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March 1995

Remediation Case Studies: Thermal Desorption, Soil Washing, and In Situ Vitrification

Prepared by the

Member Agencies of the Federal Remediation Technologies Roundtable

NOTICE

Remediation Case Studies: Thermal Desorption, Soil Washing, and In Situ Vitrification

Prepared by Member Agencies of the
Federal Remediation Technologies Roundtable

Environmental Protection Agency
Department of Defense
- U.S. Air Force
- U.S. Army
- U.S. Navy

Department of Energy
Department of Interior
National Aeronautics and Space Administration
Tennessee Valley Authority
Coast Guard

March 1995

FOREWORD

This report is a collection of eight case studies of thermal desorption, soil washing, and in situ vitrification projects prepared by Federal agencies. The case studies, collected under the auspices of the Federal Remediation Technologies Roundtable, were undertaken to document the results and lessons learned from early technology applications. They will help establish benchmark data on cost and performance which should lead to greater confidence in the selection and use of cleanup technologies.

The Roundtable was created to exchange information on site remediation technologies, and to consider cooperative efforts that could lead to a greater application of innovative technologies. Roundtable member agencies, including the U.S. Environmental Protection Agency, U.S. Department of Defense, and U.S. Department of Energy, expect to complete many site remediation projects in the near future. These agencies recognize the importance of documenting the results of these efforts, and the benefits to be realized from greater coordination.

There are four case study reports, organized by technology, in this series. In the future, the set will grow through periodic supplements tracking additional progress with site remediation. In addition to this report on thermal desorption, soil washing, and in situ vitrification projects, the following volumes are available:

Remediation Case Studies: Bioremediation;
Remediation Case Studies: Groundwater Treatment; and
Remediation Case Studies: Soil Vapor Extraction.

Ordering information for these and other Roundtable documents is on the following page.

Walter W. Kovalick, Jr., Ph.D.
Chairman
Federal Remediation Technologies Roundtable

Ordering Instructions

The following documents are available free-of-charge from the U.S. EPA/National Center for Environmental Publications and Information (NCEPI). To order, mail or fax the completed form below to: U.S. EPA/National Center for Environmental Publications and Information, P.O. Box 42419, Cincinnati, OH 45242, or FAX requests to (513) 489-8695.

Title	Number	Price	Please Send
Abstracts of Remediation Case Studies [106pp]	EPA-542-R-95-001	Free	_____
Guide to Documenting Cost and Performance for Remediation Projects [64pp]	EPA-542-B-95-002	Free	_____

Name _____ Date _____

Organization _____

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_____

City/State/Zip _____ Telephone _____

Internet Address _____

The following documents are available by calling the National Technical Information Service (NTIS) at 703-487-4650 or writing them at: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161

Title	Number	Price*
Remediation Case Studies: Bioremediation	PB95-182911	$17.50
Remediation Case Studies: Groundwater Treatment	PB95-182929	$17.50
Remediation Case Studies: Soil Vapor Extraction	PB95-182937	$25.50
Remediation Case Studies: Thermal Desorption, Soil Washing, and In Situ Vitrification	PB95-182945	$17.50
Remediation Case Studies: Four Document Set	PB95-182903	$67.00

Other Federal Remediation Technology Roundtable (FRTR) documents available from NTIS:

Title	Number	Price*
Accessing Federal Databases for Contaminated Site Clean-Up Technologies (3rd Edition)	PB94-144540	$17.50
Federal Publications on Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation (3rd Edition)	PB94-144557	$17.50
Synopses of Federal Demonstrations of Innovative Site Remediation Technologies (3rd Edition)	PB94-144565	$44.50
Remediation Technologies Screening Matrix and Reference Guide (2nd Edition)	PB95-104782	$45.00

* Additional fee for shipping and handling; next day delivery also available. Major credit cards accepted.

TABLE OF CONTENTS

INTRODUCTION

The purpose of this report is to provide case studies of site cleanup projects utilizing thermal desorption, soil washing, and in situ vitrification. This report is one of four volumes which are the first in a series of studies that will be prepared by Federal agencies to improve future remedy selection at contaminated sites. For projects that are ongoing, interim findings will be updated in future publications as additional data become available.

The case studies were developed by the U.S. Environmental Protection Agency (EPA), the U.S. Department of Defense (DoD), and the U.S. Department of Energy (DOE). They present cost and performance information for full-scale remediation efforts and several large-scale demonstration projects and were prepared retrospectively, based on available information and interviews with project personnel. The case studies are meant to serve as primary reference sources, and contain information on the site; contaminants and media treated; technology and vendor; cost and performance; and points of contact for the technology application. The studies contain varying levels of detail, reflecting the differences in the availability of data and information. Full-scale cleanup efforts are not conducted primarily for the purpose of technology evaluation, and data collection is often limited to establishing compliance with contractual requirements or regulatory levels.

This volume contains reports on projects using thermal desorption, including six completed applications at sites contaminated with PCBs, pesticides, or chlorinated aliphatics. Two projects in this volume used soil washing and in situ vitrification technologies.

Table 1 provides a project summary including information on technology used, contaminants and media treated, and project duration. The table also notes highlights of the technology applications.

Table 2 summarizes cost data, including information on quantity of media treated and contaminant removed. In addition, Table 2 shows a calculated unit cost for some projects, and identifies key factors potentially affecting project cost. While a summary of project costs is useful, it is difficult to compare costs for different projects because of site-specific factors and differences in level of detail.

Cost data are shown on Table 2 as reported in the case studies, and have not been adjusted for inflation to a common year basis. The dollar values shown in Table 2 should be assumed to be dollars for the time period that the project was in progress (shown on Table 1 as project duration).

The project costs shown in the second column of the table were compiled consistently. However, the case studies themselves vary in terms of the level of detail and format of the available cost data. Where possible, project costs were categorized according to

an interagency Work Breakdown Structure (WBS).[1] The WBS specifies costs as 1) before-treatment costs, 2) after-treatment costs, or 3) treatment costs. (Table 2 provides some additional information on activities falling under each category.) In many cases, however, the available information was not sufficiently detailed to be broken down in this way.

The column showing the calculated treatment cost provides a dollar value per unit of soil or groundwater treated and, if possible, per pound of contaminant removed. Note that comparisons using the information in this column are complicated by the fact that calculated costs may only be available on a per cubic yard or per ton basis, and cannot be converted back-and-forth due to limited availability of soil bulk density data.

Key factors that potentially affect project costs include economies of scale, concentration levels in contaminated media, required cleanup levels, completion schedules, and hydrogeological conditions. It is important to note that several projects in the case study series represent early applications, and the costs of these technologies are likely to decrease in the future as firms gain experience with design and operation.

Abstracts and On-Line Access

The case studies have been summarized in abstracts which precede each study and provide key project information in a consistent format. The abstracts are based on recommended terminology and procedures from the Guide to Documenting Cost and Performance for Remediation Projects.

The case study abstracts are also available on-line through EPA's Cleanup Information Bulletin Board System (CLU-IN). To access CLU-IN by modem, call (301) 589-8366, or to contact the CLU-IN help desk, call (301) 589-8368. CLU-IN is available on the Internet; the telnet address is clu-in.epa.gov or 134.67.99.13.

[1]Additional information on the contents of the Work Breakdown Structure and on whom to contact for WBS and related information is presented in the Guide to Documenting Cost and Performance for Remediation Projects - see ordering instructions on page iii.

Table 1. Summary of Remediation Case Studies: Thermal Desorption, Soil Washing, and In Situ Vitrification

Site Name, State (Technology)	Contaminants Treated							Media (Quantity)	Project Duration	Highlights
	BTEX and/or TPH	Chlorinated Aliphatics	Pesticides	Polynuclear Aromatic Hydrocarbons	Polychlorinated Biphenyls	Metals	Source of Contamination (Principal Contaminants)			
Anderson Development Company Superfund Site, MI (Thermal desorption)		●		●			Manufacturing process (MBOCA, phenol, phthalates)	Soil (5,100 tons)	1/92 - 6/93	Treatment using a thermal auger system with hollow-screw conveyors
King of Prussia Technical Corporation Superfund Site, NJ (Soil washing)						●	Surface impoundment (Cr, Cu, Ni)	Soil and sludge (19,200 tons)	6/93 - 10/93	Innovative on-site monitoring technique, including use of X-ray fluorescence; early full-scale soil washing application at a Superfund site
McKin Superfund Site, ME (Thermal desorption)	●	●		●			Disposal Pit (TCE)	Soil (11,500 yd^3)	7/86 - 4/87	Early full-scale application of thermal desorption
Outboard Marine Corporation Superfund Site, OH (Thermal desorption)					●		Surface water & sewer discharges	Soil and sediment (12,755 tons)	1/92 - 6/92	Achieved PCB mass removal efficiency of 99.98%--much higher than the 97% requirement
Parsons Chemical/ETM Enterprises Superfund Site, MI (In situ vitrification)			●	●		●	Surface water & sewer discharges (DDT, mercury, dioxins)	Soil (3,000 yd^3)	5/93 - 5/94	First application at a Superfund site; melt requires one year to cool, and final results expected after May 1995
Pristine, Inc. Superfund Site (Thermal desorption)		●	●	●			Spills and on-site disposal (aldrin, DDT, dieldrin, dioxin)	Soil (12,800 tons)	11/93 - 3/94	Contaminated soils exhibited a wide range of pH and moisture conditions, and contained greater than 2% elemental sulfur
T H Agriculture & Nutrition Company Superfund Site, GA (Thermal desorption)			●				Spills and leaks (DDT, toxaphene, BHC)	Soil (4,300 tons)	7/93 - 10/93	Soils contaminated with a mixture of organochlorine pesticides; interlock process control system monitored 9 process parameters
Wide Beach Development Superfund Site, NY (Thermal desorption w/dehalogenation)					●		Road oiling (PCB 1254)	Soil (42,000 tons)	10/90 - 9/91	Thermal desorption combined with APEG dechlorination

Key:

BTEX - Benzene, Toluene, Ethylbenzene, and Xylene
TPH - Total Petroleum Hydrocarbons

Table 2. Remediation Case Studies - Summary of Cost Data for Thermal Desorption, Soil Washing, and In Situ Vitrification Projects

Site Name, State (Technology)	Project Cost ($)*	Quantity Treated	Quantity of Contaminant Removed	Calculated Cost for Treatment**	Key Factors Potentially Affecting Project Costs
Anderson Development Company Superfund Site, MI (Thermal desorption)	Not available	5,100 tons of soil	--	Projected costs range from $190 to $340/ton of soil treated (SITE program cost estimates based on demonstration project)	Projected costs affected by soil moisture content
King of Prussia Technical Corporation Superfund Site, NJ (Soil washing)	7,700,000	19,200 tons of soil and sludge	--	Not Calculated	No information available on components of total cost
McKin Superfund Site, ME (Thermal desorption)	2,900,000	11,500 cubic yards of soil	--	Not Calculated	Limited information available on components of total cost
Outboard Marine Corporation Superfund Site, OH (Thermal desorption)	T - 2,474,000 B - 900,000	12,755 tons of soil and sediment	--	$190/ton of soil and sediment treated	--
Parsons Chemical/ETM Enterprises Superfund Site, MI (In situ vitrification)	T - 800,000 B - 800,000 A - 90,000	3,000 cubic yards of soil	--	$270/cubic yard of soil treated	Application involved excavation and staging of wastes
Pristine, Inc. Superfund Site, OH (Thermal desorption)	Not available	12.800 tons of soil	--	--	--
T H Agriculture & Nutrition Company Superfund Site, GA (Thermal desorption)	T - 849,996 B - 252,582	4,300 tons of soil (2,500 cubic yards)	--	$200/ton of soil treated $340/cubic yard of soil treated	Small project limited economies-of-scale; cleanup completed in 4 months

Project Cost*

T = Costs for treatment activities, including preprocessing, capital equipment, operation, and maintenance
B = Costs for before-treatment activities, including site preparation, excavation, and sampling and analysis
A = Costs for after-treatment activities, including disposal of residuals and site restoration
C = Capital costs
O = Annual operating costs

Calculated Cost for Treatment**

**Calculated based on costs for treatment activities (T): excludes costs for before- (B) and after-(A)treatment activities. Calculated costs shown as "Not Calculated" if an estimate of treatment costs unavailable.

Table 2. Remediation Case Studies - Summary of Cost Data for Thermal Desorption, Soil Washing, and In Situ Vitrification Projects (Continued)

Site Name, State (Technology)	Project Cost ($)*	Quantity Treated	Quantity of Contaminant Removed	Calculated Cost for Treatment**	Key Factors Potentially Affecting Project Costs
Wide Beach Development Superfund Site, NY (Thermal desorption/dehalogenation)	T - 11,600,000 B - 908,000 A - 3,400,000	42,000 tons of soil	--	$280/ton of soil treated	Lack of structural integrity of treated soil led to need for off-site disposal

Project Cost*

T = Costs for treatment activities, including preprocessing, capital equipment, operation, and maintenance
B = Costs for before-treatment activities, including site preparation, excavation, and sampling and analysis
A = Costs for after-treatment activities, including disposal of residuals and site restoration
C = Capital costs
O = Annual operating costs

Calculated Cost for Treatment**

**Calculated based on costs for treatment activities (T): excludes costs for before- (B) and after-(A)treatment activities. Calculated costs shown as "Not Calculated" if an estimate of treatment costs unavailable.

THERMAL DESORPTION, SOIL WASHING, AND IN SITU VITRIFICATION CASE STUDIES

Thermal Desorption at the Anderson Development Company Superfund Site Adrian, Michigan

Case Study Abstract

Thermal Desorption at the Anderson Development Company Superfund Site, Adrian, Michigan

<table>
<tr><td>Site Name:
Anderson Development Company Superfund Site</td><td rowspan="2">Contaminants:
Chlorinated Aliphatics, PAHs, Other Organics, and Metals
- MBOCA (4,4-methylene bis(2-chloroaniline) primary contaminant concentration in untreated soil
- Manganese at levels up to 10%</td><td>Period of Operation:
January 1992 to June 1993</td></tr>
<tr><td>Location:
Adrian, Michigan</td><td>Cleanup Type:
Full-scale cleanup</td></tr>
<tr><td>Vendor:
Michael G. Cosmos
Weston Services
1 Weston Way
West Chester, PA 19380
(610) 701-7423</td><td rowspan="2">Technology:
Thermal Desorption
- Solids pretreated by shredding, screening, and dewatering
- Thermal processor consisting of 2 jacketed troughs
- Hollow screw conveyors in the troughs mix, transport, and heat the contaminated soil
- Soil residence time 90 minutes, temperature of soil/sludge 500-530°F
- Treated soil was discharged into a conditioner, where it was sprayed with water</td><td>Cleanup Authority:
CERCLA and State: Michigan
- ROD Date: 9/30/91
- PRP Lead</td></tr>
<tr><td>SIC Code:
2869 (Industrial Organic Chemicals, Not Elsewhere Classified)</td><td>Point of Contact:
Jim Hahnenburg (HSRW-6J)
Remedial Project Manager
U.S. EPA Region 5
77 West Jackson Boulevard
Chicago, IL 60604
(312) 353-4213</td></tr>
<tr><td>Waste Source:
Surface Impoundment/Lagoon</td><td colspan="2" rowspan="2">Type/Quantity of Media Treated:
Soil and Sludge
- 5,100 tons treated
- Moisture content: soil - not available, sludge - 65-70% (before dewatering), 41-44% (after dewatering)
- pH: <7 (before dewatering), 10.9-11.2 (after dewatering)</td></tr>
<tr><td>Purpose/Significance of Application:
Treatment using a thermal auger system; main contaminant is a hardener for plastics.</td></tr>
<tr><td colspan="3">Regulatory Requirements/Cleanup Goals:
- Soil - MBOCA: 1.684 mg/kg
- Soils/sludges - VOCs and SVOCs: Michigan Environmental Response Act (MERA) Number 307, Regulation 299.5711, compliance with Type B criteria for soil standards; off-site disposal required for treated soil due to elevated manganese levels</td></tr>
<tr><td colspan="3">Results:
- Analytical data for 6 piles of treated soil indicated that the cleanup goals for MBOCA and VOCs were met
- Seven of eight SVOCs met cleanup goals; analytical problems were identified for bis(2-ethylhexyl)phthalate
- Treated soil disposed off site due to elevated manganese levels</td></tr>
<tr><td colspan="3">Cost Factors:
Information not available</td></tr>
</table>

Thermal Desorption at the Anderson Development Company Superfund Site, Adrian, Michigan (Continued)

Description:
Between 1970 and 1979, the Anderson Development Company (ADC) site located in Adrian, Lewanee County, Michigan, was used for the manufacture of 4,4-methylene bis(2-chloroaniline) or MBOCA, a hardening agent used in plastics manufacturing. Process wastewaters were discharged to an unlined lagoon. A remedial investigation determined that soil and sludges in and around the lagoon were contaminated. Contaminated soils and sludges were excavated, dewatered, and stockpiled. A Record of Decision (ROD), signed in September 1991, specified thermal desorption as the remediation technology for the excavated soil. Soil cleanup goals were established for MBOCA and specific volatile and semivolatile organic constituents.

Thermal desorption using the Roy F. Weston LT^3 system was performed from January 1992 to June 1993. The LT^3 thermal processor consists of two jacketed troughs. Hollow-screw conveyors move soil across the troughs, and act to mix and heat the contaminated soil. The thermal processor discharges treated soil to a conditioner where it is sprayed with water. Thermal desorption achieved the soil cleanup goals specified for MBOCA and all volatile organic constituents. Seven of eight semivolatile organic constituents met cleanup goals; analytical problems were identified for bis(2-ethylhexyl)phthalate.

Information on costs for this application were not available at the time of this report. Originally, the treated soils were to be used as backfill for the lagoon. However, the state required off-site disposal of treated soils due to the presence of elevated levels of manganese.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report presents cost and performance data for a thermal desorption treatment application at the Anderson Development Company (ADC) site located in Adrian, Lewanee County, Michigan. Between 1970 and 1979, the ADC site was used for the manufacture of 4,4-methylene bis(2-chloroaniline) or MBOCA, a hardening agent used in plastics manufacturing. Process wastewaters were discharged to an unlined lagoon. A subsequent remedial investigation determined that soil and sludges in and around the lagoon were contaminated and contaminated soils and sludges were excavated, dewatered, and stockpiled. A Record of Decision (ROD), signed in September 1991, specified thermal desorption as the remediation technology for the excavated soil. Soil cleanup goals were established for MBOCA and specific volatile and semivolatile organic constituents.

Thermal desorption using the Roy F. Weston LT^3® system was performed from January 1992 to June 1993. The LT^3® thermal processor consisted of two jacketed troughs, and operated with a residence time of 90 minutes and a soil/sludge temperature of 500-530°F in this application. Hollow-screw conveyors moved soil across the troughs, and acted to mix and heat the contaminated soil. The thermal processor discharged treated soil to a conditioner where it was sprayed with water. Thermal desorption achieved the soil cleanup goals specified for MBOCA and all volatile organic constituents. Seven of eight semivolatile organic constituents met cleanup goals; analytical problems were identified for bis(2-ethylhexyl)phthalate.

Information on costs for this application were not available at the time of this report. Originally, the treated soils were to be used as backfill for the lagoon. However, the state required off-site disposal of treated soils due to the presence of elevated levels of manganese.

SITE INFORMATION

Identifying Information

Anderson Development Company
Adrian, Michigan

CERCLIS # MID002931228

ROD Date: September 30, 1991

Treatment Application

Type of Action: Remedial

Treatability Study associated with application? Yes (see Appendix A)

EPA SITE Program test associated with application? Yes (see Reference 9)

Period of Operation: 1/92 - 6/93

Quantity of material treated during application: 5,100 tons of soil and sludge

Background [1, 2, 5, 11]

Historical Activity that Generated Contamination at the Site: Chemical Manufacturing - plastics hardener

Corresponding SIC Code: 2869 (Industrial Organic Chemicals, Not Elsewhere Classified)

Waste Management Practice that Contributed to Contamination: Surface Impoundment/Lagoon

Site History: The Anderson Development Company (ADC) is a specialty chemical manufacturer located in Adrian, Lewanee County, Michigan, as shown on Figure 1. The ADC site covers approximately 12.5 acres of a 40-acre industrial park. Residential areas surround the industrial park. Figure 2 shows a layout of the ADC site.

SITE INFORMATION (CONT.)

Background [1, 2, 5, 11] (cont.)

Between 1970 and 1979, ADC manufactured 4,4-methylene bis(2-chloroaniline), or MBOCA. MBOCA is a hardening agent used in the manufacture of polyurethane plastics. As part of the manufacturing process, process wastewaters containing MBOCA were discharged to an unlined 0.5-acre lagoon.

In May 1986, Anderson Development Company (ADC) entered into an Administrative Order by Consent with EPA to conduct a Remedial Investigation/Feasibility Study (RI/FS). The remedial investigation determined that soil and sludge in and around the lagoon were contaminated, and contaminated soils and sludges were excavated, dewatered, and stockpiled.

Regulatory Context: A 1990 ROD selected in situ vitrification (ISV) as the remediation technology. An amended ROD was issued in September 1991 which specified thermal desorption as the remediation technology, with ISV as a contingent remedy if thermal desorption was found to be not effective. In August 1991, ADC signed a consent decree to conduct a Remedial Design/ Remedial Action (RD/RA) to remediate the site according to the specifications in the 1991 Record of Decision (ROD).

Figure 1. Site Location [1]

Remedy Selection: Thermal desorption was selected based on a review of the results from a bench-scale thermal desorption study. The performance data from the bench-scale test indicated that thermal desorption was capable of meeting the MBOCA cleanup levels. Additionally, the costs projected for thermal desorption treatment were lower than costs projected for other technologies.

Site Logistics/Contacts

Site Management: PRP Lead

Oversight: EPA

Remedial Project Manager:
Jim Hahnenburg (HSRW-6J)
U.S. EPA Region 5
77 West Jackson Boulevard
Chicago, IL 60604
(312) 353-4213

State Contact:
Brady Boyce
Michigan Department of Natural Resources
Knapp's Office Centre
P.O. Box 30028
Lansing, MI 48909
(517) 373-4824

Treatment System Vendor:
Michael G. Cosmos
Weston Services
1 Weston Way
West Chester, PA 19380
(610) 701-7423

SITE INFORMATION (CONT.)

Site Logistics/Contacts (cont.)

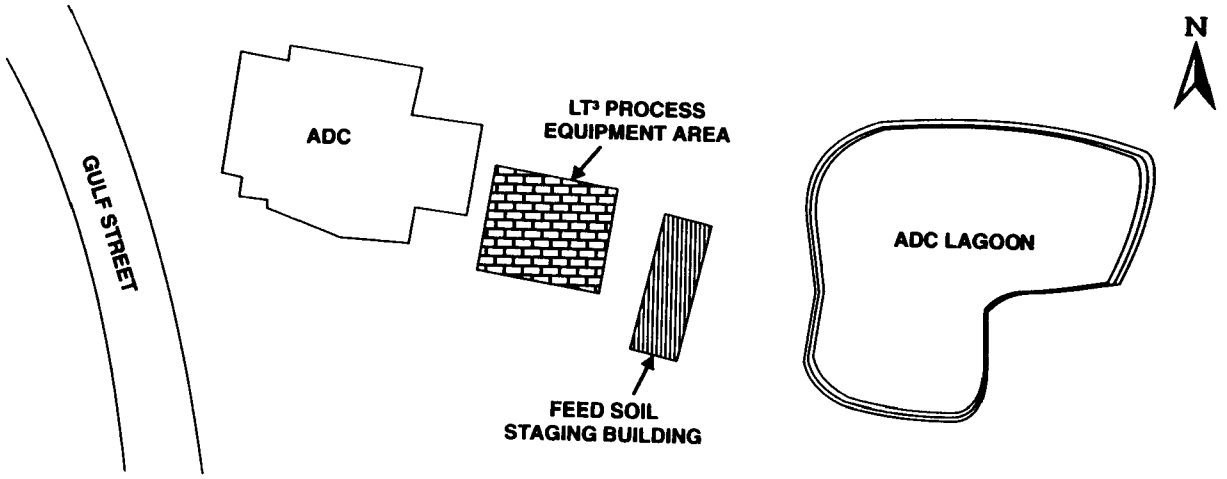

Figure 2. Site Layout [adapted from [1]]

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix processed through the treatment system:
Soil (ex situ)/Sludge (ex situ)

Contaminant Characterization

Primary contaminant groups: Halogenated and nonhalogenated volatile organic compounds and polynuclear aromatic hydrocarbons

The contaminants in the lagoon area identified during the remedial investigation included volatile organic compounds (VOCs), phthalates, phenols, and polynuclear aromatic hydrocarbons (PAHs). 4,4-Methylene bis(2-chloroaniline) (MBOCA) was identified as the primary constituent of concern. Other VOCs present included toluene and degradation products of MBOCA. High levels of metals (e.g., manganese at levels up to 10%) were also present at the site. [1,2]

Matrix Characteristics Affecting Treatment Cost or Performance

Listed below in Table 1 are the major matrix characteristics affecting cost or performance for this technology.

Table 1. Matrix Characteristics [9]

Parameter	Value	Measurement Procedure
Soil Classification	A-7-6 Soil Group	ASTM (no further description available at this time)
Clay Content and/or Particle Size Distribution	Arithmetic mean diameter of untreated sludge was 765 microns	Not available
Moisture Content	Soil: Not available Sludge: 65-70% (before dewatering) Sludge: 41-44% (after dewatering)	Not available
pH	<7 (before dewatering) 10.9-11.2 (after dewatering)	Not available
Oil and Grease or Total Petroleum Hydrocarbons	Not available	-
Bulk Density	Not available	-
Lower Explosive Limit	Not available	-

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology Type:

Thermal Desorption

Supplemental Treatment Technology Types: [2]

Pretreatment (Solids): Shredding/Screening/ Dewatering

Post-Treatment (Water): Oil-Water Separator, Filter, Carbon Adsorber

Post-Treatment (Air): Baghouse, Condenser, Carbon

Thermal Desorption System Description and Operation

The following treatment technology description is an excerpt from the Applications Analysis Report [9]:

"The LT³® system consists of three main treatment areas: soil treatment, emissions control, and condensate treatment. A block flow diagram of the system [see Figure 3] is described below.

Soil is treated in the LT³® thermal processor. The thermal processor consists of two jacketed troughs, one above the other. Each trough houses four intermeshed, hollow-screw conveyors. A front-end loader transports feed soil (or sludge) to a weigh scale before depositing the material onto a feed conveyor. The feed conveyor discharges the soil into a surge hopper located above the thermal processor.

