, OR	Treatability study	Solidification	Zinc	123,700	38.5 ppm	99.9	43	yes	Soil	Metal plating Wastes	NA	2	Off-site
			Lead	12,115	15.5 ppm	99.8	7.5	yes (>TC)					
			Barium	1,165	ND	>99.9	210	yes					
			Nickel	107	ND	>99.9	136	yes					
			Chromium	50	35 ppm	30	8.5	no					
			Cadmium	17	0.4 ppm	97.6	2	yes					
Vendor Demonstration - HWT Chemical Fixation Technology	Treatability study	Stabilization	Chromium	630	0.03-0.04 ppm	>99	8.5	yes	Soil	Metals contaminated soil	NA	2	NA
			Antimony	13	0.7 ppm	94.6	0.7	yes					
VeriTec Corp.	Full-scale	Solidification	Chromium	73 mg/L	2.9 ppm	96	8.5	yes	Soil	Metal plating sludge	NA	2	NA
			Nickel	65.6 mg/L	1 ppm	98.5	136	yes					
Confidential Clients	Bench-scale	Stabilization	Lead	1 mg/L	NA	63-95	7.5	yes	NA	NA	NA	2	NA
			Chromium	1 mg/L	NA	NA	8.5	unknown					
Rollins Environmental, CO	Treatability analysis (commercial treatment facility data)	Stabilization	Antimony	2.9 mg/L	0.039	99	0.7	yes	72,000 - 90,000 tons process waste (1)	Mixed hazardous waste for treatment	NA	3	On-site
			Arsenic	2.69 mg/L	0.038	98.6	50	yes					
			Barium	8.05 mg/L	1.29	84	210	yes					
			Beryllium	0.012 mg/L	0.005	58	0.2	yes					
			Cadmium	1.58 mg/L	0.005	99	2	yes					
			Chromium	93 mg/L	0.017	>99	8.5	yes					
			Lead	533 mg/L	0.12	>99	7.5	yes					
			Nickel	0.94 mg/L	0.023	97	136	yes					
			Cadmium	1.03 mg/L	0.005	99	2	yes					
			Chromium	0.173 mg/L	0.02	88	8.5	yes					
			Lead	379 mg/L	0.13	>99	7.5	yes					
			Selenium	0.91 mg/L	0.058	93.6	57	yes					
			Silver	0.01 mg/L	0.01	0	1.1	yes					
			Mercury	0.02 mg/L	0.01	50	2.5	yes					

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Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	After (mg/L unless noted)	% Re-duced	10x UTS	Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
Slag from Several Lead Smelters - Resource Consultants	Treatment analysis	Stabilization	Lead	NA	4.69 ppm	NA	7.5	yes	Slag and soil	Lead smelter slag	NA	4	NA
NL Industries, Pedricktown, NJ	Full-scale	Solidification	Lead Cadmium Antimony	>500 NA NA	5 1 NA	NC NC NA	7.5 2 0.7	yes yes unknown	54,500 cy soil and sediment	Spent battery recycling wastes	24 months	1	On-site
Arctic Surplus Salvage Yard, Fairbanks, AK	Full-scale	Solidification	Lead	>1000	5	>98	7.5	yes	NA	Salvage yard wastes	NA	1	On-site
Roebling Steel, NJ	Full-scale	Stabilization	Lead Antimony Arsenic Barium Beryllium Cadmium Mercury Nickel Silver Thallium Vanadium Zinc	<8650 <45.8 <64.3 <588 <1.4 <9.7 <458 <1480 <8.1 <1.1 <732 <3050	5 NA 5 100 NA 1 2 NA 5 NA NA NA	NC NA NC NC NA NC NC NA NC NA NA NA	7.5 0.7 50 210 0.2 2 2.5 136 1.1 2 16 43	yes unknown yes yes unknown yes yes unknown no unknown unknown unknown	160 cy slag contam-inated soil	Slag waste	12 months	1	Off-site
Schuylkill Metal, FL	Full-scale	Solidification	Lead Cadmium	>500 NA	5 1	NC NC	7.5 2	yes yes	38,000 cy soil and sediment	Battery recycling wastes	6 months	1	On-site
O'Connor Company, Augusta, ME	Bench-scale	Solidification	Lead	NA	5	NA	7.5	yes	Soil	Salvage yard wastes	NA	1	NA
Nascolite Corp., Millville and Vineland, NJ	Full-scale	Solidification	Lead	NA	5	NA	7.5	yes	8,000 cy soil	Sheet metal manufacturing waste	NA	1	On-site

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Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance					Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
				Before (ppm unless noted)	After (mg/L unless noted)	% Re-duced	10x UTS	Meets LDR					
Florida Steel Co., Indiantown, FL	Full-scale	Solidification	Lead Arsenic	>600 NA	5 5	NC NA	7.5 50	yes yes	37,000 cy soil and ash	Steel mill wastes	9 months	1	On-site
Peak Oil/Bay Drum, Tampa, FL	Full-scale	Solidification	Lead	>284	5	NC	7.5	yes	46,000 cy soil	Used oil refinery wastes	NA	1	On-site
Fourth Street Refinery, Oklahoma City, OK	Full-scale	Solidification	Lead Arsenic	NA NA	5 5	NA NA	7.5 50	yes yes		Refinery wastes	NA	1	Off-site
Flowood Site, Flowood, MS	Full-scale	Stabilization	Lead	>500	5	NC	7.5	yes	6,000 cy soils and sediment	Metal contaminated soil	NA	1	
Interstate Lead Co., Leeds, AL	Full-scale	Solidification	Arsenic Beryllium Cadmium Lead Nickel Zinc	>13 NA NA >1000 NA NA	5 NA 1 5 NA NA	NC NA NA NC NA NA	50 0.2 2 7.5 136 43	yes yes yes yes yes yes	45,000 cy soil	Lead battery recycling wastes	NA	1	On-site
Double Eagle Refinery, Oklahoma City, OK	Full-scale	Solidification	Arsenic Lead	NA >500	5 5	NA NC	50 7.5	yes yes	54,600 cy	Oil recycling wastes	24 months	1	Off-site
Rhone-Poulenc/Zoecon Corp., East Palo Alto, CA	Full-scale	Solidification	Arsenic Lead	>500 NA	5 5	NC NA	50 7.5	yes yes	18,000 cy soil	Pesticide manufacturing	9 months	1	On-site

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Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	After (mg/L unless noted)	% Re-duced	10x UTS	Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
Anaconda Co., Smelter, MT	Full-scale	Stabilization	Arsenic	NA	5	NA	50	yes	316,500 cy	Flu dust	NA	1	On-site
			Cadmium	NA	1	NA	2	yes	dust and				
			Lead	NA	5	NA	7.5	yes	soil				
Dupont, Newport, ED	Full-scale	Solidification	Arsenic	NA	5	NA	50	yes	Soil	Paint pigment Manufacturing	NA	1	On-site
			Lead	>500	5	NC	7.5	yes					
			Chromium	NA	NA	NA	8.5	yes					
Hastings Groundwater Contamination, Hastings, NE	Full-scale	Stabilization	Arsenic	<22	5	NC	50	yes	39,000 cy soil	Industrial wastes	NA	1	On-site
			Barium	<1,000	NA	NA	210	unknown					
			Cadmium	<167	NA	NA	2	unknown					
			Chromium	<10,600	NA	NA	8.5	yes					
			Lead	<6730	5	NC	7.5	yes					
Agrico Chemical, Pensacola, FL	Full-scale	Solidification	Arsenic	>16	5	NC	50	yes	32,500 cy soil	Fertilizer manufacturing	NA	1	On-site
			Lead	>500	5	NC	7.5	yes					
PSC Resources, Palmer, MA	Full-scale	Solidification	Arsenic	>12	5	NC	5	yes	Soil and sediment	Waste oil and solvent recovery waste	NA	1	On-site
			Lead	>500	5	NC	7.5	yes					
Sullivan's Ledge, New Bedford, MA	Full-scale	Solidification	Lead	NA	5	NA	7.5	yes	26,100 soil and sediment	Landfill waste	6 months	1	On-site
			PCBs	NA	NA	NA	NA	unknown					
Gold Coast Oil, Miami, FL	Full-scale	Solidification	Lead	NA	5	NA	7.5	yes	NA	Solvent recovery wastes	NA	1	On-site
Whitmoyer Labs, Inc., Myerstown, PA	Full-scale	Stabilization	Arsenic	NA	5	NA	50	yes	Sludge	Pharm. manufacturing wastes	NA	1	Off-site
Midco II Site, Gary, IN	Full-scale	Stabilization	Arsenic	NA	5	NA	50	yes	40,000 cy soil and sediment	Industrial wastes	NA	1	On-site

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Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	After (mg/L unless noted)	% Re-duced	10x UTS	Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
Adams Plating, Lansing, MI	Full-scale	Stabilization	Arsenic Chromium	6.7 26.1	<5 NA	NC NA	50 8.5	yes yes	4,700 cy soil	Metal plating wastes	NA	1	Off-site
Pesses Chemical, Fort Worth, TX	Full-scale	Stabilization	Cadmium Lead Nickel	<2,400 <46,000 <3,200	1 5 NA	NC NC NC	2 7.5 136	yes yes yes	Soil	Cadmium and nickel battery recycling wastes	6 months	1	On-site
Pacific Hide and Fur Recycling, Pocatello, ID	Full-scale	Incineration/ Stabilization	Lead	NA	5	NA	7.5	yes	900 cy soil solidified only, 100 cy incinerated/ solidified	Scrap metal and hide recycling wastes	NA	1	Off-site
Douglassville Disposal, PA	Full-scale	Incineration/ Stabilization	Lead	NA	5	NA	7.5	yes	48,400 cy	Used oil recycling wastes	NA	1	On-site
Sangam Crab Orchard National Wildlife Refuge, USDOI, Carterville, IL	Full-scale	Incineration/ Stabilization	Lead Other metals	>450 NA	5 NA	NC NA	7.5 NA	yes unknown	Soil	Industrial waste	NA	1	On-site
Vogel Paint & Wax Co., Maurice, IA	Full-scale	Bioreme-diation/ Solidification	Chromium Lead Cadmium Arsenic Zinc	21,000 41,000 6 12 12,000	5 5 1 5 NA	NC NC NC NC NA	8.5 7.5 2 5 43	yes yes yes yes unknown	Soil	Paint wastes	1-3 months	1	On-site
J.H. Baxter Co., Weed, CA	Full-scale	Bioreme-diation/ Stabilization	Arsenic	>8	NA	NA	50	yes	41,000 cy soil	Wood preserving wastes	NA	1	On-site
Silresim Chemical, Lowell, MA	Full-scale	In-situ vapor extraction/ Solidification	Arsenic Chromium Lead	>21 NA >500	5 5 5	NC NA NA	50 8.5 7.5	yes yes yes		Chemical manufacturing wastes	NA	1	On-site
FMC Corp., Fresno, CA	Full-scale	Soil washing/ Stabilization	Arsenic Lead Chromium	NA NA NA	<60 <39 <100	NA NA NA	5 7.5 8.5	unknown unknown unknown	25,000 cy sludge and soil	Herbicide manufacturing	NA	1	On-site

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Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	After (mg/L unless noted)	% Re-duced	10x UTS	Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
			Pesticides	NA	NA	NA	NA	unknown					
United Scrap Lead, Troy, OH	Full-scale	Soil washing	Arsenic Lead	NA >500	5 5	NA NC	50 7.5	yes yes	45,000 cy soil	Lead reclamation from used batteries	NA	1	On-site
Confidential Industrial Explosives Manufacturer	Full-scale	Soil washing	Arsenic Lead	97-227 3500-6300	6.6-142 ppm 9.8-306 ppm	34-93 95-99	50 7.5	portion yes (>TC)	200 tons soil	Herbicide and organic material production wastes	NA	5	NA
Confidential Munitions Manufacturer	Full-scale	Soil washing	Arsenic Lead Zinc	2-129 495-25,800 146-1,120	<0.61-3.1 ppm 32.4-999 ppm 21.5-513 ppm	69.5-97.5 93.5-96.5 54.2-85.2	50 7.5 43	yes yes (>TC) no	600 tons soil and sediment	Munitions manufacture wastes	NA	5	NA
Alaska Battery Superfund Site, AK	Pilot -scale	Soil washing	Lead	2,280-10,374	15-2,541 ppm	75.5->99	7.5	portion	130 cy soil	Lead battery recycling wastes	NA	6	On-site

