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Presumptive Remedies:

Site Characterization and Technology Selection For CERCLA Sites With Volatile Organic Compounds In Soils

Office of Emergency and Remedial Response
Hazardous Site Control Division 5203G
Quick Reference Fact Sheet

Since Superfund's inception in 1980, the remedial and removal programs have found that certain categories of sites have similar characteristics, such as types of contaminants present, types of disposal practices, or how environmental media are affected. Based on information acquired from evaluating and cleaning up these sites, the Superfund program is undertaking an initiative to develop presumptive remedies to accelerate future cleanups at these types of sites. The presumptive remedy approach is one tool of acceleration within the **Superfund Accelerated Cleanup Model (SACM).**

Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. The objective of the presumptive remedies initiative is to use the program's past experience to streamline site investigation and speed up selection of cleanup actions. Over time presumptive remedies are expected to ensure consistency in remedy selection and reduce the cost and time required to cleanup similar types of sites. Presumptive remedies are expected to be used at all appropriate sites except under unusual site-specific circumstances.

This directive identifies the presumptive remedies for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites with soils contaminated by ***volatile organic compounds (VOCs).*** In addition, EPA is developing guidance on presumptive remedies for wood treatment, municipal landfill, PCB, grain storage, coal gasification, and contaminated ground-water sites. EPA has also developed a directive entitled *Presumptive Remedies: Policy and Procedures*, (Directive 9355. 0-47FS) which outlines and addresses the issues common to all presumptive remedies (e.g., role of *innovative technologies,* consistency with the NCP, State, community involvement).

PURPOSE

The purpose of this directive is to provide guidance on selecting a presumptive remedy at sites with soils contaminated with VOCs. Specifically this guidance:

- Presents the presumptive remedies for this site type;
- Describes the presumptive remedy process in terms of site characterization and technology screening steps; and
- Outlines the data required to select these presumptive remedies.

Since a presumptive remedy is a technology that EPA believes, based upon its past experience, generally will be the most appropriate remedy for a specified type of site, the presumptive remedy approach will accelerate site-specific analysis of remedies by focusing the feasibility study efforts. Where several presumptive remedies are identified, EPA believes that all deserve substantial consideration before utilizing the presumptive remedy approach. EPA personnel should review the directive entitled *Presumptive Remedies: Policy and Procedures* (Directive 9355.0-47FS) for general information on the presumptive remedy process.

Soil vapor extraction (SVE), thermal resorption, and **incineration** are the presumptive remedies for Superfund sites with VOC-contaminated soil assuming the site characteristics meet certain criteria. Table 1 provides a brief description of each of these presumptive remedies.

The decision to establish these technologies as presumptive remedies for this site type is based on EPA's collective knowledge about site investigation and remedy selection for VOC-contaminated soils,

TABLE 1 Presumptive Remedies for VOCs in Soil
Soil Vapor Extraction - Soil vapor extraction (SVE) is an in-situ or ex-situ process which physically removes contaminants from ***vadose zone*** soils by inducing air flow through the soil matrix. The flowing air strips volatile compounds from the solids and carries them to extraction wells. The recovered vapors may require further treatment. In-situ SVE is the primary focus of this document.
Thermal Resorption - Thermal desorption is an ex-situ process that uses direct or indirect heat exchange to vaporize organic contaminants from soil, sediment, sludge or other solid and semisolid matrices. The vapors are then condensed or otherwise collected for further treatment.
Incineration - Incineration is an ex-situ engineered process that employs thermal decomposition via oxidation at temperatures usually greater than 900 °C to destroy the organic fraction of the waste.
The major difference between thermal desorption and incineration is that incineration oxidizes organic compounds, thereby destroying the hazardous material. Thermal desorption volatilizes contaminants, then concentrates them. Thermal desorption reduces the volume of contamination, but the concentrated waste stream still requires treatment. Disposal or treatment of residual waste stream, ash, and concentrated VOC effluent is not covered by this directive. Options such as off-site disposal/regeneration or reuse should be considered.

including field experience from the Superfund, Resource Conservation and Recovery Act (RCRA), and Underground Storage Tank (UST) programs. In addition, EPA conducted an analysis of FY86 to FY91 Records of Decision (RODS) for sites where VOC contamination drove remedy selection. The results of this analysis, which are provided in Appendix A, demonstrate that these three technologies represent over 90% of the remedies selected in the RODS analyzed.

USE OF DOCUMENT

This directive is primarily intended for use by Superfund site managers. However, site managers in other programs (such as RCRA corrective action, the UST program, States), and the private sector, may also use this directive.

This directive is not a "stand alone" document. To ensure a full understanding of VOC site characterization and remedy selection, site managers should refer to all documents cited in the directive. For assistance in understanding complex site conditions, an experienced site manager, the presumptive remedy expert team, the Superfund Technical Assistance and Response Team (START) team, or the Environmental Response Team should be consulted.

ANTICIPATED BENEFITS OF PRESUMPTIVE REMEDIES

Use of this directive will reduce cost and time in remedy selection at VOC sites in the following ways:

1. The directive facilitates identification of the presumed or likely remedial options early in the investigation process, hence allowing for a more focused collection of data during the remedial investigation (RI) or removal site evaluation. In addition, knowledge of the presumptive remedy may facilitate collection of some remedial design data before the ROD or action memo, thereby allowing the action to proceed more quickly after signature of the decision document.

2. This directive eliminates the need for the initial step of identifying and screening a variety of alternatives during the Feasibility Study. Additionally, it will reduce the number of technologies identified and analyzed in the EE/CA. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Section 300.430(e)(1)) states that "the lead agency shall include an alternatives screening step, when needed, (emphasis added) to select a reasonable number of alternatives for detailed analysis." EPA's analysis of feasibility studies for VOC-contaminated soil sites (see Appendix A) found that certain technologies are routinely screened out based on effectiveness, implementability, or excessive costs, consistent with NCP Section 300.430(e)(7). Accordingly, EPA has determined that, when using presumptive remedies at VOC-contaminated sites, site-specific identification and screening of alternatives is not necessary. However, this directive and supporting documentation (see "Feasibility Study Analysis for CERCLA Sites with Volatile Organic Compounds in Soils") should be included in the Administrative Record for all sites that use the presumptive remedy(ies) to document the basis for eliminating the "site-specific identification and

TABLE 2
Typical VOCs Addressed by this Directive

Halogenated Volatile Organics

Carbon Tetrachloride
Chlorobenzene
Chloroethane
Chloroform
1,1-Dichloroethane
1,1-Dichloroethylene
1,2-Dichlorobenzene
1,2-Dichloroethane
1,2-Dichloroethylene
1,2-Dichloropropane
1,4-Dichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane
Ethylene Dibromide
Methylene Chloride
Tetrachloroethylene
Trichloroethlyene
Vinyl Chloride

Non-Halogenated Volatile Organics

Ketones/Furans
Acetone
Methyl Ethyl Ketone
Methyl Isobutyl Ketone

Aromatics
Benzene
Ethyl Benzene
Styrene
Toluene
m-Xylene
o-Xylene
p-Xylene

Note: Other compounds that have physical/chemical characteristics similar to the compounds listed may also be addressed by the presumptive remedy process.

screening of technologies" section. In addition, other supporting materials (e.g., FS reports included in the analysis, technical reports) will be made available at EPA Headquarters and are available for inclusion in the Administrative Record if needed.

3. This directive streamlines the detailed analysis portion of the FS. Remedial alternatives developed for a site must be evaluated against the nine criteria (required under NCP Section 300.430(e)(9)). Under this presumptive remedy approach, the detailed analysis can be limited to the three presumptive remedies (in addition to the no-action alternative), thereby streamlining that portion of the FS. Appendix B provides a generic evaluation of the presumptive remedies for seven of the nine criteria. This evaluation may serve as a basis for each detailed analysis conducted under the presumptive remedy process and should be augmented, as needed, to address site-specific conditions.