The surge hopper is equipped with level sensors and provides a seal over the thermal processor to minimize air infiltration and contaminant loss. The conveyors move soil across the upper trough of the thermal processor until the soil drops to the lower trough. The soil then travels across the processor and exits at the same end that it entered. Hot oil circulates through the hollow screws and trough jackets and acts as a heat transfer fluid. During treatment in the processor, each hollow-screw conveyor mixes, transports, and heats the contaminated soil. The thermal processor discharges treated soil into a conditioner, where it is sprayed with water to cool it and to minimize fugitive dust emissions. An inclined belt conveys treated soil to a truck or pile.

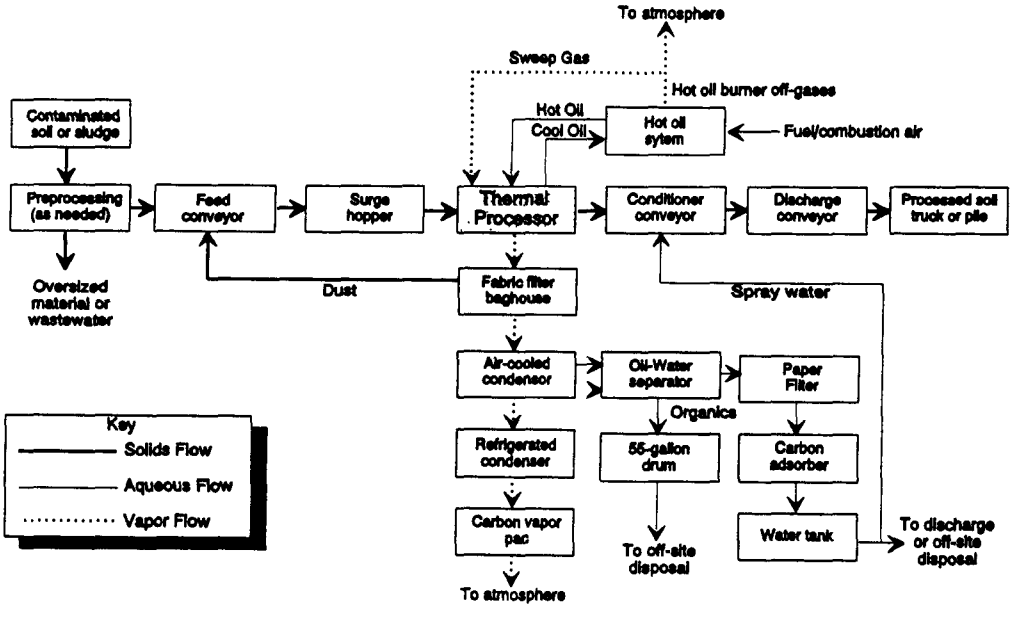

Figure 3. LT³® System Block Flow Diagram [9]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Thermal Desorption System Description and Operation (cont.)

A burner heats the circulating oil to an operating temperature of 400 to 650°F (about 100°F higher than the desired soil treatment temperature). Combustion gases released from the burner are used as sweep gas in the thermal processor. A fan draws sweep gas and desorbed organics from the thermal processor into a fabric filter. Dust collected on the fabric filter may be retreated or drummed for off-site disposal. Exhaust gas from the fabric filter is drawn into an air-cooled condenser to remove most of the water vapor and organics. Exhaust gas is then drawn through a second, refrigerated condenser, which lowers the temperature further and reduces the moisture and organic content of the off-gases. Electric resistance heaters then raise the off-gas temperature back to 70°F. This temperature optimizes the performance of the vapor-phase, activated carbon column, which is used to remove any remaining organics. At some sites, caustic scrubbers and afterburners have been employed as part of the air pollution control system, but they were not used at the ADC site.

Condensate streams from the air-cooled and refrigerated condensers are typically treated in a three-phase, oil-water separator. The oil-water separator removes light and heavy organic phases from the water phase. The aqueous portion is then treated in the carbon adsorption system to remove any residual organic contaminants; after separation and treatment, the aqueous portion is often used for soil conditioning. The organic phases are disposed of off site. When processing extremely wet materials like sludge, the oil-water separation step may not be appropriate due to the high volume of condensate generated. In such cases, aqueous streams from the first and second condensers may be pumped through a disposable filter to remove particulate matter prior to carbon adsorption treatment and off-site disposal."

System Operation [2]

At ADC, contaminated soil and sludge were excavated and screened. Additionally, sludges were dewatered with a filter press to reduce the moisture content to levels sufficient for thermal treatment. The soil and dewatered sludge were then stockpiled in the feed soil staging building prior to thermal treatment. No information is available at this time on the disposition of water extracted by the filter press.

Treated soils, sludges, and fly ash were sent off-site for disposal at the Laidlaw Landfill, a Type II facility located in Adrian, Michigan. The ROD originally called for backfilling the excavated lagoon with the treated soil, sludge, and fly ash. However, due to high manganese levels, off-site disposal was required. Second-time fly ash, which is fly ash generated during the treatment of fly ash through the LT^3® system, did not meet the established guidelines, and could not be disposed in the landfill. Instead, the second-time fly ash was barreled and incinerated at Petrochem Processing, Inc. in Detroit, Michigan.

Operating Parameters Affecting Treatment Cost or Performance

Table 2 lists the major operating parameters affecting cost or performance for this technology and the values measured for each.

Table 2. Operating Parameters [9]*

Parameter	Value
Residence Time	90 minutes
System Throughput	2.1 tons/hr
Temperature (Soil/Sludge)	500° -530° F

**Values reported during SITE Demonstration.*

TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

A timeline of key activities for this application is shown in Table 3.

Table 3. Timeline [2]

Start Date	End Date	Activity
-	5/86	Administrative Order by Consent entered by PRP to conduct RI/FS
-	8/91	Administrative Order by Consent entered by PRP to conduct RD/RA
-	9/8/83	Site Placed on NPL
-	9/28/90	ROD signed
-	9/30/91	ROD amendment signed
-	9/91	Thermal Desorption Treatability Study conducted
9/91	-	Contract led to Weston Services for site remediation
10/91	-	LT³® mobilized to Anderson Development Company Site
11/91	12/91	Dewatering activities for high water content sludges
11/91	-	1st LT³® Operations test (delayed due to transportation problems)
12/91	-	2nd LT³® Operations test (required because results from 1st test were destroyed in a fire)
12/91	-	Results from 2nd LT³® Operations test received
1/92	-	LT³® Operations started
5/92	-	LT³® operations stopped to assess operability of the process and to review potential problems with the analytical method for MBOCA
6/92	8/92	Evaluation of QAPP, resampling of treated materials, evaluation of operating temperatures via pilot plant test
9/92	-	Restart of LT³® operation
6/93	-	LT³® operations complete
10/93		LT³® removed from site
3/24/93	-	Memo from MDNR to EPA indicating that all ARARs have been achieved and delisting process can proceed

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

The Consent Decree and ROD amendment identified cleanup goals for volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) in treated soil and sludge, including an MBOCA cleanup standard of 1.684 mg/kg. Cleanup goals for VOCs and SVOCs in soil and sludge were identified as the Michigan Environmental Response Act (MERA) Number 307, Regulation 299.5711, Type B criteria for soil. Cleanup goals were

TREATMENT SYSTEM PERFORMANCE (CONT.)

Cleanup Goals/Standards (cont.)

not identified for metals. The specific constituents from the MERA 307 list with which ADC was required to comply are not available at this time. In addition, no information is shown on any air emission standards in the references available at this time. [1, 2, 6]

Additional Information on Goals

The cleanup goal for MBOCA, as specified in the ROD, is based on EPA guidance documentation and is based on the excess lifetime cancer risk level of 1×10^{-6}.

Treatment Performance Data

During treatment, treated soils and sludges were placed in eight composite soil piles (piles A through H). All eight soil piles were approved by EPA for off-site disposal. Tables 4, 5, and 6 show the range of concentrations for MBOCA, VOCs, and SVOCs for piles B through G, respectively. No data are available at this time on the concentration of these items in the soils and sludges prior to treatment or on the concentrations of these contaminants in piles A or H. Table 7 shows the range of concentrations for 13 metals in treated soil piles B and G. [12]

Chlorinated dibenzo-p-dioxins (CDDs) and furans (CDFs) were measured during the SITE Demonstration in the untreated and treated sludge, filter dust, liquid condensate, exhaust gas from refrigerated condenser, and stack gas. The results for 11 specific CDDs and CDFs measured in these locations are shown in Table 8. [9]

Table 4. Range of 4,4-Methylene bis(2-chloroaniline) (MBOCA) Concentrations in Treated Soil Piles [12]

Constituent	Cleanup Goal	Pile B 9/17-11/22	Pile C 11/30-12/12	Pile D 12/13-1/7	Pile E 1/7-1/22	Pile F 1/26-2/13	Pile G 4/8-4/30
MBOCA (mg/kg)	1.684	BDL-1.63	0.55-1.52	0.28-1.66	0.21-1.67	0.36-1.60	<0.05-1.59

BDL - Below Detection Limit (detection limit not reported)

Table 5. Range of VOC Concentrations in Treated Soil Piles [12]

Constituent	Cleanup Goal	Pile B 9/17-11/22	Pile C 11/30-12/12	Pile D 12/13-1/7	Pile E 1/7-1/22	Pile F 1/26-2/13	Pile G 4/8-4/30
Acetone (µg/kg)	14,000	100-5,400	NA	100-300	100-300	500	100-600
Benzene (µg/kg)	20	NA	NA	NA	NA	NA	20
Methylene Chloride (µg/kg)	100	10-20	NA	10-20	0-20	10-20	10-20
2-Butanone (µg/kg)	8,000	100-200	NA	100	NA	NA	100
1,1,1-Trichloroethane (µg/kg)	4,000	NA	NA	NA	NA	10	NA
Toluene (µg/kg)	16,000	20-110	NA	20	NA	NA	NA

NA - Not Available

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (cont.)

Table 6. Range of SVOC Concentrations in Treated Soil Piles [12]

Constituent	Cleanup Goal	Pile B 9/17-11/22	Pile C 11/30-12/12	Pile D 12/13-1/7	Pile E 1/7-1/22	Pile F 1/26-2/13	Pile G 4/8-4/30
Chrysene (µg/kg)	330	BDL (200)-BDL (1,100)	NA	NA	NA	BDL (700)-BDL (5,300)	BDL (3,900)-BDL (12,000)
Phenanthrene (µg/kg)	Not Identified	200-300	300	NA	NA	400-1,800	700-3,200
Pyrene (µg/kg)	4,000	200-300	200	NA	NA	300	700-2,300
Benzo(k)fluoranthene (µg/kg)	330	NA	NA	NA	NA	NA	300
Phenol (µg/kg)	80,000	200-14,000	3,300-5,700	NA	NA	4,700-5,900	300-1,000
Benzo(b)fluoranthene (µg/kg)	330	NA	NA	NA	NA	NA	200-300
Fluoranthene (µg/kg)	6,000	200-300	200	NA	NA	200-300	200-300
Bis(2-ethylhexyl)-phthalate (µg/kg)	40	300	NA	NA	NA	NA	NA
Isophorone (µg/kg)	160	200-600	NA	NA	NA	NA	NA
4-Methyl Phenol (µg/kg)	8,000	600	NA	NA	NA	NA	NA

BDL - Below Detection Limit (value in parentheses is reported method detection limit)
NA - Not Available

Table 7. Range of Metals Concentrations in Treated Soil Piles [12]

Constituent	Cleanup Goal	Pile B 9/17-11/22	Pile G 4/8-4/30
Antimony (mg/kg)	Not Identified	BDL-11	0.5-3.6
Arsenic (mg/kg)	Not Identified	BDL-25	16-31
Barium (mg/kg)	Not Identified	67-110	61-130
Cadmium (mg/kg)	Not Identified	BDL-8.6	4.1-7.7
Chromium (mg/kg)	Not Identified	BDL-31	16-46
Copper (mg/kg)	Not Identified	23-48	30-1150
Lead (mg/kg)	Not Identified	13-39	26-140
Manganese (mg/kg)	Not Identified	8,700-18,000	6,700-22,000
Mercury (mg/kg)	Not Identified	BDL-0.3	<0.1-<0.2
Selenium (mg/kg)	Not Identified	0.2-3.5	<0.5-140
Silver (mg/kg)	Not Identified	BDL-3.4	1.2-3
Thallium (mg/kg)	Not Identified	3-38	26-54
Zinc (mg/kg)	Not Idenified	3.2-14,000	4,000-8,500

BDL - Below Detection Limit (detection limit not reported)

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (cont.)

Table 8. Arithmetic Mean Concentrations of CDDs and CDFs Measured During SITE Demonstration [9]

	Sampling Location					
Parameter	Untreated Sludge (ng/kg)	Treated Sludge (ng/kg)	Filter Dust (ng/kg)	Liquid Condensate (ng/L)	Exhaust Gas from Refrigerated Condenser (ng/dscm)	Stack Gas (ng/dscm)
2,3,7,8-TCDD	BDL	BDL	0.1	BDL	0.01	0.001
TCDD	BDL	0.987	6.54	119	0.137	0.0087
TCDF	BDL	2.42	19.8	697	0.178	0.066
PeCDD	BDL	0.534	5.98	60	0.2	0.0089
PeCDF	BDL	0.066	2.49	47.7	0.14	BDL
HxCDD	BDL	BDL	0.81	BDL	0.002	BDL
HxCDF	BDL	BDL	0.5	2.8	0.0004	0.0003
HpCDD	BDL	BDL	1.38	BDL	0.023	0.017
HpCDF	BDL	BDL	0.14	BDL	0.005	0.0012
OCDD	0.21	BDL	3.20	BDL	0.121	0.025
OCDF	BDL	BDL	0.04	BDL	0.0067	0.0024

All CDDs and CDFs shown as Below Detection Limit (BDL) are assigned a value of 0
Detection limits in untreated sludge ranged from 0.04 to 0.80 nanograms per gram (ng/g). Detection limits in treated sludge ranged from 0.07 to 1.6 ng/g. Detection limits in fabric filter dust ranged from 0.14 to 9.6 ng/g. Detection limits in the liquid condensate ranged from 1.4 to 17 ng/L

Performance Data Assessment

As shown in Tables 4, 5, and 6, MBOCA, other VOCs, and SVOCs met the cleanup goals for 6 soil piles treated, with 2 exceptions. In soil pile B, bis(2-ethylhexyl)phthalate (BEHP) was measured as 300 µg/kg, and the cleanup goal was 40 µg/kg. BEHP is a common laboratory contaminant, and its presence was attributed to analytical problems rather than presence in the treated soil. [12]

As shown in Table 6, isophorone was initially measured in soil pile B at levels ranging from 200-600 µg/kg, and the cleanup goal was 160 µg/kg. Additional samples from soil pile B showed that isophorone and other SVOCs were measured at levels below the detection limit. The RPM stated that, prior to disposal, soil at this site had to be retreated until all cleanup goals were met. Soil from pile B was disposed off site. It is not known at this time if soil from pile B that showed the elevated levels of isophorone was retreated.

As shown in Table 7, the treated soils contained concentrations of manganese ranging from 6,700 mg/kg to 22,000 mg/kg. Due to these high concentrations of manganese, ADC was required to dispose of these residuals in an off-site landfill, instead of being backfilled on site.

As shown in Table 8, dioxins and furans were present in some treatment residuals. The fabric filter dust contained the highest concentrations of dioxins/furans and was the only solid residual containing measurable amounts of 2,3,7,8-TCDD.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Completeness

Data are available on the concentrations of MBOCA, VOCs, and SVOCs in six of eight treated soil piles; these data are adequate for comparison with cleanup goals. Data are also available on the concentrations of CDDs and CDFs in six sampling locations.

Performance Data Quality

EPA SW-846 methods were used for sampling soil piles at ADC; no information is available at this time on the analytical methods used.

Analytical problems were identified by the PRP for chrysene, BEHP, and isophorone in soil pile B. For chrysene, analytical data sheets were identified incorrectly; problems for BEHP and isophorone are described above under "Performance Data Assessment."

TREATMENT SYSTEM COST

Procurement Process [2]

The PRPs contracted with nine firms to provide support services for the ADC remediation. Weston Services served as the primary contractor for soil excavation and treatment at ADC. Table 9 lists each contractor and their role in this cleanup. No information is available at this time on the competitive nature of these procurements.

Table 9. ADC Remediation and Support Contractors [2]

Contractor	Activity
Weston Services	Soil excavation and treatment
Clayton Environmental Consultants	Analytical services
Chester LabNet	Analytical services
Laidlaw Waste Systems	Transport and disposal of treated soils, sludge, and fly ash
Simon Hydro-Search	Environmental consultants, Project management
OHM	Dewatering of high moisture content sludges
Environmental Science and Engineering	Installation of groundwater monitoring wells
Clean Harbors	Disposal of wastewater and contaminated stormwater
Environmental Management Control, Inc.	Backfilling the excavated lagoon

Treatment System Cost

No information is available at this time on the costs for the thermal desorption treatment application at ADC.

Projected Cost

The Applications Analysis Report [9] includes cost projections for using the LT^3® system at other sites. As shown in Tables 10, 11, and 12, costs are divided into 12 categories and are reported as cost per ton of soil treated, for three different soil moisture contents. The values are based on using an LT^3® system similar to the system used at the Anderson site. [9]

The costs are shown in Tables 10, 11, and 12 according to the format for an interagency Work Breakdown Structure (WBS). The WBS specifies 9 before-treatment cost elements, 5 after-treatment cost elements, and 12 cost

TREATMENT SYSTEM COST (CONT.)

Projected Cost (cont.)

elements that provide a detailed breakdown of costs directly associated with treatment. Tables 10, 11, and 12 present the cost elements exactly as they appear in the WBS, along with the specific activities, and unit cost and number of units of the activity (where appropriate), as provided in the Applications Analysis Report.

Table 10. Projected Costs for Activities Directly Associated with Treatment [9]

Cost Categories	Cost Per Ton of Soil Treated (dollars)[a]		
	Soil Moisture Content		
	20%	45%	75%
Startup/Testing/Permits			
Startup Costs[b]			
Mobilization	10 00	10.00	10.00
Assembly	25.00	25.00	25.00
Shakedown	15.00	15.00	15.00
Total Startup Costs	50 00	50.00	50.00
Operation (Short-Term - up to 3 years)			
Labor Costs[c]			
Operations Staff	39.00	79.50	79.50
Site Manager	21.60	44.30	44.30
Maintenance Supervisor	7.20	14.60	14.60
Site Safety Officer	7.20	14.60	14.60
Total Labor Costs	75.00	153.00	153.00
Supply and Consumable Costs			
PPE[c]	6.00	10.00	10.00
PPE Disposable Drums[c]	0.50	1.00	1.00
Residual Waste Disposal Drums	1 20	1.20	1 20
Activated Carbon[e]	8.00	24.00	24.00
Diesel Fuel[c]	0 62	1.00	1.00
Calibration Gases[e]	0 35	1.10	1.10
Total Supply and Consumable Costs	16.70	38.30	38.30
Utility Costs			
Natural Gas (@ $1.43/1,000 ft³)	7.80	26.00	26.00
Electricity (@ $0.18/kWh)	2.10	6.30	6.30
Water (@$1.00/100 gal.)	0.60	0.60	0.60
Total Utility Costs	10.50	32.90	32.90
Equipment Repair and Replacement Costs			
Maintenance	11.70	19.80	19 80
Design Adjustments[f]	0.00	0.00	0.00
Facility Modifications[f]	0.00	0.00	0 00
Total Equipment Repair and Replacement Costs	11 70	19.80	19.80
Cost of Ownership			
Equipment Costs			
LT³® Rental[c]	13.00[d]	22.00	22.00
Support Equipment Rental			
Dumpsters[c]	0.70	1.35	1.35
Wastewater Storage Tanks[e]	1 00	2.00	2 00
Steam Cleaner	0.10	0.10	0.10
Portable Toilet[c]	0.10	0.20	0.20
Optional Equipment Rental[c]	12.00	20.00	20.00
Total Equipment Costs	26.90	45.65	45.65
Total	**190.80**	**339.65**	**339.65**

[a] = *Cost per ton of soil treated; figures are rounded and have been developed for a 3,000-ton project.*
[b] = *Fixed cost not affected by the volume of soil treated.*
[c] = *Costs are incurred for the duration of the project.*
[d] = *Feed rate is double that of soils with 45% moisture content.*
[e] = *Costs are incurred only during soil treatment activities.*
[f] = *Cost included in the cost of renting the LT³® system.*

TREATMENT SYSTEM COST (CONT.)

Projected Cost (cont.)

Table 11. Projected Costs for Before-Treatment Activities [9]

Cost Categories	Cost Per Ton of Soil Treated (dollars)[a]		
	Soil Moisture Content		
	20%	45%	75%
Mobilization and Preparatory Work			
Site Preparation Costs			
Administrative Costs	11.00	11.00	11.00
Fencing Costs	0.40	0.40	0.40
Construction Costs	0.70	0.70	0.70
Dewatering Costs	NA	NA	187.90
Total Site Preparation Costs	12.10	12.10	200.00
Permitting and Regulatory Costs			
Permit	3.30	3.30	3.30
Engineering Support	80.00	80.00	80.00
Total Permitting and Regulatory Support	83.30	83.30	83.30
Monitoring, Sampling, Testing, and Analysis			
Analytical Costs			
Treatability Study[b]	10.00	10.00	10.00
Sample Analysis for VOCs	4.20	12.00	12.00
Total Analytical Costs	14.20	22.00	22.00
Total	**109.60**	**117.40**	**305.30**

NA = Not Applicable
[a] = Cost per ton of soil treated; figures are rounded and have been developed for a 3,000-ton project.
[b] = Fixed cost not affected by the volume of soil treated.

Table 12. Projected Costs for After-Treatment Activities [9]

Cost Categories	Cost Per Ton of Soil Treated (dollars)[a]		
	Soil Moisture Content		
	20%	45%	75%
Disposal (Commercial)			
Residual Waste and Waste Shipping, Handling, and Transportation Costs			
Oversized Material (2% of feed soil)	5.40	5.40	5.40
Drums	27.00	27.00	27.00
Wastewater	7.20	14.40	14.40
Total Residual Waste and Waste Shipping, Handling, and Transportation Costs	39.60	46.80	46.80
Demobilization			
Site Demobilization Costs	33.00	33.00	33.00
Total	**72.60**	**79.80**	**79.80**

[a] = Cost per ton of soil treated; figures are rounded and have been developed for a 3,000-ton project.

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- No information is available at this time on the costs for the thermal desorption treatment application at ADC.
- Projected costs for treatment activities ranging from $190 to $340 per ton of soil treated were identified by the SITE program based on the results of a demonstration test. The SITE program identified moisture content as a key parameter affecting costs.

Performance Observations and Lessons Learned

- Cleanup goals for treated soil and sludge in this application were specified for 4,4-Methylene bis(2-chloroaniline) and six other VOCs, and nine SVOCs. Cleanup goals ranged from 20 ppb (e.g., for benzene) to 80,000 ppb (e.g., for phenol).
- Analytical data for six treated soil piles show that MBOCA and all other VOCs met the cleanup goals. Eight of nine SVOCs met cleanup goals; analytical problems were identified for BEHP.
- Elevated levels of manganese were measured in the treated soil; as a result, ADC was required to dispose of treated soils in an off-site landfill.
- SITE program data indicate that dioxins and furans were present in some treatment residuals; of all solid residuals, the fabric filter dust contained the highest concentrations of dioxins and furans.
- This cleanup of 5,100 tons of soil and sludge was completed in a 17 month period, which included several months of system downtime.

Other Observations and Lessons Learned

- The technology tested in the treatability study was not used in the full-scale application; the reason for this is not available at this time.

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11. Comments on 30 November 1994 Draft Report from Jim Hahnenburg, RPM, received January 18, 1995.

12. Memorandum from Mark Hastings, Anderson Development Company, to James J. Hahnenberg, U.S. EPA, regarding Offsite disposal of Composite Soil Pile B, December 3, 1992.

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14. Memorandum from Mark Hastings, Anderson Development Company, to James J. Hahnenberg, U.S. EPA, regarding Offsite disposal of Composite Soil Pile C, December 22, 1992.

15. Memorandum from Mark Hastings, Anderson Development Company, to James J. Hahnenberg, U.S. EPA, regarding Offsite disposal of Composite Soil Pile D, January 20, 1993.

16. Memorandum from Mark Hastings, Anderson Development Company, to James J. Hahnenberg, U.S. EPA, regarding Offsite disposal of Composite Soil Pile E, February 18, 1993.

17. Memorandum from Mark Hastings, Anderson Development Company, to James J. Hahnenberg, U.S. EPA, regarding Offsite disposal of Composite Soil Pile F, March 10, 1993.

18. Memorandum from Mark Hastings, Anderson Development Company, to James J. Hahnenberg, U.S. EPA, regarding Offsite disposal of Composite Soil Pile G, May 13, 1993.

Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Radian Corporation under EPA Contract No. 68-W3-0001.

APPENDIX A - TREATABILITY STUDY RESULTS

Treatability Study Objectives

Canonie conducted a bench-scale treatability study using their Low Temperature Thermal Aeration (LTTA) process on contaminated soil from the Anderson site. The study had the following objectives [10]:

- Determine the effectiveness of the LTTA process to reduce MBOCA concentrations in contaminated sludge and clay from the Anderson site to levels below the cleanup goal of 1.684 mg/kg;
- Optimize the operating parameters, especially bed temperature and residence time; and
- Develop cost estimates for the full-scale treatment application.

Treatability Study Test Description

The treatability study consisted of six runs. A bench-scale thermal desorption system was used during the study to simulate the full-scale LTTA system. The bench-scale system utilized a batch process, and consisted of a hollow rotating cylinder with a metal shell which simulated the rotary drum dryer in the LTTA system. The shell was heated externally, which in turn heated the soil fed into the cylinder. In the full-scale design, heat transfer is accomplished directly, and includes a continuous feed of soil.

Off-gasses from the soil were carried from the dryer by induced air flow through the rotating cylinder. Air flow was induced through the cylinder at a rate of 0.25 to 0.30 cubic feet per minute (cfm). The amount of air flow per mass of soil in the dryer was much smaller than in the full-scale unit. Because of the relatively lesser amount of particulates produced, a baghouse was not included in the design of the bench-scale unit.

The off-gasses from the bench-scale unit were first vented through a series of water cooled condensers, which simulated the Venturi scrubber in the full-scale system. This unit condensed water vapor and some volatile and semivolatile organics, including MBOCA. For the fifth and sixth run, the condenser off-gas was vented through Tenax or polyurethane foam (PUF) tubes, respectively, to sample for volatile or semivolatile compounds which remained in the off-gas. This measured the amount of volatiles and semivolatiles which would enter the vapor phase carbon unit in the full-scale system.