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Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	After (mg/L unless noted)	% Re-duced	10x UTS	Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
Palmetto Wood Preserving Cayce, SC	Full-scale	Soil washing	Arsenic Chromium	2-6,200 4-6,200	<1 ppm 627 ppm	>99 89.9	50 8.5	yes no	13,000 cy soil	Wood preserving wastes	4 months	7	On-site
King of Prussia Technical Corporation, PA	Full-scale	Soil washing	Chromium Mercury Nickel	11,300 16,300 11,100	<483 ppm <1 ppm <1,935 ppm	<95.7 >99.0 >82.6	8.5 2.5 136	yes(>TC) yes no	19,200 tons of soil	Electroplating waste	NA	8	On-site
Composite Data for Several Sites	Full-scale	Soil washing	Arsenic Cadmium Chromium Zinc	243 18 49 72	57 ppm 10.3 ppm 17.2 ppm 59.1 ppm	76.4 42.7 64.9 17.9	50 2 8.5 43	no no no no	Soil	NA	NA	9	NA
Chrystal Chemical, Houston, TX	Full-scale	Vitrification	Arsenic	>300	5	>90	50	yes	16,500 cy soil	Herbicide manufacturing	NA	1	On-site
DOE, Butte, MT	Full-scale	Ex-situ vitrification	Zinc	28,000	ND	>99.9	43	yes	NA	Heavy metal wastes	NA	5	NA
Babcock & Wilcox	Full-scale	Ex-situ vitrification	Cadmium Chromium Lead	49.9 2.67 97.1	<0.12 ppm 0.22 ppm <0.31 ppm	>99.7 91.8 >99.6	2 8.5 7.5	yes yes yes	Soil	Metals and organic containing soils	NA	5	NA
HRD Facility	Full-scale	Ex-situ vitrification	Arsenic Barium Cadmium Chromium Lead	5,200 860 410 88 54,000	0.474 ppm 0.175 ppm <0.05 ppm <0.06 ppm <0.33 ppm	>99.9 >99.9 >99.9 >99.9 >99.9	50 210 2 8.5 7.5	yes yes yes yes yes	Soil	Metals and organic containing soils	NA	5	NA
Component Development & Integration Facility	Full-scale	Ex-situ vitrification	Cadmium Nickel	0.067 0.22	<0.039 ppm <0.11 ppm	>41.8 >50	2 136	yes yes	1.5 tons soil	Mining wastes, INEL wastes, DOD wastes	Approx. 4 months	6	NA

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Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	After (mg/L unless noted)	% Re-duced	10x UTS	Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
Parsons Chemical, MI	Full-scale	In-situ vitrification	Arsenic Chromium Lead Mercury	NA NA NA NA	<4-30.5 ppm <10-17.1 ppm <50-4,290 ppm <0.2-0.23 ppm	NA NA NA NA	50 8.5 7.5 2.5	yes >10xUTS >10xUTS yes	3,000 cy soil	Agricultural chemical wastes	10-19.5 days	5	On-site
Alaskan Battery Enterprises Superfund Site, Fairbanks, AK; vendor unknown	NA	High temperature thermal desorption	Lead	2,280 - 10,374	15 - 2,541 ppm	75.5 - 99.3	7.5	yes	NA	Battery waste	NA	14	NA
Confidential Industrial Explosives Manufacturer, location unknown; Metcalf & Eddy, Inc.	NA	Soil washing	Arsenic Lead	97-227 3500-6300	6.6-142 ppm 9.8-306 ppm	34.4-93.1 95.1-99.7	50 7.5	yes yes	200 tons soil	Herbicide and organic material production wastes	NA	11	NA
Confidential Munitions Manufacturer, location unknown; Metcalf & Eddy, Inc.	NA	Soil washing	Arsenic Lead Antimony Zinc	2-129 495-28,400 8.7-573 146-1,120	<0.61-3.1 ppm 32.4-999 ppm <.58-13.1 ppm 21.5-513 ppm	69.5-97.5 93.5-96.5 93.3-97.7 54.2-85.2	50 7.5 12 43	yes yes yes no	600 tons soil	Munitions manufacture wastes	NA	11	NA
Alaskan Battery Superfund Site; vendor unknown	NA	Soil washing	Lead	2,280 - 10,374	15 - 2,541 ppm	75.5 - >99	7.5	no	NA	NA	NA	14	NA
Palmetto Wood Preserving, SC; En-Site	NA	Soil washing	Arsenic Chromium	2 - 6,200 4 - 6,200	<1 ppm 627 ppm	>99.9 89.9	50 6	yes	13,000 cy soil	Wood preserving wastes	4 months	12	NA
King of Prussia Technical Corporation Superfund Site, PA; Alternative Remedial Technologies, Inc.	NA	Soil washing	Chromium Copper Mercury Nickel	11,300 16,300 100 11,100	<483 ppm <3,571 ppm <1 ppm <1,935 ppm	>95.7 >78.1 >99.0 >82.6	6 NA 0-25 110	yes no yes no	19,200 cy soil	Electroplating waste at sludge processing center	NA	15	NA

Exhibit E-5. Case Summaries of Metal Contaminated Soil (continued)

Site	Study Type	Treatment Technology	Contaminants	Technology Performance: Before (ppm unless noted)	After (mg/L unless noted)	% Reduced	10x UTS	Meets LDR	Waste Volume/ Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
Composite Data for Several Sites	NA	Soil washing	Arsenic	243	57 ppm	76.4	50	no	NA	NA	NA	13	NA
			Cadmium	18	10.3 ppm	42.7	1.1	no					
			Chromium (total)	49	17.2 ppm	64.9	6	no					
			Zinc	72	59.1 ppm	17.9	43	no					

Notes:

1. LDR treatment requirements for process wastes are set at the UTS which is lower than for soil. However, these data are presented to demonstrate technology treatment performance.

Sources:

1. Superfund Record of Decisions, Superfund Public Information System, CD-ROM database of RODs and other public data related to CERCLA sites, USEPA, May 1997.
2. Summary of Treatment Technology Effectiveness for Contaminated Soil, EPA/540/2-89/053, USEPA, June 1990.
3. Memorandum, "Final Revised Calculations of Treatment Standards Using Data Obtained from Rollins Environmental's Highway 36 Commercial Waste Treatment Facility and GNB's Frisco, Texas Waste Treatment Facility," from Howard Finkel, ICF Inc., to Anita Cumming
4. Letter to Jean Beaudoin, Johnson Controls Battery Group, Inc., and Gerald Dubinski, Standard Industries, "Summary Report on Chemical Stabilization of Secondary Lead Smelter Slag and Lead Contaminated Soil," Resource Consultants, Inc., dated November 20, 1995.
5. Department of Defense Environmental Technology Transfer Committee, "Remediation Technologies Screening Matrix and Reference Guide," Second Edition, Federal Remediation Technologies Roundtable, EPA-542-B-94-013, USEPA, October 1994.
6. Vendor Information System for Innovative Treatment Technologies (VISITT) - version 5.0, Office of Solid Waste and Emergency Response, USEPA , April 1996.
7. Innovative Treatment Technologies: Annual Status Report (Fifth Edition) - Applications of New Technologies at Hazardous Waste Sites, Office of Solid Waste and Emergency Response, EPA-542-R-93-003, USEPA, September 1993.
8. Engineering Bulletin, Soil Washing, Office of Research and Development, EPA/540/2-90/017, USEPA, September 1990.
9. Final Proposed Best Demonstrated Available Technology (BDAT) Background Document for Hazardous Soils, Office of Solid Waste, USEPA , August 1993.
10. Contaminated Soil Treatment Technologies Analysis of Treatibility Data, Office of Solid Waste, USEPA, April 1997.
11. U.S. EPA, "Vendor Information System for Innovative Treatment Technologies (VISITT) - Version 5.0," Office of Solid Waste and Emergency Response, August 1996.
12. U.S. EPA, "Innovative Treatment Technologies: Annual Status Report (Fifth Edition) - Applications of New Technologies at Hazardous Waste Sites," Office of Solid Waste and Emergency Response, EPA-542-R-93-003, September 1993.
13. U.S. EPA, "Final Proposed Best Demonstrated Available Technology (BDAT) Background Document for Hazardous Soil," Office of Solid Waste, August 1993.
14. Department of Defense Environmental Technology Transfer Committee, "Remediation Technologies Screening Matrix and Reference Guide," Second Edition, Federal Remediation Technologies Roundtable, EPA-542-B-94-013, October 1994.
15. U.S. EPA, "Engineering Bulletin, Soil Washing," Office of Research and Development, EPA/540/2-90/017, September 1990.

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance: Before (ppm unless noted)	Technology Performance: After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR	Contaminant Source	Treatment Duration	Data Source
Super Value Site, NM; Billings & Associates, Inc.	In-situ biodegradation	Benzene Toluene Ethylbenzene Xylene	25 25 25 25	0.01 <1.0 <1.0 <1.0	99.96 >96 >96 >96	100 100 100 300	yes yes yes yes	Leaking gasoline UST	Approx. 9 months	1
Port Hueneme Military Facility - Tank Area; SBP Technologies, Inc.	In-situ biodegradation	Benzene	5 - 20,000 ppb	0 - 1 ppb	80-100	100	yes	Leaking gasoline UST	Approx. 4 months	1
Grocery Store, IL; B&S Research	In-situ biodegradation	BTEX (1)	0 - 2,070	ND	>99.9	100-300	yes	Leaking UST	NA	1
Dry Cleaner, FL; Microbial International	In-situ biodegradation	Trichloroethylene	180 - 1,500 ppb	ND - 14 ppb	92-100	60	yes	Dry cleaning wastes	Approx. 3 months	1
Clark's Gulf Gasoline Station, MA; Waste Stream Technology, Inc.	In-situ biodegradation	BTEX (1)	100	ND	>99.9	100-300	yes	Leaking UST	Approx. 18 months	1
Upjohn Manufacturing Co. PR; Soil Tech	Soil vapor extraction	Carbon tetrachloride	70	<0.002	>99.9	60	yes	NA	5 years	2
Rocky Mountain Arsenal, CO; Woodward Clyde	Soil vapor extraction	Trichloroethene	60 (in gas)	2 - 3(in gas)	95-97	60	yes	Cleaning solvents discharged to land	7 months	2
Tyson's Dump Superfund Site, PA; Terra Vac, Inc.	Soil vapor extraction	Benzene Trichloroethene Tetrachloroethene Tricresyl Phosphate	200-500 200-500 500-13,000 1,500-25,000	10-100 10-100 10-100 1,000-10,000	98 98 >99.9 96	100 60 60 NA	yes yes yes yes	Releases from chemical storage facility	NA	1