One of these presumptive remedies is expected to be used for all VOC sites except under unusual circumstances. Such circumstances may include unusual site soil characteristics, demonstration of significant advantages of alternate (or other innovative) technologies over the presumptive remedies, or extraordinary community and state concerns. If such circumstances are encountered, additional analyses may be necessary or a more conventional detailed RI/FS may be performed.

PRESUMPTIVE REMEDIES PROCESS

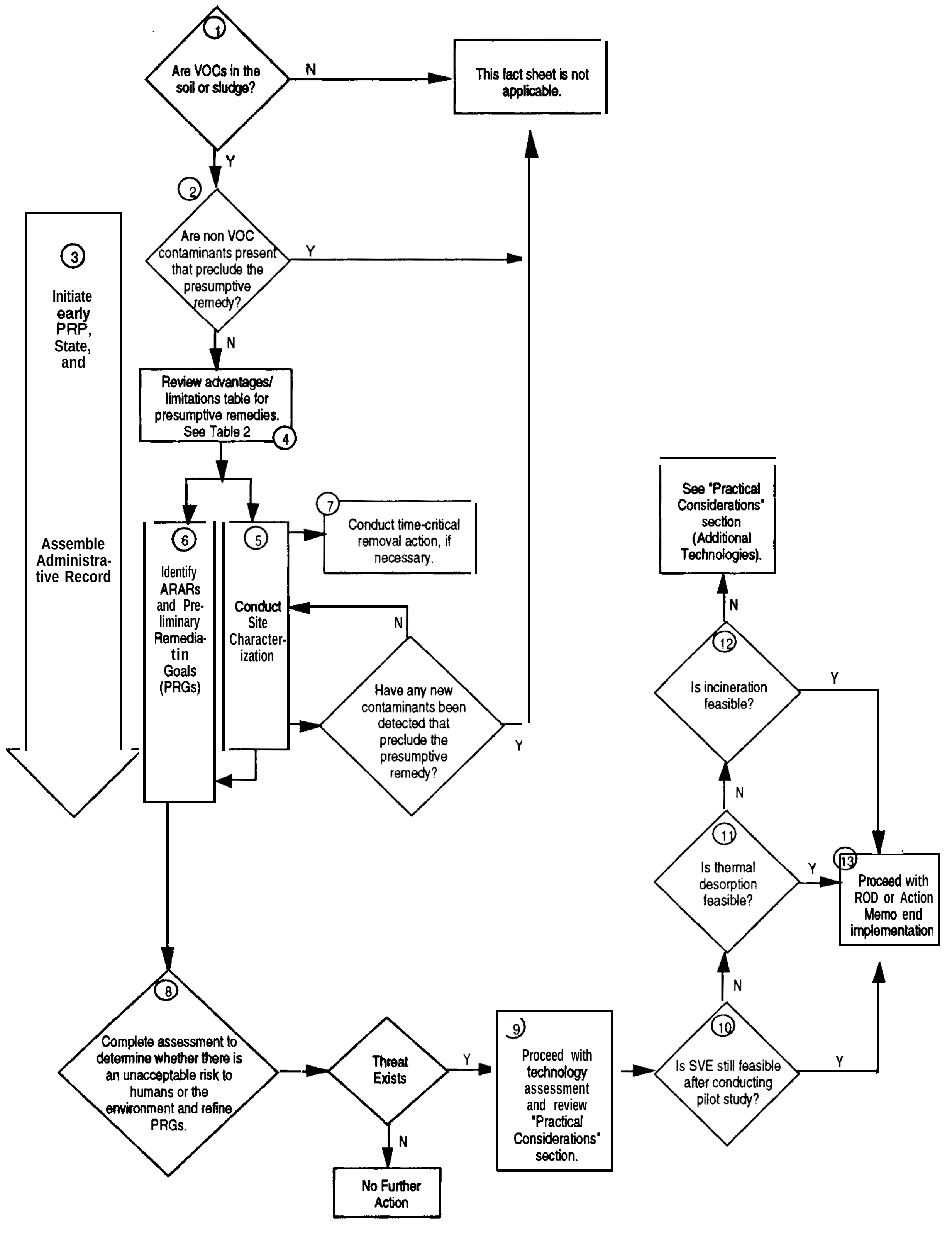
This section and the accompanying diagram (Figure 1) describe the sequence of steps involved in the presumptive remedy process (site characterization and technology selection) for sites containing soil contaminated with VOCs. While the process is not mandatory, EPA believes that following the steps outlined below will expedite the clean-up process for this category of sites.

SVE is the primary presumptive remedy. SVE has been selected most frequently to address VOC contamination at Superfund sites and initial performance data indicate that it effectively treats waste in place at a relatively low cost. In cases where SVE will not work or where there is very highly concentrated contamination, thermal desorption may be the more appropriate response technology. In a limited number of situations, incineration may be more appropriate.

The numbered paragraphs below correspond to the numbered steps in Figure 1 and provide a detailed discussion of each step.

1. Are *VOCs Present in the Soil?* The first step is to determine whether VOCs are the major contaminant present in soil at the site. Table 2 lists the VOCs that are amenable to the presumptive remedies outlined in this directive. If VOCs are present at levels of concern (see forthcoming guidance on soil screening levels), then the presumptive remedies outlined in this directive may be applicable. However, if it is confirmed (at this point or at any later point during the presumptive remedy process) that there are no VOCs present in the soil, then this directive is not applicable for use in technology selection at the site.

FIGURE 1
Decision Tree for Investigating and Selecting a Remedy at Solvent Sites



Most likely, this analysis will occur during scoping of the RI/FS or EE/CA. However, there may be only limited information available at that time about the site. Therefore, whatever information is available should be used to determine whether VOCs are present or suspected in the soil based on prior use. Chemical use at a site can be ascertained from a number of sources such as facility records, previous sampling efforts by local or State agencies or through Information Request letters.

2. Are *Non-VOC Contaminants Present That Preclude the Use of Presumptive Remedies?* In addition to determining whether VOCs are present in the soil, it is also necessary to identify other non-VOC contaminants, if any, present in the soil.

The site characterization and technology selection procedures outlined in this directive are recommended for use primarily on soil containing VOCs only. See Table 2 for VOCs that are amenable to the presumptive remedies.

For sites containing a mixture of VOCs and other contaminants in soil, the presumptive remedies should be considered only if they can also be effective in removing the non-VOC contaminants or combined with other, non-presumptive remedies in a treatment train, assuming the presumptive remedies do not exacerbate the problems presented by the non-VOCs. For example, sites with VOCs and metals commingled in soil may be effectively remediated by employing SVE to remove VOCs followed by fixation or solidification to address the metal contamination. In contrast, a VOC and polyaromatic hydrocarbons (PAHs) contaminant combination may be treated more appropriately with a single biological treatment scheme that would be effective for both the VOCs and PAHs. Note that sites containing mixtures of VOCs and non-VOCs are varied, and, for this reason, remedy selection may be more complicated than the framework presented in this directive; therefore, the presumptive remedy analysis may need to be supplemented or modified on a site-specific basis.

3. *Initiate Early Community, State, and Potentially Responsible Party (PRP) Involvement.* As early in the clean-up process as possible, EPA should notify the community, State, and any PRPs that a presumptive remedy is being considered for the site. It is important for all stakeholders to understand completely how the presumptive remedy process varies from the usual clean-up process and the benefits of using the presumptive remedies process.