The first four runs of the treatability study were preliminary runs, while the last two were system optimization runs. Canonie performed the runs on contaminated sludge and clay from the Anderson site. The clay was shredded to a particle size of less than one-half inch and then dried. The procedure used for the treatability study follows:

1. Contaminated wet sludge and shredded, dried clay were mixed at a ratio of approximately one to three or one to four (weight-to-weight basis).
2. Between 1,300 and 1,400 grams were batch fed into the preheated dryer cylinder for each run.
3. Air was induced through the dryer cylinder at a flow rate between 0.2 and 0.3 cfm.
4. The residence time was 10.0 minutes for the first, second, and sixth runs, and 12.5 minutes for the third, fourth, and fifth runs. The cylinder was rotated at 6 rpm for all six runs.
5. Off-gas from the process was vented through a series of condensers, and a glass container was used to collect the condensate.
6. During the fifth run, a portion of the off-gas was vented through Tenax tubes to sample for volatiles. During the sixth run, the off-gas was passed through PUF tubes to sample for semi-volatiles. In both runs, the off-gas passed through the tubes after it had passed through the condensers.

APPENDIX A - TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Test Description (cont.)

7. The soil inside the cylinder was heated to temperatures (bed temperature) between 480°F and 700°F. [10]

Treatability Study Performance Data

Untreated and treated soil samples from each run were analyzed for MBOCA. The operating parameters and the MBOCA data for the six runs are presented in Table A-1. The results show that runs with a bed temperature of greater than 600°F (runs 1 and 2) had a removal efficiency of greater than 99.99%, removing MBOCA to concentrations of less than 0.05 mg/kg. Runs 3 and 4 showed that when the bed temperature was below 600°F and untreated soil concentrations were relatively high (300 mg/kg or higher), large concentrations of MBOCA remained in the treated soils.

Samples from Runs 5 and 6 were analyzed for concentrations of volatile and semivolatile organics. The results, shown in Table A-2, show that volatile and semivolatile soil concentrations were relatively low before treatment, and that the technology reduced concentrations of toluene. Other compounds showed no decrease or an increase in concentration. Results of the condensate analysis are presented in Table A-3.

Results of the off-gas analysis show that no semivolatiles were present and only low levels of volatiles were present. Of the volatiles, acetone and acetaldehyde were present at the greatest concentrations, at 20 μg/kg and 6 μg/kg, respectively. The off-gas analytical data is presented in Table A-4. [10]

Canonie estimated that they could perform the full-scale remediation for a fixed price of $810,000. This estimate was based on a maximum of 2,000 tons of soil. This estimated cost does not include site preparation, electrical costs, or waste disposal.

Table A-1. MBOCA Concentrations in Pre- and Post-Treatment Soil and Relative Test Run Conditions

	MBOCA (mg/kg)			Test Run Conditions	
Test Run No.	Pretreatment	Post-Treatment	Percent Reduction in MBOCA	Median Bed Temperature (F°)	Run Time (min)
1	570	<0.05	99.99	700	10
2	1100	<0.05	99.99	600	10
3	300	13	95.67	500	12.5
4	320	240	25	480	12.5
5	9.2	<0.05	99.45	520	12.5
6	81	0.23	99.72	520	10.0

APPENDIX A - TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Performance Data (cont.)

Table A-2. Summary of Volatile and Semivolatile Organics in Pre- and Post-Treatment Soil

Test Run No.	Compound Detected	Concentration (µg/kg)	
		Pretreatment Sample	Post-Treatment Sample
5	Volatiles		
	Acetone	1,900	1,900
	Benzene	ND	8
	Chlorobenzene	40	ND
	Methyl Chloride	ND	58
	Tetrachloroethene	40	ND
	Toluene	1,800	54
	Xylenes (Total)	40	5
	Semivolatiles		
	Bis(2-ethylhexyl)phthalate	1,000	1,200
	4-Methylphenol	2,600	2,100
6	Volatiles		
	Acetone	ND	2,600
	Benzene	ND	12
	Methyl Chloride	ND	200
	Toluene	720	98
	Xylenes (Total)	ND	12
	Semivolatiles		
	Bis(2-ethylhexyl)phthalate	1,200	ND
	4-Methylphenol	2,100	ND

ND - Not detected

Table A-3. Summary of Volatile and Semivolatile Organics In Condenser Off-Gas

Test Run No.	Compound Detected	Concentration (µg/kg)
5	Volatiles Only*	
	C_4H_8 Hydrocarbon	0.2
	Acetaldehyde	6
	C_5H_{10} Hydrocarbon	0.1
	C_5H_{12} Hydrocarbon	0.07
	C_5H_8 Hydrocarbon	0.08
	Furan	0.08
	Carbon Disulfide	0.7
	Propanol	3
	Acetone	20
	C_6H_{12} Hydrocarbons	0.9
	Acetonitrile	0.3
	C_6H_{14} Hydrocarbons	3
	Methyl Acetate	0.2
	Methyl Propanol + C_6H_{12} Hydrocarbon	0.8
	Methyl Propanol	0.1
	C_6H_{10} Hydrocarbon + C_6H_{12} Hydrocarbon	0.07
	Unknown Compound	0.08
	Butanol	0.9
	Unknown Compound	0.03
6	Semivolatiles Only*	
	None Detected	-

**The GC column was not heated during VOC analyses, hence the list presented may not include all the volatile compounds present in the sample*

APPENDIX A - TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Performance Data (cont.)

Table A-4. Summary of Condensate Analyses

Compound Detected	Concentration (µg/L)
MBOCA	860
Volatiles	
Acetone	30,000
Toluene	600
Acetaldehyde	1,000
Methyl Ester of Methyl Propeonic Acid	300
Semivolatiles	
4-Chloroaniline	1,500
4-Methylphenol	12,000
Phenol	5,100
Aniline	20,000
Pyridine	800
Furancarboxaldehyde	900
Dimethyl Pyridine	800
Benzaldehyde	2,000
Bromophenol + Acetophenone	900
Chloroaniline Isomer	200,000
Benzothiazole	1,000
Chloromethyl Benzeneamine	1,000
Bromophenol	900
Unknown Nitrogen Compound	1,000
Dibromophenol	3,000
Chloro Methoxy Pyrimidinamine	8,000
Unknown Nitrogen Compound	3,000

Treatability Study Lessons Learned

- Canonie's LTTA technology was effective in reducing concentrations of MBOCA to levels below the cleanup goal of 1.684 mg/kg, when operated at temperatures of 520°F or greater.
- The vendor specified that optimal operating parameters for the full-scale system would be a residence time of 10 minutes at 600°F to 650°F, and a system throughput of 35 to 40 tons per hour. Under these conditions, the system would be effective in meeting the cleanup goals.
- According to the vendor, the full-scale LTTA system would achieve a greater removal efficiency than the bench-scale system due to the direct heating and the greater air flow in the full-scale unit.
- Canonie estimated that they could perform the full-scale remediation for a fixed price of $810,000. This estimate was based on a maximum of 2,000 tons of soil. This estimated cost does not include site preparation, electrical costs, or waste disposal.

Soil Washing at the
King of Prussia Technical Corporation Superfund Site
Winslow Township, New Jersey

Case Study Abstract

Soil Washing at the King of Prussia Technical Corporation Superfund Site Winslow Township, New Jersey

Site Name:
King of Prussia Technical Corporation Superfund Site

Contaminants:
Metals
- Beryllium, chromium, copper, nickel, zinc, lead, mercury
- Highest metals concentrations in sediments - chromium (8,010 mg/kg), copper (9,070 mg/kg), mercury (100 mg/kg)
- Highest metals concentration in sludge - chromium (11,300 mg/kg), copper (16,300 mg/kg), lead (389 mg/kg), nickel (11,100 mg/kg)

Period of Operation:
June 1993 to October 1993

Location:
Winslow Township, New Jersey

Cleanup Type:
Full-scale cleanup

Vendor:
Mike Mann
Alternative Remediation Technologies, Inc.
14497 Dale Mabry Highway
Tampa, FL 33618
(813) 264-3506

Technology:
Soil Washing
Materials Handling
- Selective excavation of metals-contaminated soil using visual inspection, confirmed using on-site X-ray fluorescence

Soil Washing System
- Four components - screening, separation, froth flotation, sludge management; rated feed capacity of 25 tons/hour
- Screening - multiple screens; coarse screen (>8 inches) and process oversize (>2 inches); wet screening of <2 inch materials
- Separation - hydroclones separate coarse and fine-grained materials
- Froth flotation - air flotation treatment units
- Sludge management - overflow from hydroclones sent through clarifier, sludge thickener, filter press; filter cake disposed off site; water reused for wet screening

Cleanup Authority:
CERCLA
- ROD Date: 9/28/90
- PRP Lead

SIC Code:
4953 (Sanitary Services-Refuse Systems)

Point of Contact:
John Gorin
Remedial Project Manager
U.S. EPA Region 2
26 Federal Plaza
New York, NY
(202) 264-7592

Waste Source:
Surface Impoundments/Lagoons

Type/Quantity of Media Treated:
Soil and Sludge
- 19,200 tons of soil and sludge
- Moisture content of approximately 15%
- pH of approximately 6.5

Purpose/Significance of Application:
EPA's first full-scale application of soil washing to remediate a Superfund site. Innovative on-site monitoring technique; selective excavation techniques, including use of X-ray fluorescence, to screen soil for cleanup.

Regulatory Requirements/Cleanup Goals:
1990 ROD identified soil cleanup levels for 11 metals
- Arsenic (190 mg/kg), beryllium (485 mg/kg), cadmium (107 mg/kg), chromium (483 mg/kg), copper (3,571 mg/kg), lead (500 mg/kg), mercury (1 mg/kg), nickel (1,935 mg/kg), selenium (4 mg/kg), silver (5 mg/kg), zinc (3,800 mg/kg)

Soil Washing at the King of Prussia Technical Corporation Superfund Site Winslow Township, New Jersey (Continued)

Results:
- Cleanup goals were met for all 11 metals
- Cleanup goals were achieved in less than 4 months

Cost Factors:
- Total cost of $7,700,000 (including off-site disposal cost)

Description:
The King of Prussia (KOP) Technical Corporation Superfund site had been used as a waste recycling facility from 1971 to 1974. An estimated 15 million gallons of liquid industrial waste were processed in six lagoons. These activities resulted in soil and sludge contamination at the site. The primary constituents of concern were chromium (at levels up to 11,300 mg/kg), copper (at levels up to 16,300 mg/kg), and nickel (at levels up to 11,100 mg/kg). The ROD, signed in September 1990, specified complete excavation of soils, sediments, and sludges from these lagoons and use of contaminant extraction (soil washing) to achieve the specified soil cleanup levels for 11 metals.

The soil washing system at KOP was selected based on the results of a treatability study and data from a demonstration run using KOP soil at a full-scale unit in the Netherlands. The soil washing system was operated at KOP from June 1993 to October 1993. The system consisted of a series of hydroclones, conditioners, and froth flotation cells. Approximately 19,200 tons of contaminated soil and sludge were treated during this application. The soil washing system achieved the specified soil cleanup levels for all 11 metals, and the treated soil was used as backfill at the site. Of note for this full-scale cleanup was the use of selective excavation techniques to screen contaminated soil and sludge for treatment. Selective excavation was performed through visual examination confirmed using on-site X-ray fluorescence, and resulted in fewer tons of soil requiring treatment.

The total cost for this application was $7,700,000, including off-site disposal costs for the sludge cake. Selective excavation reduced the overall costs for the application by reducing the amount of soil requiring treatment by a factor of two. Further, the data from the demonstration run expedited the design schedule of the full-scale unit by more than a year.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report summarizes cost and performance data for a soil washing treatment application at the King of Prussia (KOP) Technical Corporation Superfund site. This site, located in Winslow Township, New Jersey, is a former waste processing facility that operated from January 1971 to April 1974. On September 28, 1990, a Record of Decision (ROD) was signed to conduct a remedial action for contaminated soil and sludge at KOP. A full-scale soil washing unit, owned and operated by Alternative Remedial Technologies, Inc. (ART) of Tampa, Florida, was used from June 28, 1993 to October 10, 1993 to treat 19,200 tons of soil and sludge at the site The soil and sludge were contaminated primarily with chromium, copper, and nickel. Maximum concentrations of these metals measured in the soil were chromium at 8,010 mg/kg; copper at 9,070 mg/kg; and nickel at 387 mg/kg. Average treatment unit feed concentrations were 660 mg/kg, 860 mg/kg, and 330 mg/kg, respectively. ART performed the soil washing operation under direct contract to the Potentially Responsible Party (PRP) committee who had received a Unilateral Administrative Order from the U.S. EPA in April 1991.

A treatability test of soil washing using soil from the KOP site was conducted in January 1992; the results from the treatability test indicated that the soil at KOP had an acceptable level of sand content and could be effectively treated by soil washing. A demonstration run was conducted in July 1992 when 164 tons of contaminated soil and sludge from the KOP site were processed through a full-scale unit in the Netherlands. The results from the demonstration run conducted in July 1992 further supported the feasibility of soil washing for treating soil from the KOP site to the ROD-specified cleanup levels.

For the full-scale remediation, ART operated the soil washing unit on a production basis with the goal of maintaining a 25 ton/hour throughput. The soil washing unit consisted of a series of hydrocyclones, conditioners, and froth flotation cells. The cleaned sand (product) and process oversize from the soil washing unit were redeposited on site while the sludge cake was disposed off site as a nonhazardous waste. Performance data showed that the cleaned sand and process oversize met the cleanup levels for 11 metals in this application.

This application was the first full-scale application of soil washing to remediate a Superfund site in the United States. In addition, a selective excavation technique was used to collect and identify contaminated soil and sludge for treatment in the soil washing unit, and the associated use of advanced on-site monitoring techniques. Selective excavation was performed through visual determination of contaminated material and confirmation of clean materials on site with an X-ray fluorescence instrument in an on-site laboratory. This excavation technique resulted in the processing of fewer tons of soil requiring soil washing than would have occurred with a less discriminating excavation technique.

Actual costs for the soil washing treatment application at the King of Prussia site, including off-site disposal costs, were approximately $7,700,000.

SITE INFORMATION

Identifying Information

King of Prussia Technical Corporation
Operable Unit 1
Winslow Township, New Jersey

CERCLIS #: NJD980505341

ROD Date: 28 September 1990

Treatment Application

Type of Action: Remedial
Treatability Study associated with application? Yes (Refer to Appendix A for additional information on treatability study and Appendix B for information on demonstration run.)
EPA SITE Program test associated with application? No
Period of Operation: 6/28/93 to 10/10/93
Quantity of soil treated during application: 19,200 tons

Background

Historical Activity that Generated Contamination at the Site: Waste processing facility

Corresponding SIC Code: 4953: Sanitary Services—Refuse Systems

Waste Management Practice that Contributed to Contamination: Surface impoundment/lagoon; and dumping—unauthorized

Site History: The King of Prussia (KOP) Technical Corporation site is located in Winslow Township, Camden County, New Jersey, as shown in Figure 1. The site, a rectangular shaped, 10-acre parcel, as shown in Figure 2, is bordered to the northeast, northwest, and southwest by a dense pine forest of the state-owned 6,000-acre Winslow Wildlife Management Area. The southeast border is Piney Hollow Road. The Great Egg Harbor River, used for recreational purposes, is located approximately 1,000 feet southwest of the site. A drainage swale in the site is dammed by two fire roads; site runoff flows toward the river. The swale has been designated as a wetlands. The site is generally barren and sandy with sparse patches of tall seed grass. [1 and 9]

The KOP Corporation began operating a waste recycling facility at this site in January 1971. The facility included six lagoons used to process liquid industrial waste. Industrial wastes were converted to materials that were intended to be marketed and sold as construction material and for other uses. Excess materials were transferred to other disposal locations. During its operation, it is estimated that at least 15 million gallons of acids and alkaline aqueous wastes were processed at this site. Site operations are believed to have ceased and site abandonment to have occurred in late 1973 to early 1974. In addition, between 1976 and 1988, illegal dumping of trash and hazardous materials was suspected to have occurred at the site. [1 and 9]

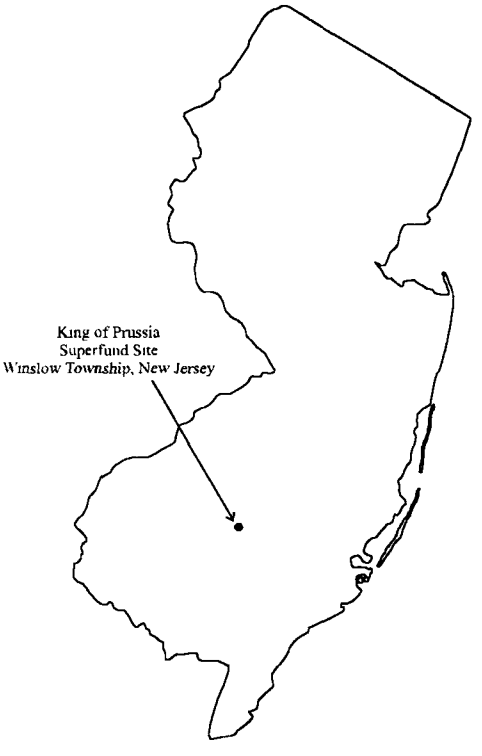

Figure 1. Site Location

SITE INFORMATION (CONT.)

Background (cont.)

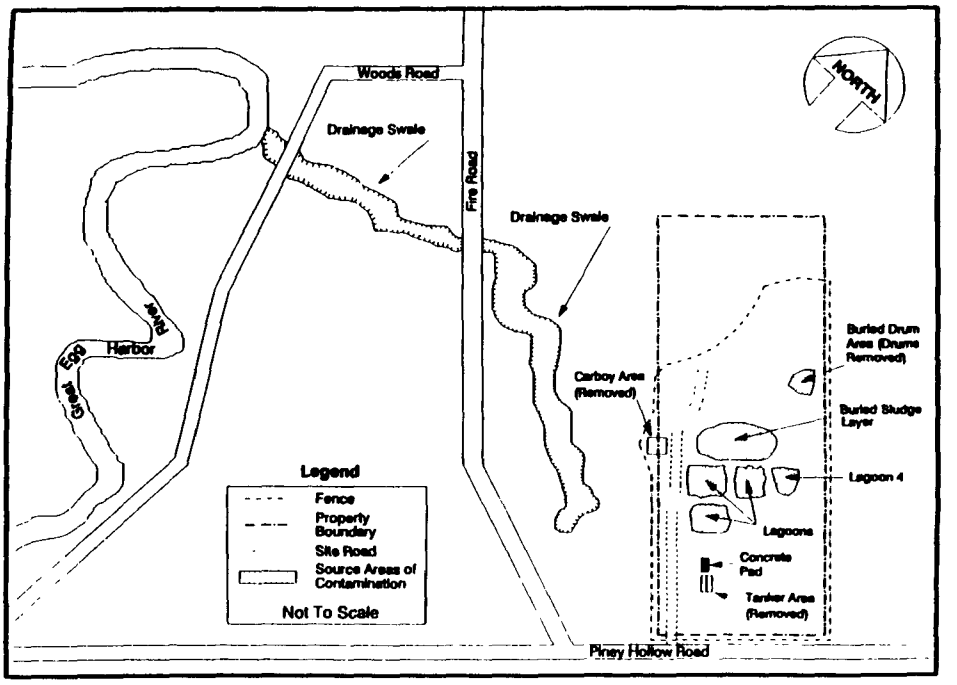

Figure 2. Site Map [9]

Soil and sediment at the site were determined to be contaminated with heavy metals. Prior to issuance of a ROD, cleanup activities at the site included excavation and removal for off-site disposal of buried plastic containers (carboys) and visibly-contaminated, surrounding soils located west of the lagoons. [1]

Regulatory Context: A ROD was issued for this site in September 1990 and defined five components of remedial activities pertaining to contaminated media, including the area relevant to this report (i.e., Component 1). These components included [1,12]:

Component 1—The metals-contaminated soils adjacent to the lagoons, the sludge in the lagoons, and the sediment in the swale. (Operable Unit One)

Component 2—The buried drums and soils contaminated with volatile organic compounds located in the northwest section of the site. (Operable Unit Two)

Component 3—Two tankers and their contents located near the southeast sections of the site.

Component 4—The groundwater at the site contaminated with organics and metals. (Operable Unit Three)

Component 5—The surface waters, sediments, and biota of the Great Egg Harbor River.

EPA issued a Unilateral Administrative Order to the PRPs in April 1991 requiring the PRPs to implement the requirements of the ROD. The remedial activities for Component 1 were led by the PRPs with EPA oversight. [9]

Remedy Selection: The following six remedial alternatives were considered for remediation of Component 1 of the KOP site:

1. No action;
2. Limited action (site and deed restrictions; additional fencing around swale area);
3. Limited excavation of sediments and soils with consolidation and capping;
4. Complete excavation of soils, sediments, and sludges that exceed the cleanup objective with contaminant extraction (soil washing), to achieve specified cleanup levels followed by redeposition on site;

SITE INFORMATION (CONT.)

Background (cont.)

5. Stabilization/solidification, either in situ or following excavation of soils, sediments, and sludges, both followed by capping; and
6. Complete removal and off-site disposal.

Soil washing was selected as the remedial alternative for Component 1. Soil was determined to provide a permanent solution by removing the contaminants from the site and thus protecting human health and the environment. In addition, the treated material could be redeposited to its original location to restore site topography. [1]

Site Logistics/Contacts

Site Management: PRP Lead

Oversight: EPA

Remedial Project Manager:
Gary Adamkiewicz (through May 1994)
John Gorin (June 1994 to Present)
U.S. EPA Region 2
26 Federal Plaza, Rm. 720
New York, NY 10278
(212) 264-7592

Treatment System Vendor:
Jill Besch/Mike Mann
Alternative Remedial Technologies, Inc.
14497 Dale Mabry Highway
Tampa, FL 33618
(813) 264-3506

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix processed through the treatment system:
Soil (ex situ)/Sediment (ex situ)/Sludge (ex situ)

Contaminant Characterization

Primary contaminant group: Heavy metals

Investigations at the site were conducted by the New Jersey Department of Environmental Protection and by the PRPs. Samples of surface soil (<2 feet deep), subsurface soil (2 to 10 feet), and sediment were collected during the investigations to characterize the soil next to the lagoons, the sediments in the swale, and the sludges in the lagoons and adjacent areas. The results from this sampling indicated that beryllium, chromium, copper, nickel, and zinc are the primary contaminants in these areas. The highest concentration of surface contamination was located in the sediments at the bottom of the swale, with maximum concentrations of chromium at 8,010 mg/kg, copper at 9,070 mg/kg, and mercury at 100 mg/kg. The highest concentrations of subsurface contamination were located in a zone of sludge-like material at a depth of 3 to 4 feet northwest of and adjacent to the lagoons. The highest concentrations of contaminants in the sludge material were chromium at 11,300 mg/kg, copper at 16,300 mg/kg, lead at 389 mg/kg, and nickel at 11,100 mg/kg. Sampling results also indicated that the soils have infrequent and low concentrations of volatile and semivolatile organic compounds. Average soil concentrations were measured as 660 mg/kg for chromium, 860 mg/kg for copper, and 330 mg/kg for nickel. [1, 9, 12]

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Cost or Performance

Listed below in Tables 1 and 2 are selected matrix characteristics which are considered to be the major matrix characteristics affecting cost or performance, and the values measured for each.

Table 1. Matrix Characteristics Affecting Treatment Cost or Performance [5, 10]

Parameter	Value	Measurement Procedure
Clay Content and/or Particle Size Distribution	See Table 2	Not available
Fines Content	0.1	Wet screening
Total Organic Carbon	Not measured	—
Cation Exchange Capacity	Not measured	—

Table 2. Particle Size Distribution of Background Soil [5]

Particle Size (microns)	Distribution (%)
>4,000	0
2,000 to 4,000	12.6
1,000 to 2,000	12.6
500 to 1,000	22.1
250 to 500	28.8
125 to 250	12.5
63 to 125	3.9
38 to 63	0.9
<38	6.6

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology Type

Soil Washing

Supplemental Treatment Technology Type

Screening

Technology Description

Excavation Description [7, 10]

Materials Handling: Selective excavation of metals-contaminated soils was completed using visual inspection and confirmed using an X-ray fluorescence (XRF) instrument in an on-site laboratory. Although 40,000 tons of material were excavated, only 20,000 tons exceeded the cleanup levels and required treatment through the soil washing unit. Selective excavation was identified as an appropriate technique for this site based on the findings of previous site investigation and excavation activities which indicated that the contaminants are associated within bands of sludge material and soils adjacent to the lagoons. Selective excavation of the soil and sludge in and adjacent to the lagoons and the swale area involved the following steps:

1. Excavation of clean, overburden soils and staging and/or transportation of material to the stockpile area;
2. Excavation of contaminated soils and transportation of contaminated soils to the screening and blending area;

TREATMENT SYSTEM DESCRIPTION (CONT.)

Technology Description (cont.)

3. XRF analysis of the contamination levels in the trench bottom soils; and
4. Backfilling of the clean trench bottom with XRF-confirmed clean material.

Excavation and blending of soils and sludges to maintain a constant ratio of soil to sludge involved the following three phases:

- Phase 1: excavating and blending of the first third of the sludge band area with material from the lagoon 1 area;
- Phase 2: excavating and blending of the second third of the sludge band area with material from the swale area; and
- Phase 3: excavating and blending of the third third of the sludge band area with material from the lagoon 6 area.

X-Ray Fluorescence: An X-ray fluorescence (XRF) instrument was used on-site during the excavation activities and during the soil washing operation for the analysis of chromium, copper, and nickel. An XRF instrument was also utilized during pre-remedial activities, including additional site characterization, the treatability study, and the demonstration run. For the treatability study and demonstration run, the XRF was calibrated with both synthetic and commercial standard reference materials. Confirmational analysis performed by an outside Contract Laboratory Program (CLP) laboratory indicated that the field results for chromium and copper were biased high by a factor of 1.3 to 2. It was determined that both synthetic and commercial calibration standards were not suitable for the concentrations and matrices encountered at the KOP site. Therefore, the XRF results relevant to the treatability study and demonstration run for this application were considered to be biased high by a factor of 1.3 to 2.

Based on a review of the confirmational analyses and calibration procedures used for the XRF instrument during the runs described above, the vendor modified the calibration standards. Calibration standards were developed for the full-scale application using samples of contaminated soil from the KOP site. Initial efforts to develop suitable calibration standards involved collecting contaminated soil from the site, manual homogenization, grinding, splitting and off-site laboratory analysis. Continuing studies for developing suitable standards resulted in refining the soil sample preparation method by replacing the manual homogenization, grinding, and splitting processes with mechanical processes for each item.