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance					Contaminant Source	Treatment Duration	Data Source
			Before	After	% Re-duced	10xUTS (mg/kg)	Meets LDR			
			ppm unless noted							
Composite Data for Several Sites	Soil vapor extraction	Chlorobenzene	1,200	293	75.6	60	no	NA	NA	3
		1,1-Dichloroethane	17	2.3	86.5	60	yes			
		1,2-Dichloroethane	28	3	89.3	60	yes			
		Methylene chloride	35	0.5	98.6	300	yes			
		Methyl isobutyl ketone	160	15	90.6	330	yes			
		Tetrachloroethene	1,500	671	55.3	60	no			
		1,1,1-Trichloroethane	120	1	99.2	60	yes			
		Trichloroethene	4,050	1871	53.8	60	no			
		Bis(2-ethylhexyl)pthalate	1,800	882	51	280	no			
		Phenanthrene	12	5.5	53.8	56	yes			
		Phenol	15	6.4	57.2	62	yes			
Verona Wellfield Superfund Site, MI; Terra Vac, Inc.	Soil vapor extraction	Acetone	130	<0.18	>99.8	1,600	yes	Leaked solvent, from solvent storage depot, and UST's	4 years	4
		2-Butanone	17	<0.018	>99.8	NA	yes			
		Chloroform	2	<0.007	>99.2	60	yes			
		1,2-Dichloroethane	27	<0.005	>99.9	60	yes			
		Ethylbenzene	78	<0.004	>99.9	100	yes			
		Methylene Chloride	60	0.002	>99.9	300	yes			
		Tetrachloroethene	1,800	<0.711	>99.9	60	yes			
		Toluene	730	<0.073	>99.9	100	yes			
		1,1,1-Trichloroethane	270	<0.004	>99.9	60	yes			
		Trichloroethene	550	<0.047	>99.9	60	yes			
		Xylenes	420	<0.018	>99.9	300	yes			
Sacramento Army Depot Superfund Site. CA; Terra Vac, Inc.	Soil vapor extraction	2-Butanone	0.011-150	<1.2	>99.2	NA	yes	Leaked solvents from UST	6 months	4
		Ethylbenzene	0.006-2,100	<6	>99.7	100	yes			
		Tetrachloroethene	0.006-390	<0.2	>99.9	60	yes			
		Xylenes	0.005-11,000	<23	>99.7	300	yes			
Ottati & Goss, Unknown location; Canonie Environmental	Low temperature thermal desorption	Trichloroethene	6.5 - 460	<0.025	>99.6	60	yes	NA	NA	5
		Tetrachloroethene	4.9-1,200	<0.025	>99.5	60	yes			
		Toluene	>87-3,000	<.025-0.11	>99.9	100	yes			
		Ethylbenzene	>50-440	<0.025	>99.9	100	yes			
		Xylene	>170->1,100	<0.025-0.14	>99.9	300	yes			

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance					Contaminant Source	Treatment Duration	Data Source
			Before	After	% Re- duced	10xUTS (mg/kg)	Meets LDR			
			ppm unless noted							
South Kearney Site, Unknown location; Canonie Environmental	Low temperature thermal desorption	Total VOCs	308.2	0.51	99.8	NA	yes	NA	NA	5
		SVOCs	0.7 - 15	ND - 1.0	93.3	NA	yes			
Letterkenny Army Depot, Unknown location; Roy F. Weston	Low temperature thermal desorption	Benzene	590	0.73	99.9	100	yes	NA	NA	5
		Trichloroethene	2,680	1.8	99.9	60	yes			
		Tetrachloroethene	1,420	1.4	99.9	60	yes			
		Xylene	27,200	0.55	>99.9	300	yes			
McKin Superfund Site, ME; Smith Environmental Technologies Corp.	Low temperature thermal desorption	Trichloroethene	3,310.00	0.04	>99.9	60	yes	Leaking from previous liquid waste treatment, storage and disposal facility	NA	1,6
		Tetrachloroethene	120.00	ND	>99.9	60	yes			
		Benzene	2.70	ND	>99.9	100	yes			
		Ethylbenzene	130.00	ND	>99.9	100	yes			
		Toluene	62.00	ND	>99.9	100	yes			
		Xylene	840.00	ND	>99.9	300	yes			
		1,2-Dichloroethylene (o)	300.00	ND	>99.9	300	yes			
		1,2-Dichlorobenzene (p)	320.00	ND	>99.9	60	yes			
Public Utility, WA; Enviro Klean Systems, Inc.	Low temperature thermal desorption	Benzene	19	ND	>99.9	100	yes	Leaking UST	NA	6
		Ethylbenzene	71	ND	>99.9	100	yes			
		Toluene	21	ND	>99.9	100	yes			
		Xylene	84	ND	>99.9	300	yes			

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance					Contaminant Source	Treatment Duration	Data Source
			Before	After	% Re-duced	10xUTS (mg/kg)	Meets LDR			
			ppm unless noted							
Composite Data for Several Sites	Low temperature thermal desorption	Acetone	4330	342	92.1	1600	yes	NA	NA	3
		Benzene	312	0.6	99.8	100	yes			
		Chlorobenzene	322	21	93.5	60	yes			
		1,2-Dichloroethane	304	2.4	99.2	60	yes			
		1,1-Dichloroethane	6.1	0.01	99.7	60	yes			
		Trans-1,2-dichloroethene	760	2	99.7	300	yes			
		Ethylbenzene	3116	56	98.2	100	yes			
		Phenol	154	32	79.2	62	yes			
		1,1,2,2-Tetrachloroethane	120	0.1	99.9	60	yes			
		Tetrachloroethene	2760	157	94.3	60	yes			
		Toluene	718	14	98	100	yes			
		Tribromomethane	101	5	94.9	150	yes			
		1,1,1-Trichloroethane	84	0.2	99.8	60	yes			
		Trichloroethene	19000	342	98.2	60	yes			
		Xylenes	5277	111	97.9	300	yes			
		Acenaphthalene	200	17	91.4	34	yes			
		Acenaphthene	505	31	93.8	34	yes			
		Anthracene	7271	291	96	34	yes			
		Benz(a)anthrecene	290	30	89.6	34	yes			
		Benzo(a)pyrene	1800	221	87.7	34	no			
		Benzo(ghi)perylene	176	26	85.3	18	no			
		Bis(2-ethylhexyl)phthalate	2527	83	86.7	280	yes			
		Butyl benzyl phthalate	151	2.4	98.4	280	yes			
		Chrysene	4150	635	84.7	34	no			
		o-Cresol	20	10	50	56	yes			
		p-Cresol	74	28	62.3	56	yes			
		Dibenz(a,h)anthracene	35	9.4	73.2	82	yes			
		o-Dichlorobenzene	320	6	98	60	yes			
		m-Dichlorobenzene	41	12.3	70	60	yes			
		p-Dichlrorobenzene	14.8	5.4	63.5	60	yes			

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance: Before (ppm unless noted)	After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR	Contaminant Source	Treatment Duration	Data Source
Sweetwater Wood Preserving Site, TN; Retec	Slurry phase biodegradation	Phenol	14.6	0.7	95.2	62	yes	Wood preserving sludge	NA	7
		Napthalene	3,670	23	99.4	56	yes			
		Fluoranthene	5470	67	98.8	34	yes			
		Carbazole	1490	4.9	99.7	NA	yes			
		Phenanthrene/Anthacene	30700	200	99.3	56/34	yes			
		Pentachlorophenol	687	12.3	98.2	74	yes			
Unknown Wood Preserving Site; Environmental Solutions, Inc.	Slurry phase biodegradation	Phenol	3.91	<0.01	>99.7	62	yes	Wood preserving sludge	NA	7
		2,4-Dimethylphenol	7.73	<0.01	>99.8	140	yes			
		p-Chloro-m-Cresol	118.62	<0.01	>99.9	140	yes			
		2,4-Dinitrophenol	4.77	<0.03	>99.3	1600	yes			
		Napthalene	1078.55	<0.01	>99.9	56	yes			
		Acenaphthylene	998.8	1.4	>99.8	34	yes			
		Phenanthrene/Anthacene	6832.07	3.8	99.9	56/34	yes			
		Fluoranthene	1543.06	4.9	99.7	34	yes			
		Chrysene/Benz(a)-anthracene	519.32	1.4	99.7	34	yes			
		Benzo(a)pyrene	82.96	0.1	99.9	34	yes			
		Indeno(1,2,3-cd)-pyrene/Dibenz (a,h)anthracene	84.88	0.5	99.4	34/82	yes			
		Carbazole	135.4	<0.05	>99.9	NA	yes			
		2-Chlorophenol	1.89	<0.01	>99.4	57	yes			
		2,4,6-Trichlorophenol	118.62	<0.01	>99.9	74	yes			
		Tetrachlorophenol	11.07	<0.02	>99.8	74	yes			
		Pentachlorophenol	420.59	3.1	99.3	74	yes			
		Benzo(b)fluroanthene	519.32	<0.03	>99.9	60	NA			
Wood Preserving Site, MO; Bogart Environmental Services, Inc	Slurry phase biodegradation	Creosote	1,000 - 10,000	<250	>75.0 ->97.5	NA	yes	Wood preserving waste	NA	1
MacGillis & Gibbs Superfund Site, Unknown location; Eimco Process Equipment Co.	Slurry phase biodegradation	Pentachlorophenol	5,500	550	90	74	yes	Wood preserving waste	NA	1

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance: Before (ppm unless noted)	After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR	Contaminant Source	Treatment Duration	Data Source
Sheridan Disposal Services, TX; Eimco Process Equipment Co.	Slurry phase biodegradation	Phenol	5,700	ND	>99.9	62	yes	Petroleum refining wastes	NA	1
		PCB	55	29	47.3	100	yes			
		BTEX (1)	4,600	ND	>99.9	100-300	yes			
		VOCs	250	0.5	98	NA	yes			
Composite Data for Several Sites	Slurry phase biodegradation	1,1-Dichloroethane	81	0.08	>99.9	60	yes	NA	NA	3
		Ethylbenzene	420	0.4	>99.9	100	yes			
		Methyl ethyl ketone	200	0.2	>99.9	360	yes			
		Methylene chloride	800	0.8	>99.9	300	yes			
		Tetrachloroethene	470	0.4	>99.9	60	yes			
		Toluene	1100	1	>99.9	100	yes			
		1,1,1-Trichloroethane	120	0.1	>99.9	60	yes			
		Trichloroethene	93	0.09	>99.9	60	yes			
		Xylenes	2100	2	>99.9	300	yes			
		Acenaphthalene	44	5.5	87.6	34	yes			
		Acenaphthene	18	2	88.5	34	yes			
		Benz(a)anthracene	12	2.2	82.1	34	yes			
		Benzo(a)pyrene	96	29	69.9	34	yes			
		Bis(2-ethylhexyl)phthalate	110	7	93.2	280	yes			
		Chrysene	14.9	2.7	81.9	34	yes			
		Di-n-butyl phthlate	37	2	94.7	280	yes			
		Diphenylnitrosamine	95	2	98	130	yes			
		Fluoranthene	115	1.3	88.6	34	yes			
		Fluorene	27	2.3	91.6	34	yes			
		Napthalene	600	16	97.4	56	yes			
		Phenanthrene	92	2	97.9	56	yes			
		Pyrene	57	9	84.1	82	yes			
		Toxaphene	819	244	70.2	26	no			
		Benzo(b)fluroanthene	190	80	58.1	68	no			
		Pentachlorophenol	5145	1312	74.5	74	no			
Escambia Wood Treating Co. Superfund Site, Pensacola, FL; vendor unknown	High temperature thermal desorption	PAH	550 - 1,700	453	91.8 - 97.4	NA	yes	Wood preserving waste	NA	8
		PCP	48 - 210	NA	93.8 - 98.6	NA	yes			

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance: Before (ppm unless noted)	After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR	Contaminant Source	Treatment Duration	Data Source
Niagra Mohawk Site, NY; Maxymilliam Technologies, Inc.	High temperature thermal desorption	Napthalene	50 - 1,000	< 3	>94 - >99.7	56	yes	Coal gasification wastes	Approx. 9 months	1
		Fluorene	51 - 1,000	< 3	>94 - >99.7	34	yes			
		Pyrene	52 - 1,000	< 3	>94 - >99.7	0.67	yes			
		Chrysene	53 - 1,000	< 3	>94 - >99.7	34	yes			
		Fluoranthene	54 - 1,000	< 3	>94 - >99.7	34	yes			
		Benzo(o)pyrene	55 - 1,000	< 3	>94 - >99.7	34	yes			
		Benzo(g,h,i)perylene	56 - 1,000	< 3	>94 - >99.7	18	yes			
		Benzo(b)fluoranthene	57 - 1,000	< 3	>94 - >99.7	68	yes			
Downhole Oil Tool Cleaning Area, TX; Hrubetz Environmental Services, Inc.	High temperature thermal desorption	Napthalene	1,500	7	99.5	56	yes	Coal gasification waste	<1 month	1
Wood preserving facility, MN; Thermotech Systems Corporation	High temperature thermal desorption	Napthalene	2900	0.31	>99.9	56	yes	Wood preserving wastes	NA	1
		1-Methylnapthalene	370	ND	>99.9	NA	yes			
		Acenaphthene	96	ND	>99.9	34	yes			
		Fluorene	130	ND	>99.9	34	yes			
		Anthracene	250	ND	>99.9	34	yes			
		Fluoranthracene	200	0.11	>99.9	34	yes			
		Pyrene	250	ND	>99.9	82	yes			
		Chrysene	100	0	>99.9	34	yes			
		Benzo(a)anthracene	24	0.13	99.5	34	yes			
		Benzo(b)fluoranthene	55	ND	>99.9	68	yes			
Wide Beach Superfund Site, NY; SDTX Tech. Inc.	Dehalogenation	PCB	120	<0.3 ppb	>99.9	100	yes	PCB wastes	NA	9
Bengart & Mernel, NY; Vendor unknown	Dehalogenation	PCB	108	<27	>75	100	yes	Drummed waste	NA	9
PWC Guam (basecat-alyzed decomposition); Vendor unknown	Dehalogenation	PCB	2,500	<10	99.6	100	yes	PCB wastes	NA	10
Marengo National PCB Demonstration, OH; Commodore AT, Inc.	Dehalogenation	PCB (Aroclor 1254)	1,000-10,000	<2	>99.8	100	yes	PCB wastes	Approx. 7 months	1
		PCB (Aroclor 1260)	1,000-10,000	<2	>99.8	100	yes			

