3.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

3.1 Introduction

Remedial alternative development requires the assembly of combinations of technologies and the media to which they would be applied into alternatives that address contamination on a site-wide basis. Prior to alternative development, general response actions that satisfy remedial action objectives and the potential technologies that are applicable to each general response action must be identified. Technologies and specific technology process options are then screened to allow the identification of technologies and representative process options that are combined to form remedial alternatives.

The following sections describe the process used to reach the alternative development stage, which is presented in Section 4.0.

3.2 Initial Identification and Screening of Technologies

The following databases, web sites and publications were researched to identify potential technologies for the Pownal Tannery site.

- U.S. EPA Hazardous Waste Clean-up Information (CLU-IN) web site
- Federal Remediation Technologies Roundtable (FRTR) web site
- Remediation Technologies Network Remediation Information Management System
- Superfund Innovative Technology Evaluation (SITE) Program
- TSD Central

The technology screening was performed as set forth in the RI/FS Guidance (EPA, 1988), with technologies screened on the basis of the technical implementability.

3.2.1 Soils and Sludge

Figure 3.2-1 presents the screening results for soil/sludges. The figure includes brief descriptions of the individual technologies or process options, and comments on their applicability at the site. Site characteristics identified during the RI were reviewed to identify conditions that would affect, limit or preclude the use of certain remedial technologies. The technologies or technology options which do not pass the screening process are shaded and will not be considered further. It is noted in the figure whether technologies were screened on the basis of overall technical implementability, specific site characteristics or waste characteristics that limit the technology's technical implementability.

Figure 3.2-1
Evaluation of Remedial Technologies for Soils and Sludges
Pownal Tannery Superfund Site
Pownal, Vermont

General Response Actions	Remedial Technology	Process Option	Description	Comments
No Action	None		No action; site monitoring.	Required as baseline for feasibility study analysis and comparison.
Institutional Control	Access Control	Land Use Restrictions	Deed restrictions on potentially contaminated areas.	Potentially viable.
		Fencing	Physical barrier to direct contact.	Potentially viable.
Containment	Capping	Clay	Placement and compaction of clay layer over contaminated soils/sludges.	Potentially viable.
		Soil/Vegetation	Placement of native soil over contaminated soils/sludges with vegetative growth.	Potentially viable.
		Asphalt	Application of bituminous material over contaminated area.	Potentially viable.
		Concrete	Installation of concrete slab over contaminated area.	Potentially viable.
		Multimedia	Multilayer cap including some combination of compacted clay, synthetic membrane, drainage layer, topsoil and vegetative cover.	Potentially viable.
Removal	Excavation	Dewatering / Excavation in the Dry	Excavation method of lowering water table to facilitate removal of saturated zone soils.	Potentially viable.
		Excavation in the Wet	Excavation of unsaturated and of saturated zone soils without local drawdown of water table.	Potentially viable.
Disposal	Landfill	On-site Landfill	Construction of RCRA-type landfill on site for contaminated soil/sludge disposal.	Potentially viable.
		Off-site Landfill	Disposal of contaminated soils/sludges in licensed hazardous waste landfill.	Potentially viable.
Ex-situ Treatment	Physical/Chemical	Soil Washing	Use of extractant solution to remove contaminants. Solutions used include water, surfactants, acids, bases, oxidizing or reducing agents.	Potentially viable.
		Separation	Physical separation (e.g.. sieving) of soil to separate fines from larger grain size fraction, thereby reducing volume requiring remediation.	Site-specific information gathered during the RI does not support retention of this process option.

Figure 3.2-1 (Cont.)