For the full-scale activities, three calibration standards, corresponding to concentrations less than, approximately equal to, and greater than the ROD-specified cleanup levels, were prepared for chromium, copper, and nickel using the refined technique and were used to calibrate the XRF instrument. The results obtained with the XRF using the mechanically prepared calibration standards showed no bias in the correlation with off-site confirmatory analysis.

Soil Washing System Description [4, 6, 7, 9, 10, 12]

The soil washing unit used to remediate the contaminated soil and sludge at the KOP site was constructed by a Swedish-based firm under contract to Alternative Remedial Technologies, Inc. The unit, shown in Figure 3, consists of four components: screening, separation, froth flotation, and sludge management (described below), and has a rated system throughput of 25 tons/hour.

The soil washing unit was built off site as a modular system, and constructed at the site, as shown in Figure 4. Construction activities began on March 30, 1993, and were completed on June 1, 1993. Following completion, a slurry run, comprised of clean site soils and water, was conducted to monitor operation of the unit. To verify that the newly erected unit was capable of treating the contaminated soil to the ROD cleanup levels, a pilot run was performed form June 3 through June 9, 1993. The pilot run consisted of processing 991 tons of contaminated soil from Lagoons 1 and 6 and the sludge band area.

TREATMENT SYSTEM DESCRIPTION (CONT.)

Technology Description (cont.)

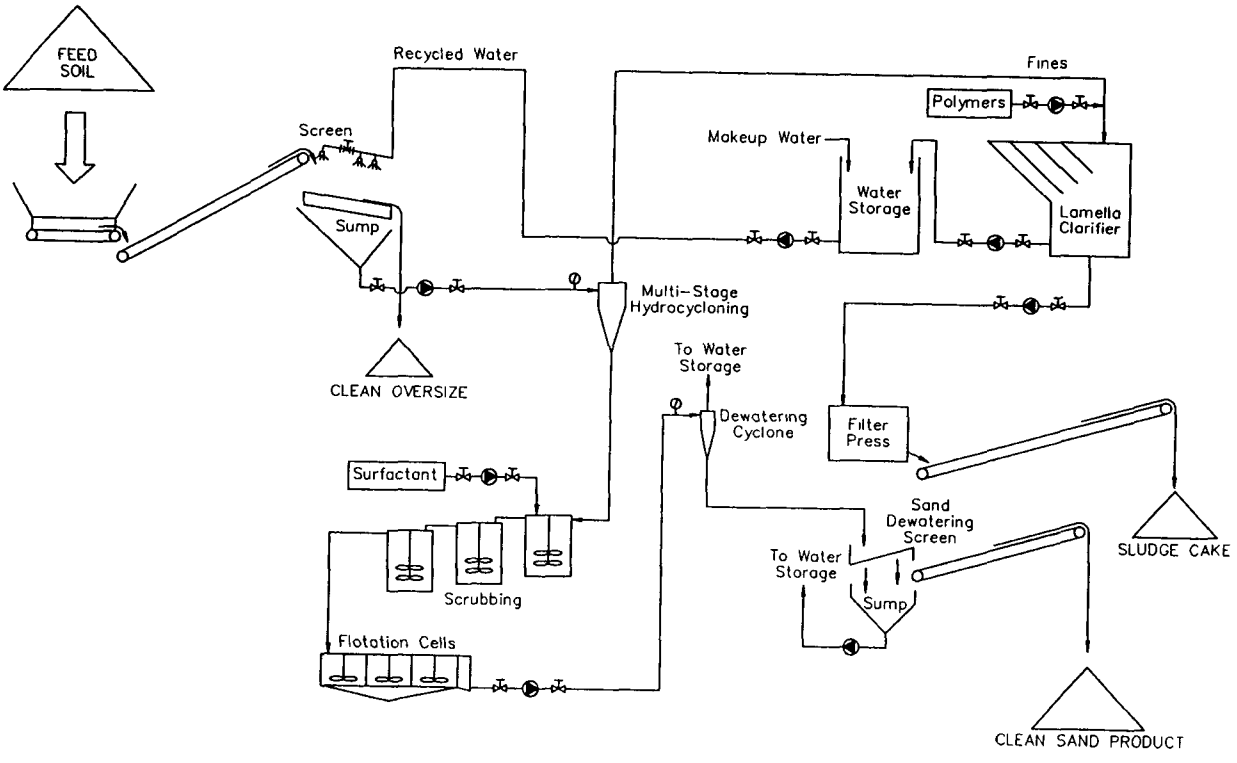

Figure 3. Soil Washing Unit Used at KOP [6]

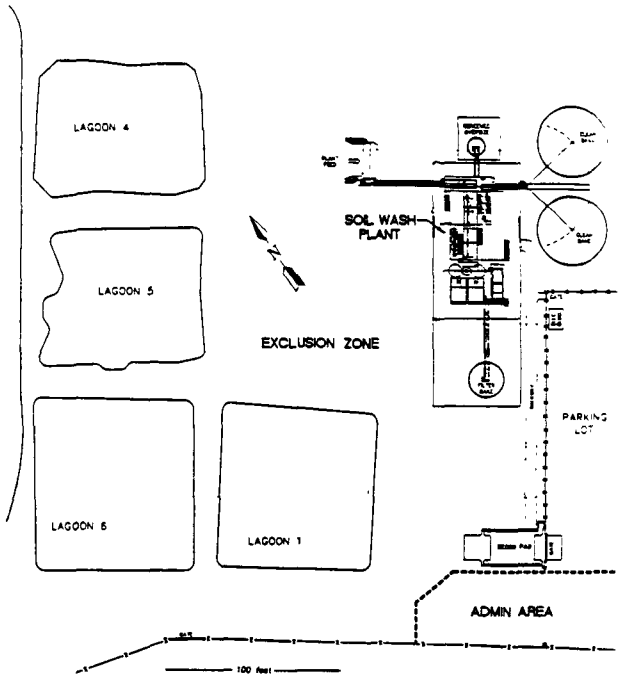

Figure 4. Remediation System Layout [12]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Technology Description (cont.)

System operation included the following processes:

Screening: This stage consists of screening out the gross oversize fraction from the pile of material to be treated by means of a hopper and a vibrating grizzly (not shown on Figure 3). The gross oversize (greater than 8-inch material), which typically consists of concrete, tree stumps, and branches, is periodically removed from the hopper and staged. The material that passes through the grizzly is then directed to another mechanical screening unit, which consists of a double-decked, coarse vibrating screen with stacking conveyors, to remove process oversize (greater than 2-inch material) from the fall-through. The fall-through (<2 inch) is then subjected to wet screening with high pressure water nozzles. The wet screening breaks up clods, drops out pea-size gravel and forms a slurry. Gravel and other material is combined with the process oversize, while the slurry is further separated.

Separation: This stage consists of separating the screened soil/water slurry into coarse- and fine-grained material through the use of multi-stage hydrocyclones. The use of multiple cyclones achieves a separation efficiency of >99% of the sands and fines. The hydrocyclones have field-adjustable cone and barrel components to set and modify as necessary the "cut-point" between coarse- and fine-grained material. For this application, the hydrocyclone cut point was set at 40 microns (the distribution among size fractions showed a diminishing removal efficiency above 40 microns), determined using the results of the treatability study. The hydrocyclones were configured to minimize the volume of sludge cake requiring off-site disposal and to minimize the amount of fines in the clean product. The underflow containing coarse-grained material from the hydrocycloning steps was conditioned and directed to the froth flotation stage while the fine-grained material was processed into a sludge cake.

Froth Flotation: This stage consists of removing the contaminants from the coarse-grained material. The removal was done by means of air flotation treatment units. For this application, an air-flotation tank equipped with mechanical aerators was used. The coarse-grained material was pumped into the tank where a surfactant was added. The surfactant, selected based on the results of the treatability test, reduced the surface tension between the contaminant and sand. The contaminants "float" into a froth and were removed from the surface of the air flotation tank and were directed to the sludge management process. Surfactant dosing, slurry flow rate, and the height of the overflow weir were continuously monitored and adjusted as appropriate. The "cleaned" underflow sands were directed to a cyclone and sand dewatering screens, where dewatering occurs. Approximately 85% of the processed material (clean sand product) from the KOP site was used as backfill, while the water was recycled back to the wet screening section.

Sludge Management: This stage of the process consists of treating the overflow from the hydrocyclones. The overflow, consisting of fine-grained material and water, was pumped to banked Lamella clarifiers. A polymer, selected based on the results of the treatability test, was added prior to introduction to the Lamella. The clarified solids were directed to a sludge thickener and ultimately to a pressurized filter press, where the 15-20% solids influent was converted into a 50-60% dry solids filter cake. The filter cake was disposed off site as a nonhazardous waste. The water from the sludge management stage was returned to the wet screening area for reuse.

TREATMENT SYSTEM DESCRIPTION (CONT.)

Operating Parameters Affecting Treatment Cost or Performance

The major operating parameters affecting cost or performance for this technology and the values measured for each during this treatment application are listed in Table 3.

ART operated the soil washing unit at KOP on a production basis, with a goal of processing 25 tons/hour of contaminated materials, and monitored and adjusted 15 operational parameters. These parameters included the pH of the conditioners and make-up streams, metering of process streams (frother, conditioners, and polymers), cyclone feed rates, operational heights of process vessels (sumps and conditioner tanks), and operating pressures of pumps and cyclones. [6, 10]

Table 3. Operating Parameters Affecting Treatment Cost or Performance [3, 10]

Parameter	Value*
Moisture Content (of untreated soil)	~15%
pH (of untreated soil)	~6.5
System Throughput	25 tons/hr
Washing/Flushing Solvent Components/Additives	Polymer and Surfactant

**Vendor provided approximate values for moisture content and pH, but did not identify the specific polymer and surfactant used in this treatment application.*

Timeline

A timeline for this application is shown in Table 4.

Table 4. Timeline [1, 3, 7, 9, 11, and 12]

Start Date	End Date	Activity
January 1971	April 1974	Operations at the KOP Technical Corporation conducted
September 1983	—	KOP added to National Priorities List
September 28, 1990	—	ROD signed
January 1992	—	Treatability test conducted
July 22, 1992	—	Demonstration run conducted
March 1, 1993	November 4, 1993	Site mobilization
March 30, 1993	June 1, 1993	Construction of soil washing unit
June 3, 1993	June 9, 1993	Pilot run conducted
June 28, 1993	October 10, 1993	Full-scale soil washing conducted
July 8, 1993	October 13, 1993	Off-site shipment of residual sludge
July 19, 1993	October 10, 1993	Backfilling of clean soils
October 11, 1993	November 1, 1993	Decontamination and disassembly of soil washing unit

TREATMENT SYSTEM PERFORMANCE

Cleanup Levels

The 1990 ROD identified cleanup levels for 11 metals in the soils in the area adjacent to the lagoons, sediments in the swale, and sludges in the lagoons (Component 1 of the site remediation). These levels are presented in Table 5. [1]

Table 5. Soil Cleanup Levels [1]

Constitutent	Soil Cleanup Levels (mg/kg)
Arsenic	190
Beryllium	485
Cadmium	107
Chromium (total)	483
Copper	3,571
Lead	500
Mercury	1
Nickel	1,935
Selenium	4
Silver	5
Zinc	3,800

Additional Information on Cleanup Levels

The cleanup levels shown in Table 5 were developed based on risk to public health using carcinogenic and noncarcinogenic effects. The carcinogenic effects were assessed using the cancer potency factors developed by the U.S. EPA, and a cancer risk of less than 1×10^{-6}. The noncarcinogenic effects were assessed using the hazard index approach, based on a comparison of expected contaminant intakes and Reference Doses. A hazard index of less than 1 was used to develop the cleanup levels from noncarcinogenic risks. The carcinogenic and noncarcinogenic risks were summed to indicate the potential risks associated with mixtures of potential carcinogens and noncarcinogens. [1]

Treatment Performance Data

Table 6 presents a summary of the treatment performance data for this application, corresponding to the four sampling points shown in Figure 3 and described below. Average concentrations and concentration ranges are provided for the untreated soil, process oversize, and clean sand, while only average concentrations are shown for the sludge cake.

- Untreated (Feed) Soil - This sampling point represents the concentration of metals in contaminated soil after excavation and blending, but prior to screening for gross or process oversize. Determination of the chromium, copper, and nickel concentrations in the untreated soil was performed using X-ray fluorescence. The concentrations of the other eight metals shown on Table 6 were measured at an off-site laboratory using samples from the demonstration run and, because the soil from the demonstration run was collected from the same excavation trenches as for the full-scale operation, are considered to be representative of the average concentration of the untreated soil processed during the full-scale operation. These average concentrations are lower than the initial concentrations measured during the site characterization, due to blending and homogenization of the feed pile prior to its introduction to the treatment unit.
- Process (Clean) Oversize - This sampling point represents the concentration of metals in the process oversize. The process oversize is that material which was screened from the untreated soil and typically measures greater than 2 inches in diameter and consists of gravel and wood. The process oversize was ultimately redeposited at the site from the location where it was excavated. Samples for off-site analysis consisted

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (cont.)

Table 6. Treatment Performance Data [9,12]

Constituent	Cleanup Level (mg/kg)	Untreated (Feed) Soil Concentration (mg/kg)		Process (Clean) Oversize Concentration (mg/kg)		Clean Sand Product Concentration (mg/kg)		Sludge Cake Average Concentration (mg/kg)
		Average	Range	Average	Range	Average	Range	
Arsenic	190	1	N/A	0 62	0.34 to 1.4	ND (0.31)	ND (0 39)	N/A
Beryllium	485	20	N/A	5.9	2.7 to 11	1.9	0.93 to 3.1	N/A
Cadmium	107	0.56	N/A	ND (0 63)	ND (0.97)	0 64	ND (0.95)	N/A
Chromium	483	660	500 to 5,000	172	81 to 310	73	37 to 94	4,700
Copper	3571	860	800 to 8,000	350	170 to 580	110	52 to 158	5,900
Lead	500	22	N/A	6 5	3.1 to 14	3.9	2.6 to 6.1	N/A
Mercury	1	0.09	N/A	ND (0.09)	ND (0.10)	ND (0.09)	ND (0.10)	N/A
Nickel	1,935	330	300 to 3,500	98	58 to 150	25	18 to 38	2,300
Selenium	4	0.36	N/A	ND (0 38)	ND (0 40)	ND (0.36)	ND (0.40)	N/A
Silver	5	0.69	N/A	ND (0.65)	ND (0 76)	ND (0.65)	ND (0.73)	N/A
Zinc	3,800	150	N/A	48	27 to 76	16	9.4 to 22	N/A

N/A - Samples were not collected - see text.
ND - Not detected (detection limit shown in parentheses).

of daily split samples that were combined into weekly composite samples. The results of the weekly samples are presented in Appendix C, Table C-1, and are summarized in Table 6.

- Clean Sand Product - This sampling point represents the concentration of metals in the treated clean sand (treated soil). After screening and separation, the coarse-grained material was directed to the froth flotation unit where the contaminants were removed. The "cleaned" material was dewatered by means of a cyclone and a dewatering unit. The clean sand (treated soil) was used as backfill at the site. Twelve samples were collected for off-site analysis and consisted of daily split samples that were combined into weekly composite samples. The results of the weekly samples are presented in Appendix C, Table C-2, and summarized in Table 6.
- Sludge Cake - This sampling point represents the concentration of metals in the sludge cake. After screening and separation, the fine-grained material was filtered. The filter (sludge) cake was disposed off site as a nonhazardous waste. Samples of the filter cake were analyzed on site using XRF for chromium, copper, and nickel, and off site for TCLP metals. No results from the TCLP analysis are contained in the references available at this time.

Performance Data Assessment

A review of the treatment performance data in Table 6 indicates that the process oversize and clean sand from the soil washing unit met the cleanup levels established for this application. As shown in Table 6, the average concentrations of beryllium, copper, lead, nickel, and zinc in the clean sand and process oversize were at least an order of magnitude lower than the cleanup levels. Cadmium, mercury, selenium, and silver were not detected in any process oversize samples; and arsenic, mercury, selenium, and silver were not detected in any clean sand samples.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment (cont.)

The data in Table 6 show that chromium, copper, and nickel were concentrated in the sludge cake, with individual contaminants measured at levels greater than 2,000 mg/kg.

Performance Data Completeness

The available performance data characterize constituent concentrations in the untreated soil, process oversize, clean sand, and sludge cake residual. Data are not available for matching specific operating conditions with treatment performance.

Performance Data Quality

The CLP SOW for Inorganic Analysis includes analysis of initial and continuing calibration checks, duplicates, matrix spike, and reagent blanks. No exceptions to the QA/QC protocol were noted by the vendor. [7]

TREATMENT SYSTEM COST

Procurement Process

ART, Inc., was under contract to the PRPs to construct and operate the soil washing treatment at the site. ART used several subcontractors to assist in the application, including activities associated with excavation, construction, and materials handling. [7, 12]

Treatment System Cost

Approximately $7.7 million were expended on the soil washing remediation at KOP, including all off-site disposal costs. [12]

No information is presented in the references available at this time to describe the items included in the $7.7 million value. Therefore, a cost breakdown using the interagency Work Breakdown Structure (WBS) is not provided in this report.

Cost Data Quality

The cost data shown above were provided by the Project Coordinator for the PRPs, and are provided in the Remedial Action Report for this application. A detailed breakdown of the cost elements is not available at this time.

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- Actual costs for the soil washing treatment application, including off-site disposal costs, at the King of Prussia site were approximately $7,700,000. No information is available at this time on the components of this total cost.

Performance Observations and Lessons Learned

- The soil washing application achieved the soil cleanup levels for the 11 metals. The process oversize (>2 inches) and clean sand were redeposited on site.
- The average concentrations of five contaminants (beryllium, copper, lead, nickel, and zinc) in the clean sand and process oversize were reduced to levels at least an order of magnitude less than the cleanup levels.
- Chromium, copper, and nickel were concentrated in the sludge cake, with individual contaminants measured at

OBSERVATIONS AND LESSONS LEARNED (CONT.)

Performance Observations and Lessons Learned (cont.)

levels greater than 2,000 mg/kg. The sludge cake was also analyzed by TCLP, and, based on these results, disposed off site as a nonhazardous waste.

Other Observations and Lessons Learned

- The treatability study accurately predicted that soil washing would meet the soil cleanup goals at this site.
- A demonstration run was completed using hazardous waste transported from the U.S. to the Netherlands. The logistics of importing and exporting hazardous waste between the U.S. and the Netherlands was coordinated through the U.S. EPA's RCRA Enforcement Division and the Dutch equivalent, VROM.
- The success of the demonstration run in treating the KOP soils expedited the design schedule of the full-scale unit by over one year.
- The results of the demonstration run provided information needed to modify the design and operation of the full-scale unit. These process modifications included:
  - — Increasing the bed length and redesigning the spray headers on the wet screen unit to prevent bypassing or short-circuiting of the feed soil;
  - — Using an alternate frother to reduce frothing;
  - — Load balancing to the hydrocyclones; and
  - — Selecting filtration-aided polymers to produce the densest sludge cake possible.
- Selective excavation with the aid of XRF reduced the amount of soil for soil washing processing by a factor of 2.
- The development and use of site matrix calibration standards generated reliable on-site XRF data that correlated well with the off-site confirmatory results.
- At the beginning of the pilot run, the polymers were not concentrating the suspended solids quickly enough before the sludge entered the belt filter press, resulting in a sludge cake that was too wet and difficult to manage. The piping between the lamella clarifiers and belt filter press was lengthened, which extended the reaction time of the polymer with the sludge. This modification produced a more manageable sludge with an increased percent density solids.
- Characterization of the contaminated soils during the treatability study showed that soils from lagoon 4 were not amenable to soil washing since they consisted primarily of synthetic precipitate materials with a fines concentration of >90 percent. This material was excavated and disposed off site.

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Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Radian Corporation under EPA Contract No. 68-W3-0001.

APPENDIX A—TREATABILITY STUDY RESULTS

Identifying Information	
King of Prussia Superfund Site Winslow Township, New Jersey	CERCLIS#: NJD980505341 ROD Date: 28 September 1990
Historical Activity at Site - SIC Codes: Historical Activity at Site - Management Practices: Site Contaminants: Type of Action: Did the ROD/Action Memorandum include a contingency on treatability study results?	4953 Sanitary Services-Refuse Systems Waste processing facility Metals, primarily chromium, copper, and nickel Remedial No
Treatability Study Information	
Type of Treatability Study: Duration of Treatability Study: Media Treated: Quantity Treated: Treatment Technology: Target Contaminants of Concern: Conducted before the ROD was signed: Additional treatability studies conducted: Technology selected for full-scale application:	Laboratory screening, bench-scale testing, and pilot-scale testing January 15, 1992 to March 27, 1992 Soil (ex situ) 188 kg Soil washing Chromium, copper, and nickel No None identified at this time Yes
Treatability Study Strategy	
Number of Runs: Key Operating Parameters Varied:	A minimum of 1 test was conducted for each unit of the soil washing system, with additional tests performed where necessary. The entire system was run 3 times during the process simulation tests. Hydrocyclone Test: cut point Flotation Test: surfactant concentration, pH, retention time, pretreatment Fines/Sludge Handling Test: polymer
Treatability Study Results	
Range of Concentrations of Metals in Soils Treated During Pilot-Scale (Process Simulation) Runs:	Cu: 62 ppm to 1,500 ppm Ni: 18 ppm to 86 ppm Cr: 13 ppm to 130 ppm

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Objectives

The treatability study on the King of Prussia Technical Corporation Superfund site soil consisted of the following three steps:

- Laboratory screening;
- Bench-scale testing; and
- Pilot-scale testing.

The laboratory screening step was performed to characterize the soil and to collect enough information to make a soil washing feasibility determination. The bench-scale testing step was performed to select and optimize the appropriate treatment unit operations for the separation and removal of target metals from the coarse-grained and fine-grained source fractions. The pilot-scale testing step was performed to determine the system operating conditions, equipment lists, utility, chemical, and personnel requirements, and to refine the capital and operating cost estimates for the full-scale operation. [5]

Treatability Study Test Description [5]

Soil was collected from eleven locations at the KOP site in January 1992. One 5-gallon bucket of soil/sediment was collected, packed and shipped to the Heidemij Reststoffendiensten treatability lab located in the Moerdijk, Netherlands for treatability testing. [5]

Laboratory Screening: Soil characterization efforts included the chemical analyses of the initial (influent) soil samples for chromium, copper, nickel, mercury, and silver. These metals were analyzed using the Dutch equivalent to SW-846 7000 series methods. Each influent soil was physically screened/sieved to define the particle size distribution. Each fraction was analyzed for chromium, copper, and nickel to determine contaminant concentrations. Scanning electron microscopy was performed to determine the physical form of the contaminants.

Bench-Scale Testing: Tests were performed on hydrocycloning, flotation, gravity separation, and sludge management by coagulation, thickening, and dewatering unit operations using soil from lagoons 1 and 6.

The hydrocycloning operation test involved processing the soil through a 5" hydrocyclone test unit at different cut points and screening/sieving the underflow and overflow fractions.

The flotation tests involved selecting a suitable surfactant and concentration and retention time for this unit operation. One sample of the sludge band soil following wet screening was used for the flotation studies, which included varying surfactant concentrations, pH, retention time, and pretreatment (attritioning scrubbing).

The gravity separation operation test involved the use of a standard lab separator/shaking table to divide a wet-screened sample of the sludge band soil and lagoon composite soil to promote additional source separation.

The sludge operation test involved four organic polymers at four dosage concentrations on the overflow (fines and water) from the hydrocycloning test.

Pilot-Scale Testing: For this test, each of the optimum unit operations evaluated in the previous steps were combined into a batch feed process system. The system consisted of a vibrating screen, three hydrocyclones, a froth flotation cell, and a spiral concentrator. Three process simulation test runs were designed and conducted for the lagoon 1 soil, lagoon 6 soil, and the sludge band soil. The sand and sludge generated from the simulation runs were collected and analyzed. The sludge cake was further subjected to a TCLP analysis for chromium.

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Performance Data

Laboratory Screening Step: The particle size distribution curves in Figure A-1 developed during the laboratory screening show the relative amounts of coarse and fine-grained sized materials in the soil and sludge tested. The concentrations of metals in each size fraction of the lagoon composite sample is shown in Table A-1. These results indicate that lagoons 1 and 6 and the sludge band area contained native soil material that might be amenable to soil washing treatment; however, lagoon 4 consisted exclusively of non-soil material with a high fines content and would not likely be amenable to soil washing treatment. Only soil from lagoons 1 and 6 and the sludge band area were further subjected to bench-scale testing. [5]

Bench-Scale Testing: The results from the bench-scale test indicated that, for the hydrocycloning operation, a cut point for the KOP soil washing unit would be set at 40 microns. Also, for the flotation studies, a surfactant concentration of 240 gr/ton and a naturally-occurring pH with pretreatment by attrition scrubbing would provide the best flotation results. For the gravity separation tests, the results indicated that gravity separation would not be effective for treatment of KOP soils, because poor separation occurred and no shifts in contaminant concentrations were observed. Also, for the sludge operation, Mogul FL-5009 would lead to the best pre-settling performance and Mogul XH-1990 would lead to the best dewatering performance. A filter cake with a dry solids concentration of 52% was produced with a plate and frame filter press during the bench-scale test. [5]

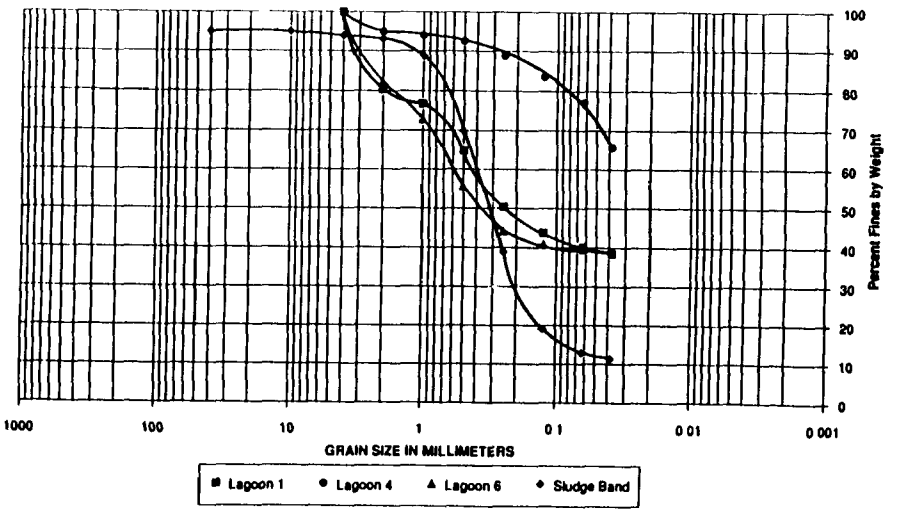

Figure A-1. Particle Size Distribution Curves

Table A-1. Particle Size Distribution and Contaminant Concentrations [5]
Lagoon Composite Sample

Size Fractions (microns)	Distribution (%)	Concentration (ppm)		
		Cu	Ni	Cr
>40,000	0.7			
10,000 to 40,000	3.8	18,000	3,900	1,600
4,000 to 10,000	2.4	18,000	3,200	1,700
2,000 to 4,000	2.5	9,400	1,700	1,300
1,000 to 2,000	7.4	6,100	1,300	1,500
500 to 1,000	12.3	2,200	450	560
250 to 500	12.7	2,600	560	710
125 to 250	7.8	7,600	1,600	1,700
63 to 125	7.1	13,000	2,900	2,500
38 to 63	10.8	12,000	2,700	2,500
20 to 38	2.5	16,000	3,800	4,200
<20	29.9	12,000	3,400	4,400
TOTAL	100	9,215*	2,227*	2,407*

**Calculated*

Pilot-Scale Testing: The mass balance/recovery results from the pilot-scale testing indicate that the process simulation equipment treated the KOP soils to meet the target cleanup goals. The sludge from each process simulation run did not exceed the chromium TCLP limit; therefore, the sludge would not be considered a RCRA hazardous waste. [5]

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Observations and Lessons Learned

- The concentrations of metals in soils treated during the pilot-scale (process simulation) runs ranged from 62 to 1,500 ppm for copper; 18 to 86 ppm for nickel; and 13 to 130 ppm for chromium.
- From the laboratory screening step, it was concluded that material from lagoons 1 and 6 contained native soil material that might be amenable to soil washing treatment, but that lagoon 4 did not contain native soil material and would not be amenable to soil washing.
- From the bench-scale flotation step, the acid consumption was very high so pH adjustment would not be performed in the pilot-scale tests. Also, no flotation occurred after 10 minutes, even though retention times were varied.