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance: Before (ppm unless noted)	After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR	Contaminant Source	Treatment Duration	Data Source
Composite Data for Several Sites	Dehalogenation	Chlorobenzene	387	5	98.6	60	yes	NA	NA	3
		1,2-Dichloroethane	151	1	99.3	60	yes			
		Tetrachloroethene	1265	43	96.6	60	yes			
		Hexachlorobenzene	450	1	99.8	100	yes			
		PCBs	7013	5	99.2	100	yes			
		Hexachlorodibenzofurans	164	0.2	>99.9	0.06	yes			
		Pentachlorodibenzofurans	49	0.05	>99.9	0.01	yes			
		DDD	1600	3	99.8	0.87	yes			
		DDE	100	5	95.2	0.87	yes			
		DDT	430	9	99.8	0.87	yes			
Confidential Munitions Manufacturer, location unknown; Metcalf & Eddy, Inc.	Soil washing	PCBs	0.053-0.310	<.033	>89.4	100	yes	Munitions manufacture wastes	NA	1
		PAHs	15,000	15	99.9	NA	yes			
Composite Data for Several Sites	Soil washing	Bis(2-ethylhexyl)phthalate	91.7	2.6	97.2	280	yes	NA	NA	1
		Fluorene	27.3	5	81.8	34	yes			
		Napthalene	27.8	2.2	92.2	56	yes			
		Pentachlorophenol	1,200	126	89.5	74	no			
		Phenanthrene	64.9	4.8	92.6	56	yes			
		Phenol	585	39.8	93.2	62	yes			
		PCBs	11.3	1.3	88.5	100	yes			
		Tetrachlorodibenzo-p-dioxins	0.67	0.1	84.8	0.01	no			

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Exhibit E-6. Case Summaries of Oraganic Contaminated Soil0 (continued)

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance: Before (ppm unless noted)	After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR	Contaminant Source	Treatment Duration	Data Source
Composite Data for Several Site	Solvent extraction	Ethyl Benzene	16	0.05	99.7	100	yes	NA	NA	3
		Phenol	110	1	99	62	yes			
		Toluene	13	0.07	99.5	100	yes			
		Xylenes (total)	44	0.09	99.8	300	yes			
		Acenaphthalene	13	0.16	98.8	34	yes			
		Acenaphthene	860	9	98.9	34	yes			
		Anthracene	1,600	29	98.2	34	yes			
		Benzo(a)anthracene	140	0.6	99.6	34	yes			
		Benzo(a)pyrene	120	2	98	34	yes			
		Benzo(b)fluoranthene	240	4.8	98	68	yes			
		Benzo(ghi)perylene	17	0.7	95.9	18	yes			
		Benzo(k)fluoranthene	240	5	98	68	yes			
		Chrysene	130	0.7	99.5	34	yes			
		o-Cresol	73	0.4	99.5	56	yes			
		p-Cresol	170	1	99.3	56	yes			
		2,4-Dimethylphenol	72	0.6	99.2	140	yes			
Composite Data for Several Sites (Continued)		Fluoranthene	1,200	32	97.3	34	yes			
		Fluorene	860	5	99.4	34	yes			
		Indeno(1,2,3-cd)pyrene	NA	NA	NA	34	NA			
		Napthalene	22	0.9	95.9	56	yes			
		Phenanthrene	1,200	8	99.3	56	yes			
		Pyrene	1,500	9	99.4	82	yes			
		AHCs	810	13	98.4	NA	yes			
		Hexachlorodibenzo-p-dioxins	0.015	3.3x10-4	97.8	0.01	yes			
		Hexachlorodibenzofurans	0.0076	1.9x10-4	97.5	0.01	yes			
		PCBs	5,800	313	94.6	100	yes			
		Mercury	6,217	143	97.7	0-25	yes			
Industrial landfill, MA; Art International	Solvent extraction	PCB (Aroclor 1254)	10,500	4	>99.9	100	yes	Landfill wastes	NA	1
		PCB (Aroclor 1260)	10,500	4	>99.9	100	yes			
Stockton Naval Air Station Superfund Site, CA; Terra Kleen, Inc.	Solvent extraction	DDT	300 - 500	<0.08	>99.9	0.87	yes	Soil contaminated with insecticides	Approx. 6 months	1
		DDD	100	ND	>99.9	0.87	yes			
		DDE	50	ND	>99.9	0.87	yes			
North Island Naval Air Station Superfund Site, CA; Terra Kleen, Inc.	Solvent extraction	PCBs	130 - 200	0.2 - 2	99.0 - 99.8	100	yes	PCB spill	Approx. 11 months	1

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Notes

(1) BTEX refers to Benzene, Toulene, Ethylbenzene, and Xylene

Data Sources

1. U.S. EPA, "Vendor Information System for Innovative Treatment Technologies (VISITT) - Version 5.0," Office of Solid Waste and Emergency Response, August 1996.
2. U.S. EPA, "Innovative Treatment Technologies: Annual Status Report (Fifth Edition) - Applications of New Technologies at Hazardous Waste Sites," Office of Solid Waste and Emergency Response, EPA-542-R-93-003, September 1993.
3. U.S. EPA, "Final Proposed Best Demonstrated Available Technology (BDAT) Background Document for Hazardous Soil," Office of Solid Waste, August 1993.
4. Federal Remediation Technologies Roundtable, "Remediation Case Studies: Soil Vapor Extraction," EPA-542-R-95-004, March 1995.
5. U.S. EPA, "Engineering Bulletin, Thermal Desorption Treatment," Office of Research and Development, EPA-540-S-94-501, February 1994.
6. Federal Remediation Technologies Roundtable, "Remediation Case Studies: Thermal Desorption, Soil Washing, and In-Situ Vitrification," EPA-542-R-95-004, March 1995.
7. U.S. EPA, "Engineering Bulletin, Slurry Biodegradation," Office of Research and Development, EPA/540/2-90/016, September 1990.
8. Department of Defense Environmental Technology Transfer Committee, "Remediation Technologies Screening Matrix and Reference Guide," Second Edition, Federal Remediation Technologies Roundtable, EPA-542-B-94-013, October 1994.
9. Freeman, M. Harry, and Harris, F. Eugene., "Hazardous Waste Remediation - Innovative Treatment Technologies," Technomic Publishing, 1995.
10. Federal Remediation Technologies Roundtable, "Remediation Technologies Screening Matrix and Reference Guide," Second Edition, EPA-542-B-94-013, October 1994.
11. U.S. EPA, "Engineering Bulletin, Soil Washing," Office of Research and Development, EPA/540/2-90/017, September 1990.

APPENDIX E-4
PHONE LOGS

US EPA ARCHIVE DOCUMENT

Soil Vapor Extraction
Phone Logs

Mr. Robert Roth
Terra Vac, Inc.
Location: Windsor, NJ
Phone: 609-371-0070
Interview conducted by: Maribelle Rodríguez
Date of interview: January 27, 1998

Mr. Roth indicated that Terra Vac conducts soil vapor extraction operations in-situ as well as ex-situ. He also indicated that Terra Vac will not have to modify their systems. Currently, they can achieve a 95 to 99 percent removal of volatile organic compounds. For semivolatile organic compounds, they can achieve a 30 to 40 percent reduction. However, if the system is run long enough to enhance biological activity, they can achieve a 90 percent reduction. Another adjustment to the remedial process might be the addition of reagents to the soil (chemical oxidation) when treating soils with high concentrations of contaminants or with compounds with high molecular weight. At this time, they are not operating at maximum capacity. They have the manpower and equipment to deal with more projects.

Mr. Scott Drew
Envirogen, Inc.
Location: Lawrenceville, NJ
Phone: 609-936-9300
Interview conducted by: Maribelle Rodríguez
Date of interview: January 27, 1998

Mr. Drew indicated that existing soil vapor extraction systems will require no modifications to meet the alternative treatment standards for contaminated soil. There might be a need for minor adjustments to the systems. For example, longer treatment duration or addition of wells. Soil vapor extraction technology can achieve a 90 percent reduction for volatile organic compounds in soil. For semivolatile organic compounds, bioventing is used and the removal depends on the contaminant. Mr. Drew also indicated that the time needed to install soil vapor extraction systems is between 1 to 5 years. This time period includes the time needed to conduct treatability studies, process design, and implementation of design. Mr. Drew stated that, currently, they are conducting operations at more than 100 sites and have the capacity to treat twice as many sites. Soil vapor extraction equipment is readily available. The only constraint for treating more sites is finding the sites that require the use of this technology. They would definitively expand their business, if there were a market for soil vapor extraction technology.

US EPA ARCHIVE DOCUMENT

Dechlorination
Phone Logs

Mr. Robert Hoch
SDTX Technologies, Inc.
Location: Princeton, NY
Phone: 518-734-4483
Interview conducted by: Maribelle Rodríguez
Date of interview: January 27, 1998

Mr. Hoch stated that the SDTX KPEG process is effective in treating soils contaminated with low or high levels of chlorinated/halogenated contaminants. He indicated that the KPEG process will not require any modifications because the alternative treatment standards for contaminated soil are going to be less stringent and, therefore, easier to meet. Mr. Hoch also indicated that the KPEG process is mostly used to treat soil contaminated with PCBs and dioxins.

US EPA ARCHIVE DOCUMENT

Soil Washing
Phone Logs

Ms. Jill Besch
Alternative Remedial Technologies, Inc.
Location: Tampa, FL
Phone: 813-264-3506
Interview conducted by: Maribelle Rodríguez
Date of interview: January 21, 1998

Ms. Besch indicated that soil washing is the primary line of business of Alternative Remedial Technologies, Inc. She also indicated that they do not expect to have to modify systems or experience any difficulties in meeting the alternative treatment standards for contaminated soil. The treatment approach is adjusted to the waste characteristics. Therefore, the equipment set up is different for each waste they treat. In general, the necessary adjustments to the system are done within a one to two month time period. This time period is used to conduct analysis of waste (e.g., contaminants present in the waste, particle size) and design the treatment process to be applied (treatability study and bench-scale to determine how surfactants and polymers will react with the soil). Currently, they are treating wastes at four sites and could treat an additional two sites without buying additional equipment or having to hire new personnel. If there was the demand, they would expand.

Mr. Dwight Gemar
OHM Remediation Services Corporation
Location: Pleasanton, CA
Phone: 510-227-1105
Interview conducted by: Maribelle Rodríguez
Date of interview: January 21, 1998

Mr. Gemar indicated that soil washing is not their primary line of business. They design treatment/remedial actions on a case-by-case basis and usually soil washing is included as part of a treatment train. He believes that soil washing is not a stand-alone technology for achieving a 90 percent reduction. At best, it could achieve an 80 percent reduction. However, combined with another treatment technology it could be effective in achieving the 90 percent reduction level. Mr. Gemar also stated that, in general, it takes 3 to 4 weeks to conduct treatability studies and an additional 3 to 4 months to pull together system components. Because they do not offer soil washing often, it takes time to set up the system. At this time, the West Division has no active soil washing jobs. They are waiting for one government job in which approximately 30,000 yards of radioactive waste has to be treated. For this job, soil washing would be used as a stand-alone technology. Historically, the soil washing market has been small and, therefore, not worth spending resources on it. However, if the market were there, they would pursue new opportunities.