Early identification of State applicable or relevant and appropriate requirements (ARARs) also is a critical part of this process. Because the presumption set forth in this directive is national in scope, it does not take into account State ARARs. For this reason, State ARARs relating to the presumptive remedies should be considered on site-specific basis. Regions may want to supplement this directive by compiling the requirements of the States in their Regions that are likely to be associated with the use of the presumptive remedies and placing them in the administrative record for a site where presumptive remedies are being considered. This directive along with the "Feasibility Study Analysis for CERCLA Sites with Volatile Organic Compounds in Soils" should be included in the administrative record for the site if one of the presumptive remedies is proposed for a particular VOC-contaminated site.

4. *Review Advantages/Limitations of the Presumptive Remedies.* During initial site characterization, Table 3 should be reviewed to consider the advantages and limitations of the presumptive remedies, This information may be useful in preparing for and/or modifying the site characterization or alternatives analysis process. The "Practical Considerations" section of this directive should also be reviewed at this time to ensure a comprehensive site characterization and remedy evaluation.

5. *Conduct Site Characterization. Site* characterization for sites using VOC presumptive remedies should be designed to:

- Positively identify the site type (i.e., VOC site);
- Obtain data to determine whether the presumptive remedy is feasible for the site;
- Focus (and possibly streamline) site characterization by collecting data to support the selection of presumptive remedy(ies) only (e.g., volume and cost information); and,
- Collect some design data (i.e., pilot studies to determine radius of influence and flow rates of SVE), thereby streamlining data collection during the remedial design stage.

Table 4 lists the data that are required for characterization of sites with soil contaminated with VOCs. This table also includes the rationale for collecting these data and references for established collection methods. Note that bench-scale and pilot/ treatability studies should be performed whenever possible concurrent with site characterization to define the parameters that will be important to designing the system.

In areas with low organic content soil (e.g., alluvial basins), or where there are impediments to obtaining soil samples (e.g., under buildings), soil gas sampling is highly recommended as a site characterization technique. In addition, the use of soil gas sampling during implementation of SVE and confirmatory soil sampling afterward is less expensive than constantly installing new soil borings, especially for deep contamination.

If incineration or thermal desorption is under serious consideration, bench-scale treatability studies may be conducted, especially if metals or other inorganic compounds are present. Thermal desorption generally should be considered if concentrations of VOCs are less than 5 to 10 percent; incineration may be appropriate if VOC concentrations exceed 5 to 10 percent. Note that excavation and mixing of soil can produce a desorber input of less than 10 percent contaminant concentration and allow thermal desorption to be chosen.

Additionally, the feasibility of excavation should be determined by evaluating surface contidions and depth of contaminants as well as the potential for any air emissions associated with the excavation. Test digs should be monitored closely to assure protection of the public and the environment.

It is important to note that during the site characterization, the volume and concentration of waste constituting the principal threats at the site should be identified. The NCP (Section 300.430(a)(1)(iii)(A) and *A Guide to Principal Threat and Low Level Threat Wastes,* Superfund Publication: 9380.3-06FS, November 1991, define principal threats as source materials, including liquids, that are highly toxic or highly mobile wastes which generally cannot be reliably contained or would present a significant risk to human health and or environment should exposure occur. In accordance with NCP expectations, waste constituting "principal threats" posed by a site generally are expected to be treated. The site manager is encouraged to characterize the site in terms of principal and low-level threat areas to determine materials to be targeted for treatment and containment.

6. *Identify Potential ARARs, To Be Considered (TBCs), and Preliminary Remediation Goals (PRGs).* Potential Federal and State ARARs and pertinent TBCs information should be identified on a chemical-, location-, and action-specific basis concurrent with site characterization. For a more detailed ARARs discussion, refer to the various ARARs fact sheets. (See *Compendium of CERCLA ARARs Factsheets and Directives*, EPA Publication 9347.3-15, October 1991).

   At this step, PRGs should also be identified (NCP Section 300.430(e)(2)(c)). Note that different health risk-based PRGs are often set for soils, depending on depth. Shallow soil levels are usually based both on direct contact exposure and protection of ground water, while levels for deeper soils are generally based only on mass transport modeling of effects on ground water. Ecological effects may also be important to consider in setting PRGs.

7. *Conduct Time-Critical Removal Action (if necessary).* During initial site characterization, data will be gathered to determine whether a time-critical removal action will be needed and to determine whether the contaminants present are amenable to the presumptive remedies. Time-critical removal actions, such as drum removal or actions addressing highly contaminated (typically small volumes) of soil, should be conducted in accordance with current guidance and regulations. The decision to take a time-critical removal action may be made by the Regional Decision Team (RDT) or if time does not permit, by an On-Scene Coordinator (OSC) or a Remedial Project Manager (RPM) in consultation with an OSC.

8. *Is There a Threat Posed by the Site?* A risk assessment must be conducted to determine if a sufficient health or environmental threat exists to warrant a removal or remedial action. (Refer to *Risk Assessment Guidance for Superfund, Volumes I and II,* EPA/540/1-89/002 and EPA/540/1-89/001). Where it is determined that such a threat exists, site-specific exposure data can be used to modify the PRGs identified in Step 6 (NCP Section 300.430(e)(2)(i)). If it is determined that such a threat does not exist, no further action at the site will be required.

9. *Proceed With Technology Assessment and Review "Practical Considerations" section.* If the analysis described in step 8 confirms that the contaminants are a threat to human health and/or the environment, a proposed remedy should then be identified.

   If this project is a remedial action, a detailed analysis using the nine criteria will be required under NCP Section 300.430(e)(9)) to justify the selection of remedy decision. Appendix B provides an analysis of SVE, thermal resorption, and incineration against seven of the nine selection criteria. In addition to the seven criteria discussed in Appendix B, community, and State acceptance must also be evaluated. If a non-time critical removal action is planned, the streamlined analysis described in the EE/CA guidance will be required that uses the three criteria of effectiveness, implementabiilty, and cost. During the technology assessment, the factors listed in the "Practical Considerations" section of this directive should be reviewed to ensure a comprehensive evaluation of alternatives.

10. *Does the Pilot /Treatability Study Indicate that SVE is Feasible?* SVE is the primary presumptive remedy. Pilot/treatability study testing of SVE should be conducted prior to final remedy selection. Such testing will provide information on the rate of removal of contaminants. EPA/540/2-91/091A cited in the References section of this directive provides guidance on conducting the pilot/treatability study. Removal efficiencies and treatment effectiveness must be carefully considered alongside the PRGs identified in the FS to estimate the potential for successful remedial action using SVE.

11. *Is Thermal Desorption Feasible?* If SVE will not be sufficiently effective in achieving PRGs due to low permeability, lithology or insufficient removal of contamination during the pilot study, thermal desorption should be considered as the primary ex-situ presumptive remedy.

    Thermal desorption technologies cover a variety of vendors and processes. However, ample data are available to substantiate remedy selection of thermal desorption for soil contaminated solely with VOCs.

12. *Is Incineration Feasible?* If contaminant concentrations and bench-scale testing indicate thermal resorption will not achieve desired PRG levels, incineration is the second ex-situ presumptive remedy.

    If incineration is planned, and a substantial number of inorganic contaminants are expected to be present based on site characterization data, materials handling problems, or slagging problems are likely.

    If none of three presumptive remeides is considered to be feasible at a particular site, it will be necessary to consider other technologies. (For more information, refer to the Practical Considerations section below.)

13. *Select Remedy for Remedial/Removal Action.* At this point, there should be enough data to identify a preferred remedy in the proposed plan and distribute the plan for public comment. Once the remedy has been selected in the ROD, the user can proceed to do a limited design which relies largely on the substantial amount of design-related data collected during the RI. The extent of additional or supplemental data required will be determined on a site-specific basis.