APPENDIX B—DEMONSTRATION RUN RESULTS

Demonstration Run Objectives

A demonstration run using soil from the King of Prussia (KOP) Technical Corporation Superfund site was performed to confirm the findings of the treatability study and to expand upon the operating parameters relating to full-scale operations. Also, a successful demonstration run would reinforce the selection and application of the ROD-specified remedy, and thereby potentially streamline the review by EPA and hasten actual construction of the full-scale unit. [6]

Demonstration Run Description

Soil was selectively excavated from the KOP site in May 1992, in accordance with an EPA-approved excavation plan. The goal of the selective excavation was to excavate soils for the demonstration run that were representative of site conditions and also be biased high, with respect to the level of contamination, to confirm the ability of the treatment system to achieve the treatment standards. Approximately 164 short tons of soil were excavated from areas in and around lagoons 1 and 6, the swale and sludge band. An on-site x-ray fluorescence (XRF) instrument was used to screen targeted soils for excavation and to quantitatively determine the concentrations of copper, chromium, and nickel in the excavated soil. [6]

The excavated soil was placed into 200 1-ton super sacks. A composite sample of soil from each sack was analyzed with the XRF to ensure that the soil contained at least one metal above the ROD cleanup requirements. The sacks were then properly labelled for shipment of hazardous waste and transported to the Port of Newark, New Jersey. The sacks were loaded onto a ship of the Mediterranean Lines, transported to the Port of Rotterdam, and ultimately trucked to the Heidemij Restoffendiensten soil washing facility in Moerdijk, Netherlands for the demonstration run. The soil was screened and blended at the facility on July 18, 1992 and processed through the unit on July 22, 1992. The duration of the demonstration run was seven hours. The process residuals were returned to the United States on October 20, 1994, again through the Port of Newark. The oversize and product were returned to the KOP site as clean material and staged for restoration of the site, while the sludge cake was disposed at the GSX Pinewood Treatment, Storage, and Disposal Facility.

Pre-Processing Activities: The contents of each of the 200 super sacks were screened at 4 cm using a Grizzly vibrating bar to remove the gross oversize, which was weighed, combined, staged, and bagged for transport back to the U.S. The screened material was carefully blended and mixed to create a single feed pile.

Feeding: The feed pile was loaded into an apron feeder using a front-end loader. The feed rate was controlled as the material was fed to the feeder conveyor and into the first process unit.

Screening: The feed soils were screened to 2 mm using a vibrating wet screen. Oversize material was removed via conveyor, staged, and rebagged for return to the site. The soil/slurry underflow from the wet screening was then pumped to separation unit.

Separation: The underflow was processed through a 10" Mozley hydrocyclone, with subsequent processing of the fines and water and the coarse-grained material through separate 5" Mozley hydrocyclones. All three hydrocyclones were adjusted at a cut point of 40 microns. The underflow (coarse-grained material) from the separation unit was further processed through a froth flotation device while the fines were managed through a sludge dewatering unit.

Froth Flotation: The sand treatment train consists of a contact scrubber, where the surfactant is added, a froth flotation cell where treatment occurs, and a sand dewatering screen. The froth was further directed to the Lamella clarifiers. The sand was dewatered on an oscillating sand dewatering screen. The dewatered sand was moved by conveyor belt to a staging area where it was weighed and bagged.

APPENDIX B—DEMONSTRATION RUN RESULTS (CONT.)

Demonstration Run Description (cont.)

Sludge Dewatering: The fines and water from the separation unit are processed through a flocculation unit, where coagulant was added and thickened on the Lamella clarifiers. The solids were dropped into the bottom hopper and the sludge was pumped to a belt filter press. The sludge was dewatered and moved to a staging area where it was weighed and bagged. During this demonstration run, 14 feed pile samples, 6 process oversize samples, 1 pre-flotation product sample, 22 sand product samples, 6 sludge cake samples (for total metals) and 2 sludge cake samples (for TCLP metals) were collected. The samples and split samples were analyzed primarily for chromium, copper, and nickel using CLP protocols by D.C. Griffith laboratory located in the Netherlands, and by IEA laboratory in North Carolina.

Demonstration Run Results

The results of the feed pile are presented in Table B-1; those of the clean sand product in Table B-2; and the sludge cake results are presented in Tables B-3 and B-4. These results indicate that the demonstration run was successful in meeting the stated objectives of treating the KOP soils to ROD-required levels with the soil washing unit configuration as recommended in the treatability study report.

Table B-1. Process Feed Material [6]
King of Prussia Technical Site Demonstration Run
Moerdijk, The Netherlands
July 22, 1992

(all mg/kg)

	Cr		Cu		Ni		Dry Solids
Sample	DCG	IEA	DCG	IEA	DCG	IEA	(%)
1	790	872	1,600	1,470	433	409	83.5
2	745		1,600		415		83
3	705	759	1,300	1,080	408	357	85.5
4	705		1,400		420		85
5	910	982	1,850	2,170	660	639	82
6	815		1,900		473		85
7	855	1,080	1,500	1,310	460	368	83.5
8	710		1,250		393		86
9	735	675	1,250	1,110	435	378	86
Average	770	870	1,500	1,430	460	430	84.4

Per the agreed plan, all discrete process materials were mixed into a feed blend pile. Results of this activity were captured on video tape.
Efficiency of the blending operation and feed to the plant was measured via a series of nine (9) radial hollow stem auger borings, analyzed for contaminant metals chromium, copper, and nickel. In addition, five (5) samples were split for CLP analysis by IEA Laboratories in the United States.
Analysis of the nine samples by D.C. Griffith (DCG) showed good consistency with averages and ranges for each metal. CLP analysis by IEA on five split samples showed similar consistency and close agreement to the results generated by the Dutch laboratory. From these data, it was concluded that the feed pile was sufficiently blended to introduce a consistent feed to the process.

APPENDIX B—DEMONSTRATION RUN RESULTS (CONT.)

Table B-2. Product Sand [6]
King of Prussia Technical Site Demonstration Run
Moerdijk, The Netherlands
July 22, 1992

(all mg/kg)

	Cr		Cu		Ni		Dry Solids
Sample	DCG	IEA	DCG	IEA	DCG	IEA	(%)
1 - 0900	No sample taken, sand not discharging						
2 - 0930	98		195		41		90
3 - 1000	250	266	465	668	105	119	81
4 - 1030	185		370		73		83
5 - 1100	130	97	270	187	53	43	84
6 - 1130	115		240		46		84
7 - 1200	155	161	315	353	67	77	83
8 - 1230	76		145		33		84
9 - 1300	150	129	305	258	63	66	84
10 - 1330	140		280		54		84
11 - 1400	140	183	310	428	65	98	84
12 - 1430	235		520		120		81
13 - 1500	185		455		87		83
14 - 1530	205		465		97		86
15 - 1600	220	195	445	429	91	99	83
16 - 1630	205		430		89		83
Average	170	170	350	390	70	80	84
Treatment Requirement	483		3,571		1,935		

Table B-3. Sludge Cake Results [6]
King of Prussia Technical Site Demonstration Run
Moerdijk, The Netherlands
July 22, 1992

(all mg/kg)

	Cr		Cu		Ni		Dry Solids
Sample	DCG	IEA	DCG	IEA	DCG	IEA	(%)
1	4,400		7,300		2,300		44
2	4,400	4,470	7,400	7,330	2,300	2,360	46
3	4,700	4,760	8,100	7,950	2,700	2,670	46
4	5,500		9,300		3,200		44
Average	4,750	4,615	8,030	7,640	2,630	2,515	45

This table tabulates the results of the produced sludge cake. The sludge cake contains the treated contaminants and will be disposed at an appropriate off-site facility.

APPENDIX B—DEMONSTRATION RUN RESULTS (CONT.)

Table B-4. Sludge Cake Results—TCLP Metals [6]
King of Prussia Technical Site Demonstration Run
Moerdijk, The Netherlands
July 22, 1992

IEA Analyses Only

TCLP Metal	Regulatory Standard (mg/L)	Results Sample Number (mg/L) 1	2	3	4
Arsenic	5	<0.61	<0.61	<0.62	<0.63
Barium	100	<14	<17	<48	<37
Cadmium	1	<0.12	<0.12	<0.12	<0.12
Chromium	5	2.1	1.8	<0.65	<0.67
Mercury	0.2	<0.02	<0.03	<0.02	<0.02
Lead	5	<0.65	<0.71	<1.0	<0.96
Selenium	1	<0.11	<0.11	<0.11	<0.11
Silver	5	<0.60	<0.60	<0.60	<0.63

The TCLP Metal Analyses confirm that the produced sludge cake does not exceed TCLP regulatory standards. The sludge cake is not the product of the treatment of any listed RCRA hazardous waste and does not demonstrate any hazardous characteristics.

Demonstration Run Observations and Lessons Learned

- The product sand from the demonstration run showed levels of 76 to 266 mg/kg for chromium, 145 to 668 mg/kg for copper, and 33 to 120 mg/kg for nickel.
- The sludge cake was analyzed by TCLP and the results were less than the regulatory standards for identification as a RCRA hazardous waste.
- The spray headers did not adequately contact all of the soil mass in the wet screening of the feed and bypassing (short-circuiting) of some soil occurred. The full-scale unit was modified by increasing the bed length and by redesigning the header bars.
- The froth flotation unit developed an excessive froth layer using the recommended surfactant. The surfactant for the full-scale unit was modified to reduce the frother strength of the surfactant.
- The average dry solids content of the sludge cake was 45%, less than the desired 55 percent. The identification of a filtration-aiding polymer was investigated for the full-scale unit.
- The demonstration run was completed using hazardous waste transported from the U.S. to the Netherlands. The logistics of importing and exporting hazardous waste between the U.S. and the Netherlands was coordinated through the U.S. EPA's RCRA Enforcement Division and the Dutch equivalent, VROM.

APPENDIX C—FULL-SCALE ANALYTICAL RESULTS

Table C-1. KOP Production Composites
Process Oversize [12]

Constituent	ROD Cleanup Level (mg/kg)	Date Sampled (week of) (mg/kg) 7/2	7/8	7/16	7/23	7/30	8/6 *	8/13 **	8/27 ***	9/10	9/24	10/8	10/11
Arsenic	190	0.43 B	0.34 U	0.32 U	0.36 U	0.39 U	0.45 B	0.82 B	0.50 B	0.98	1.4 B	0.76 B	0.66 B
Beryllium	485	5.3	3	3.1	2.7	2.7	6.8	7.4	7.2	9.6	11	7.3	4.5
Cadmium	107	0.36 U	0.36 U	0.57 U	0.47 U	0.45 U	0.59 U	0.57 B	0.80 U	0.80 U	0.80 U	0.80 U	0.97 B
Chromium	483	120	98	110	81	92	210	210	220	280	310	200	130
Copper	3,571	230	190	250	180	170	380	330	420	520	545	580	320
Lead	500	9.6	3.1	3.4	3.5	3.1	6.2	4.5	6.9	14	12	8.3	5.6
Mercury	1	0.09 U	0.10 U	0.09 U	0.10 U	0.10 U	0.09 U	0.10 U	0.08 U	0.10 U	0.10 U	0.10 U	0.10 U
Nickel	1,935	72	72	79	58	58	120	97	120	150	150	110	77
Selenium	4	0.36 U	0.34 U	0.32 U	0.36 U	0.39 U	0.39 U	0.20 U	0.20 U	0.40 U	0.40 U	0.40 U	0.40 U
Silver	5	0.72 U	0.72 U	0.76 U	0.63 U	0.60 U	0.79 U	0.60 U	0.60 U	0.60 U	0.60 U	0.80 U	0.60 U
Zinc	3,800	29	28	34	26	27	69	50	71	76	68	59	39

**Last IEA Result*
***First ITCorp Result*
****Beginning of Two Week Composite*

Table C-2. KOP Production Composites
Clean Sand [12]

Constituent	ROD Cleanup Level (mg/kg)	Date Sampled (week of) (mg/kg) 7/2	7/8	7/16	7/23	7/30	8/6 *	8/13 **	8/27 ***	9/10	9/24	10/8	10/11
Arsenic	190	0.36 U	0.37 U	0.34 U	0.33 U	0.36 U	0.36 U	0.39 B	0.20 U	0.22 B	0.36 B	0.24 B	0.20 B
Beryllium	485	2.8	1.8	1.5	0.93	0.96	1.7	3.1	2.1	2.6	2.3	1.9	1.8
Cadmium	107	0.36 U	0.34 U	0.49 U	0.53 U	0.55 U	0.54 U	0.76 U	0.80 U	0.80 U	0.95 B	0.80 U	0.80 U
Chromium	483	73	58	63	38	37	62	94	61	70	63	57	44
Copper	3,571	150	100	100	61	52	85	140	110	158	150	150	100
Lead	500	6.1	3.9	3.3	3.3	2.6	2.6	3.4	3.5	4.3	3.4	3.4	3.6
Mercury	1	0.08 U	0.09 U	0.09 U	0.08 U	0.09 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Nickel	1,935	32	28	30	20	18	27	36	32	38	27	23	21
Selenium	4	0.36 U	0.37 U	0.34 U	0.33 U	0.36 U	0.36 U	0.20 U	0.20 U	0.2	0.40 U	0.40 U	0.40 U
Silver	5	0.73 U	0.08 U	0.65 U	0.71 U	0.73 U	0.71 U	0.57 U	0.60 U	0.60 U	0.59 U	0.60 U	0.60 U
Zinc	3,800	16	15	17	11	9.4	17	23	18	22	19	15	12

**Last IEA Result*
***First ITCorp Result*
****Beginning of Two Week Composite*

Thermal Desorption at the McKin Company Superfund Site Gray, Maine

Case Study Abstract

Thermal Desorption at the McKin Company Superfund Site Gray, Maine

Site Name:
McKin Company Superfund Site

Location:
Gray, Maine

Contaminants:
Chlorinated Aliphatics; Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX); Polynuclear Aromatic Hydrocarbons (PAHs)
- Excavated soil contained up to 3,310 mg/kg TCE, 130 mg/kg Ethylbenzene, and 35 mg/kg Toluene

Period of Operation:
July 1986 to April 1987

Cleanup Type:
Full-scale cleanup

Vendor:
Canonie Environmental
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

Technology:
Thermal Desorption
- Rotary kiln desorber 7 feet in diameter and 28 feet long
- Soil heated to 250-400°F and a residence time of 6 minutes
- Offgases treated using HEPA filter, baghouse, scrubber, and carbon adsorption

Cleanup Authority:
CERCLA
- ROD Date: 7/22/85
- PRP Lead

SIC Code:
4953E (Refuse Systems - Sand and Gravel Pit Disposal)

Point of Contact:
Sheila Eckman
Remedial Project Manager
U.S. EPA Region I
John F. Kennedy Federal Bldg., Room 2203
Boston, MA 02203
(617) 573-5784

Waste Source:
Disposal Pit

Type/Quantity of Media Treated:
Soil
- 11,500 cubic yards
- No information available on matrix characteristics

Purpose/Significance of Application:
This treatment application is notable for being one of the earliest full-scale applications of thermal desorption to remediate halogenated volatile organic compounds at a Superfund site.

Regulatory Requirements/Cleanup Goals:
- Soil performance standard of 0.1 mg/kg for TCE, with retreatment as necessary
- Performance standards of 1 mg/kg for individual aromatic organic compounds, 1 mg/kg for individual PAHs, and 10 mg/kg for total PAHs

Results:
- All cleanup goals achieved
- 11,500 tons of soil treated within 10-month period
- Ambient air concentrations for VOCs were less than 2 ppm above background

Cost Factors:
- Total Cost - $2,900,000 (including salaries and wages, rental, supplies, subcontracts, fuel, and other professional services)

Thermal Desorption at the McKin Company Superfund Site Gray, Maine (Continued)

Description:
The McKin Company (McKin), in Gray, Maine, was a former waste collection, transfer, storage, and disposal facility. Soil at McKin was contaminated with halogenated VOCs and petroleum products, including polynuclear aromatic hydrocarbons (PAHs) and aromatic compounds. During the remedial investigation at McKin, soil contamination levels were measured as high as 1,500 mg/kg for trichloroethylene (TCE), 49 mg/kg for methylene chloride, and 21 mg/kg for xylenes. The ROD identified several areas at McKin that required on-site thermal desorption treatment for contaminated soil. These areas were grouped into a "VOC-Contaminated Area" and a "Petroleum-Contaminated Area." The treatment performance standard, stipulated in the ROD, required treatment of TCE in the soil to a concentration of 0.1 mg/kg. In addition to the TCE requirement, treatment performance standards for PAHs and aromatic organics were specified for the petroleum-contaminated area. Ambient air monitoring was required during the application.

The thermal desorption system included a rotary kiln desorber with offgases treated using a filter, baghouse, scrubber, and carbon adsorption. Thermal desorption of approximately 11,000 cubic yards of soil was completed at McKin between July 1986 and April 1987. This treatment application is notable for being one of the earliest full-scale applications of thermal desorption to remediate halogenated volatile organic compounds at a Superfund site. Treatment performance and air monitoring data collected during this application indicated that all performance standards and monitoring requirements were achieved through use of the thermal desorption technology.

The total cost for this application was $2,900,000. According to the vendor, this cost included rental supplies, labor, subcontracts, fuel and other professional services, and estimated that over 80% of the cost was associated with the treatment of the contaminated soil. A pilot-scale treatability study indicated that thermal desorption would be effective in treating soils at the McKin site.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report presents cost and performance data for a thermal desorption treatment application at the McKin Company Superfund site (McKin) located in Gray, Maine. McKin is a former waste collection, transfer, storage, and disposal facility. Soil at McKin was contaminated with halogenated volatile organic compounds (VOCs) and petroleum products, including polynuclear aromatic hydrocarbons (PAHs) and aromatic compounds. During the remedial investigation at McKin, soil contamination levels were measured as high as 1,500 mg/kg for trichloroethene (TCE), 49 mg/kg for methylene chloride, and 21 mg/kg for xylenes.

A Record of Decision (ROD) was signed in July 1995 and specified thermal desorption for treatment of contaminated soil at McKin. The ROD identified several areas at McKin that required treatment. These areas were grouped into a "VOC-contaminated area" and a "petroleum-contaminated area." The treatment performance standard stipulated in the ROD required treatment of TCE in the soil to a concentration of 0.1 mg/kg. In addition to the TCE requirement, treatment performance standards for PAHs and aromatic organics were specified for the petroleum-contaminated area. Ambient air monitoring was required during the application. Thermal desorption of approximately 11,000 cubic yards of soil was completed at McKin between July 1986 and April 1987.

Treatment performance and air monitoring data collected during this application indicated that all performance standards and monitoring requirements were achieved through use of the thermal desorption technology. This treatment application is notable for being one of the earliest full-scale applications of thermal desorption to remediate halogenated VOCs at a Superfund site.

Prior to completing the full-scale treatment application of thermal desorption at McKin, a pilot-scale treatability study was conducted from February to May 1986. The results of this treatability study indicated that thermal desorption achieved the TCE performance standard of 0.1 mg/kg. As a result of this treatability study, specific changes were incorporated into the design and operation of the full-scale remediation system.

The vendor stated that $2,900,000 were expended for the remediation of soils at McKin, including costs for salaries and wages, rental, supplies, subcontracts, fuel, and other professional services.

SITE INFORMATION

Identifying Information

McKin Company Superfund Site
Gray, Maine
CERCLIS # MED980524078
ROD Date: 07/22/85

Treatment Application

Type of Action: Remedial
Treatability Study Associated with Application? Yes (see Appendix A)
EPA SITE Program Test Associated with Application? No
Operating Period: July 1986 to April 1987
Quantity of Soil Treated During Application: 11,500 cubic yards

SITE INFORMATION (CONT.)

Background

Historical Activity that Generated Contamination at the Site: Waste Collection, Transfer, Storage, and Disposal Facility

Corresponding SIC Code:
4953E (Refuse Systems-Sand and Gravel Pit Disposal)

Waste Management Practice that Contributed to Contamination: Disposal Pit

Site History: The McKin Company Superfund site (McKin) is located on the west side of Mayhall Road between Route 115 and Pownall Road in Gray, Maine, 15 miles north of Portland, Maine, as shown on Figure 1. This site was reportedly used as a sand and gravel pit prior to its purchase in 1963 by the McKin Company. From 1964 to 1978, the McKin Company operated a tank cleaning and waste removal business. The McKin site was used to collect, store, dispose, and transfer petroleum and industrial chemical waste until operations ceased in the late seventies. The site included 22 above-ground storage tanks, an asphalt-lined lagoon used for storage of wastes, and an incinerator. The incinerator was used to treat wastes from an oil tanker and was operated from about 1970 until 1973. [2]

In addition, wastes were discharged to the ground and buried on site. Between 1972 and 1977, 100,000 to 200,000 gallons of liquid waste were processed on site each year. A site plan for McKin is shown in Figure 2. [2]

Reports of groundwater and soil contamination began in 1973, when residents in East Gray reported odors in well waters and discoloration of laundry. Based on these reports, numerous investigations and activities were completed by the Maine Department of Environmental Protection (MDEP), the Town of Gray, and EPA. A Remedial Action Master Plan (RAMP) was prepared by EPA in April 1983. The RAMP recommended collecting appropriate data, developing a Remedial Investigation/Feasibility Study (RI/FS), and implementing some Initial Remedial Measures (IRMs). [2]

In June 1983, the MDEP entered into a Cooperative Agreement with EPA to implement the IRMs and develop the RI/FS. A ROD, signed in July 1983, required removal of the liquid wastes from the storage tanks. [2]

As a result of the remedial investigation, completed in February 1985, several areas of soil contaminated were identified. These areas were grouped into a "VOC-contaminated area" and a "petroleum-contaminated area." [2]

Regulatory Context: A ROD signed on July 22, 1985, required on-site thermal desorption treatment for soils in the VOC-contaminated area and the petroleum-contaminated area. The treatment performance standard stipulated in the ROD required treatment of TCE in the soil to a concentration of 0.1 mg/kg. In addition to the TCE requirement, treatment performance standards for PAHs and aromatic organics were specified for the petroleum-contaminated area.

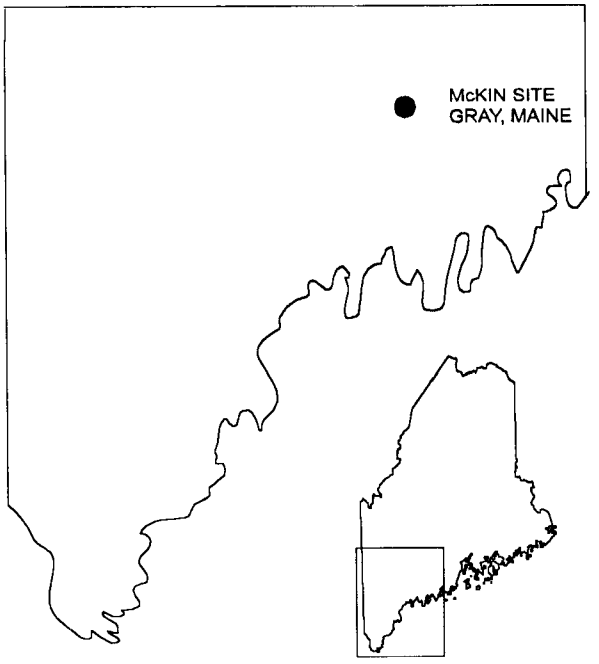

Figure 1. McKin Site, Gray, Maine [2]

SITE INFORMATION (CONT.)

Background (cont.)

EPA stipulated that prior to its use as a full-scale remedy for soil contamination at McKin, a pilot-scale study using thermal desorption was required to determine the effectiveness of treatment for soils at McKin and the impact on ambient air quality. [2]

Remedy Selection: Several alternative technologies were considered for the treatment of contaminated soils at the McKin site, including capping, landfilling, thermal desorption, and incineration. Thermal desorption was selected as a cost-effective alternative technology for remediation of soil from both contaminated areas at McKin.