General Response Actions	Remedial Technology	Process Option	Description	Comments
Ex-situ Treatment (cont.)	Physical/Chemical (cont.)	Chemical Extraction	Contaminated soils/sludges and extractant (e.g., acid, solvent) are mixed in an extractor, dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use.	Potentially viable.
		Vapor Extraction	Moving air stream used to partition volatile contaminants from sorbed state to vapor state. Air stream is collected and treated prior to discharge.	Not applicable due to low volatility of dioxin and inorganics.
		Solar Detoxification	Destruction of contaminants by photochemical and thermal reactions using solar derived ultraviolet energy.	Not applicable due to inorganic contaminants of concern.
		Oxidation/Reduction	Raising or lowering of molecular oxidation state to render contaminants less toxic.	Potentially viable.
	Stabilization/ Solidification	Cement-based	Soils/sludges are mixed with Portland cement, forming rigid concrete mix.	Potentially viable.
		Pozzolonic	Siliceous material (e.g., fly ash), lime and water mixed with contaminated soils/sludges to form rigid matrix.	Potentially viable.
		Thermoplastic	Wastes sealed in deformable plastic matrix.	Not proven in large-scale application.
		Phosphate-based	Dibasic and tribasic calcium phosphates are mixed with contaminated soils to form rigid matrix.	Potentially viable.
		Sulfate-based	Sodium silicate and potassium silicate are added to contaminated soils/sludges as liquids, and form highly insoluble metal silicates.	Potentially viable.
	Biologica	Several	Biodegradation of contaminants in soils/sludges.	Not applicable to inorganic contaminants of concern.
	Thermal	Incineration	Combustion of organic contaminants at high temperatures.	Not applicable to inorganic contaminants of concern. Potentially viable for dioxins
		Thermal Desorption	Enhances volatilization of contaminants using high temperatures.	Potentially viable.
		Pyrolysis	Chemical decomposition of organic contaminants at high temperatures in the absence of oxygen.	Not applicable to inorganic contaminants of concern. Potentially viable, but largely unproven, for dioxins.

General Response Actions	Remedial Technology	Process Option	Description	Comments
In-situ Treatment	Physical/Chemical	Soil Flushing	Contaminated soils/sludges are flooded with water and/or suitable aqueous based solvents. The elutriated solution is collected and treated prior to discharge.	Potentially viable for inorganic constituents. Less effective for dioxins.
		Electrokinetic Separation	Metals and some (polar) organics are desorbed from soils/sludges via a low-intensity direct current applied through the waste between ceramic electrodes, and then removed.	Potentially viable.
		Chemical Oxidation	Chemical treatment involving reduction/oxidation reactions to render hazardous contaminants to nonhazardous or less toxic compounds.	Potentially viable.
		Vapor Extraction	Enhanced in-situ air flow used to partition volatile contaminants from sorbed state to vapor state. Air stream is collected and treated prior to discharge.	Not applicable due to low volatility of dioxin and inorganics.
	Stabilization/ Solidification	Cement-based	Soils/sludges are mixed with Portland cement, forming rigid concrete mix.	Potentially viable.
		Pozzolonic	Siliceous material (e.g., fly ash), lime and water mixed with contaminated soils/sludges to form rigid matrix.	Potentially viable.
		Thermoplastic	Wastes sealed in deformable plastic matrix.	Not proven in large-scale application.
		Phosphate-based	Dibasic and tribasic calcium phosphates are mixed with contaminated soils to form rigid matrix.	Potentially viable.
		Silicate-based	Sodium silicate and potassium silicate are added to contaminated soils/sludges as liquids, and form highly insoluble metal silicates.	Potentially viable.
		Vitrification	Contaminated soils are melted, via electric heating, into a stable vitrified mass.	Not proven in large-scale applications.
	Biological	Phytoremediation	Concentration of contaminants in vegetative biomass.	Potentially viable.
		Microbial Methods	Biodegradation of contaminants in soils/sludges utilizing microbes.	Not applicable to inorganic contaminants of concern.
	Thermal	Several	Contaminants destroyed by thermal destruction.	Not applicable to inorganic contaminants of concern.