Practical Considerations

The following factors should be considered prior to taking any remedial action.

Enforcement: This directive applies to fund-lead sites as well as to sites where a PRP is conducting the investigation and/or response action. In the event that there is an ongoing PRP-lead RI/FS, the scope of work may be amended to reflect the presumptive remedy approach to site characterization and remedy selection. The potential savings in time and money to be gained by using the presumptive remedy approach are expected to outweigh the burden of modifying the scope of work in many cases.

Initial Site Actions: If the VOC material is still in original, intact containers, it may be returned to the manufacturer (if the manufacturer is willing to accept these containers), assuming this response is a cost-effective and feasible action as opposed to treating the material. Reuse of material (i.e., process liquids and relocation of equipment to other permitted facilities) should also be considered. Further, phase separation should be conducted and recycling considered depending on the purity of the recovered phase or for any existing liquids that are high enough in concentration. Refer to Appendix C for a list of the currently recognized waste exchanges.

Site Characterization: Site characterization should proceed as a single, multi-media activity whenever possible. Field screening methods should be integrated into the sampling and analysis plan in order to accelerate information gathering. Data quality must reflect the ultimate use of the information.

Ground Water: The decision maker should consider the ground-water strategy for the site since soil clean-up levels are often set to protect ground-water quality. Therefore, ground-water clean-up levels may have a direct impact on the selected clean-up levels for soil. (See forthcoming guidance on Soil Screening Levels and the directive entitled *Presumptive Remedies: Remedial Strategy and Treatment Technologies for CERCLA Sites with Contaminated Ground Water.)* It should be noted that, of the VOC-type contaminants, listed in Table 2, the halogenated volatiles are dense nonaqueous phase liquids (dense NAPLs or DNAPLs) and many of the others are light NAPLs (LNAPLs) in their pure liquid form. If LNAPLs are present, it may be possible to address thereby lowering the water table, removing free product (if present), and applying SVE. To address DNAPLs contamination, refer to the above mentioned ground-water guidance.

Management of Different Soils: A situation may arise where highly contaminated shallow material cannot be addressed by SVE. The action to address this contamination may differ from the rest of the soil contamination and will most likely involve incineration or thermal desorption. If it is suspected that soil contamination existing at greater depths will also be treated in this manner, then the excavated shallow material should be staged and stored in order to treat it with the deep material.

Another situation may arise where VOCs are mixed with metals, and none of the presumptive remedies can address both sets of contaminants. The action to address this situation may consist of a treatment train where VOCs are addressed through SVE or thermal resorption and the metals are addressed through fixation.

Finally, the site manager should be aware of situations where a mixture of principal and low-level threat wastes call for the use of treatment (i.e., SVE or thermal treatment) of principal threat waste and containment (capping) of low-level contamination. (See *A Guide to Principal Threat and Low-Level Wastes* in Reference Section).

Off-Site Disposal: In general, it may not be cost-effective to ship quantities of contaminated soil in excess of 5,000 cubic yards for off-site disposal. For this reason, pretreatment of soil and water may be required prior to shipment or discharge to another treatment facility.

Capping: Capping alone is not recommended to control the migration of VOCs. However, capping can improve the effectiveness of SVE by decreasing the rate of infiltration of residual VOCs through the vadose zone into the ground water as well as possibly increasing the radius of influence and preventing "short circuiting" of air pathways in the vicinity of the extraction well. Capping can also be used to address non-principal threat waste unless it is more cost-effective to treat this waste along with more highly contaminated materials.

Patents: SVE is a patented technology. Royalty payments may be required under certain conditions of implementation.

Attainment of Remediation Goals: It should be noted that, like other in-situ technologies, it is difficult to ascertain with confidence whether SVE will attain remediation goals until the action is actually implemented. However, the lower cost and ease of SVE implementation will often weigh heavily in its favor, as long as protection of human health and the environment is ensured.

Additional Technologies: If for some reason none of the presumptive remedies is applicable to a particular site, the site manager is encouraged to refer to EPA's forthcoming document entitled *Contaminants and Remedial Options at Solvent Sites* for a discussion of additional VOC treatment technologies. It should be noted that this comprehensive document, which identifies additional VOCs and technologies, may be appropriate to consider on a site-specific basis.

Thermal Treatment Technologies: The site manager should refer to EPA's Draft Strategy for Combustion of Hazardous Waste (May 18, 1993) when considering any thermal treatment technologies at a particular site.

Conclusion

For sites containing VOC-contaminated soil and appropriate soil characteristics, SVE is a relatively inexpensive and efficient technology. If material needs to be excavated, thermal desorption is preferred. In a few cases, incineration may be the most appropriate remedy -- for example, where SVE and thermal desorption will not meet clean-up criteria based on contaminant concentrations or composition.

As remedies other than SVE, thermal desorption and incineration become more widely used in the future, this directive may be modified to reflect these trends. For further assistance on presumptive remedy related activities consult the Regional Presumptive Remedies contact.

TABLE 3
Comparison of Technologies for VOC Sites

	PERFORMANCE[(1)]	ADVANTAGES	LIMITATIONS	COSTS[(1)]
Soil Vapor Extraction	Can be as high as 99% removal of VOC contaminants but is typically lower than other technologies with range of 85-99%	• High level of effectiveness in removing VOCs. • Relatively inexpensive. • Little site disturbance; no excavation required. • Effective for waste under buildings or other construction.	• Soil that is tight or has high moisture content (>50%) has a reduced permeability to air, hindering the operation of SVE. • Soil with a high degree of heterogeneity has highly variable permeabilities, resulting in uneven delivery of gas glow to the contaminated regions, which in turn reduces removal rates by SVE. • Soil with high organic content or that is extremely dry has a high sorption capacity for VOCs, which results in reduced removal rates. • SVE may require treating residual soil tailings, liquids, and spent activated carbon. • Air emissions must be controlled to eliminate possible harm to the public and the environment. • SVE is not effective in the saturated zone. However, lowering the aquifer can expose more media to SVE (this may address concerns regarding LNAPLs).	$10-150/ton
Thermal Desorption	95-99% removal of VOCs	• All compounds that are listed on Table 2 are readily treated by thermal desorption. • Because of lower treatment temperatures and often lower oxygen levels, thermal desorbers should produce less nitrogen oxides and sulfur dioxide than incinerators. • Process can be performed onsite or offsite. • Lower temperatures produce fewer products of incomplete combustion (PICs).	• Requires excavation. If contamination is very deep or below the water table, excavation may be difficult and expensive. • Mercury, if present, can be removed from soil by thermal desorption and impose additional treatment costs for the offgas. • Soil containing high fractions of clay or silt may result in a high percentage of particulate carry-over from the desorber into downstream treatment devices. • Soil that contains constituents greater than 1 to 2 inches in diameter will require screening or crushing to prevent jamming the mechanical equipment. • Soil with a high moisture content (>30%) can result in low processing rates, high operating costs, and difficulty in materials handling. • High or low pH wastes may corrode the metal components of the system, requiring pretreatment. • Potential process residuals are treated solids, oversized debris, condensed contaminants and water, particulate control system solids, and contaminated activated carbon. • Air pollution control system required.	$200-300/ton
Incineration	>99% removal of VOCs	• Capable of accepting a wide range of media. • Processes can be performed onsite or offsite. • Metals can be concentrated in the residuals.	• Requires excavation. If contamination is very deep or below the water table, excavation may be difficult and expensive. • Soil containing high fractions of clay or silt may result in a high percentage of particulate carry-over from the incinerator into downstream treatment devices. • Air pollution control equipment is required. • High treatment temperatures, as compared to thermal desorption, can produce nitrogen oxides, sulfur dioxides, and PICs. • Solids with volatile metals may require additional treatment or more elaborate air pollution equipment.	$200 - 1700/ton

NOTES:

(1) Actual performance and cost for any remediation technology is highly site specific. Both depend upon the original and target clean-up level concentrations of contaminants, soil quantity to be treated, soil characteristics, and the design and operation of the remediation technology equipment used.