US EPA ARCHIVE DOCUMENT

Thermal Desorption
Phone Logs

Mr. Mark McCabe
Remediation Technologies, Inc. (ReTec)
Location: Concord, MA
Phone: 508-371-1422
Interview conducted by: Maribelle Rodríguez
Date of interview: January 21, 1998

Mr. McCabe indicated that, as a result of the alternative treatment standards for contaminated soils, they do not expect any significant modifications to their systems. Currently, they aim for a 90 percent reduction. At worst, they will probably need to treat the waste for a longer period of time. He believes that a 90 percent reduction is within the capability of current thermal treatment technologies. ReTec has approximately 100,000 to 150,000 tons/year of additional soil treatment capacity. This includes off-site and on-site treatment capacity. For the off-site services, it would probably take approximately two weeks to characterize the waste. The system is already set up and ready to use. For on-site services, it would take approximately one month for system set up and line up. If the market was there, they would expand.

Mr. Michael Cosmos
Roy F. Weston, Inc.
Location: West Chester, PA
Phone: 610-701-7423
Interview conducted by: Maribelle Rodríguez
Date of interview: January 21, 1998

Mr. Cosmos indicated that most of their projects are Superfund sites and that remedial action plans are designed on a case-by-case basis. For thermal desorption, there are basically two system elements that you could adjust: duration and temperature of treatment. In some cases, equipment needs to be added in order to reach the desired temperature and treatment duration. Although he is not certain of the exact value of the alternative treatment standards, he believes that it would be possible to achieve them if they are in ppm range for semivolatile organic compounds and in ppb range for volatile organic compounds. Contaminant reduction depends on particle size (e.g., sand vs clay matrix). After a certain point, you cannot extract contaminants form the medium no matter what the temperature or duration of treatment is. In general, they need approximately 3 to 6 months for pre-planning and permitting activities. They have one mobile unit with a capacity of 5-7 tons/hour. At this time, this unit is not being used because there is no current contract. If there was the demand, they would expand.

US EPA ARCHIVE DOCUMENT

APPENDIX E-5
TREND ANALYSIS ON THE USE OF INNOVATIVE TREATMENT TECHNOLOGIES

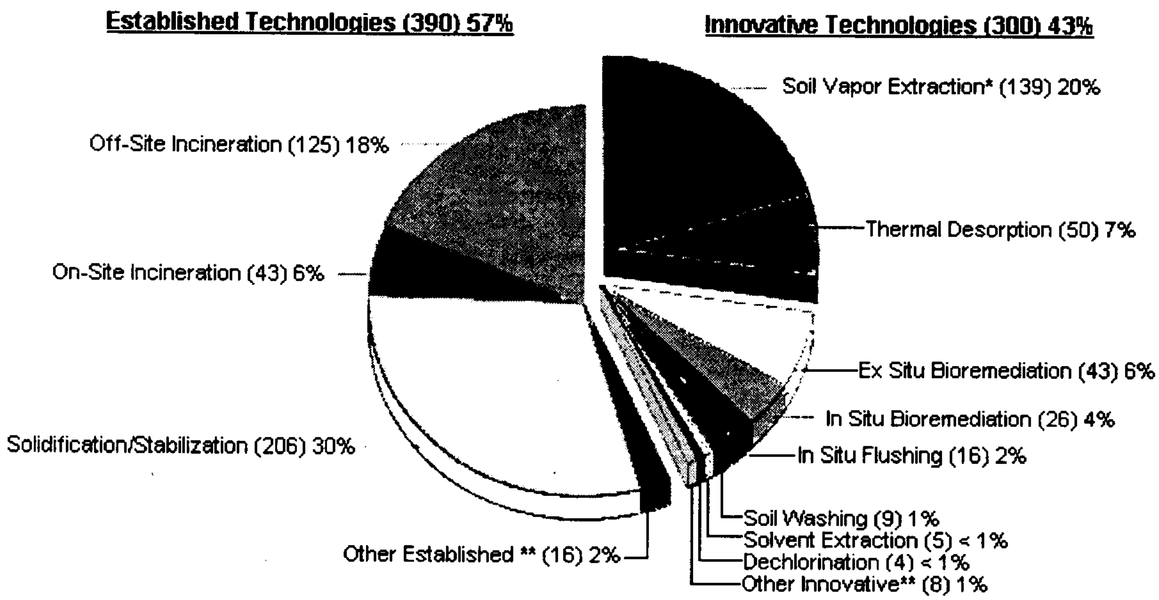
US EPA ARCHIVE DOCUMENT

E-5. Trend Analysis on the Use of Innovative Treatment Technologies

The approach for cleaning up contaminated sites has evolved from emphasizing containment of waste to promoting waste treatment. Prior to the promulgation of Superfund Amendments and Reauthorization Act (SARA) in 1986, the most common methods for remediating hazardous waste were to excavate the contaminated material and dispose of it in an off-site landfill or to contain the waste on site. Because SARA provided a preference for the use of permanent remedies to reduce the toxicity, mobility, or volume of waste, development and use of treatment technologies at remedial sites has increased.

Exhibit 1 presents a summary of source control treatment technologies selected at remedial sites through fiscal year (FY) 1995. As seen in this exhibit, established technologies account for approximately 57 percent of all technology applications for source control at National Priorities List (NPL) sites. Established technologies are those for which cost and performance information is readily available. Innovative treatment technologies account for the remainder 43 percent of all technology applications. For these technologies, there is lack of readily available performance data and cost.

Exhibit 1
Summary of Source Control Treatment Technologies Selected Through Fiscal Year 1995



Note: Data for off-site incineration, solidification/stabilization, and other established technologies based on Records of Decision (RODs) for fiscal years 1982-1995. Data for innovative technologies and on-site incineration based on anticipated design and construction activities as of August 1996. A site may use more than one technology.

( ) Number of times this technology was selected or used.

* Includes three dual-phase extraction projects also listed as in situ groundwater technologies.

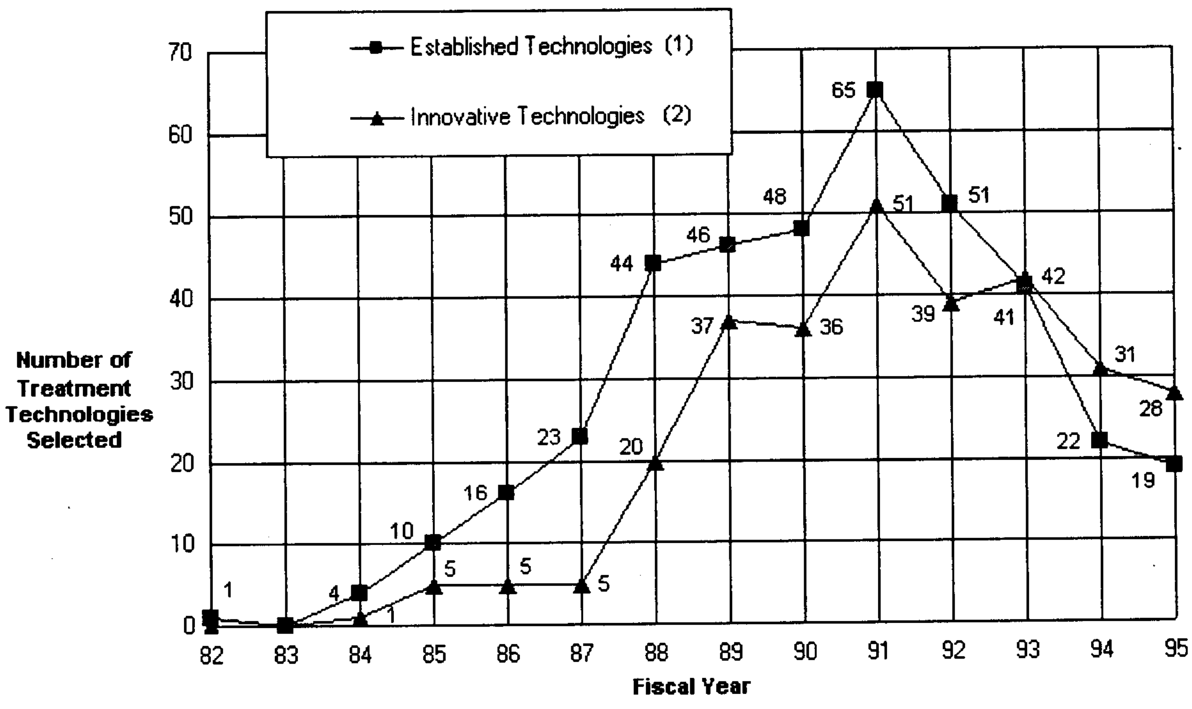
** "Other" established technologies are soil aeration, open detonation, and chemical neutralization. "Other" innovative technologies are hot air injection, physical separation, contained recovery of oily wastes (CROW™), cyanide oxidation vitrification, and plasma high temperature metals recovery.

Source: USEPA, Office of Solid Waste and Emergency Response, Technology Innovation Office, *Innovative Treatment Technologies: Annual Status Report (Eighth Edition)*, EPA-542-R-96-010, November 1996.

Overall, solidification/stabilization has been the most commonly selected technology at the sites, where it accounts for approximately 30 percent of all technology applications for source control. The second most frequently selected technology is incineration. On-site and off-site incineration account for approximately 24 percent of all technology applications. These two technologies are considered established technologies. The third most frequently selected technology is soil vapor extraction (SVE), which accounts for approximately 20 percent of all technology applications. SVE is considered an innovative treatment technology. Other innovative treatment technologies commonly selected at NPL sites are bioremediation (in-situ and ex-situ, 10 percent), thermal desorption (7 percent), soil flushing (2 percent), and soil washing (1 percent).

Although the overall selection of innovative treatment technologies has been lower than that of established treatment technologies, this trend has reversed in recent years for the first time. Exhibit 2 compares the relative use of established and innovative treatment technologies for FY 1982 through FY 1995. As shown in the exhibit, the selection of innovative treatment technologies at NPL sites has surpassed that of established treatment technologies since FY 1993. Preference for the use of these technologies can be likely attributed to their cost-effectiveness and performance.

