2.0 SUMMARY OF RESULTS

Information was compiled and evaluated for six categories of remediation technologies. Information about each remediation technology is summarized in Table 2-1. The remediation technologies can be categorized as follows:

in-situ approaches

soil vapor extraction
in-situ biodegradation
soil flushing

ex-situ approaches

thermal desorption
ex-situ biodegradation
incineration
soil washing
solvent extraction

Information on excavation also is included because the *ex-situ* approaches all require that the contaminated soil be excavated and fed to the treatment unit. The fugitive emissions from the materials handling operations for *ex-situ* processes often are overlooked or ignored, but they may represent a significant fraction of the total emissions from the remediation effort.

A variety of control devices may be employed with each of the remediation technologies. The most commonly used controls for each technology are shown in Table 2-2.

Air emission data for each remediation technology were compiled. The reported data primarily are measured concentrations in the exhaust gas or offgas (i.e. mass/volume of air), but measured emission rate data (mass/time) also are available. There was not sufficient data to develop meaningful VOC emission factors based on starting soil contamination levels for the remediation technologies of interest.

Typical treatment cost data are given in Table 2-3 for treatment operations with and without emission controls. The emission factors are based on "reasonable" operating conditions for the remediation of sites contaminated with petroleum fuels, but these estimates may not be applicable to some clean-up programs. A range of costs are given in most cases and these estimates are considered to be the best available information in the literature. The cost estimates are not all based on the same remediation scenario, so the data for a given remediation technology may not be directly comparable to the data for another remediation technology because the underlying assumptions of the volume of contaminated soil, the types and mass of contaminants that are present, the rate of treatment, the type of controls employed, etc. may vary.

Table 2-1

Table 2-2
Typical Control Technologies Used for Remediation Technologies

Emission Source	VOCs/SVOC[a]s	Particulate Matter and Metals	Acid Gases
Materials Handling			
Excavation	Operational Controls Foams Enclosure	Water Sprays	NA
Storage Piles	Polymer Sheeting	Cover Wind Screen	NA
Transport Vehicles	Cover Foam	Cover	NA
Roadways	NA	Gravel/Paving Water Sprays Water Sprays w/Additives	NA
Thermal Desorption	Condensers Thermal Incineration Carbon Adsorption	Cyclone Venturi Scrubber Fabric Filter HEPA Filter	Wet Scrubber Dry Scrubber
Soil Vapor Extraction	Carbon Adsorption Catalytic Incineration Thermal Incineration Internal Combustion Engine	NA	NA
In-situ Bioremediation	Carbon Adsorption	NA	NA
Ex-situ Bioremediation	Carbon Adsorption	NA	NA
Incineration	NA	Cyclone Venturi Scrubber Ionizing Wet Scrubber Wet ESP Fabric Filter	Wet Scrubber Dry Scrubber
Soil Washing	Carbon Adsorption	NA	NA
Solvent Extraction	Thermal Incineration	NA	NA
Soil Flushing	Carbon Adsorption	NA	NA

[a] SVOC = Semi-Volatile Organic Compound

Table 2-3
Summary of Cost Information for the Treatment of Contaminated Soil

Technology	Estimated Treatment Cost, $/Mg ($/ton)	
	Controlled	Uncontrolled
Excavation and Removal	ND	68 -454 (75 - 500)
Thermal Desorption	32 - 113 (35 - 125)	NA
Soil Vapor Extraction	47/Mg of VOC (52/ton of VOC)	24/Mg of VOC (26/ton of VOC)
In-situ Biodegradation	NA	91 (100)
Ex-situ Biodegradation	ND	64 - 118 (70 - 130)
On-Site Incineration	354 - 925[a] (390-1020[a])	NA
Soil Washing	NA	48 - 195 (53 - 215)
Solvent Extraction	NA	95 - 476 (105 - 525)
Soil Flushing	NA	ND

[a]Assumes incineration of hazardous waste (as opposed to incineration of soil contaminated with petroleum fuels) and a relatively small site.

ND = Not determined
NA = Not applicable