TABLE 4
Information Required for Characterization and Technology Selection at VOC Sites

INFORMATION	RATIONALE FOR COLLECTING INFORMATION	REFERENCE
All Technologies:		
Site Geology	SVE is most effective in porous, permeable, homogeneous soil. Highly heterogeneous soil (i.e., fractured porous rock or sands interspersed with clay lenses) may exhibit air flow channeling through highly permeable soils. Also, desorption kinetics may be slow in some situations (i.e., high organic content or high clay content soil). In these cases, mass transfer kinetics may reduce the rate of removal of SVE below that which is expected by calculations with a local equilibrium model or pilot scale experiments carried out for only a few days. Often diffusion kinetics limitations can be substantially reduced by proper design of the SVE facility.	Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
USGS Soil Classification	For SVE to be effective, the soil must have sufficient pneumatic permeability ($>10^{-6}$ cm^2) to permit air to move through the medium. Sandy, gravely soils are the most conductive to SVE, while clays and silts are less conductive. However, remediations using SVE in clays and silts have been successful. Soil permeability may need to be measured in the field.	ASTM D 2487 ASTM D 2488
Soil Moisture	High moisture content in soil may drastically decrease its air permeability and, thus, the effectiveness of SVE. The site must be sufficiently well drained to prevent the severe reduction in air permeability, which occurs when the percent water saturation of the soil is greater than 50%. Conversely, organics can be strongly adsorbed onto extremely dry soils, which also impedes SVE. The moisture content of the soil will affect the amount of energy required to heat the soil, the target temperature and the handling properties of fine-grained soil. Thermal desorption requires that the moisture content of the soil be less than 30%.	ASTM D 2216 ASTM D 3017
Depth to Ground Water	SVE is not effective in saturated soil. However, the water table can be lowered by pumping. Thermal desorption and incineration are more expensive for high moisture soil.	Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
Contaminant Identity and Properties	Boiling Point - Thermal desorption target temperature is dependent on contaminant boiling point. Vapor Pressure - SVE is effective for compounds with a vapor pressure greater than 0.5 mm Hg at soil temperatures. Dimensionless Henry's Constant - SVE is effective for compounds with a dimensionless Henry's constant higher than 0.01 at soil temperatures. Water Solubility - SVE is more successful for componds with lower solubilities. Liquid and Vapor Density - A contaminant with a density greater than water may form a DNAPL. A contaminant with a density less than water may form an LNAPL. The flow characteristics of a compund's vapor for SVE is a function of its vapor density.	CRC Chemical Handbook

TABLE 4
Information Required for Characterization and Technology Selection at VOC Sites
(Continued)

INFORMATION	RATIONALE FOR COLLECTING INFORMATION	REFERENCE
All Technologies: (continued)		
Contaminant Concentration, Location, Volume, and Depth	These data can be gathered via soil matrix and/or soil gas sampling. Soil gas sampling, both shallow and at depths, may be more appropriate, given depth to ground water and stratigraphy.	Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
Presence of Pipes or Subsurface Material	The presence of water or electircal conduits, soil fracture lines, debris, or any other objects that are more permeable than the surrounding soil will be the preferred pathway for the advecting gases.	Geotechnical Techniques
SVE Only:		
Soil/Air Filled Porosity	Porosity should be less than 40% for SVE to be effective.	Guidance for Conducting Remedial Investigations and Feasiblitiy Studies Under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
Soil/Air Permeability	Soil/Air Permeability should be greater than 10^{-6} cm^2 for air to move throughout the contaminated soil. SVE is potentially effective in less permeable soul (i.e., between 10^{-6} to 10^{-10} cm^2), but further pilot-scale testing and/or mathematical modeling is recommended to better predict the time for cleanup (which is likely to be prolonged for lower permeability soil).	Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
Soil Temperature	Contaminant vapor pressure, dimensionless Henry's Law constant, water solubility, and phase density are strong functions of temperature.	Guidance for Conducting Remedial Investigations and Feasiblitiy Studies Under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
Soil Humic Content	Solvents adhere strongly to soil with high humic content, which decreases the effectiveness of SVE.	Guidance for Conducting Remedial Investigations and Feasiblitiy Studies Under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
Contaminant Soil Sorption Coefficient Kd (Since Kd is less readily available, Koc, the equilibrium between contaminants sorbed onto organic carbon versus the ground water is used.)	This parameter describes the tendency of the solvent to sorb onto soil or organic matter in the soil. Higher Koc's indicate that a subsurface is more likely to bind to carbon righ media (i.e., soil) than to remain in water.	RREL Treatability Database
Contaminant Adsorption Characteristics on Activated Carbon	This parameter is related to the feasibility of removing contaminants from residuals by carbon adsorption. This parameter is important since compounds such as MEK become unstable as they are adsorbed onton carbon.	RREL Treatability Database

TABLE 4
Information Required for Characterization and Technology Selection at VOC Sites
(Continued)

INFORMATION	RATIONALE FOR COLLECTING INFORMATION	REFERENCE
Incineration and Thermal Desorption Only:		
Soil Plasticity	Plastic soil, when subjected to compressive forces, can become molded into large particles that are difficult to heat.	Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (pp. 3-3 to 3-20) EPA/540/G-89/004
Soil BTU Content	The soil BTU content determines the fuel requirements for thermal desorption and incineration.	ASTM D 3286
Contaminant Combustion Characteristics	Information on combustion characteristics of a VOC is required in order to determine the combustion characteristics of the incinerator.	Bench/Pilot Testing
Soil Particle Size Distribution	Thermal desorption usually requires that soil be pretreated to a maximum soil particle size ranging from 1 to 2 inches.	ASTM D 422
Alkaline Metal Salts (e.g., $NaSO_4$, KSO_4)	Alkaline metal salts may cause refractory attack and slagging at high temperatures.	Percentage of Na, K
Volatile Metals Content (e.g., Hg, Pb, Cd, Zn, Sn)	High metal content may cause ash leaching and stack emissions problems.	Heavy Metals Analysis

BTU = British Thermal Units
LNAPL = Light Nonaqueous Phase Liquid
DNAPL = Dense Nonaqueous Phase Liquid
mmHg = millimeters of mercury pressure
NAPL = Nonaqueous Phase Liquid
PIC = Products of Incomplete Combustion

APPENDIX A
TECHNICAL BASIS FOR PRESUMPTIVE REMEDIES

This Appendix summarizes the analyses that EPA conducted of Record of Decision (ROD) and Feasibility Study (FS) data from VOC-contaminated sites which led to establishing soil vapor extraction (SVE), thermal desorption, and incineration as the presumptive remedies for Superfund sites with VOC-contaminated soil. The analyses consisted of:

- Identifying VOC-contaminated sites
- Determining the frequency of technology selection for VOC sites
- Identifying sites for the feasibility study (FS) analysis
- Conducting the FS analysis.

Results of these analyses, along with the scientific and engineering analysis of the performance data on technology application (Primary Reference document), provide a support for the decision to eliminate the initial alternatives identification and screening step for this site type. These technical reviews found that certain technologies are appropriately screened out based on effectiveness, implementability or excessive costs. Review of technologies against the nine criteria led to elimination of additional alternatives. Provided below is a discussion of each analysis.