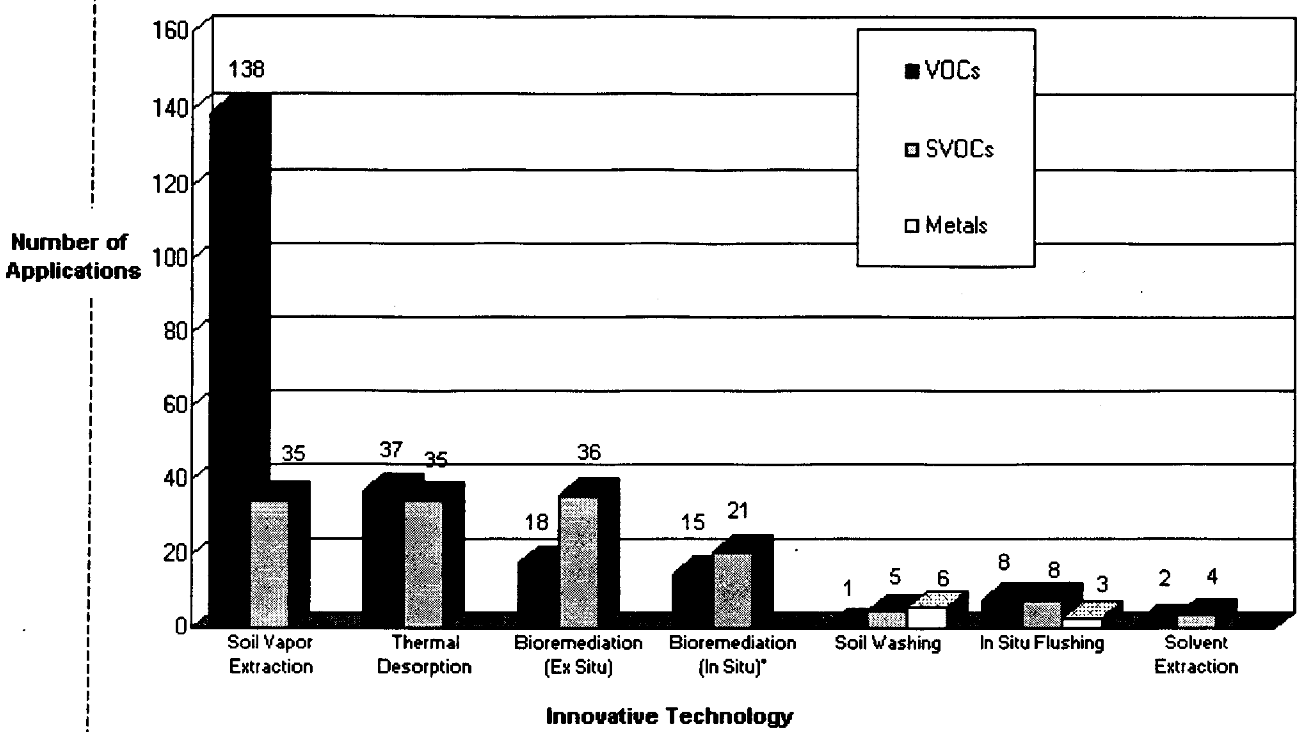
Exhibit 2
Relative Use of Established and Innovative Treatment Technologies



(1) Data based on Records of Decision (RODs), except on-site incineration data, which are based on anticipated design and construction activities as of August 1996.
(2) Data based on anticipated design and constuction activities as of August 1996.
Note: A site may use more than one technology.

Source: USEPA, Office of Solid Waste and Emergency Response, Technology Innovation Office, *Innovative Treatment Technologies: Annual Status Report (Eighth Edition)*, EPA-542-R-96-010, November 1996.

Exhibit 3
Frequency of Selection of Innovative Treatment Technologies



Note: Data are derived from Records of Decision (RODs) for fiscal years 1982-1995 and anticipated design and construction activities as of August 1996.

* Does not include in situ groundwater bioremediation.

Source: USEPA, Office of Solid Waste and Emergency Response, Technology Innovation Office, *Innovative Treatment Technologies: Annual Status Report (Eighth Edition)*, EPA-542-R-96-010, November 1996.

Exhibit 3 shows the frequency of selection of the various innovative treatment technologies to treat each of the three major contaminant groups: volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals. For VOCs in soil, SVE has become the preferred innovative treatment technology. Thermal desorption and bioremediation also are commonly used to treat VOCs. For SVOCs, bioremediation and thermal desorption are the most frequently selected innovative technologies for NPL sites. In addition, SVE has been selected for some of the more volatile SVOCs.[6] For metals, the most frequently selected innovative treatment technology is soil washing. This technology is being used to remediate metals at sites that also contain organics.[7]

The analysis presented in this section reflects the increased use and reliance on innovative treatment technologies. EPA expects this trend to continue as existing technologies are improved and new technologies are developed.

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[6] USEPA, Office of Solid Waste and Emergency Response, Technology Innovation Office, *Innovative Treatment Technologies: Annual Status Report Database* (ITT Database), EPA-542-C-96-002, Draft, January 1997.

[7] USEPA, Office of Solid Waste and Emergency Response, *Cleaning Up the Nation's Waste Sites: Markets and Technology Trends (1996 Edition)*, EPA-542-R-96-005, April 1997.

US EPA ARCHIVE DOCUMENT

APPENDIX E-6
VENDORS OF INNOVATIVE TREATMENT TECHNOLOGIES*

* Information obtained from USEPA, *Vendor Information System for Innovative Treatment Technologies (VISITT)*, EPA 542-R-93-001, April 1996.

GEO-CON, INC.

Address: 4075 Monroeville Boulevard
Corporate One, Building II, Suite 400
City: Monroeville, Pennsylvania 15146
Contact: Linda M. Ward
Title: Regional Director of Business Dev.
Phone: (412) 856-7700

TERRA VAC, INC.

Address: 92 North Main Street, Building 15
P.O. Box 468
City: Windsor, New Jersey 08561-0468
Contact: Louren Martin
Title: Vice President
Phone: (609) 371-0070

ENVIROGEN, INC.

Address: 4100 Quakerbridge Road
Princeton Research Center
City: Lawrenceville, New Jersey 08648
Contact: Scott Drew
Title: Director, Business Development
Phone: (609) 936-9300

DAMES & MOORE

Address: 2325 Maryland Road
City: Willow Grove, Pennsylvania 19090
Contact: Joseph M. Tarsavage, P.E.
Title: Senior Chemical Engineer
Phone: (215) 657-5000

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QUATERNARY INVESTIGATIONS, INC.

Address: 300 West Olive Street, Suite A
City: Colton, California 92324
Contact: Tony Morgan
Title: President
Phone: (800) 423-0740

IT CORPORATION

Address: 2925 Briar Park
City: Houston, Texas 77042
Contact: John Mastroianni
itle: Project Manager
Phone: (713) 784-2800

APPLIED REMEDIAL TECHNOLOGIES

Address: 220 Montgomery Street, Suite 432
City: San Francisco, California 94104
Contact: Mr. Apri S. Ghuman/
Siby A. Vadakekkara
Title: Principal Engineer/Asociate Engineer
Phone: (415) 986-1284

DECHLORINATION

SDTX TECHNOLOGIES, INC.

Address: 706 Sayre Drive
City: Princeton, New York 08540
Contact: Robert Hoch
Title: Vice President, Technology
Phone: (518) 734-4483

COMMODORE APPLIED TECHNOLOGIES, INC.

Address: 1487 Delashmut Avenue
City: Columbus, Ohio 43212
Contact: Neil Drobny/Albert Abel
Title: Group Vice President/Senior Scientist
Phone: (614) 297-0365

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WESTINGHOUSE REMEDIATION SERVICES, INC.

Address:	675 Park North Boulevard Building F, Suite 100
City:	Clarkston, Georgia 30021
Contact:	William E. Norton, P.E.
Title:	Senior Engineer
Phone:	(404) 299-4736

ALTERNATIVE REMEDIAL TECHNOLOGIES, INC.

Address:	14497 North Dale Mabry Highway Suite 240/140
City:	Tampa, Florida 33618
Contact:	Michael J. Mann, P.E./Jill Besch
Title:	President
Phone:	(813) 264-3506

DIVESCO, INC.

Address:	5000 Highway 80 East
City:	Jackson, Mississippi 39208
Contact:	W. L. Strickland
Title:	President
Phone:	(601) 825-4644

METCALF & EDDY, INC.

Address:	Route 22 West & Station Road
City:	Branchburg, New Jersey 08876
Contact:	Michael F. Warminsky
Title:	Hazardous Waste Product Manager
Phone:	(908) 685-6067

BERGMANN USA

Address:	1550 Airport Road
City:	Gallatin, Tennessee 37066-3739
Contact:	Jan Limaye
Title:	Senior
Phone:	(615) 452-5500

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TVIES, INC.

Address:	440 Benmar, Suite 2250
City:	Houston, Texas 77060
Contact:	Randy Hall
Title:	Vice President in Marketing
Phone:	(713) 447-5544

HYDRIPLEX, INC.

Address:	14730 Sandy Creek Drive
City:	Houston, Texas 77070
Contact:	John S. Crowley/Gary Walter
Title:	Vice-President/Sales Manager
Phone:	(713) 370-2778

B&W NUCLEAR ENVIRONMENTAL SERVICES, INC.

Address:	2220 Langhorne Road
City:	Lynchburg, Virginia 24506-0548
Contact:	Richard Lynch
Title:	Senior Business Analyst
Phone:	(804) 948-4673

EARTH DECONTAMINATORS, INC. (EDI)

Address:	2803 Barranca Parkway
City:	Irvine, California 92714
Contact:	Luis Pommier
Title:	Managing Director
Phone:	(714) 262-2292

OHM REMEDIATION SERVICES CORPORATION

Address:	5731 West Las Positas Boulevard
City:	Pleasanton, California 94588
Contact:	Dwight Gemar
Title:	Senior Project Engineer
Phone:	(510) 227-1105

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SMITH ENVIRONMENTAL TECHNOLOGIES CORP.

Address:	304 Inverness Way South, Suite 200
City:	Englewood, Colorado 80112
Contact:	Dave Ehlers
Title:	Director - Waste Treatment Technologies
Phone:	(303) 790-1747

SOIL FLUSHING - IN SITU

HORIZONTAL TECHNOLOGIES, INC.

Address:	4767 Pine Island Road, NW
City:	Matlacha, Florida 33993
Contact:	Donald R. Justice
Title:	President or Vice President
Phone:	(941) 283-5640

THERMAL DESORPTION

HRUBETZ ENVIRONMENTAL SERVICES, INC.

Address:	5949 Sherry Lane, Suite 525
City:	Dallas, Texas 75225
Contact:	Barbara Hrubetz
Title:	Chief Executive Officer
Phone:	(214) 363-7833

RECYCLING SCIENCE INTERNATIONAL, INC.

Address:	175 West Jackson Boulevard, Suite A1934
City:	Chicago, Illinois 60604-2601
Contact:	William C. Meenan/Neil Ryan
Title:	President / CFO
Phone:	(312) 663-4242

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SOIL REMEDIATION OF PHILADELPHIA, INC.

Address:	3201 South 61st Street
City:	Philadelphia, Pennsylvania 19153
Contact:	Matthew Paolino
Title:	General Manager
Phone:	(215) 724-5520

SEPARATION AND RECOVERY SYSTEMS, INC.

Address:	1762 McGaw Avenue
City:	Irvine, California 92714-4962
Contact:	William J. Sheehan
Title:	Senior Vice President
Phone:	(714) 261-8860

THERMOTECH SYSTEMS CORPORATION

Address:	5201 North Orange Blossom Trail
City:	Orlando, Florida 32810
Contact:	M.A. Howard, P.E.
Title:	Product Manager
Phone:	(407) 290-6000

DURATHERM, INC.

Address:	P.O. Box 58466
City:	Houston, Texas 77258
Contact:	Brad Hogan
Title:	Vice president
Phone:	(713) 339-1352

SMITH ENVIRONMENTAL TECHNOLOGIES CORP.

Address:	304 Inverness Way South, Suite 200
City:	Englewood, Colorado 46304
Contact:	Joseph H. Hutton
Title:	Regional Manager
Phone:	(303) 790-1747

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MERCURY RECOVERY SERVICES, INC.

Address:	700 Fifth Avenue
City:	New Brighton, Pennsylvania 15066
Contact:	William F. Sutton
Title:	President
Phone:	(412) 843-5000

PET-CON SOIL REMEDIATION, INC.

Address:	P.O. Box 205
City:	Spring Green, Wisconsin 53588
Contact:	Tom Labudde
Title:	General Manager
Phone:	(608) 588-7365

CARLO ENVIRONMENTAL TECHNOLOGIES, INC.

Address:	44907 Trinity Drive P.O. Box 744
City:	Clinton Township, Michigan 48038-0744
Contact:	Keith Flemingloss
Title:	Manager of Environmental Services
Phone:	(810) 468-9580

ARIEL INDUSTRIES, INC.

Address:	2204 Industrial South Road
City:	Dalton, Georgia 30721
Contact:	Timothy L. Boyd
Title:	N/A
Phone:	(706) 277-7070

ADVANCED ENVIRONMENTAL SERVICES, INC.

Address:	Corporate Centre 200, Box 160 200 35th Street
City:	Marion, Iowa 52302-0160
Contact:	Tad Cooper
Title:	Business Director
Phone:	(800) 289-7371

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ROY F. WESTON, INC.