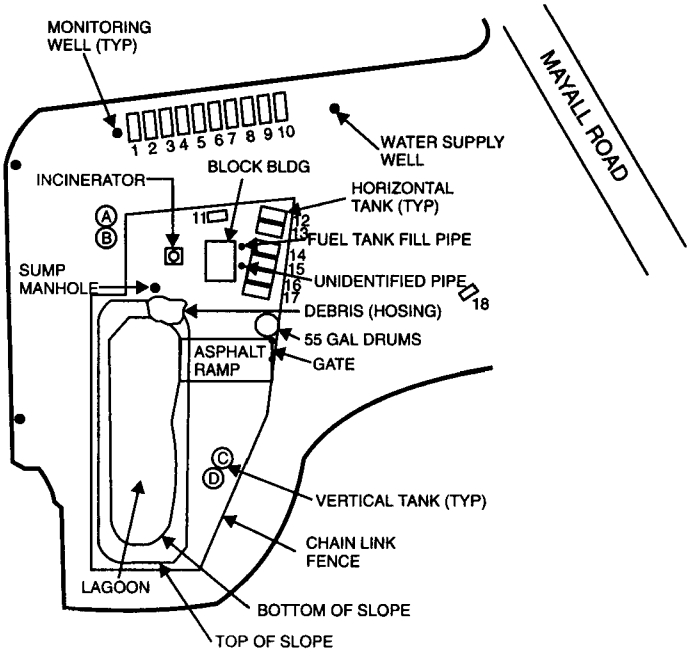

Figure 2. McKin Site Plan, Gray, Maine [2]

Site Logistics/Contacts

Site Management: PRP Lead

Oversight: EPA

Remedial Project Manager:
Sheila Eckman
U.S. EPA, Region 1
John F. Kennedy Federal Building, Room 2203
Boston, Massachusetts 02203
(617) 573-5784

Treatment Vendor:
Canonie Environmental
800 Canonie Drive
Porter, Indiana 46304
(219) 926-8651
(contact not available)

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Soil (ex situ)

Contaminant Characterization

Primary Contaminant Groups: Halogenated volatile organic compounds; and Polynuclear Aromatic Hydrocarbons

MATRIX DESCRIPTION (CONT.)

Contaminant Characterization (cont.)

Excavated soil treated in this application contained up to 3,310 mg/kg of TCE. [4] RI results indicated concentrations as high as 1,500 mg/kg for TCE, 49 mg/kg for methylene chloride, and 21 mg/kg for xylenes. [2]

Matrix Characteristics Affecting Treatment Cost or Performance

The major matrix characteristics affecting cost or performance for this technology are listed below; the values for these parameters are not provided in the available references:

- Soil classification
- Clay content and/or particle size distribution
- Moisture content
- Oil and Grease or Total Petroleum Hydrocarbons
- Bulk density
- Lower explosive limit

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology Type:

Thermal Desorption

Supplemental Treatment Technology Types:

Pretreatment (Solids): Screening,; Mixing; Post-treatment (Air): Baghouse, Scrubber; Post-treatment (Water): Carbon Adsorption

Thermal Desorption Treatment System Description and Operation

The thermal desorption treatment system used at McKin, shown in Figure 3, consisted of pretreatment processes for screening and mixing, a cylindrical desorber, and an air treatment system.

Excavation and Pretreatment
Contaminated soil at McKin was excavated using buckets and augered steel cylinder caissons. The caissons were used to prevent collapse of excavation holes and reduce vaporization of organic contaminants from the soil. Excavated soil and debris were separated by screening the soil with a coarse grate. Petroleum-contaminated soils, which had a tendency to agglomerate or "ball up" in the desorber, were mixed with clean makeup soil prior to treatment to minimize this agglomeration. [4]

Thermal Desorber
The thermal desorber used at McKin was a rotating cylindrical drum 7 feet in diameter and 28 feet in length. Mixing and aeration were accomplished through use of longitudinal flights within the cylinder and rotation of the cylinder, at speeds of approximately 6 revolutions per minute. Forced hot air, generated by an oil burner, was used to heat the soil in the cylinder. To increase the residence time of soil in the cylinder, soil was treated with several passes through the cylinder. Soil was heated to an exit temperature of 250 to 400°F with a residence time of 6 minutes (2 minutes per pass and three passes through unit). [5]

A bucket elevator and chute system were used to transport treated soil to the head of the desorber or to a cement mixer. Treatment residuals (fines) were transported, using a series of augers, from a baghouse to a slurry box, and from the slurry box to a cement mixer. The cement mixer was used to increase the stability of the material prior to redisposition into excavation holes on site. [4]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Thermal Desorption Treatment System Description and Operation (cont.)

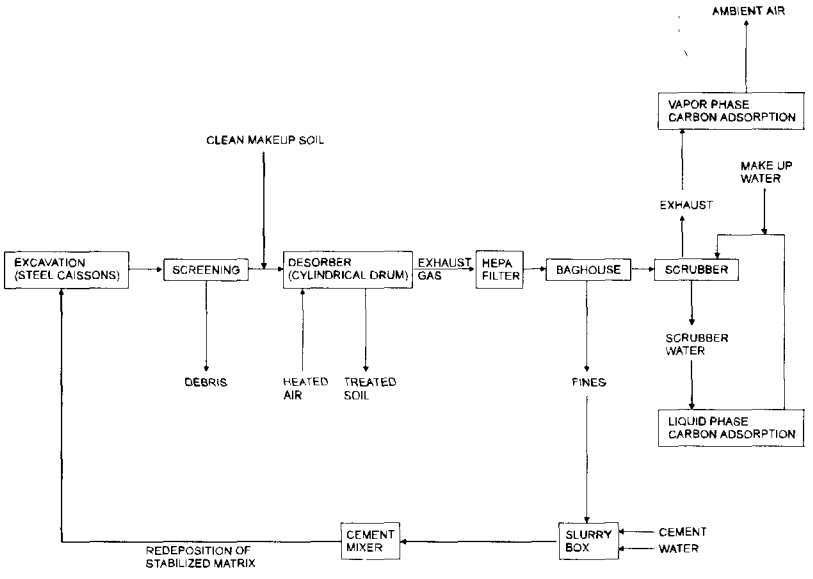

Figure 3. Thermal Desorption Treatment System Used at McKin [4]

Air Treatment System

The air treatment system used at McKin consisted of a HEPA filter, a baghouse, a scrubber, and a vapor-phase carbon adsorption system, in series. The system was designed to remove particulates and organic vapors from the desorber exhaust gases. The HEPA filter was used to remove smoky particulates (smokey particulates were identified during the pilot-scale study). The baghouse, which consisted of an enclosed series of six banks of fine-mesh synthetic fabric filters, was used to remove particulates. Baghouse fines were transported via augers to the slurry box. The countercurrent flow scrubber, a 10-foot tall cylindrical tower with a 6-foot diameter, filled with plastic packing media, was used to condition the air, remove water soluble chemicals, and remove most remaining particulates. Scrubber water was regenerated in a liquid phase carbon adsorption unit and recycled to the scrubber. Scrubber exhaust was treated using a vapor phase carbon adsorption unit, consisting of 15 tons of activated carbon. Scrubber exhaust entered through the bottom of the bed and then was exhausted to ambient air. [4]

Residuals

Residual solids (fines and treated soil) were mixed with cement and water and redeposited into the excavated caisson holes from the original on-site excavation. Additional residuals generated during this treatment application included 38 drums of spent HEPA filters, 29 drums of spent baghouse bags, and 42 drums of used Personal Protection Equipment (PPE) which were incinerated at Trade Waste Incineration of Sauget, IL. Spent vapor-phase carbon was regenerated by Calgon Carbon in Neville Island, PA and Columbus, OH. Between 1986 and 1987, 45,000 pounds of carbon were regenerated. An analysis of the spent carbon for total chlorinated compounds indicated concentrations of less than 1%. One thousand pounds of spent liquid-phase carbon were regenerated in 1987 by Adsorption Systems in Millburn, NJ. [4]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Operating Parameters Affecting Treatment Cost or Performance

Table 1 presents the major operating parameters affecting cost or performance for this technology and the values measured for each during this treatment application.

Table 1. Operating Parameters [3, 4]

Parameter	Value	Measurement Method
Air Flow Rate	15,000 acfm	—
Residence Time per Pass	2 minutes	—
Number of Passes	3	—
Total Residence Time	6 minutes	—
System Throughput	8 to 9 cubic yards/batch	—
Temperature of Soil Exiting Heating Chamber	250 to 400°F	Sensor at soil discharge chute

Timeline

A timeline for this application is shown in Table 2.

Table 2 . Timeline [1, 3]

Start Date	End Date	Activity
1964	1978	Tank cleaning and waste collection, transfer, storage, and disposal operations conducted at McKin
1979	1987	Interim remedial measures implemented
July 1983	—	First ROD signed
September 1983	—	McKin added to National Priorities List
July 1985	—	Second ROD signed
23 August 1985	—	Administrative order signed for conducting pilot-scale test
February 1986	April 1986	Pilot-scale study of thermal desorption conducted
7 July 1986	—	Administrative order signed for conducting full-scale treatment
July 1986	February 1987	Full-scale treatment of VOC-contaminated area soils using thermal desorption
March 1987	April 1987	Full-scale treatment of petroleum-contaminated area soils using thermal desorption
June 1987	—	Site demobilization

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

The 1985 ROD identified a performance standard for TCE in soil of 0.1 mg/kg averaged over a treatment volume. Samples of treated soil were required to be collected at the midpoint of each batch and analyzed for TCE. If the average concentration of TCE contained in these samples exceeded the performance standard, the soil treated that day was required to be retreated until the daily average concentration of TCE met the performance standard. [3]

For metal contaminants detected in soils at the McKin site, the ROD indicated that extraction procedure (EP) toxicity standards or results from solute fate and transport modeling would be protective of public health via groundwater contamination exposures. [2]

TREATMENT SYSTEM PERFORMANCE (CONT.)

Cleanup Goals/Standards (cont.)

Additional treatment performance standards for aromatic organic compounds and poly-nuclear aromatic hydrocarbons were specified in a contractor's report for the petroleum-area soils. [3] Performance standards for treatment of soil from the petroleum-contaminated areas at McKin were specified as 1 mg/kg for individual aromatic organic compounds, 1 mg/kg for individual PAHs, and 10 mg/kg for total PAH constituents. Samples were collected and analyzed for these additional parameters in a manner similar to that described above for TCE. The cleanup goals set for this application were technology-based. The vendor was given six weeks to demonstrate the technology's performance in treating site soils to the specified levels.

Volatile organic compounds, including TCE, were required to be analyzed on site using EPA Method 8010/8020. Semivolatile organic compounds were required to be analyzed using EPA Method 8270. Ten percent of the samples were required to be analyzed off site for confirmatory analyses. [3]

Continuous air monitoring was required for organic vapors near site activities and public notification was required if downwind organic vapors at the site perimeter were greater than 2 ppm above background. [5]

Treatment Performance Data [3]

Analytical data for VOCs and PAHs in soil measured during this application are shown in Tables 3 and 4, respectively. Ambient air monitoring at the site perimeter indicated that TCE was present at levels ranging from less than 0.002 up to 0.01 ppm, less than the 2 ppm above background action level. Air samples were collected using carbon and Tenax tube (charcoal tube) sampling, and desorbed using a NIOSH carbon disulfide procedure. [3]

Table 3. VOC Data [3]

Constituent	Maximum Untreated Soil Concentration (mg/kg)	Range of Treated Soil Concentrations (mg/kg)
Chloroform	30	Not analyzed
1,2-Dichlorobenzene	320	ND (0.02)
trans-1,1-Dichloroethene	6.1	ND (0.02)
Tetrachloroethane	120	ND (0.02)
1,1,1-Trichloroethane	19	ND (0.02)
Trichloroethene	3,310	ND (0.02) to 0.04

N/A = Not applicable
ND = Not detected. Number in parenthesis is the detection limit.

Table 4. PAH Data [3]

Constituent	Range of Treated Soil Concentrations (mg/kg)*
Acenaphthene	ND (0.66)
Anthracene	ND (0.17) to 0.975
Benzo(a)anthracene	ND (0.17) to 0.42
Chrysene	ND (0.17) to 0.495
Fluoranthrene	ND (0.33) to 0.38
Fluorene	ND (0.66)
Naphthalene	ND (0.66)
Phenanthrene	ND (0.33) to 2.5
Pyrene	ND (0.33) to 0.76

ND = Not detected. Number in parenthesis is the detection limit.
**From Table 8 of Reference [3]; covers period from 3/16/87 - 4/17/87.*

Performance Data Assessment

Soil sampling results for both VOC- and petroleum-contaminated areas indicate that the TCE performance standard was achieved during this application. Retreatment of soil was required only once during the full-scale remediation, on January 9, 1987. It was determined that a portion of the baghouse dust transfer chute was plugged at that time, with roots and debris, and inhibited the treatment of dust at that location. The transfer chute was cleaned and no subsequent retreatment was required.

The results shown in Table 3 indicate treatment of soil to levels below the reported detection limit for six chlorinated aliphatics.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment (cont.)

The results for PAHs shown in Table 4 indicate treatment to levels less than 1 mg/kg, with one exception. The one exception, phenanthrene, was detected at levels ranging from 0.8 to 2.5 mg/kg during the last two weeks of treatment for petroleum-contaminated area soils. The average concentration of phenanthrene measured during the application was 0.92 mg/kg, and this value was accepted by EPA and MDEP as indicative of a successful application.

Performance Data Quality

Soil samples were analyzed on site using SW-846 analytical methods, and 10% of the samples were analyzed off site for confirmatory purposes. No exceptions to established data quality objectives were identified by the vendor for this application.

Performance Data Completeness

Data from this application are available for characterizing treated soil concentrations and for comparing these performance results with operating conditions.

TREATMENT SYSTEM COST

Procurement Process

The Potentially Responsible Parties (PRPs) contracted with Canonie Environmental to complete this treatment application. [3] No information is available at this time on the competitive nature of the procurement process.

Treatment System Cost

The vendor stated that $2,900,000 were expended for the full-scale remediation of soils at McKin, including costs for salaries and wages, rental, supplies, subcontracts, fuel, and other professional services. This value does not include costs for mobilization, site characterization, pilot-scale treatability study, waste material disposal, site closure, and demobilization. Table 5 shows a cost breakdown for the treatment of VOC - and petroleum contaminated soils, as provided by the vendor. [3]

No additional information is presented in the references to fully describe the items included in each cost element shown Table 5. Therefore, a cost breakdown using the interagency Work Breakdown Structure (WBS) is not provided in this report.

Table 5. Cost Breakdown Provided By Vendor [3]

Cost Elements	Cost Breakdown for Treatment of VOC-Contaminated Area Soils	Cost Breakdown for Treatment of Petroleum-Contaminated Area Soils
Salaries and Wages	$405,450	$88,910
Rental	$596,250	$130,880
Supplies	$453,150	$93,370
Subcontracts	$620,100	$135,980
Fuel	$47,700	$10,460
Other Professional Services	$262,350	$57,530
TOTAL	**$2,385,000**	**$517,130**

TREATMENT SYSTEM COST (CONT.)

Cost Data Quality

The costs shown in Table 5 were provided by the vendor in a site closeout report prepared for the PRPs. Limited information is available on the specific elements included in the total cost value.

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- The vendor stated that $2,900,000 were expended for the full-scale remediation of soils at McKin. The total cost value includes costs for salaries and wages, rental, supplies, subcontracts, fuel, and other professional services. Over 80% of the costs were for treatment of VOC-contaminated soils

Performance Observations and Lessons Learned

- Thermal desorption reduced concentrations of TCE in soil from levels as high as 3,310 mg/kg to less than the 0.1 mg/kg treatment performance standard for this application.
- Thermal desorption reduced concentrations of other volatile and semi-volatile organic contaminants from levels as high as 320 mg/kg to levels less than 1 mg/kg in this application with one exception for phenanthrene.
- Full-scale thermal desorption treatment of 11,500 tons of soil from the VOC- and petroleum-contaminated areas at McKin was completed within a 10-month period.
- Ambient air concentrations for TCE, ranged from less than 0.002 to 0.01 ppm.

Other Observations and Lessons Learned

- The pilot-scale treatability study accurately predicted that thermal desorption would be effective in treating soils at the McKin site and achieving the performance standard for the application.
- The following improvements to the design and operation of the full-scale remediation system were made based on the results of the pilot-scale treatability study:
  - — Fugitive dust emissions were controlled by enclosing materials handling processes;
  - — Temperature, residence time, and air flow were optimized for TCE removal efficiency;
  - — Wetting procedures were determined to be ineffective and difficult to utilize in the system;
  - — Addition of a HEPA filter to the exhaust gas treatment system reduced smoke particulates; and
  - — The mixing of clean soil and petroleum contaminated soil eliminated agglomeration of the petroleum contaminated soil in the thermal desorption unit.
- The treatability study indicated that at temperatures below 250°F, there was not a significant reduction of TCE in the soil, and at temperatures above 350°F, the soil behaved as a viscous fluid on the conveyor bed and reacted violently with water during wetting.

REFERENCES

1. U.S. EPA Office of Emergency and Remedial Response. *Superfund Record of Decision: McKin Site, ME.* EPA/ROD/R01-83/003, Washington, D.C., July 1983.
2. U.S. EPA Office of Emergency and Remedial Response. *Superfund Record of Decision: McKin Site, ME (Second Remedial Action, 07/22/85).* EPA/ROD/R01-85/009, Washington, D.C., July 1985.
3. Canonie Environmental. Report, Soil Remediation and Site Closure - McKin Superfund Site, Gray, Maine. Prepared for: Potentially Responsible Parties. Project 84-130. July, 1987.
4. Webster, David. "Hazardous Waste Management, Pilot Study of Enclosed Thermal Soil Aeration for Removal of Volatile Organic Contamination at the McKin Superfund Site". In: *Journal of the Air Pollution Control Association.* Volume 36, No. 10. U.S. EPA Waste Management Division, Boston, MA. October 1986.
5. Webster, David M., "Pilot Study of Enclosed Thermal Soil Aeration for Removal of Volatile Organic Contamination at the McKin Superfund Site", presented at Engineering Foundation Conference on Alternative Technologies for Hazardous Waste Management; Henniker, New Hampshire, June 16-20, 1986.
6. NPL Public Assistance Database (NPL PAD); McKin Company, Maine; EPA ID # MED980524078; March 1992.

Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Radian Corporation under EPA Contract No. 68-W3-0001.

APPENDIX A—TREATABILITY STUDY RESULTS

Treatability Study Objectives

A pilot-scale treatability study was conducted from February through May 1986 by Canonie Environmental to determine the effectiveness of soil treatment at McKin and to assess the impact of treatment on ambient air quality. Approximately 400 cubic yards of soil from the VOC and petroleum areas at McKin were used for the study.

Treatability Study Test Description

The pilot-scale study consisted of four phases of tests in which operating parameters were varied and the treatment apparatus modified to optimize the system. A 100-foot crane, equipped with a kelly bar caisson rig and a digging bucket, was used for soil excavation. A front end loader equipped with a removable plastic cover was used to transfer contaminated soil to the treatment apparatus.

The soil treatment apparatus consisted of a rotating materials dryer fed by a conveyor belt. The dryer rotated at approximately six revolutions per minute at drying temperatures ranging from 150°F to 380°F. To enhance volatilization of contaminants, an oil burner produced hot air which was blown into the drying drum at flow rates between 7,500 and 15,000 cubic feet per minute (cfm). Pre- and post-treatment soil samples were analyzed for VOCs to determine if sufficient contaminant reduction had been achieved from aeration. After aeration in the dryer, treated soils were stabilized with a lean mixture of cement and redeposited into the excavation cavity.

The system also treated the resulting air exhaust from the dryer. Exhaust air was first vented through a baghouse which removed particulates. The collected particulates were then treated in a heated screw conveyor, which returned the treated particulates to the treated soil. Next, the exhaust traveled through an air scrubber to remove water soluble contaminants and remaining particles. Lastly, the exhaust was vented to a vapor phase carbon adsorption bed which removed VOCs.

Operating conditions were varied during each of the four phases of the pilot study. The first phase varied soil volume, dryer temperature, dry flue gas temperature, dryer air flow, soil wetting procedures for dust control, and baghouse operation. Phase Two focused on dryer temperature and air flow. Drying temperature was varied between 150°F and 325°F, and dryer airflow was set at 15,000 cfm. Furthermore, during Phase Two, soils were recirculated through the dryer 4 or 5 times. The purpose of Phase Three was to determine if desired treatment levels could be achieved in repeated runs, under full-day operation. During the second half of this phase, dryer temperatures were kept roughly constant, between 290°F and 310°F, and dryer airflow was set at 15,000 cfm. Soil volume was set at 3 cubic yards per run and residence time in the dryer was set at approximately 6 minutes for the three passes through the dryer. For Phase Four, the dust control and soil handling systems were modified. The conveyor belt was replaced with a bucket conveyor recirculation system. Also, treated soils were placed directly into the cement mixer truck, skipping the stockpiling step.

Site air was monitored throughout the study for any possible decline in ambient air quality caused by thee excavation and aeration of contaminated soils. Organic vapors and particulates were measured at various locations around the site perimeter and within the site to detect any danger to public health resulting from the treatment.

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Performance Data

The treatability study results showed that the thermal desorption system was effective in reducing TCE concentrations in the treated soil to less than 0.1 mg/kg using the higher temperatures and the maximum airflow tested. Fugitive particulate emissions could be controlled by enclosing much of the system. TCE concentrations in ambient air measured during the pilot-scale treatment did not exceed background levels. The study also determined that additional volatile organic contaminants such as BTEX could be treated with the same operating parameters as those used to optimize TCE removal efficiency.

The treatability study established a correlation with increased dryer temperatures (from 150°F to 380°F) and increased airflow (up to 15,000 cfm) with higher removal efficiencies of TCE. Higher removal efficiencies of TCE were also achieved by treating soils with multiple passes through the unit, thus increasing residence time. An optimum temperature of 300°F was determined on the basis that below 250°F there was not a significant reduction of TCE concentrations, and above 350°F the soil behaved as a viscous fluid on the conveyor bed and reacted violently with water during wetting.

During the treatability study, fugitive particulate emissions from transporting soils on belt conveyors within the treatment system were found to impede cycle times. Prior to the full-scale remediation, the conveyors were replaced with enclosed transport systems, using a bucket and chute system and augers to reduce fugitive particulate emissions. Wetting procedures were initially used, but were discontinued during the pilot-scale treatability test due to a lack of effectiveness in reducing emissions, interference with GC analysis of treated soils, and added difficulty in materials handling. Bluish smoke was observed during the pilot-scale treatability study, and was subsequently controlled by installing a HEPA filter at the dryer exhaust.

Treatability Study Lessons Learned

- The pilot-scale treatability study indicated that thermal desorption would be effective in treating soils at the McKin site and achieving the performance standards for this application.
- The following improvements to the design and operation of the full-scale remediation system were made based on the results of the pilot-scale treatability study:
  - — Fugitive dust emissions were controlled by enclosing materials handling processes;
  - — Temperature, residence time, and air flow were optimized for TCE removal efficiency;
  - — Wetting procedures were determined to be ineffective and difficult to utilize in the system;
  - — Addition of a HEPA filter to the exhaust gas treatment system reduced smoke particulates; and
  - — The mixing of clean soil and petroleum contaminated soil eliminated agglomeration of the petroleum contaminated soil in the thermal desorption unit.

Thermal Desorption at the Outboard Marine Corporation Superfund Site Waukegan, Illinois

Case Study Abstract

Thermal Desorption at the Outboard Marine Corporation Superfund Site Waukegan, Illinois

Site Name:
Outboard Marine Corporation
Superfund Site

Location:
Waukegan, Illinois

Contaminants:
Polychlorinated Biphenyls (PCBs)
- PCB concentrations in material feed to thermal desorber ranged from 2,400 to 23,000 mg/kg PCBs

Period of Operation:
January 1992 to June 1992

Cleanup Type:
Full-scale cleanup

Vendor:
Joseph Hutton
SoilTech ATP System, Inc.
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

Technology:
Thermal Desorption
- Rotary kiln desorber with proprietary sand seals
- Retort zone temperature 1,207°F
- Preheat and retort zone residence time 30-40 minutes
- Air emissions controlled using cyclones, baghouse, scrubbers, fractionator, condenser, gas-oil-water separator, and carbon adsorption
- Water treated on site using sand filtration, Klensorb® filtration, ultraviolet oxidation, cartridge filtration, and carbon adsorption

Cleanup Authority:
CERCLA
- ROD Date: 3/31/89
- PRP Lead

SIC Code:
3363 (Aluminum Die-Casting)

Point of Contact:
Bill Bolen - RPM
(Cindy Nolan - former RPM)
U.S. EPA, Region 5
77 West Jackson
Chicago, IL 60604
(312) 353-6316

Waste Source:
Other: Discharge to Sewer/Surface Water; Surface Disposal Area

Type/Quantity of Media Treated:
Soil and Sediment
- 12,755 tons treated
- 12.9% moisture; pH of 8.59

Purpose/Significance of Application:
This application was an early application of SoilTech's ATP system for treating soil and sediment at a Superfund Site contaminated with PCBs.

Regulatory Requirements/Cleanup Goals:
- Soil and Sediment - PCBs: 97% removal by mass
- Air - PCBs: Destruction and Removal Efficiency (DRE) of 99.9999%, Dioxins/Furans: 30 ng/dscm

Results:
Soil and Sediment - Achieved PCB cleanup goal for soil and sediment; average PCB removal efficiency of 99.98%; PCB concentrations in treated soil ranged from 0.4 mg/kg to 8.9 mg/kg; most samples less than 2 mg/kg
Air - Stack gas requirements met for PCBs; stack gas requirements met for dioxins/furans after system modifications

Cost Factors:
- $2,474,000 - Actual total costs for cost elements directly associated with treatment (including solids preparation and handling, startup/testing/permits, operation, capital equipment, and demobilization)
- $900,000 for before-treatment costs (including mobilization and preparatory work, and monitoring, sampling, testing, and analysis)

Thermal Desorption at the Outboard Marine Corporation Superfund Site Waukegan, Illinois (Continued)

Description:
Outboard Marine Corporation (OMC), located on Lake Michigan, performed marine product manufacturing operations at the site. Contamination of the soil and sediments at the site resulted from the discharge of hydraulic fluid containing PCBs through floor drains which discharged to several areas at the site and into Waukegan Harbor. An estimated 700,000 pounds of PCBs were discharged to the OMC site and 300,000 pounds of PCBs were discharged to Waukegan Harbor. Based on a 1989 Consent Decree and Record of Decision, remedial activities selected for the site included excavation, stockpiling, and treatment of soil and sediment contaminated with PCBs. A cleanup goal for PCBs in soil and sediment of 97% removal was specified in the 1989 ROD.

SoilTech's mobile Anaerobic Thermal Processor (ATP) system was selected for treating the PCB-contaminated soil and sediment at OMC. The ATP system was operated at the site from January 23, 1992 until June 23, 1992. During this time, 12,755 tons of PCB-contaminated soils and sediments were treated. The ATP system met the cleanup goal for PCBs in soil and sediment by achieving an average removal efficiency of 99.98% for total PCB concentrations. PCBs in treated soil ranged from 0.4 to 8.9 mg/kg. The PCB DRE of 99.9999% and total dioxin and furan stack emission requirements of 30 ng/dscm were met during the cleanup.