Identification of VOC-Contaminated Sites

The first analysis involved generating a list of signed Records of Decision (RODS) (post-SARA), documenting VOC contamination, from which data could be used for subsequent analyses. The ROD Information Directory database was used for this purpose. Of the 821 signed FY86-FY91 RODS, 418 are identified in the database as containing VOC contamination in source material. This list of RODS was subsequently divided into two lists: RODS where VOCs were the only contaminants of concern identified in the source material and RODS containing VOCs, as well as other contamination, in source material. For those RODS involving VOC plus other contaminants, a review of the ROD document was conducted to identify cases where only VOCs were driving the selection of remedy. To make this determination, the Remedial Response Objectives and Selected Remedy sections of the ROD were reviewed to identify specific language indicating that the remedial action was designed to address only the VOCs at the site. In addition, if cleanup goals were specified only for VOCs, the assumption was made that VOCs were driving the remedy.

As a result of this analysis, 88 RODS were identified as VOC-only RODS or VOCs plus other contaminants RODS where a clear determination could be made that VOCs were driving the selection of remedy.

Frequency fo Technology Selection for VOC-Contaminated Sites

Table 1 presents the distribution of the 88 FY86-FY91 RODS among the treatment technologies used to address VOCs in soil. This table demonstrates that the three presumptive remedies (SVE, thermal desorption, and incineration) together were selected more often (over 90% of the RODS analyzed) than the other applicable technologies. Presumptive Remedies were also those remedies where a fair amount of performance data on technology implementation was available. Furthermore, SVE, chosen in over two-thirds of the RODS analyzed, was the primary presumptive remedy selected.

Identification of Sites for Feasibility Study Analysis

The purpose of the FS analysis was to document the technology screening step in FSs of VOC-contaminated soil/sludge sites and identify the principal reasons given for eliminating technologies from further consideration. To achieve a representative sample of FSs for the analysis, sites were selected using ROD data according to the following criteria:

APPENDIX A
TECHNICAL BASIS FOR PRESUMPTIVE REMEDIES
(Continued)

Table 1

Presumptive Remedy VOC Site Treatment Summary Table, FY86-FY91*

TECHNOLOGIES USED TO ADDRESS VOCs IN SOIL	TOTAL
Bioremediation [(1)]	3
Incineration	11
Soil Flushing/Washing [(1)]	3
Soil Vapor Extraction	62
Thermal Treatment [(2)]	9
Total	88

Source: ROD Information Directory (RID), FY86 - FY91

Notes: (1) Relatively limited amount of performance data available for these technologies versus the presumptive remedies.

(2) Thermal treatment includes RODS employing thermal desorption, thermal aeration, low-temperature thermal desorption, and the generic remedy "thermal treatment".

* A population of 418 RODS was identified for this study based on the parameters: FY 1986-1991, and VOC contamination of source media.

- Sites were chosen, based on the selected remedy, to ensure an even distribution among the five treatment technologies for VOCs in soil (i.e., bioremediation incineration, SVE, soil flushing, and thermal treatment).

- Whenever possible, both VOC-only sites and VOC and other contamination sites were represented under each technology.

- Sites were selected to ensure an even distribution in geographic location, ROD signature date, and site size.

Feasibility Study Analysis

The FS analysis involves a review of the technology screening phase, including any pre-screening steps, followed by a review of the detailed analysis and comparative analysis phases in each FS and ROD. Information derived from each review was documented on site-specific data collection forms, which are available for evaluation as part of the Administrative Record for this directive. (See "Feasibility Study Analysis for CERCLA Sites with Volatile Organic Compounds in Soils", September 1993, available at EPA Headquarters and Regional Offices.)

APPENDIX A
TECHNICAL BASIS FOR PRESUMPTIVE REMEDIES
(Continued)

For the screening phase, the full range of technologies considered was listed on the data collection forms, along with the key reasons given for eliminating technologies from further consideration. These reasons were categorized according to the screening criteria: cost, effectiveness, or implementability. The frequency with which specific reasons were given for eliminating a technology from further consideration was then tallied and compiled into a screening phase summary table (Table 2).

For the detailed analysis and comparative analysis, information on the relative performance of each technology/alternative with respect to the nine NCP criteria was documented on the site-specific data collection forms. The advantages and disadvantages associated with each clean-up option were highlighted. In some cases, a VOC technology was combined with one or more technologies that address minor site contaminants into one or more alternatives. Only the component of the alternative which addressed the VOC contamination was evaluated in this analysis. The disadvantages of a technology/alternative were then compiled into a detailed analysis/comparative analysis summary table, under the assumption that these disadvantages contributed to non-selection. All summary tables are available for review as part of the Administrative Record.

The FS analysis has been completed for 21 sites (representing approximately 25% of universe studied). The information from these FSs has been compiled and summarized in Table 2. Additional FS analysis is planned and will be added to the Administrative Record, when available. Table 2 demonstrates that technologies, other than the presumptive remedies, are consistently eliminated from further consideration in the screening phase due to effectiveness, implementability, or excessive costs. In addition, the analysis indicates that, although certain technologies routinely passed the screening phase, these technologies were selected infrequently because they did not provide the best overall performance with respect to the nine criteria. Together these analyses (Appendix A to this directive and "Feasibility Study Analysis for CERCLA Sites with Volatile Organic Compounds in Soils"), along with the scientific analysis of performance data (USEPA (In Progress) Contaminants and Remedial Options at Solvent Sites) will support the decision of using presumptive remedies and bypassing the technology identification and screening step for a particular site. As previously indicated, this factsheet and accompanying analysis should be part of the Administrative Record for the site. Further supporting materials, not found in the Regional files, can be provided by Headquarters, as needed.

TABLE 2 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR VOC SITES[1]

REMEDIAL TECHNOLOGY OR TREATMENT[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out[3]: Cost	Effectiveness	Implement	# RODs Tech. Selected	# RODs Tech. Not Selected	#RODs Where Criterion Contributed to Non-selection: Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
Capping	21	8	7	6	1	6	2	0	8	5	3	7	6	6	3	1	---	---
Offsite Nonhazardous Landfill	4	0	2	2	0	2	1	0	0	0	0	0	0	0	0	0	---	---
Offsite RCRA Disposal	18	12	4	2	1	3	3	2	10	3	6	7	3	9	5	7	---	---
Onsite Encapsulation	3	1	2	0	1	1	0	0	1	0	0	1	0	0	0	0	---	---
Onsite Nonhazardous Landfill	2	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	---	---
Onsite RCRA Landfill	14	1	11	2	0	8	7	0	1	0	0	1	0	1	1	0	---	---
Activated Sludge	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	---	---
Composting	4	1	3	0	0	3	0	0	1	0	0	0	0	1	0	1	---	---
Land Farming	3	0	3	0	0	1	1	0	0	0	0	0	0	0	0	0	---	---
Bioremediation (unspecified)	6	0	6	0	0	5	4	0	0	0	0	0	0	0	0	0	---	---
Ex-Situ Bioremediation	7	1	6	0	2	5	2	1	0	0	0	0	0	0	0	0	---	---
In-Situ Bioremediation	11	1	10	0	2	9	4	0	0	0	0	0	0	0	0	0	---	---
Dechlorination/ APEG	3	0	3	0	0	3	1	0	0	0	0	0	0	0	0	0	---	---

TABLE 2 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR VOC SITES (Continued)[1]