Screened on the basis of:

- Site Characteristics
- Waste Characteristics
- Technical Feasibility

3.3 Process Option Evaluation

Upon identification of those technologies that are technically implementable at the Pownal Tannery Site, potential process options are further evaluated to allow the selection of a representative process option for each technology type. The process options are evaluated on the basis of effectiveness, implementability, and cost. Process option evaluations are presented in Figure 3.3-1 for soils and sludges. The selected representative process options are summarized in Table 3.3-1. Selected process options and process options that passed the process screening stage but were not chosen to be a representative process option (that is, one of the process options carried forward into the assembly of remedial alternatives) are briefly described below.

Table 3.3-1: Representative Process Option Summary

Media	Technology	Representative Process Option
Soil/sludges	No Action	Not applicable
	Institutional Controls	Land Use Restrictions
	Containment	Multimedia cap
	Removal	Excavation in the wet
	Disposal	Off-site landfill
	Ex-situ physical/chemical treatment	Oxidation/reduction
	Ex-situ Solidification/Stabilization	Cement-based reagents
	In-situ physical/chemical Treatment	Chemical oxidation
	In-situ Solidification/Stabilization	Cement-based reagents

Institutional Controls: Land use restrictions (e.g., deed restrictions) were chosen as a representative process option under the category of institutional controls due to their ability to limit future site activities to those that pose no risk of exposure. Although fencing could be used to restrict access to portions of the site containing elevated levels of PAHs and inorganics, fencing alone could not reduce identified exposures by limiting site access and activities, and thus was not retained for further evaluation.

Containment: A multimedia cap was chosen as a representative process option from several capping options despite higher costs due to its low susceptibility to cracking/weathering and overall effectiveness in reducing exposure to contaminated, untreated soil/sludges. In addition, it is anticipated that a multimedia cap such as those employed for landfill or land-based hazardous waste site closure would be the most acceptable process option to regulatory entities. However, a soil/vegetative cap was also chosen for further evaluation if constructed following treatment of soil/sludges (such as by Solidification/Stabilization). Because a soil/vegetative cap is more susceptible to erosion, stabilization of the cap (such as by installation of rip-rap) should be considered as part of this process option. Other caps that will not be considered further include clay cap, asphalt cap and concrete cap.

Figure 3.3-1
Evaluation of Process Options for Soils and Sludges
Pownal Tannery Superfund Site
Pownal, Vermont

General Response Actions	Remedial Technology	Process Option	Effectiveness	Implementability	Cost
No Action	None	Not Applicable. *	Does not achieve remedial action objectives. No action alternative retained to provide baseline analysis as required under NCP.	Technically implementable. Not acceptable to regulatory entities.	None.
Institutional Control	Access Control	Land Use Restrictions *	Limits future site use and activities that pose no risk to exposure.	Readily implemented. Enforcement of site use restrictions may be difficult in the long term.	Negligible cost.
		Fencing	Limits direct contact with site; contamination not reduced.	Readily implemented.	Low capital; low maintenance.
Containment	Capping	Clay	Susceptible to cracking.	Easily implemented; future land use restrictions required.	Low capital; low maintenance.
		Soil/Vegetation *	Susceptible to erosion, may require armoring with rip-rap.	Easily implemented; future land use restrictions required.	Low capital; low maintenance.
		Asphalt	Susceptible to weathering.	Easily implemented; future land use restrictions required.	Low capital; high maintenance.
		Concrete	Susceptible to weathering.	Easily implemented; future land use restrictions required.	Low capital; moderate maintenance.
		Multimedia *	Least susceptible to cracking/weathering.	Easily implemented; future land use restrictions required.	Moderate capital; moderate maintenance.
Removal	Excavation	Dewatering / Excavation in the Dry	Most effective for high permeability soils/sludges.	Implementable. Dewatering in excavation zones in lagoon areas may prove difficult given low permeability of sludge.	Low capital; low maintenance.
		Excavation in the Wet *	Most effective for low permeability soils/sludges.	Implementable.	Low capital; low maintenance.
Disposal	Landfill	On-site landfill	Contains but does not treat contaminants.	Implementable. Permit required.	High capital; low maintenance.
		Off-site landfill *	Eliminates contamination on site; contamination not treated.	No landfill in the United States currently accepts dioxin-containing wastes.	High capital; low maintenance.