During the proof-of-process period (January 23 until March 5), the DRE for PCBs was not met, and EPA shut the system down. From March 5 until May 30, SoilTech made modifications to the system, and the stack gas emissions requirements were met during the remainder of the soil cleanup. An EPA SITE Demonstration was conducted at the OMC site in June 1992. During this demonstration, 255 tons of soil and sediment were treated. The total cost for the full-scale application of thermal desorption at the OMC site was $2,474,000.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report presents cost and performance data for a thermal desorption treatment application at the Outboard Marine Corporation (OMC) Superfund Site, located in Waukegan, Illinois. OMC performed marine product manufacturing operations at the site. Hydraulic fluid containing polychlorinated biphenyls (PCBs) was discharged through floor drains, resulting in the contamination of soil in several areas of the site and contamination of sediment in nearby Waukegan Harbor.

Based on a 1989 Consent Decree and Record of Decision, the remedial activities selected for the site included excavation, stockpiling, and treatment of PCB-contaminated soil and sediment. The specified cleanup goals for the site for PCBs was 97 percent removal by mass in treated soil and sediment. In addition, a destruction and removal efficiency (DRE) of 99.9999% for PCBs and a limit of 30 nanograms per dry standard cubic meter (ng/dscm) for dioxins and furans were required for stack gas emissions.

SoilTech's mobile Anaerobic Thermal Processor (ATP) system was selected for treating the PCB-contaminated soil and sediment at OMC. The SoilTech ATP system included a feed system, the ATP unit (rotary kiln thermal desorber), a vapor recovery system, a flue gas treatment system, and a tailings handling system. Wastewater from the vapor recovery system was treated in an on-site wastewater treatment system and then discharged to a sanitary sewer. Most of the PCBs desorbed from the contaminated soil and sediment were contained in oil from the vapor recovery system. Approximately 50,000 gallons of oil were generated during full-scale cleanup and were disposed off site. The treated soil and sediment were placed into containment cells constructed on site.

The ATP system was operated at the OMC site from January 22, 1992 until June 23, 1992 and was used to treat approximately 12,700 tons of PCB-contaminated soil and sediment. The ATP system met the cleanup goal for PCBs in soil and sediment by achieving an average removal efficiency of 99.98 percent for total PCBs. PCB concentrations in the treated soil ranged from 0.4 to 8.9 mg/kg. The PCB DRE of 99.9999% and total dioxin and furan stack emission requirements of 30 ng/dscm were met during the full-scale cleanup.

During the proof-of-process period (January 23 until March 5), the DRE for PCBs was not met, and EPA shut the system down. From March 5 until May 30, SoilTech made modifications to the ATP system, and the stack gas emissions requirements were met during the remainder of the soil cleanup.

A SITE Demonstration was conducted at the OMC site during June 1992. During this demonstration, 255 tons of soil and sediment were treated.

The remediation of contaminated soils and sediments at OMC was completed at a cost of $2,474,000 for activities directly attributed to treatment (corresponding to $190/ton of soil and sediment treated) and $900,000 for before-treatment activities.

SITE INFORMATION

Identifying Information

Outboard Marine Corporation Superfund Site
Waukegan, Illinois
CERCLIS #: ILD000802827
ROD Date: 31 March 1989

Treatment Application

Type of Action: Remedial
Treatability Study Associated with Application? Yes (see Appendix A and Reference 6)
EPA SITE Program Test Associated with Application? Yes (see Reference 5)
Operation Period: 1/22/92 to 6/23/92
Quantity of Material Treated During Application: 12,755 tons of soil and sediment

Background

Historical Activity that Generated Contamination at the Site: Aluminum die-casting, machining

Corresponding SIC Code: 3363 (Aluminum Die-Castings)

Waste Management Practice that Contributed to Contamination: Discharge to Sewer/ Surface Water, Surface Disposal Area

Site History: The Outboard Marine Corporation (OMC) Superfund Site is located in Waukegan, Illinois on the western shore of Lake Michigan, approximately 10 miles south of the Wisconsin border, as shown in Figure 1. OMC, a marine products manufacturer, used hydraulic fluid containing polychlorinated biphenyls (PCBs) as a lubricant for its aluminum casting and machining operations from 1961 to 1972. During these operations, hydraulic fluid was discharged through floor drains to an oil receptor system. The oil receptor system subsequently discharged to several areas at the site. It is estimated that approximately 700,000 pounds of PCBs were discharged to the OMC site and approximately 300,000 pounds of PCBs were discharged to Waukegan Harbor. The main areas of PCB contamination at the site, shown in Figure 2, are: Slip No. 3, a parking lot, the North Ditch, the Oval Lagoon, the Crescent Ditch, and Waukegan Harbor. [2, 3, 4, 5, and 12]

Regulatory Context: A Record of Decision (ROD) was signed in 1984 and engineering design work began in 1984. However, this work was suspended in late 1985 due to litigation between OMC and EPA concerning EPA's access to OMC property. In 1989, EPA and OMC negotiated a consent decree, and the 1984 ROD was amended in March 1989 to add a requirement for treatment of the contaminated soil and sediment on site. While the amended ROD did not require a specific treatment technology, the ROD did specify a treatment performance goal of 97 percent removal of PCBs.

Figure 1. Site Location

SITE INFORMATION (CONT.)

Background (cont.)

The following remedial actions were specified:

- Excavation and treatment of Slip No. 3 sediment with PCB concentrations greater than 500 ppm;
- Dredging of sediment in the Upper Harbor with PCB concentrations exceeding 50 ppm and placement of the dredged sediment in the Slip No. 3 containment cell for future treatment;
- Removal and treatment of soil and sediment in the Crescent Ditch and Oval Lagoon areas with PCB concentrations greater than 10,000 ppm;
- Construction of a containment cell at Slip No. 3;
- Construction of a new slip to replace Slip No. 3;
- Construction of a west containment cell to hold treated solids;
- Construction of an east containment cell in the parking lot area;
- Construction of a temporary on-site wastewater treatment facility for treatment of dredged water and a permanent wastewater treatment facility for treatment of containment cell wastewater;
- Capping of all containment cells; and
- Groundwater monitoring around the containment cells.

Figure 2 shows the areas at the site where PCB concentrations were between 50 and 500 ppm and areas where PCB concentrations exceeded 500 ppm.

Site Logistics/Contacts

Site Management: PRP Lead

Oversight: EPA

Remedial Project Manager:
Bill Bolen (HSRL-6J)
(Cindy Nolan-former RPM)
U.S. EPA - Region 5
77 West Jackson
Chicago, IL 60604
(312) 353-6316

Treatment System Vendor:
Joseph Hutton
Operations Manager
SoilTech ATP Systems
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

Construction Manager:
Kevin Brissett
Canonie Environmental Services
800 Canonie Drive
Porter, IN 46034
(219) 926-8651

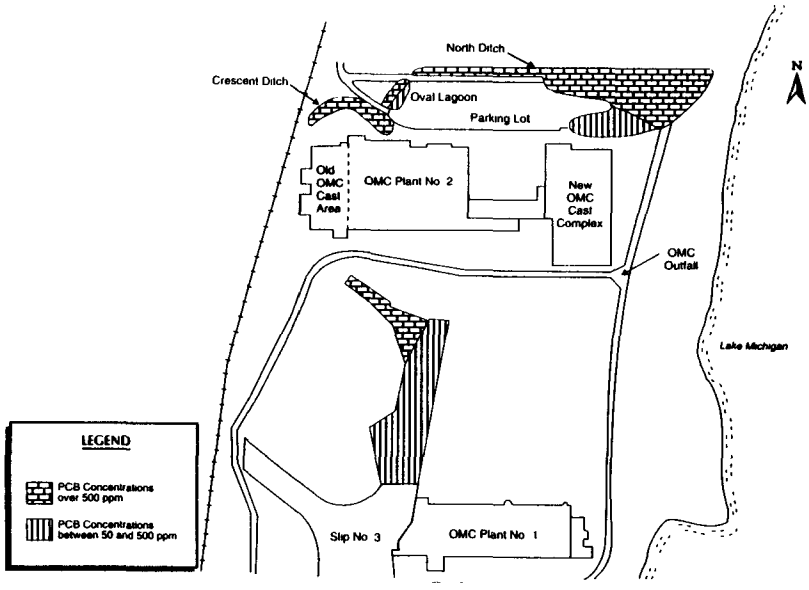

Figure 2. OMC Site Before Remedial Action (adapted from [4])

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Soil (ex situ), sediment (ex situ)

Contaminant Characterization

Primary Contaminant Groups: PCBs

The ROD specified excavation and treatment of soils from the Crescent Ditch and Oval Lagoon areas with PCB concentrations in excess of 10,000 ppm and sediments from Slip 3 with PCB concentrations grater than 500 ppm. The concentration of PCBs in the soil/sediment feed to the ATP unit (measured in daily composite samples collected from the feed conveyor to the ATP unit) ranged from 2,400 to 23,000 mg/kg. PCBs were measured in untreated soil/sediment samples using EPA Method 8080. [4, 5, 9, 10, and 13]

Matrix Characteristics Affecting Treatment Cost or Performance

The major matrix characteristics affecting cost or performance for this technology and their measured values are presented in Table 1.

Table 1. Matrix Characteristics [1,5]*

Parameter	Value	Measurement Method
Soil Classification	Sand	Not Reported
Bulk Density	1.87 g/cm^3	Not Reported
Moisture Content	12.9%	Not Reported
pH	8.59	Not Reported
Total Organic Carbon	16,000 ppm	Not Reported
Total Petroleum Hydrocarbons	3,033 ppm	Not Reported
Chloride	303 ppm	Not Reported
Extractable Organic Halides	1,900 ppm	Not Reported
Particle Size Distribution		
<4.75 mm	5.55%	Not Reported
<4.75 mm > 2 mm	2.93%	Not Reported
< 2 mm > 0.425 mm	7.60%	Not Reported
<0.425 mm > 0.075 mm	68.69%	Not Reported
<0.075 mm > 0.005 mm	7.88%	Not Reported
<0.005 mm	5.67%	Not Reported
Lower Explosive Limit	Not Available	—

**The values presented in the table above are the average results for the three composite samples of the contaminated feed collected during the three test runs of the SITE Demonstration (conducted in June 1992).*

These values are representative of 255 of the 12,755 tons of soil and sediment treated at OMC and are the only data available at this time. The methods used to measure these parameters were not identified in available references.

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology Type

Thermal desorption

Supplemental Treatment Technology Types [5,11]

Post-treatment (air): The ATP system used at the OMC site included two off gas treatment systems. The flue gas treatment system designed to treat gases from the combustion zone of the ATP unit included the following technologies:

- Cyclone;
- Quench;
- Baghouse; and
- Carbon adsorption.

The vapor recovery system designed to treat vapors from the preheat and retort zones of the ATP unit consisted of the following technologies:

- Cyclone;
- Condenser; and
- Gas-oil-water separators.

Post-treatment (water): The condensed water from the vapor recovery system was discharged to an on-site wastewater treatment system utilizing sand filtration, Klensorb® filtration, ultraviolet oxidation, cartridge filtration (0.5 microns), and activated carbon filtration.

SoilTech ATP Thermal Desorption Technology Description and Operation

The SoilTech Anaerobic Thermal Processor (ATP), shown in Figure 3, is a mobile treatment system consisting of six main process units, including a soil pretreatment system, a feed system, an anaerobic thermal processor unit, a vapor recovery system, a flue gas treatment system, and a tailings handling system. [5]

The feed system consists of two feed hoppers and a conveyor belt. One feed hopper contains the contaminated soil and the other contains clean sand. The sand is fed to the ATP unit during system startup and shutdown periods, serving as a heat carrier. Sand was also fed during upset conditions. [5]

The ATP unit is a rotary kiln which contains four separate internal zones, separated using proprietary sand seals. As shown in Figure 4, these include the preheat, retort, combustion, and cooling zones. The feed enters the preheat zone where it is heated and mixed, vaporizing water, volatile organics, and some semivolatile organics. The solids then enter the retort zone where they are further heated, causing vaporization of heavy oils and some thermal cracking of hydrocarbons, resulting in the formation of coked solids and decontaminated solids. The solids from the retort zone then enter the combustion zone where coked solids are combusted. A portion of the decontaminated solids are recycled to the retort zone via a recycle channel. The recycling of these solids helps to maintain an elevated temperature in the retort zone. The decontaminated solids remaining in the combustion zone enter the cooling zone where they are cooled to an appropriate exit temperature. [5]

The vapor recovery system consists of two parallel systems. One system condenses water and vapors from the preheat zone of the ATP unit and consists of a cyclone, a condenser, and a gas-oil-water separator. The other system condenses water and vapors from the retort zone and consists of two cyclones, a scrubber, a fractionator, a condenser, and a gas-oil-water separator. Oil from the vapor recovery system containing PCBs is discharged to a storage tank for off-site disposal. During the full-scale treatment of 12,755 tons of soil and sediment at OMC, approximately 50,000 gallons of oil containing PCBs were collected and disposed off site. [5]

Condensed water from the vapor recovery system was treated in an on-site wastewater

TREATMENT SYSTEM DESCRIPTION (CONT.)

SoilTech ATP Thermal Desorption Technology Description and Operation (cont.)

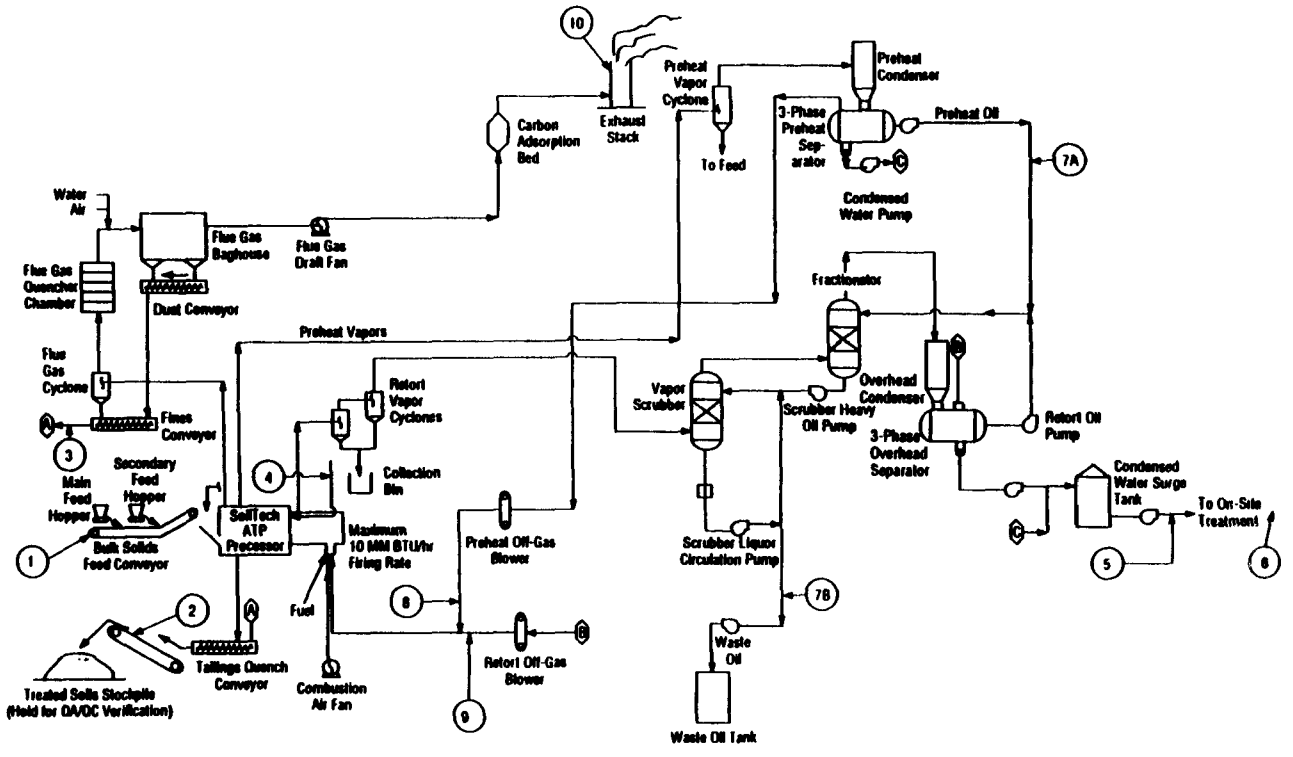

Figure 3. ATP Schematic [1]

treatment system, which consisted of the following treatment processes:

- Sand filtration;
- Klensorb® filtration;
- Ultraviolet oxidation;
- Cartridge filtration; and
- Carbon adsorption.

The wastewater from this system was discharged to a sanitary sewer. [11, 12]

Effluent testing following mobilization of the ATP unit to the site identified the presence of phenols, acetone, and other breakdown products. The wastewater system was modified to reduce phenol and acetone to levels acceptable for discharge to the sanitary sewer. [3]

The flue gas treatment system consists of a cyclone with fines conveyor, flue gas quencher chamber, baghouse with dust conveyor, acid gas scrubber, and activated carbon unit. This system removes particulates and trace hydrocarbons from the flue gas exiting the combustion zone of the ATP. Fines from the baghouse and cyclone are mixed with the treated solids exiting the ATP unit. The treated flue gas is released to the atmosphere. [5]

During the proof-of-process period (January 22, 1992 to March 5, 1992), the ATP system did not meet the stack gas emission requirement of 99.9999 percent DRE for PCBs. The ATP system was shut down on March 5, 1992 and the following modifications were made to the flue gas treatment system:

- The carbon bed depth in the stack was increased to 24 inches;
- The scrubber was converted to an adsorption unit by adding two new carbon beds to the scrubber; and
- Activated carbon beds were installed in the vapor return lines for the preheat and retort zones.

TREATMENT SYSTEM DESCRIPTION (CONT.)

SoilTech ATP Thermal Desorption Technology Description and Operation (cont.)

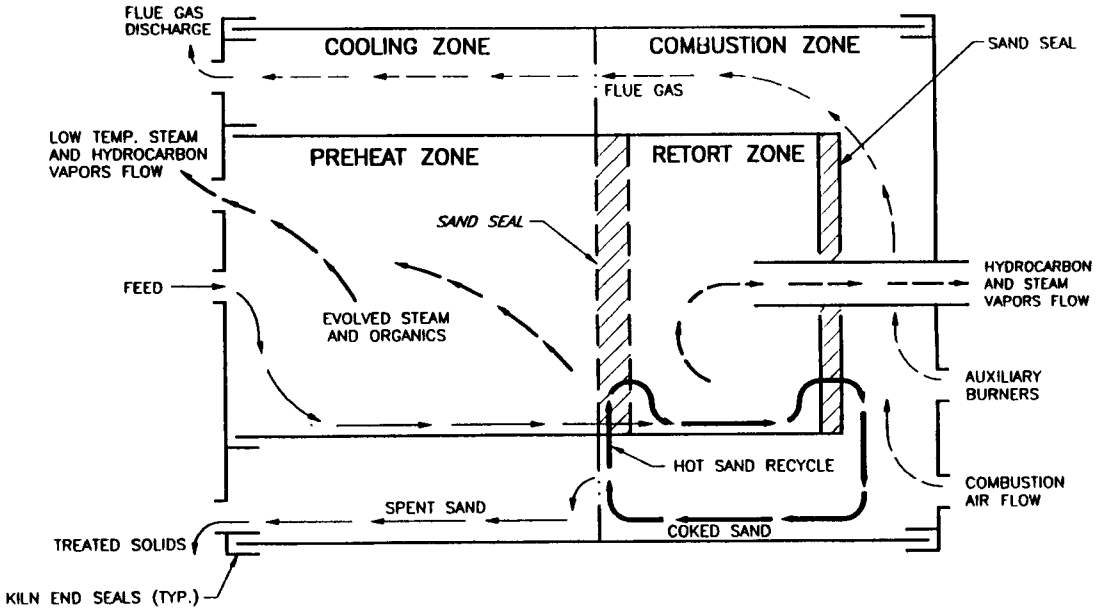

Figure 4. Simplified Sectional Diagram Showing the Four Internal Zones [5]

In early May, SoilTech discovered a gap in the flue gas carbon bed seal, which allowed an estimated 70% of the flue gas stream to bypass the carbon bed. This problem was corrected prior to the stack gas testing on May 12. The PCB DRE of 99.9999% was achieved during the remainder of this application. [12]

The tailings (treated solids) handling system was used to cool and remove treated solids from the ATP. The treated solids exiting the ATP were quenched with process and scrubber water and transported to storage piles using belt and screw conveyors. [5]

The primary innovative features of the ATP unit are the four internal zones and the use of proprietary sand seals at each end of the retort zone which are designed to maintain an oxygen-free environment in the retort zone. The oxygen-free environment in the retort zone helps to prevent the oxidation of hydrocarbons and coke. [5]

A SITE Demonstration was conducted at the OMC site in June 1992. The purpose of the SITE demonstration was to obtain information on the performance and cost of the technology and to assess its effectiveness at the OMC site. During the three test runs of the demonstration, 255 tons of soil and sediment were treated. [1]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Operating Parameters Affecting Treatment Cost or Performance [5,12]

The major operating parameters affecting cost or performance for this technology and the values measured for each during this treatment application are presented in Table 2.

The average preheat and retort zone off-gas flow rates measured during the SITE Demonstration were 211 and 88 actual cubic feed per minute (acfm), respectively. The average stack gas flow rate during the SITE Demonstration was 6,580 standard cubic feet per minute (scfm).

Table 2. Operating Parameters [5, 12]*

Parameter	Value	Measurement Method
Operating Pressure	Negative pressure	Pressure to electrical transducer
Preheat and Retort Zone Residence Time	30 to 40 minutes	Engineering design calculations
Preheat Zone Temperature	851°F	Thermocouples in preheat zone
Retort Zone Temperature	1,207°F	Thermocouples in retort zone
Combustion Zone Temperature	1,339°F	Thermocouples in combustion zone
Cooling Zone Temperature	764°F	Thermocouples on cooling zone
System Throughput	8.31 tons per hour	Weight of treated solids measured using a truck scale

**The values presented in the table above are the average results for the three test runs of the SITE Demonstration conducted in June 1992. They are based on the operating conditions used for treating 255 of the 12,755 tons of soil and sediment at OMC. [5, 12]*

Timeline

The timeline for this application is presented in Table 3.

Table 3. Timeline [1, 2, 4, 5, 9, 10, 11, and 12]

Start Date	End Date	Activity
1961	1972	OMC used hydraulic fluid that contained PCBs in its manufacturing operations.
May 15, 1984	—	ROD signed.
March 31, 1989	—	Consent Decree signed and ROD amended requiring on-site treatment rather than off-site disposal of contaminated soil and sediment.
1989	—	Site construction activities initiated, including stockpiling of soil and sediment for treatment.
November 1991	January 1992	SoilTech ATP system assembled and shakedown of system conducted
January 22, 1992	February 24, 1992	Contaminated soil and sediment treated using the ATP system (30-day proof-of-process period).
February 24, 1992	February 29, 1992	ATP system shutdown for maintenance.
March 1, 1992	March 5, 1992	System restarted but shut down 5 days later by EPA due to nonattainment of stack gas emission standards.
March 5, 1992	March 17, 1992	ATP system modified.
March 17, 1992	March 18, 1992	Stack gas testing conducted.
March 19, 1992	April 9, 1992	ATP system modified.
April 8, 1992	April 16, 1992	Stack gas testing conducted.
April 17, 1992	May 12, 1992	ATP system modified.
May 12, 1992	May 14, 1992	Stack gas testing conducted. Emissions standards met.
May 30, 1992	June 15, 1992	ATP system restarted and operated continuously.
June 16, 1992	June 19, 1992	SITE Demonstration conducted.
June 20, 1992	June 23, 1992	Treatment of soil and sediment using the ATP system completed.

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Requirements [4, 5, and 12]

The 1989 ROD specified a cleanup goal for PCBs in soil and sediment of 97 percent removal by mass. Stack gas emission requirements were specified in the Consent Decree for PCBs (99.9999 percent destruction and removal efficiency (DRE) for PCBs). A stack gas emission requirement for dioxins and furans of 30 nanograms per dry standard cubic meter (ng/dscm) was also specified by EPA.

Additional Information on Goals [5, 9, 10, 11, and 12]

The 1989 ROD stated that sediment from Slip No. 3 and Waukegan Harbor with PCB concentrations exceeding 500 ppm and soil and sediment from the Crescent Ditch and Oval Lagoon areas with PCB concentrations exceeding 10,000 ppm required on-site treatment.

Treatment Performance Data [9, 10, 11, and 12]

Table 4 summarizes the analytical results for PCBs in untreated soil/sediment and treated soil/sediment during the treatment application at OMC. Appendix B contains PCB analytical results for each day samples were collected.

Table 5 shows stack gas results for the PCB DRE and total dioxin and furan concentration during the proof-of-process and modifications period (samples collected from 1-28-92 to 4-10-92). Table 6 shows stack gas results for the PCB DRE and total dioxin and furan concentration after the process modifications were completed (samples collected from 5/12/92 to 6/16/92). Appendix B contains the results for each stack gas test conducted at OMC.

Table 4. PCB Analytical Results [9, 10, 11]

	Range	Average	Number of Data Points
Untreated Soil/Sediment	2,400 to 23,000 mg/kg	10,484 mg/kg	75
Treated Soil/Sediment	0.4 to 8.9 mg/kg	2.2 mg/kg	75
PCB Removal Efficiency	99.91 to >99.99%	99.98%	N/A

N/A - Not applicable.

Table 5. Stack Gas Results During Proof-of-Process Period (Samples taken between 1/28/92 and 4/10/92) [10,11]

	Range	Number of Data Points
PCB DRE	99.568 to 99.99968%	10
Total Dioxin/Furan Concentration	19.66 to 1,037 ng/dscm at 7% O_2	10

Table 6. Stack Gas Results After Process Modifications Completed (Samples taken between 5/12/92 and 6/16/92) [10,11]

	Range	Number of Data Points
PCB DRE	99.99991 to 99.99999%	8
Total Dioxin/Furan Concentration	NA	0

NA - Not analyzed.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data [9,10,11,12] (cont.)