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City:	West Chester, Pennsylvania 19380
Contact:	Michael G. Cosmos, P.E./Al Murphy
Title:	Treatment Systems Department Manager
Phone:	(610) 701-7423

WESTINGHOUSE REMEDIATION SERVICES, INC.

Address:	675 Park North Boulevard Building F, Suite 100
City:	Clarkston, Georgia 30021-1962
Contact:	Jeff Rouleau
Title:	Project Engineer
Phone:	(404) 299-4698

RUST INTERNATIONAL, INC.

Address:	Clemson Technology Center 100 Technology Drive
City:	Anderson, South Carolina 29625
Contact:	Carl Palmer
Title:	Project Manager
Phone:	(864) 646-2413

SOIL SOLUTIONS, INC.

Address:	1703 Vargrave Street
City:	Winston-Salem, North Carolina 27107
Contact:	Jon Ransom
Title:	Business Manager
Phone:	(910) 725-5844

MIDWEST SOIL REMEDIATION, INC.

Address:	1480 Sheldon Drive
City:	Elgin, Illinois 60120
Contact:	Bruce Penn
Title:	General Manager
Phone:	(847) 742-4331

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REMTECH, INC.

Address:	9109 West Electric Avenue
City:	Spokane, Washington 99204-9035
Contact:	Keith G. Carpenter/William R. Bloom
Title:	President/Operations Manager
Phone:	(509) 624-0210

MAXYMILLIAN TECHNOLOGIES, INC.

Address:	1801 East Street
City:	Pittsfield, Massachusetts 01201
Contact:	Neal Maxymillian
Title:	Vice President
Phone:	(617) 557-6077

KALKASKA CONSTRUCTION SERVICE, INC.

Address:	500 South Maple
	P.O. Box 427
City:	Kalkaska, Michigan 49646
Contact:	David Hogerheide/Justin Straksis
Title:	Vice President/Superintendent
Phone:	(616) 258-9134

COVENANT ENVIRONMENTAL TECHNOLOGIES, INC.

Address:	45 South Idlewild, Suite 107
City:	Memphis, Tennessee 38104
Contact:	Valerie Humpherys
Title:	Controller
Phone:	(901) 278-2134

REMEDIATION TECHNOLOGIES, INC.

Address:	9 Pond Lane
	Damonmill Square
City:	Concord, Massachusetts 01742
Contact:	Mark Mccabe
Title:	Scientist
Phone:	(508) 371-1422

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PURGO, INC.

Address:	11023 Washington Highway, Suite 100
City:	Glen Allen, Virginia 23059
Contact:	David Holcomb/Coleman King/Bill Grove
Title:	Sales Exec./Spec. Projects Manager/VP
Phone:	(804) 550-0400

SOUTHWEST SOIL REMEDIATION, INC.

Address:	3951 East Columbia Street
City:	Tucson, Arizona 85714
Contact:	Trevor Johansen
Title:	President
Phone:	(602) 571-7174

CONTECK ENVIRONMENTAL SERVICES, INC.

Address:	22460 Highway 169 Northwest
City:	Elk River, Minnesota 55330-9235
Contact:	Chris Kreger
Title:	President
Phone:	(612) 441-4965

ENVIRO-KLEAN SOILS, INC.

Address:	P.O. Box 2003
City:	Snoqualmie, Washington 98065
Contact:	R.T. Cokewell
Title:	President
Phone:	(206) 888-9388

SPI/ASTEC

Address:	P.O. Box 72787 4101 Gerome Avenue
City:	Chattanooga, Tennessee 37407
Contact:	Wendell R. Feltman, P.E.
Title:	Vice President
Phone:	(423) 867-4210

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MCLAREN/HART ENVIRONMENTAL ENGINEERING

Address:	9323 Stockport Place
City:	Charlotte, North Carolina 28273
Contact:	Jeff O'Ham/Cary Lester
Title:	Technical Director/Project Manager
Phone:	(704) 587-0003

PHILIP ENVIRONMENTAL SERVICES CORP.

Address:	10 Duff Road, Suite 500
City:	Pittsburgh, Pennsylvania 15235
Contact:	Teresa Sabol Spezio
Title:	Senior Engineer
Phone:	(412) 244-9000

SOILTECH ATP SYSTEMS, INC.

Address:	304 Inverness Way South
City:	Englewood, Colorado 80112
Contact:	Joe Hutton
Title:	President
Phone:	(303) 790-1747

TPS TECHNOLOGIES, INC.

Address:	1964 South Orange Blossom Trail
City:	Apopka, Florida 32703
Contact:	George Chapas
Title:	Director of Sales and Marketing
Phone:	(407) 886-2000

CLEAN-UP TECHNOLOGY, INC.
Technology Trade Name: N/A

Address:	145 West Walnut Street
City:	Gardena, California 90248
Contact:	Ron Morris
Title:	National Sales Manager
Phone:	(310) 327-8605

BIOLOGICAL TREATMENT

MICROBIAL ENVIRONMENTAL SERVICES (MES)

Address: 11270 Aurora Avenue
City: Des Moines, Iowa 50322-7905
Contact: Jack Sheldon
Title: Branch Manager
Phone: (515) 276-3434

BILLINGS & ASSOCIATES, INC.

Address: 3816 Academy Parkway N-N.E.
City: Albuquerque, New Mexico 87109
Contact: Dr. Gale K. Billings
Title: General Manager
Phone: (505) 345-1116

SBP TECHNOLOGIES, INC.

Address: One Sabine Island Drive
City: Gulf Breeze, Florida 32561-3999
Contact: James Mueller, Ph.D.
Title: Environmental Microbiologist
Phone: (904) 934-9352

B&S RESEARCH, INC.

Address: 4345 Highway 21
City: Embarrass, Minnesota 55732
Contact: H.W. Lashmett
Title: CEO
Phone: (218) 984-3757

KELLER ENVIRONMENTAL INC.

Address: 1325 West Lake Street
City: Roselle, Illinois 60172
Contact: Glen A. Gorski, P.E.
Title: Business Development Manager
Phone: (630) 529-5858

US EPA ARCHIVE DOCUMENT

BIOGEE INTERNATIONAL, INC.

Address:	16300 Katy Freeway, Suite 100
City:	Houston, Texas 77094-1609
Contact:	Trey Barber
Title:	President
Phone:	(713) 578-3111

MICROBIAL INTERNATIONAL

Address:	463 North Shattuck Place
City:	Orange, California 92866
Contact:	Bud Kennedy/Larry Christensen
Title:	CEO/Marketing
Phone:	(714) 666-0924

MIDWEST MICROBIAL, L.C.

Address:	15446 214th Street
City:	Council Bluffs, Iowa 51503
Contact:	Del Christensen/Al Lees
Title:	N/A
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APPENDIX E-7
CAPACITY ANALYSIS UPDATE FOR WOOD PRESERVING SOILS

Capacity Analysis Update for Wood Preserving Soils

This appendix re-evaluates the two-year capacity variance provided previously for soils contaminated with newly listed Phase IV wood preserving wastes (62 FR 25998, May 12, 1997) in light of the alternative soil treatment standards currently being promulgated.

Background

The final Phase IV rule potentially provides relief to the treatment of wood preserving remediation soils by relaxing LDR soil treatment standards to 10 times the Universal Treatment Standard (UTS) or 90 percent reduction, thus allowing the use of less aggressive innovative treatment technologies. For example, some soil volumes with high contaminant concentrations treated by incineration to meet current UTS could shift, under the final Phase IV rule, to a non-combustion treatment technology to meet 10 times UTS or 90 percent reduction. This potential shift away from incineration could increase available combustion capacity. Furthermore, other soil that contain high concentrations of organics that currently need to be incinerated to meet UTS could also shift under the Phase IV rule to non-combustion treatment technologies. If the shift away from incineration is large enough to increase available combustion capacity to meet the required combustion capacity, there may no longer be a need for a two-year capacity variance for wood preserving remediation soils.

The final LDR rulemaking on newly listed wastes from wood preserving (62 FR 25998, May 12, 1997) granted a two-year national capacity variance for soil and debris contaminated with newly listed wood preserving waste because of an available combustion capacity shortfall. The Agency estimated that available capacity to treat only soils and debris that require combustion is about 12,900 to 49,775 tons/year. In contrast, the Agency estimated that between 100,000 and 260,000 tons/year of soil and debris from Superfund remedial actions that are contaminated with mixtures of F032 F034 and F035 wastes may require additional combustion capacity. The required capacity is even larger when soils and debris generated under RCRA corrective actions and closures, State cleanups, and voluntary cleanups are included in the required capacity estimate. Furthermore, logistics issues may severely hamper the ability of a site manager to obtain adequate incinerators in the near term. Most incinerators that can manage non-pumpable materials only accept such materials in small quantities, and fewer than five of the RCRA-permitted incinerators can handle truckloads or railcar volumes of contaminated waste.

The Phase IV alternative soil treatment standards would not apply to debris wastes. Although, the Agency did not estimate required capacity separately for soil and debris, based on the 1993 BRS data used by EPA in its original capacity analysis, wood preserving remediation wastes consist of greater than 99 percent soil and less than one percent debris.

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Approach

To analyze the effect of the alternative soil treatment standards on combustion capacity for wood preserving wastes, the following information was obtained and evaluated.

- Case summaries of wood preserving waste sites to determine whether non-combustion technologies can meet the Phase IV alternative soil treatment standards.

- Estimates of the volume of wood preserving wastes that are likely to require combustion to meet the alternative soil treatment standards.

Capability of Non-combustion Treatment to Meet Alternative Soil Standards for Wood Preserving Wastes

Tables 1 and 2 contain case summaries of wood preserving sites containing organic and inorganic wastes, respectively. As seen by these tables, only a limited number of completed sites with data could be found on initial search, notwithstanding the fact that more than 50 wood preserving sites listed on the National Priorities List (NLP) have a signed ROD. This could be because many of the sites are using innovative technologies such as bioremediation to address large volumes of lower concentration contaminated soil and have removed and treated hot spots using incineration. Although the hot spot removal and treatment can be completed in a short period of time the larger volumes of soil treated using bioremediation can take much longer. Thus, the sites are not reported as complete until all soil treatment is complete. The available data on completed sites is very limited and may not be representative of the overall treatment effectiveness of a particular technology for a waste type. Nevertheless, the limited data shows that for the major contaminants, treatment is meeting the alternative soil treatment standards. It should be noted, however, that at none of the case studies identified are treatment data presented for dioxins or furans. These constituents are generally the most difficult to treat with non-combustion technologies. The lack of treatment information for dioxins and furans may indicate that, at some sites, soils contaminated with these constituents are being segregated from other soils, excavated and incinerated off-site.

Effect of Alternative Treatment Standards on Available Combustion Capacity

EPA recently analyzed the expected changes in soil treatment as part of the economic impact analysis of the Phase IV rule.[8] EPA expects that facilities generating soil exhibiting the TC for organic constituents and non-TC soils containing listed wastes will most likely recognize cost savings as a result of the new soil standards because they will be treated with less expensive treatment methods, thus possibly freeing up combustion capacity for wood preserving wastes.

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[8] EPA, "Application of the Phase IV Land Disposal Restrictions to Contaminated Media: Cost, Cost Savings, and Economic Impacts," Office of Solid Waste prepared by ICF Inc., Contract Number 68-W4-0040, February 23, 1998.