* Chosen as representative process option.

Figure 3.3-1 (Cont.)

General Response Actions	Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Ex-situ Treatment	Physical/Chemical	Soil Washing	Complex waste mixtures (e.g., metals with organics) make formulating washing fluid difficult. High humic content in soil may require pretreatment. Additional treatment steps may be required to address hazardous levels of washing solvent remaining in the treated residuals. Not effective for material with high content of fines.	Implementable. Used extensively in Europe, two pilot scale demonstrations were carried out at Fort Polk, Louisiana in 1996.	Low to Moderate processing costs; moderate operation & maintenance (O&M).
		Separation	Gravity separation and sieving/physical separation are full-scale, well-established technologies used mostly for treatment of contaminated soil, sediment, and sludge.	Implementable	Low to Moderate capital; low O&M. High clay and moisture content will increase treatment cost.
		Chemical Extraction	High clay content may reduce extraction efficiency and require longer contact times. Treatability study may be required to evaluate effectiveness of process on site soil types and moisture content levels.	Implementable. Commercial systems readily available.	High capital; moderate O&M.
		Oxidation/Reduction *	Process targets inorganics. Unproven for dioxin containing materials.	Implementable.	Moderate capital; moderate O&M.
	Stabilization/Solidification	Cement-based *	Treatability study required.	Readily implemented; several vendors available.	Moderate to high capital; low maintenance.
		Pozzolonic	Treatability study required.	Readily implemented; several vendors available.	Moderate to high capital; low maintenance.
		Phosphate-based	Treatability study required. Phosphates typically used to treat low levels of soluble lead (i.e., in the range of 5 to 20 mg/L). Relatively unproven in large-scale applications.	Implementable; vendor availability somewhat limited.	High capital; low maintenance.
		Silicate-based	Treatability study required. Relatively unproven in large-scale applications.	Implementable; vendor availability somewhat limited.	High capital; low maintenance. More expensive than other S/S process options due to large volume of reagent generally required.

* Chosen as representative process option.

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Figure 3.3-1 (Cont.)

General Response Actions	Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Ex-situ Treatment (cont.)	Thermal	Incineration **	Effective for destruction of dioxins; ineffective for inorganics.	Implementable.	High capital; low O&M.
Ex-situ Treatment (cont.)	Thermal	Thermal Desorption **	Effective for low-level contaminated soils; ineffective for inorganics.	Implementable.	High capital; low O&M.
In-situ Treatment	Physical/Chemical	Soil Flushing	Low permeability or heterogeneous soils are difficult to treat. Regulatory entities concerned whether elutriate can be recaptured and treated.	Implementable.	Moderate capital; moderate O&M.
In-situ Treatment	Physical/Chemical	Chemical Oxidation *	Process targets inorganics, providing that ambient groundwater is not excessively reduced. Unproven for dioxin containing materials. Low permeability soils are difficult to treat.	Implementable.	Moderate capital; moderate O&M.
In-situ Treatment	Physical/Chemical	Electrokinetic Separation	Most applicable for metals and polar organics in low permeability, heterogeneous soils.	Unproven in large-scale applications. Process may result in undesirable and/or hazardous byproducts (such as chlorine gas).	Moderate capital; moderate O&M.
In-situ Treatment	Stabilization/Solidification	Cement-based *	Treatability study required.	Readily implemented; vendor availability somewhat limited.	Moderate capital; low maintenance.
In-situ Treatment	Stabilization/Solidification	Pozzolonic	Treatability study required.	Readily implemented; vendor availability somewhat limited.	Moderate capital; low maintenance.
In-situ Treatment	Stabilization/Solidification	Phosphate-based	Treatability study required. Unproven in large-scale applications.	Implementable; vendor availability somewhat limited.	High capital; low maintenance.
In-situ Treatment	Stabilization/Solidification	Silicate-based	Treatability study required. Unproven in large-scale applications.	Implementable; vendor availability somewhat limited.	High capital; low maintenance.
In-situ Treatment	Biological	Phytoremediation **	Treatability study required. Effectiveness is limited to shallow soils, within the root zone.	Implementable. Treatability study may be required.	Low capital; low maintenance.