REMEDIAL TECHNOLOGY OR TREATMENT[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out 3: Cost	Effectiveness	Implement	# RODs Tech. Selected	# RODs Tech. Not Selected	#RODs Where Criterion Contributed to Non-selection: Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
Other Chemical Destruction	3	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	---	---
Reduction	7	0	6	1	0	5	1	0	0	0	0	0	0	0	0	0	---	---
Neutralization	6	0	6	0	0	5	0	0	0	0	0	0	0	0	0	0	---	---
Oxidation	6	1	5	0	0	4	0	0	1	0	0	0	0	1	1	1	---	---
Offsite Incineration (unspecified)	16	7	8	1	5	5	2	0	7	2	0	1	0	7	6	2	---	---
Onsite Incineration (unspecified)	7	1	6	0	2	3	5	0	1	0	0	0	0	1	1	0	---	---
Fluidized Bed	5	0	4	1	3	1	2	0	0	0	0	0	0	0	0	0	---	---
Infrared	5	1	4	0	2	2	1	1	0	0	0	0	0	0	0	0	---	---
Pyrolysis	3	0	3	0	2	1	1	0	0	0	0	0	0	0	0	0	---	---
Multiple Hearth	5	0	4	1	2	4	1	0	0	0	0	0	0	0	0	0	---	---
Rotary Kiln	11	6	3	2	3	2	3	2	4	1	0	0	0	5	3	4	---	---
Other Incineration	13	1	12	0	5	6	5	1	0	0	0	0	0	0	0	0	---	---
Other Thermal Treatment	6	0	6	0	2	4	3	0	0	0	0	0	0	0	0	0	---	---

TABLE 2 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR VOC SITES (Continued)[1]

REMEDIAL TECHNOLOGY OR TREATMENT[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out[3]: Cost	Effectiveness	Implement	# RODs Tech. Selected	# RODs Tech. Not Selected	#RODs Where Criterion Contributed to Non-selection: Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
Vitrification	12	0	11	1	2	8	5	0	0	0	0	0	0	0	0	0	---	---
Wet Air Oxidation	6	1	5	0	1	4	3	0	1	0	0	0	1	1	1	0	---	---
Low Temperature Thermal Desorp/ Stripping	13	10	3	0	1	1	2	3	7	2	1	1	2	7	3	4	---	---
In-situ Steam Stripping	3	2	1	0	0	1	0	2	0	0	0	0	0	0	0	0	---	---
Soil Flushing	15	3	12	0	0	9	5	0	3	1	1	1	2	2	1	3	---	---
Soil Washing	14	2	12	0	1	10	9	0	2	0	0	1	0	2	2	1	---	---
In-situ Vacuum Extraction	17	11	6	0	0	6	2	10	2	0	0	0	1	0	0	2	---	---
B.E.S.T. Process	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	---	---
Liquified Gas	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	---	---
Other Physical Extraction	4	0	4	0	0	3	0	0	0	0	0	0	0	0	0	0	---	---
Fixation	7	1	6	0	0	6	0	0	1	0	0	1	1	0	1	1	---	---
Stabilization/ Solidification	13	2	7	4	0	6	2	0	2	0	0	2	2	2	0	2	---	---
Aeration	12	2	10	0	1	9	2	1	1	0	0	0	1	1	1	0	---	---

TABLE 2 • SUMMARY OF SCREENING AND DETAILED ANALYSIS FOR VOC SITES (Continued)[1]

REMEDIAL TECHNOLOGY OR TREATMENT[2]	# FSs Where Technology Considered	# FSs Tech. Passed Screening	# FSs Tech. Screened Out	Tech. Not Primary Component of Alternative	# FSs Where Criterion Contributed To Screening Out 3			# RODs Tech. Selected	# RODs Tech. Not Selected	#RODs Where Criterion Contributed to Non-selection								
					Cost	Effectiveness	Implement			Protect	ARARs	TMV Through Treatment	Long-term Effect.	Short-term Effect.	Cost	Implem.	State Concerns[4]	Community Concerns[4]
In-situ Hydrolysis	4	0	4	0	0	3	2	0	0	0	0	0	0	0	0	0	---	---
Soil Slurries	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	---	---

1 This study was conducted on 21 RODs and their corresponding FSs.

2 This does not include the no-action or instututional control only alternatives. No RODs selected either of these as remedies.

3 FSs and RODs may contain more than one criterion for screening or non-selection of technology. Also, some FSs did not fully explain the criteria for screening out a technology. Thus, the totals for screening and non-selection criteria are not equal to the number of FSs and RODs considered.

4 Information on State and community concerns was not included in this analysis because FSs do not contain this information and RODs generally only reference supporting documentation (i.e., State concurrence letter and responsiveness summary).

APPENDIX B
Criteria Evaluation for Technologies Used to Treat VOC-Contaminated Soil

	CRITERIA						
	Overall Protection of Human Health and the Environment	Compliance With Federal ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost[(1)]
SOIL VAPOR EXTRACTION	• Provides both short- and long-term protection by reducing concentration and exposure to VOCs in soil. • Depending on site-specific conditions, prevents further ground water contamination.	• Does not trigger LDRs because it does not involve placement of waste. • Because waste is removed in place through limited construction and no excavation, few impacts to wetlands, floodplains, or water quality are likely. • Depending on site-specific conditions, treats wastes to levels that will prevent exceedance of groundwater clean-uplevels. • Emission controls are needed to ensure compliance with air quality standards.	• Effectively removes contamination source. • Is a well-demonstrated technique for removing VOCs from soil/sludge. • Requires some treatment of residuals (spentcarbon or concentrated VOC waste stream) generally through regeneration or disposal. • Hazardous wastes left in place will require 5-year review.	• Significantly reduces toxicity, mobility, or volume through treatment. • Produces few waste streams.	• Does not present substantive risks to on site workers or community; potential for some dust generation during well installation. • Potential air emissions are easily controlled through activated carbon adsorption or other technologies. • Generally involves relatively short time frame to achieve clean-up levels; however, difficulty in estimating time frame may exist due to site uncertainties (e.g., irregular soil permeabilities). • Effective for treating waste under buildings. Can be performed on active facilities. • Hardware, such as vacuum blower, is readily available from many sources, but SVE system performance is highly dependent upon the lithology of the site and system design.	• Few administrative difficulties. Technology is readily available from many sources. • Used successfully at numerous Superfund sites to address VOC contamination. • Installing and operating extraction wells requires fewer engineering controls than other technologies (i.e.,excavation and incineration). • Requires series of soil gas sampling to determine when clean-up levels are achieved.	$10-150/ton $50/ton avg.

1. Note: Actual cost of a remediation technology is highly site-specific. It is dependent upon the original and target clean-up level concentrations of contaminants, soil characteristics, and the design and operation of the remediation technology used.

APPENDIX B
Criteria Evaluation for Technologies Used to Treat VOC-Contaminated Soil
(CONTINUED)

	CRITERIA						
	Overall Protection of Human Health and the Environment	**Compliance With Federal ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost[(1)]**
THERMAL DESORPTION	• Provides both short- and long-term protection by eliminating exposure to VOCs in soil/sludge. • Prevents further groundwater contamination and offsite migration. • Requires measures to protect workers and community during excavation, handling, and treatment.	• Requires compliance with RCRA removal, treatment, transportation (if offsite treatment), and land disposal regulations (if a hazardous waste). • Excavation, construction, and operation of onsite treatment unit may require compliance with wetlands and other location-specific ARARs. • Treats hazardous waste to BDAT levels; thus, there is no LDR problem with residuals. • Generally, treats wastes to levels that will prevent exceedance of ground-water clean-up levles. • Emission controls are needed to ensure compliance with air quality standards.	• Effectively removes contamination source. • Is a well-demonstrated technique for removing VOCs from soil/sludge. • Involves some treatment or disposal of residuals generally through use of carbon adsorption/regeneration or disposal.	• Significantly reduces toxicity, mobility, or volume of contaminants through treatment. • Generally requires test runs to ensure effective treatment.	• Presents potential short-term risks to workers and community from air release during excavation and treatment (if onsite treatment). • Involves potential short-term risks from handling and transporting waste (if offsite treatment). • Relatively short time frame to achieve clean-up levels.	• Construction and substantive permit requirements of an onsite treatment unit may persent some difficulties. Mobile incineration units for onsite treatment are available. • Limited offsite treatment capacity exists. • Used successfully at other Superfund sites to address solvent contamination. • Requires engineering measures to control air emissions, fugitive dust,run-off, erosion and sedimentation, site access, and transportation.	$200-$300/ton $250/ton avg.