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Table 1
Case Summaries of Organic Contaminated Wood Preserving Waste Sites Treated Using Innovative Technologies

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance					Contaminant Source	Treatment Duration	Data Source
			Before (ppm unless noted)	After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR			
Sweetwater Wood Preserving Site, TN; Retec	Slurry Phase Biodegradation	Phenol	14.6	0.7	95.2	62	yes	Wood Preserving Sludge	NA	1, 2
		Napthalene	3,670	23	99.4	56	yes			
		Fluoranthene	5470	67	98.8	34	yes			
		Carbazole	1490	4.9	99.7	NA	yes			
		Phenanthrene/Anthacene	30700	200	99.3	56/34	yes			
		Pentachlorophenol	687	12.3	98.2	74	yes			
Unknown Wood Preserving Site; Environmental Solutions, Inc.	Slurry Phase Biodegradation	Phenol	3.91	<0.01	>99.7	62	yes	Wood Preserving Wastes	NA	1, 2
		2,4-Dimethylphenol	7.73	<0.01	>99.8	140	yes			
		p-Chloro-m-Cresol	118.62	<0.01	>99.9	140	yes			
		2,4-Dinitrophenol	4.77	<0.03	>99.3	1600	yes			
		Napthalene	1078.55	<0.01	>99.9	56	yes			
		Acenaphthylene	998.8	1.4	>99.8	34	yes			
		Phenanthrene/Anthacene	6832.07	3.8	99.9	56/34	yes			
		Fluoranthene	1543.06	4.9	99.7	34	yes			
		Chrysene/Benz(a)-anthracene	519.32	1.4	99.7	34	yes			
		Benzo(a)pyrene	82.96	0.1	99.9	34	yes			
		Indeno(1,2,3-cd)-pyrene/dibenz (a,h)-anthracene	84.88	0.5	99.4	34/82	yes			
		Carbazole	135.4	<0.05	>99.9	NA	yes			
		2-Chlorophenol	1.89	<0.01	>99.4	57	yes			
		2,4,6-Trichlorophenol	118.62	<0.01	>99.9	74	yes			
		Tetrachlorophenol	11.07	<0.02	>99.8	74	yes			
		Pentachlorophenol	420.59	3.1	99.3	74	yes			
		Benzo(b)fluroanthene	519.32	<0.03	>99.9	60	yes			
Wood Preserving Site, MO; Bogart Environmental Services, Inc.	Slurry Phase Biodegradation	Creosote	1,000 - 10,000	<250	>75.0 ->97.5	NA	yes ?	Wood Preserving Wastes	NA	1, 3
MacGillis & Gibbs Superfund Site, Unknown Location; Eimco Process Equipment Co.	Slurry Phase Biodegradation	Pentachlorophenol	5,500	550	90	74	yes	Wood Preserving Wastes	NA	1, 3

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Table 1 (continued)
Case Summaries of Organic Contaminated Wood Preserving Waste Sites Treated Using Innovative Technologies

Site/Vendor	Treatment Technology	Contaminant(s)	Technology Performance					Contaminant Source	Treatment Duration	Data Source
			Before (ppm unless noted)	After (ppm unless noted)	% Re-duced	10xUTS (mg/kg)	Meets LDR			
Escambia Wood Treating Co. Superfund Site, Pensacola, FL; Vendor Unknown	High Temperature Thermal Desorption	PAH	550 - 1,700	453	91.8 - 97.4	NA	yes	Wood Preserving Wastes	NA	1, 4
		PCP	48 - 210	NA	93.8 - 98.6	NA	yes			
Wood Preserving Facility, MN; Thermotech Systems Corporation	High Temperature Thermal Desorption	Napthalene	2900	0.31	>99.9	56	yes	Wood Preserving Wastes	NA	1, 3
		1-Methylnapthalene	370	ND	>99.9	NA	yes			
		Acenaphthene	96	ND	>99.9	34	yes			
		Fluorene	130	ND	>99.9	34	yes			
		Anthracene	250	ND	>99.9	34	yes			
		Fluoranthracene	200	0.11	>99.9	34	yes			
		Pyrene	250	ND	>99.9	82	yes			
		Chrysene	100	0	>99.9	34	yes			
		Benzo(a)anthracene	24	0.13	99.5	34	yes			
		Benzo(b)fluoranthene	55	ND	>99.9	68	yes			
Scott Lumber	Bioremediation (ex situ) - Land Treatment	PAH	560 - 700	130 - 155	77 - 78	NA	unknown	Wood Preserving Wastes	10 months	5
		Benzo(a)pyrene	16 - 23	8 - 10	50 - 57	34	yes			
Burlington Northern Railroad Tie Treating Plant	Bioremediation (ex situ) - Land Treatment	PAH	8632	100	98.8	NA	yes	Wood Preserving Wastes	8 years	5
		SVOC	NA	NA	NA	NA	unknown			
		Methylene chloride	NA	NA	NA	NA	unknown			

Data Sources

1. Excerpt from table in "Contaminated Soil Treatment Technologies Analysis of Treatability Data," Office of Solid Waste, US EPA, April 1997.
2. U.S. EPA, "Engineering Bulletin, Slurry Biodegradation," Office of Research and Development, EPA/540/2-90/016, September 1990.
3. U.S. EPA, "Vendor Information System for Innovative Treatment Technologies (VISITT) - Version 5.0," Office of Solid Waste and Emergency Response, August 1996.
4. Department of Defense Environmental Technology Transfer Committee, "Remediation Technologies Screening Matrix and Reference Guide," Second Edition, Federal Remediation Technologies Roundtable, EPA-542-B-94-013, October 1994.
5. U.S. EPA, "Innovative Treatment Technologies: Annual Status Report Database (Version 2.0) - ITT Database", Office of Solid Waste and Emergency Response, EPA-542-C-96-002, 1996.

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Table 2
Case Summaries of Inorganic Contaminated Wood Preserving Waste Sites Treated Using Innovative Technologies

Site	Study Type	Treatment Technology	Contaminants	Technology Performance					Waste Volume /Type	Contaminant Source	Treatment Duration	Data Source	Mgmt On- or Off-site
				Before (ppm)	After (ppm)	% Re-duced	10x UTS	Meets LDR					
Valley Wood Preserving Inc., Turlock, CA	Full-scale	Stabilization	Arsenic Chromium IV	>2 >4	NA NA	NA NA	50 8.5	unknown unknown	15,000cy soil	Wood preserving wastes	NA	1	On-site
J.H. Baxter Co., Weed, CA	Full-scale	Bioremediation/ Stabilization	Arsenic	>8	NA	NA	50	unknown	41,000cy soil	Wood preserving wastes	NA	1	On-site
Palmetto Wood Preserving Cayce, SC	Full-scale	Soil Washing	Arsenic Chromium	2-6,200 4-6,200	<1 627	>99 89.9	50 8.5	yes no ?	13,00cy soil	Wood preserving wastes	4 months	7	On-site

Data Sources

1. Superfund Record of Decisions, Superfund Public Information System, CD-ROM database of RODs and other public data related to CERCLA sites, USEPA, May 1997.

2. Innovative Treatment Technologies: Annual Status Report (Fifth Edition) - Applications of New Technologies at Hazardous Waste Sites, Office of Solid Waste and Emergency Response, EPA-542-R-93-003, USEPA, September 1993.

The Agency estimates that in the absence of the Phase IV alternative soil treatment standards, 52 percent of the TC organic soils and 11 percent of the listed soils treated ex-situ would be treated by incineration or thermal desorption. The Agency's analysis assumes, based on recent technology trends, that within this portion of soil (11 percent), 75 percent would be treated by incineration and 25 percent by thermal desorption. This analysis also estimates that, of the TC organic and listed soil that currently is treated by incineration or thermal desorption under existing LDRs, 14 percent would switch to other ex-situ treatment methods as a result of the alternative soil treatment standards. Table 3 presents EPA's estimates of soil that would shift from incineration to other treatment under the Phase IV rule. The shift from combustion to non-combustion treatment by TC organic and listed soils would free up about 10,000 tons/year of combustion capacity.

The Agency estimated that between 100,000 and 260,000 tons/year of soil and debris from Superfund remedial actions that are contaminated by mixtures of F032, F034, and F035 wastes may require incineration to meet the wood preserving wastes final rule.[9] (This estimate is about 10 to 28 percent of the total volume of soil estimated to be treated ex-situ outside of a CAMU or AOC (about 940,000 tons/year). However, between 1985 and 1993, 1,261 RODs were signed.[10] Of those, 51 RODs or four percent were for wood preserving sites.[11] If these estimates are correct, it would appear that wood preserving sites generate significantly larger volumes of highly contaminated soil that other remediation sites.) A portion of this waste would be expected to shift from combustion to non-combustion treatment under the Phase IV rule. However, there is insufficient information on the characteristics of this waste to determine whether the portion of wood preserving soil that would shift is similar to the portion of TC organic or listed soil that is expected to shift. EPA suspects that a smaller portion of wood preserving soil would shift to non-combustion treatment, because the soil contains high concentrations of chemicals such as dioxins and furans that are difficult to treat by alternative technologies. Nevertheless, as an upper bound estimate, EPA assumes that the portion of wood preserving soil that would shift to non-combustion treatment is similar to the portions (14 percent) of TC organic and listed soil that EPA expects will shift under the Phase IV rule. Thus, at most about 14,000 to 36,400 tons/year of wood preserving soils that EPA expected to be incinerated under the wood preserving waste LDR final rule would shift to non-combustion treatment under the Phase IV rule. Based on this upper bound estimate, about 86,000 to 223,000 tons/year of wood preserving soil from Superfund remedial actions would continue to require incineration (in addition to soil from RCRA corrective actions and other sources).

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[9] EPA, " Background Document for Land Disposal Restrictions - Wood Preserving Wastes (Final Rule), Capacity Analysis and Response to Capacity-Related Comments," April 1997a.

[10] EPA, "Cleaning Up the Nation's Waste Sites: Markets and Technology Trends, " EPA 542-R-96-005, April 1997b.

[11] EPA, 1997a, *op cit*., Appendix H.

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Available combustion capacity for soil is about 12,900 to 49,775 tons/year.[12] As described above, about 10,000 tons/year of combustion capacity could become available under the Phase IV rule because of the shift from incineration of TC organics and listed soil to other treatment. This newly available combustion capacity would not be sufficient to meet the required capacity for wood preserving soils. If additional combustion becomes available because of wood preserving soils switching to non-combustion treatment, then at the upper bound, available combustion capacity could rise to about 26,900 to 95,500 tons/year. This potential increase in combustion capacity, at best, might meet the lower bound required combustion capacity for wood preserving soils.

[12] EPA, 1997a, *op cit*.

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Table 3
Estimated Volume of Soil Shifting from Incineration Under Phase IV Rule (Tons/Year)

Remediation Category	Treated Ex-Situ Outside of CAMU or AOC	Exhibiting TC for Organics		TC Organic Soil Treated Ex-Situ with Incineration/Thermal Desorption		TC Organic Soil Treated Ex-Situ w/ Incineration Only		Switching Ex-Situ Treatments	
		%	Tons	%	Tons	%	Tons	%	Tons
CERCLA Remedial Action Soil	140,000	9	12,600	52	6,552	75	4,914	14	688
RCRA Corrective Action Soil	110,000	18	19,800	0	0	0	0	0	0
RCRA Closures Soil	50,000	18	9,000	0	0	0	0	0	0
State Superfund Soil	130,000	12	15,600	52	8,112	75	6,084	14	852
Voluntary Cleanup Soil	510,000	12	61,200	52	31,824	75	23,868	14	3,342
Totals	940,000		118,200		46,488		34,866		4,881

Remediation Category	Treated Ex-Situ Outside of CAMU or AOC	Non-TC (Listed)		Non-TC Soil Treated Ex-Situ with Incineration/Thermal Desorption		TC Organic Soil Treated Ex-Situ w/ Incineration Only		Switching Ex-Situ Treatments	
		%	Tons	%	Tons	%	Tons	%	Tons
CERCLA Remedial Action Soil	140,000	68	12,600	11	1,386	75	1,040	14	146
RCRA Corrective Action Soil	110,000	75	19,800	0	0	0	0	0	0
RCRA Closures Soil	50,000	75	37,500	0	0	0	0	0	0
State Superfund Soil	130,000	68	88,400	11	9,724	75	7,293	14	1,021
Voluntary Cleanup Soil	510,000	68	346,800	11	38,148	75	28,611	14	4,006
Totals	940,000		505,100		49,258		36,944		5,172

Total Switching from Incineration 10,053

Source: EPA, "Application of the Phase IV Land Disposal Restrictions to Contaminated Media: Cost, Cost Savings, and Econiomic Impacts," Office of Solid Waste, prepared by ICF, Inc., Contract No. 68-W4-0400, February 23, 1998, Exhibits 3-4 and 3-5.

CAMU - Corrective Action Management Unit, AOC - Area of Contamination

US EPA ARCHIVE DOCUMENT