* Chosen as representative process option.

** Although process option is technically implementable and may be effective for certain impacted materials on site, it has not been chosen for further evaluation in the FS due to site-wide considerations (refer to Section 3.3 for more detail).

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Removal: If excavation of saturated zone soils is necessary, dewatering can be performed to lower the water table to facilitate removal activities. We anticipate that this could be performed effectively in certain areas of the site containing soils with moderate to high permeabilities. However, excavation in the wet was chosen as the representative process option given that the majority of materials targeted for removal would be low-permeability soil/sludges within the lagoon areas.

Disposal: Off-site landfill disposal was chosen over the on-site landfill disposal option due to the potential for cost savings and due to the fact that there is not enough room to accommodate all of the waste on-site. Various solid waste landfill facilities were contacted to determine whether this material would be acceptable for disposal. There are facilities that would consider accepting the waste, assuming that the average dioxin concentration is within facility-specific guidelines and assuming state concurrence. If high dioxin concentrations prevent off-site disposal, it is possible that the high concentration dioxin waste could be segregated and disposed in Cell 4 of the Pownal Tannery Landfill.

Ex Situ Treatment: Oxidation/reduction is deemed the most effective of the physical/chemical treatment options in treating inorganics. Although some potential concerns exist about the ability of this process to effectively treat dioxin-containing materials, oxidation/reduction is retained for further consideration. Soil washing and chemical extraction are not retained for further consideration; soil washing is not retained due to the high percentage of silt particles that would reduce the phase transfer efficiency necessitating costly, specialized surfactants to enhance the process, and chemical extraction is considered ineffective for inorganics.

Incineration and thermal desorption technologies are representative of a relatively small number of technologies that are capable of the destruction and/or detoxification of dioxins. However, a site-wide view of the contaminant composition in the soil and sludge reveals that there is very little, if any, soil contaminated with dioxins that is not also impacted with inorganics (primarily arsenic). The toxicity of inorganics is not affected by incineration, so that further treatment and/or disposal would be required for site soil and sludge. Given the already high cost of incineration, the technical and logistical issues required to create a treatment train utilizing incineration, and the incremental reduction in risk that would result, thermal treatment technologies were not included for further evaluation.

Cement-based Solidification/Stabilization was chosen as the representative process option from several Solidification/Stabilization options based on preliminary treatability study results, which indicate that cement-based reagents will yield favorable physical characteristics including compressive strength. The effectiveness of pozzolonic-based Solidification/Stabilization is currently being evaluated in the treatability study being performed for the site, and may be included as part of a Solidification/Stabilization remedy, if selected, pending the results of the treatability study. Other Solidification/Stabilization options, including phosphate-based and silicate-based, will not be considered further due to their relatively high costs and that they are relatively unproven in large-scale applications.

In Situ Treatment: Phytoremediation was not retained for further evaluation due to several deficiencies in its effectiveness. Phytoremediation has been shown in some cases to be an effective bioaccumulator of inorganics, allowing for harvesting of the inorganic enriched biomass for further treatment and/or disposal. However, the effectiveness of phytoremediation relative to SVOCs and dioxins is less established. In addition, this process option is not effective at addressing contamination that lies below a relatively shallow root zone.