1. Note: Actual cost of a remediation technology is highly site-specific. It is dependent upon the original and target clean-up level concentrations of contaminants, soil characteristics, and the design and operation of the remediation technology used.

APPENDIX B
Criteria Evaluation for Technologies Used to Treat VOC-Contaminated Soil
(CONTINUED)

	CRITERIA						
	Overall Protection of Human Health and the Environment	Compliance With Federal ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost[1]
INCINERATION	• Provides both short- and long-term protection by eliminating exposure to solvent contaminants in soil. • Prevents further groundwater contamination and offsite migration. • Requires measures to protect workers and community during excavation, handling, and treatment.	• Requires compliance with RCRA removal, treatment, transportation (if offsite treatment), and land disposal regulations (if a hazardous waste). • Excavation, construction, and operation of onsite incinerators may require compliance with wetlands and other location-specific ARARs. • Treats hazardous waste to BDAT levels; thus, there is no LDR problem with residuals. • Treats wastes to levels that will prevent exceedance of ground-water clean-up levles. • Emission controls are needed to ensure compliance with air quality standards during excavation and construction.	• Effectively destroys source of contamination. • Is a well-demonstrated technique for removing VOCs from soil/sludge. • Involves some treatment or disposal of residuals generally through use of carbon adsorption/ regeneration or disposal.	• Significantly reduces toxicity, mobility, or volume of contaminants through treatment.	• Presents potential short-term risks to workers and community from air release during excavation and treatment (if onsite treatment). • Involves potential short-term risks from handling and transporting waste (if offsite treatment). • Relatively short time frame to achieve clean-up levels.	• Construction and substantive permit requirements of an onsite incinerator may be somewhat difficult. Mobile incinerators are readily available. • Limited offsite incineration capacity exists. • Used successfully at other Superfund sites to address VOC contamination.	$200-$1700/ton $400/ton avg.

1. Note: Actual cost of a remediation technology is highly site-specific. It is dependent upon the original and target clean-up level concentrations of contaminants, soil characteristics, and the design and operation of the remediation technology used.

APPENDIX C
U.S. Waste Exchanges

CALIFORNIA WASTE EXCHANGE
Robert McCormick
Department of Health Services
Toxic Substances Control Division
400 P Street
Sacramento, CA 95812
(916) 324-1807

INDIANA WASTE EXCHANGE
Environmental Quality Control
1220 Waterway Boulevard
P.O. Box 1220
Indianapolis, IN 46206
(317) 232-8188

INDUSTRIAL MATERIAL EXCHANGE SERVICE
Diane Shockey
2200 Churchill Road, #31
Springfield, IL 62794-9276
(217) 782-0450
FAX: (217) 782-9142

INDUSTRIAL MATERIALS EXCHANGE
Bill Lawrence
172 20th Avenue
Seattle, WA 98122
(206) 296-4899
FAX: (206) 296-0188

PACIFIC MATERIALS EXCHANGE
Bob Smee
1522 North Washington Street, Suite 202
Spokane, WA 99205
(905) 325-0551
FAX: (509) 325-2086

NATIONAL WASTE EXCHANGE NETWORK
1-800-858-6625

RENEW
Hope Castillo
Texas Water Commission
P.O. Box 13087
Austin, TX 78711
(512) 463-7773
FAX: (512) 463-8317

INDUSTRIAL WASTE INFORMATION EXCHANGE
William E. Payne
New Jersey Chamber of Commerce
5 Commerce Street
Newark, NJ 07102
(201) 623-7070

MONTANA INDUSTRIAL WASTE EXCHANGE
Don Ingles
Montana Chamber of Commerce
P.O. Box 1730
Helena, MT 59624
(406) 442-2405

NORTHEAST INDUSTRIAL WASTE EXCHANGE
Lewis M. Culter
90 Presidential Plaza, Suite 122
Syracuse, NY 13202
(315) 422-6572
FAX: (315) 422-9051

SOUTHEAST WASTE EXCHANGE
Maxi May
Urban Institute
Department of Civil Engineering
University of North Carolina
Charlotte, NC 28223
(704) 547-2307

SOUTHERN WASTE INFORMATION EXCHANGE
Gene Jones
P.O. Box 960
Tallahassee, FL 32313
(904) 644-5516
FAX: (904) 574-6704

APPENDIX D
GLOSSARY

Applicable or Relevant and Appropriate Requirements (ARARs) - CERCLA Section 121(d) and the NCP require that onsite remedial actions must attain (or justify a waiver of) requirements of environmental laws that are determined to be Federal or more stringent State applicable or relevant and appropriate requirements.

Dense Non-Aqueous Phase Liquid (DNAPL) -DNAPLs are immiscible hydrocarbon liquids that are denser than water, such as chlorinated solvents (either as a single component or as mixtures of solvents), wood preservative wastes, coal tar wastes, PCBs and some pesticides. DNAPLs can sink to great depths, can penetrate into bedrock fractures, can move as a liquid in a direction different from the flow of groundwater and can act as a continual source of groundwater contamination over time.

Engineering Evaluation/Cost Assessment (EE/CA) - An analysis of removal alternatives for non-time critical removal actions.

Ex-Situ Treatment - Removal of material from the ground for treatment.

Feasibility Study (FS) - A description and analysis of the potential clean-up alternatives for a site. It is generally conducted concurrently with the remedial investigation (RI); together the studies are referred to as an RI/FS. (See remedial investigation.)

In-Situ Treatment - The treatment or remediation of media occurring in-place.

Innovative Treatment Technologies - Technologies that have been tested, selected, or used for treatment of hazardous substances or contaminated materials but lack well-documented cost and performance under a variety of operating conditions.

Land Disposal Restrictions (LDRs) - The Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) include specific restrictions on the land disposal of RCRA hazardous wastes. These restrictions, known as LDRs, prohibit the land disposal of restricted RCRA hazardous wastes unless these wastes meet treatment standards specified in 40 CFR 268 or other compliance options.

Light Non-Aqueous Phase Liquids (LNAPL) - Like DNAPLs, LNAPLs are immiscible liquids, but are lighter than water and therefore float on water. As they are lighter than water, they are most frequently found at the ground-water table/vadose zone interface.

Record of Decision (ROD) - A public document that explains the basis for selecting the clean-up alternative(s) that will be taken or served under CERCLA.

Remedial Desigh (RD) - The remedial action that involves designing and testing to determine whether the remedy will be effective at a site.

Remedial Investigation (RI)- An in-depth study designed to gather the data necessary to determine the nature and extent of the threat posed by contamination at a Superfund site. It also helps to establish the preliminary criteria for cleaning up the site in the FS and supports the technical and cost analyses of the alternatives. It is generally completed and combined with the FS and referred to as the RI/FS.

Risk Assessment - The qualitative and/or quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by actual and potential exposures to specific pollutants in air, water, soil or other media.

Superfund Accelerated Cleanup Model (SACM) - An initiative designed to accelerate all aspects of the Superfund clean-up process.

Vadose Zone - The zone in soil that lies above the permanent water table.

Volatile Organic Compounds (VOCs) - Any organic compound which readily dissipates into the air.

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