During the SITE Demonstration conducted at the OMC site in June 1992, stack gas emissions were analyzed for individual dioxins and furans during three test runs. The results, shown in Table 7, indicate that only TCDF was present at detectable levels. [5]

The PCB results for untreated soil/sediment and treated soil/sediment presented in Table 4 are for composite samples collected each day the system was operated. Soil/sediment and stack gas samples were analyzed for PCBs using EPA Method 8080. Stack gas samples were analyzed for dioxins and furans using EPA Method 8280. [5, 9, 10, 11, 12, and 13]

Table 7. Dioxin and Furan Stack Gas Emissions Measured During the SITE Demonstration [5]

Compound	Average Dioxin and Furan Concentrations in Stack Gas Emissions (ng/dscm)
Tetrachlorinated dibenzo-p-dioxins (TCDD)	<0.029
Tetrachlorinated dibenzofurans (TCDF)	0.0787
Pentachlorinated dibenzofurans (PeCDF)	<0.022
Hexachlorinated dibenzofurans (HxCDF)	<0.018
TOTAL	0.0787[a]

[a] *Total stack gas concentration of 0.0787 ng/dscm is equivalent to a 2,3,7,8-TCDD concentration of zero.*

Performance Data Assessment

As shown in Table 4 and Appendix B, the SoilTech ATP system achieved the cleanup goal of 97% removal by mass of PCBs in soil and sediment, achieving an average PCB removal efficiency of 99.98%. Treated soil PCB concentrations ranged from 0.4 to 8.9 mg/kg. The PCB DRE requirement was achieved for stack gas emissions after the process modifications described above were made in early May 1992.

As shown in Table 5 and Appendix B, the concentration of total dioxins and furans in the stack gas was less than the stack gas emission requirement of 30 nanograms per dry standard cubic meter (ng/dscm) in 3 of the 10 stack gas tests conducted prior to completing the process modifications described above. The concentrations of total dioxins and furans measured near the conclusion of the modifications period (4/10/92) was 24.7 ng/dscm. Total dioxins and furans were not analyzed in subsequent stack gas tests. The concentration of total dioxins and furans in the stack gas during the three test runs conducted during the SITE Demonstration on June 16, 1992 was 0.0787 ng/dscm.

Performance Data Completeness

Paired untreated and treated soil and sediment concentrations were obtained for each day of operation of the ATP system at the OMC site. Daily values for operating parameters, however, are not available.

Performance Data Quality

EPA SW-846 methods were used for analysis of the soil samples and stack gas emissions in this application. No exceptions to the QA/QC requirements were noted in the available reference.

TREATMENT SYSTEM COST

Procurement Process

The potentially responsible parties (PRPs) for this site selected Canonie Environmental Services to provide the engineering design and construction services for the OMC/Waukegan Harbor project through a competitive procurement procedure. Canoine subcontracted SoilTech ATP Systems, Inc. to treat the PCB-contaminated soil/sediment using the SoilTech ATP system.

Treatment System Cost

SoilTech was contracted to remediate the soils and sediments at OMC for $700,000 in fixed costs and $185 per ton of material processed. These costs did not include utilities, site preparation, excavation of contaminated soil, or disposal of PCB condensate produced. [14]

Tables 8 and 9 present the actual costs for the thermal desorption application at OMC. In order to standardize reporting of costs across projects, costs are shown in Tables 8 and 9 according to the format for an interagency Work Breakdown Structure (WBS). The WBS specifies 9 before-treatment cost elements, 5 after-treatment cost elements, and 12 cost elements that provide a detailed breakdown of costs directly associated with treatment. Tables 8 and 9 present the cost elements exactly as they appear in the WBS, along with the specific activities, as provided by EPA in the Draft Applications Analysis Report.

In preparing the Applications Analysis Report, EPA obtained actual cost data from SoilTech for treating 12,755 tons of soil at OMC. [5]

The cost data in Table 8 show a total of $2,474,000 for cost elements directly associated with treatment of 12,755 tons of soil (i.e., excluding before and after treatment cost elements). This total treatment cost corresponds to $190 per ton of soil treated. In addition, Table 9 shows a total of $900,000 for before-treatment costs. There were no costs in this application for the following elements in the WBS: Liquid Preparation and Handling, Vapor/Gas Preparation and Handling, Pads/Foundations/Spill Control, Training, Operation (Long Term - Over 3 Years), Dismantling, Site Work, Surface Water Collection and Control, Air Pollution/Gas Collection and Control, Solids Collection and Containment, Liquids/Sediments/Sludges Collection and Containment, Drums/Tanks/Structures/ Miscellaneous Demolition and Removal, Decontamination and Decommissioning, Disposal (Other than Commercial), Disposal (Commercial), Site Restoration, and Demobilization.

Table 8. Costs Directly Associated with Treatment [5]

Cost Elements	Cost (dollars)
Solids Preparation and Handling	
- residuals and waste handling and transporting	186,000
Startup/Testing/Permits	
- permitting and regulatory	188,000
- startup	158,000
Operation (Short Term - Up to 3 years)	
- labor	854,000
- supplies and consumables	139,000
- utilities	65,000
- equipment repair and replacement	133,000
Cost of Ownership	
- capital equipment	361,000
Demobilization	390,000
TOTAL DIRECT TREATMENT COSTS	**2,474,000**

TREATMENT SYSTEM COST (CONT.)

Treatment System Cost (cont.)

Table 9. Before-Treatment Cost Elements [5]

Cost Elements	Costs (dollars)
Mobilization and Preparatory Work - transport of ATP unit to site - initial setup - installing fence around location for ATP unit	655,000
Monitoring, Sampling, Testing and Analysis - effluent monitoring - analytical services	207,000 38,000
TOTAL BEFORE TREATMENT COSTS	900,000

Cost Data Quality

Treatment cost information shown in Table 8 represents actual costs for this application, and include costs for seven specific elements in the WBS.

Vendor Input

According to the treatment vendor, in general, the costs for treatment using the SoilTech ATP system vary depending on the character of the waste material, with treatment costs ranging from $150 to $250 per ton for a 10-ton per hour ATP System. The factors identified by the vendor that affect costs include:

- Moisture content of feed material;
- Particle size;
- Hydrocarbon content;
- Material handling characteristics; and
- Chemical characteristics.

Vendor estimates for mobilization and demobilization costs for a 10-ton per hour system range from $700,000 to $1.5 million. [12]

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- The actual cost for activities directly related to treatment was $2,474,000 which corresponds to $190 per ton of soil treated.
- A total of $900,000 was expended in this application for before-treatment activities, including mobilization and preparatory work and monitoring, sampling, testing, and analysis.

Performance Observations and Lessons Learned

- The ATP system achieved an average mass removal efficiency of 99.98 percent for PCBs during the full-scale cleanup; this was much higher than the PCB soil/sediment cleanup goal of 97 percent removal. Treated soil PCB concentrations ranged from 0.4 to 8.9 mg/kg.
- The PCB DRE and total dioxin and furan stack gas emission requirements of 99.9999% DRE and 30 ng/dscm, respectively, were met after making several modifications to the flue gas treatment system.
- The majority of PCBs accumulated in the vapor scrubber oils. Approximately 50,000 gallons of oil were generated during full-scale cleanup and were disposed off site.

OBSERVATIONS AND LESSONS LEARNED (CONT.)

Other Observations and Lessons Learned

- Bench-scale treatability study results were an accurate predictor of full-scale PCB removal and indicated that a thermal treatment system removed more than 99% of a PCB congener from the soil/sediment at OMC.
- Pilot study testing of effluent was limited to PCBs and total suspended solids (TSS). Discharged water was subject to a limit of 1 part-per-billion (ppb) for PCBs. Effluent testing following mobilization of the ATP unit to the site identified the presence of contaminants including phenols and acetone. The wastewater system was modified to reduce phenol and acetone levels to acceptable levels for discharge to a POTW. PCB levels were less than the 1 ppb limit.

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Analysis Preparation

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APPENDIX A—TREATABILITY STUDY RESULTS

Treatability Study Objectives [6]

- Determine the effectiveness of a thermal treatment system for treating different matrices containing polychlorinated biphenyls (PCBs) at the Outboard Marine Corporation (OMC) Superfund Site.
- Assess the affect of varying process operating conditions, including residence time and type of feed material, on the treatment effectiveness and concentration of PCBs in the treatment residuals.
- Determine if PCBs break down during the treatment process.
- Determine if the char and ash residuals contain dioxins.
- Obtain data needed to evaluate the operation of a thermal treatment system to be used for a full-scale remediation of the OMC site.

Treatability Study Test Description

System Description: The bench-scale system, shown in Figure A-1, consisted of a 12-inch by 12-inch rotary kiln, a hot vapor condenser, a condensed liquid collector, a gas filter, a gas compressor, and a gas sample bomb. Material was fed into the kiln through a 4-inch port, and treated solids were withdrawn through the same port. Vapors from the kiln were condensed and collected. Condensed vapors were separated into water, oil, and sludge subfractions. Non-condensible gasses were filtered, measured, and collected. Treatment residuals included treated solids (char and ash), water, oil, and gasses.

Feed Material: The PCB-contaminated material (feed material) used in the treatability study included organic silt (muck) and sand that were collected from a soil boring at the site (the Crescent Ditch area near a former outfall). The muck was an oily sediment, containing leaves and other decomposing material, with a high water content. The sand was fine, of uniform size, with a high water content. The sand was used as the feed material for Run No. 2; the muck was used at the feed material for Run No. 1; and muck mixed with clean sand was used as the feed

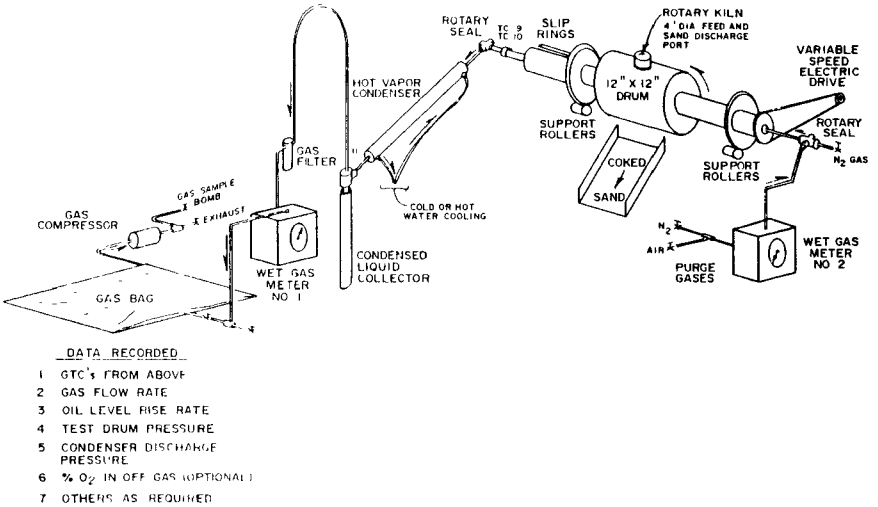

Figure A-1 - Bench-Scale Treatability Test System [6]

Note: Not to scale.

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Test Description (cont.)

material for Run Nos. 3 and 4, as described below.

Test Runs: The study consisted of four test runs. For each run (batch) treated, two residual fractions of volatilized liquids were collected; one fraction (referred to as the retort water) was collected at a kiln temperature of approximately 375-500°F; the second fraction (referred to as the retort oil) was collected at a kiln temperature of approximately 650-1,116°F. These fractions were subdivided for chemical analysis into oil, water, and sludge subfractions. The test runs were conducted under the following conditions, as summarized in Table A-1.

- Run No. 1: The feed consisted of Crescent Ditch muck. The rotary kiln was preheated to 300°F and the temperature in the kiln was increased stepwise to a maximum kiln temperature of 1,116°F. The total residence time for the run was 117 minutes.
- Run No. 2: The feed consisted of Crescent Ditch sand. For this run, the rotary kiln was not preheated. Upon addition of the sand, the temperature was increased stepwise to a maximum kiln temperature of 1,085°F. The total residence time for the run was 118 minutes.
- Run No. 3: The test conditions for Run No. 3 were the same as used in Run No. 1 except the feed consisted of a mixture of clean sand and Crescent Ditch muck at a ratio of 2.2:1 of sand:muck. In this run, the rotary kiln was not preheated, the maximum kiln temperature was 1,088°F, and the residence time was increased to 171 minutes.
- Run No. 4: The test conditions for Run No. 4 were the same as for Run No. 3 except the maximum kiln temperature was 1,059°F, and the residence time was 90 minutes.

Table A-1. Test Conditions [6]

Parameter	Run No. 1	Run No. 2	Run No. 3	Run No. 4
Feed Material	Muck	Sand	Muck and Clean Sand	Muck and Clean Sand
Mass of Feed Material (grams)	1,212.9	3,711.7	3,490.1	827.8
Rotational Speed of Kiln (rpm)	3.5	3.5	3.5	3.5
Maximum Temperature of Heating Chamber (°F)	1,116	1,085	1,088	1,059
Residence Time (min)	117	118	171	90

Treatability Study Performance Data and Analysis

Treatment Performance Data: Feed materials and solid and liquid residuals were collected and analyzed for PCB 1242 (gaseous residuals were not analyzed). Table A-2 shows the concentration of PCB 1242 in the untreated feed materials and treated solids, and the calculated percent removal, for the four test runs. PCB 1242 was analyzed for in the feed material for Run Nos. 1 and 2 only (feed materials were analyzed twice for PCB 1242 in these runs), and the treated solids from Run Nos. 1, 2, and 3 only; the reason for not analyzing untreated feed from Run Nos. 3 and 4, or treated solids from Run No. 4, is not available at this time.

Table A-3 shows the concentrations of PCB 1242 in the liquid residuals (oil, water, and sludge), and the volume of liquid residuals, for the first two test runs. Data for liquid residuals from the latter two test runs are not available at this time.

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Performance Data and Analysis (cont.)

Table A-2. Treatment Performance Data [6]

Run No.	Untreated Feed		Treated Solids	Percent Removal (%)
	Analysis 1	Analysis 2		
1	61,335	16,866	ND (0.1)	>99
2	26,437	28,900	ND (0.1)	>99
3	NA	—	ND (0.1)	NA
4	NA	—	NA	NA

ND = Not detected. Number in parentheses is the reported detection limit.
NA = Not available.

Table A-3. Liquid Residuals Analytical Data and Volume Measured [6]

Fraction	Run No.1		Run No. 2	
	PCB 1242 Concentration (mg/L)	Fraction Volume (mL)	PCB 1242 Concentration (mg/L)	Fraction Volumes (mL)
Retort Water				
Oil	50,877	4	68,861	24
Water	70	602.9	114	502.4
Sludge	5,492	8.1	10,223	trace
Retort Oil				
Oil	235,308	86.3	959,170	49.3
Water	16	44.3	12	32.1

The char and ash from Run No. 1 were analyzed for 2,3,7,8-tetrachlorodibenzo-p-dioxin. The concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin in the char and ash products from Run No. 1 was less than the reported detection limit of 0.3 ng/g.

Performance Data Assessment: The performance data comparing PCB concentrations in untreated feed and treated solids (Table 2) shows that the thermal treatment system removed more than 99% of PCB 1242 and achieved a concentration in the treated solids of less than the analytical detection limit (0.1 mg/kg) for both muck and sand feed materials.

Varying feed material (muck and sand) did not appear to affect the treatment performance achieved by the thermal desorption system, but did affect the concentration of PCB 1242 in the liquid residuals. Treatment of sand generated higher concentrations of PCB 1242 in the retort water and oil than treatment of muck. Insufficient data were collected to determine whether residence time affected treatment effectiveness or concentration of PCBs in the treatment residuals. Insufficient data were collected to assess the effectiveness of treating mixtures of muck and clean sand.

To determine if PCBs break down during the treatment process, the mass of PCB 1242 fed to the treatment system was compared with the mass of PCB 1242 exiting the system. This calculation, shown below in Table A-4, provides inconclusive information concerning the potential breakdown of PCBs.

Table A-4 shows that the mass of PCB 1242 entering and exiting the system compared well for Run No. 1 (20.5 gm entering and 20.6 gm exiting), and not as well for Run No. 2 (107.3 gm entering and 49.1 gm exiting). Although different materials were fed to the system in the two runs (muck and sand), which may account for the variation in results, it seems more likely that the variation in results is due to uncertainties concerning analytical accuracy, potential losses of PCBs in gas streams or as coatings on collection lines or because of lack of homogeneity in samples of feed material. Dilutions of up to 30,000 to 1 were used to quantitate the PCB concentrations in feed materials and treatment residu-

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Performance Data and Analysis (cont.)

*Table A-4. Calculated Mass of PCB 1242 in Run Nos. 1 and 2**

	Quantity of Material	PCB 1242 Concentration	Mass of PCB 1242 (gm)
Run No. 1			
Feed Material	1,212.9 gm	16,866 mg/kg	20.5
Retort Water			
Oil	4 mL	50,877 mg/L	0.2
Water	602.9 mL	70 mg/L	0.04
Sludge	8.1 mL	5,492 mg/L	0.04
Retort Oil			
Oil	86.3 mL	235,308 mg/L	20.3
Water	44.3 mL	16 mg/L	0.0007
Run No. 2			
Feed Material	3,711.7 gm	28,900 mg/kg	107.3
Retort Water			
Oil	24 mL	68,861 mg/L	1.7
Water	502.4 mL	114 mg/L	0.06
Sludge	trace	10,223 mg/L	—
Retort Oil			
Oil	49.3 mL	959,170 mg/L	47.3
Water	32.1 mL	12 mg/L	0.0004

**Treated solids are not shown on this table because PCB 1242 was not detected in this residual.*

als. Dilutions of this magnitude tend to limit the accuracy of analytical results; the treatment vendor indicated that additional laboratory work was required to improve the accuracy of the results.

Limited data were collected to determine if dioxins appear in the treatment residuals. The one sample of char and ash analyzed for dioxins showed that the concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin was less than the reported detection limit of 0.3 ng/gm.

Limited data needed to evaluate the operation of a thermal treatment system to be used for a full-scale remediation of the OMC site were obtained during this treatability study. Treatment performance data were obtained on the affect of varying feed materials, but not on the affect of varying kiln temperature or residence time. Additional data on concentrations of PCBs in liquid residuals collected at varying temperatures were also obtained during this study.

Performance Data Completeness: Data are available to perform a limited material balance on PCB 1242 concentrations during two test runs of this study, including data on untreated feed materials, treated solids, and liquid residuals. No data are available on off-gasses from the system. Information linking treatment performance with key operating parameters (temperature, residence time) are also available for this study.

Performance Data Quality: Several items concerning limitations on analytical data quality were identified during this study, including dilution and lack of homogeneity of samples. Samples were required to be diluted up to 30,000 to one prior to chemical analysis for PCB 1242. Such dilutions (over 4 orders of magnitude) tend to limit the accuracy of analytical results. Multi-phase samples (e.g., feed materials) were mixed prior to chemical analysis. Mixing may not have produced a completely homogeneous sample for analysis.

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Observations and Lessons Learned

Performance Observations and Lessons Learned

- Treatment performance data indicated that the thermal treatment system removed more than 99% of PCB 1242, and achieved a concentration in the treated solids of less than the analytical detection limit (0.1 mg/kg) for both muck and sand feed materials.
- Preliminary results were inconclusive in showing whether PCBs break down during treatment.
- The char and ash residuals did not contain detectable levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin.

Other Observations and Lessons Learned

- The water and oil residuals produced during treatment contained PCBs, and the oil contained the highest concentrations of PCBs.
- Analytical limitations regarding sampling dilution and lack of homogeneity limited the usefulness of this study.
- Because mixed clean sand/contaminated media feed materials were not tested in this study, information useful for scale-up under these conditions was not obtained during this study.

APPENDIX B—ANALYTICAL RESULTS

PCB Analytical Results Untreated and Treated Soil/Sediment [10, 11]

Sample Date	Untreated Soil/Sediment Concentration(a) (mg/kg)	Treated Soil/Sediment Concentration(a) (mg/kg)	PCB Removal Efficiency (%)
01/22/92	11,000	2 2	99.98
01/23/93	23,000	2.2	99.99
01/24/92	15,000	4.5	99 97
01/25/92	13,000	5.9	99.95
01/26/92	8,500	7.4	99.91
01/27/92	9,600	8 9	99.91
01/28/92	9,600	1.2	99 99
01/29/92	2,400	1.5	99.94
01/30/92	9,600	3.9	99.96
01/31/92	12,000	5.9	99.95
02/01/92	13,000	3.7	99.97
02/02/92	8,600	1.6	99.98
02/03/92	14,000	3.5	99.98
02/04/92	15,000	2.1	99.99
02/05/92	10,000	2.5	99 98
02/06/92	12,000	1.5	99.99
02/07/92	12,000	1 5	99 99
02/08/92	10,000	2	99.98
02/09/92	12,000	1.8	99.99
02/10/92	14,000	1 2	99.99
02/11/92	14,000	2.3	99.98
02/12/92	12,000	3.9	99.97
02/13/92	13,000	2.4	99.98
02/14/92	14,000	2.9	99.98
02/15/92	13,000	3.8	99.97
02/16/92	11,000	2.1	99.98
02/17/92	9,200	4.1	99.96
02/18/92	9,000	1.4	99.98
02/19/92	9,500	1.5	99.98
02/20/92	10,000	2.5	99.98
02/21/92	11,000	2.2	99.98
02/22/92	7,300	1.3	99.98
02/23/92	6,900	1.8	99.97
02/24/92	7,300	1.6	99.98
02/29/92	7,500	0.99	99.99
03/01/92	7,900	0.86	99.99
03/02/92	6,400	0.43	99.99
03/03/92	8,100	0.51	99.99
03/04/92	6,600	0.61	99.99
03/05/92	6,300	0.53	99.99
03/17/92	9,900	1.4	99.99
03/18/92	10,000	3.8	99.96

APPENDIX B—ANALYTICAL RESULTS (CONT.)

PCB Analytical Results Untreated and Treated Soil/Sediment (continued)

Sample Date	Untreated Soil/Sediment Concentration(a) (mg/kg)	Treated Soil/Sediment Concentration(a) (mg/kg)	PCB Removal Efficiency (%)
04/08/92	9,200	1.5	99.98
04/09/92	8,600	1	99.99
04/10/92	9,000	1.1	99.99
04/12/92	8,700	1.4	99.98
04/13/92	11,000	0 93	99.99
04/14/92	14,000	2.3	99.98
04/15/92	14,000	1.3	99.99
04/16/92	21,000	1.2	99.99
05/12/92	5,400	0.95	99.98
05/13/92	10,000	2	99.98
05/14/92	11,000	1.2	99.99
05/30/92	12,000	0.69	99.99
05/31/92	9,200	0.57	99.99
06/01/92	12,000	0.72	99.99
06/02/92	12,000	1.3	99 99
06/03/92	10,000	0.82	99.99
06/04/92	9,200	0 4	99.99
06/05/92	11,000	0.43	99.99
06/06/92	10,000	7.1	99 93
06/07/92	9,400	3.1	99.97
06/08/92	8,000	1.3	99 98
06/09/92	8,900	1.1	99.99
06/10/92	11,000	1.8	99.98
06/11/92	9,700	0.61	99.99
06/12/92	9,700	1.4	99.99
06/15/92	10,000	1.6	99.98
06/16/92	10,000	0.71	99 99
06/17/92	8,600	1	99.99
06/18/92	10,000	1.7	99.98
06/19/92	11,000	0 75	99.99
06/20/92	9,900	2.6	99.97
06/21/92	9,800	4.8	99.95
06/22/92	8,800	5	99.94

(a)Untreated and treated soil/sediment concentrations are based on composites generated from 8:00 AM on the corresponding date to 8:00 AM the next morning.

Stack Gas Test Results [11]

Stack Gas Test Date	PCB DRE (%)	Total Dioxin/Furan Concentration (ng/dscm at 7% O_2)
01/28/92	99.9925	1,037.00
02/04/92	99.9568	19.66
02/10/92	99.9708	661.60
02/18/92	99.9944	289.80
03/04/92	99.9962	109.40
03/05/92	99.9985	71.43
03/05/92	99.9992	31.84
03/17/92	99.99944	13.74
04/09/92	99.99768	77.8
04/10/92	99.99968	24.7
05/12/92	99.99991	NA
05/13/92	99.99997	NA
05/13/92	99.99997	NA
05/14/92	99.99998	NA
06/02/92	99.99994	NA
06/02/92	99.99991	NA
06/09/92	99.99997	NA
06/16/92	99.99999	NA

NA = Not Analyzed.

In Situ Vitrification at the Parsons Chemical/ETM Enterprises Superfund Site Grand Ledge, Michigan (Interim Report)

Case Study Abstract

In Situ Vitrification at the Parsons Chemical/ETM Enterprises Superfund Site, Grand Ledge, Michigan

Site Name:
Parsons Chemical/ETM Enterprises Superfund Site

Location:
Grand Ledge, Michigan

Contaminants:
Pesticides, Heavy Metals, Phthalates, Polynuclear Aromatic Hydrocarbons (PAHs), and Dioxins
- Pesticides - up to 340 mg/kg for DDT
- Heavy metals - up to 34 mg/kg for mercury
- Dioxin - up to 1.13 µg/kg

Period of Operation:
May 1993 to May 1994

Cleanup Type:
Full-scale cleanup (interim results)

Vendor:
James E. Hanson
Geosafe Corporation
2950 George Washington Way
Richland, WA 99352
(509) 375-0710

Technology:
In Situ Vitrification
- 9 melt cells; each cell 26 feet by 26 feet with cells installed in a 16-foot deep treatment trench
- Air emissions control system - offgas collection, hood, water scrubber, and thermal oxidizer

Cleanup Authority:
CERCLA (Removal Action) and State: Michigan
- Action Memo Date: 9/21/90
- Fund Lead

SIC Code:
2879 (Agricultural Chemicals, Not Elsewhere Classified)

Point of Contact:
Len Zintak, OSC
U.S. EPA Region 5
77 West Jackson Boulevard
Chicago, IL 60604
(312) 886-4246

Waste Source:
Other: Discharge to sewer/surface water (floor drains, septic tank, leach field)

Type/Quantity of Media Treated:
Soil
- 3,000 cubic yards
- Silty clay with high moisture content
- Soil reported to be difficult to work with under very wet and very dry conditions

Purpose/Significance of Application:
First application of full-scale in situ vitrification at a Superfund site to treat soils and sediments contaminated with pesticides, heavy metals, and dioxins.

Regulatory Requirements/Cleanup Goals:
- Soil cleanup standards and standards for offgases established for four constituents. Soil cleanup/offgas standards were - chlordane (1 mg/kg / 25 lbs/hr); DDT (4 mg/kg / 0.01 lbs/hr); dieldrin (0.08 mg/kg / 0.00028 lbs/hr); mercury (12 mg/kg / 0.00059 lbs/hr)
- Offgas standards based on State ARARs

Results:
- Specific performance data for soils were not available at the time of this report
- According to the vendor, near-surface vitrified materials had "acceptable" levels of pesticides and mercury
- Additional samples will not be taken until after the melt has cooled (estimated May 1995)
- Data on air emissions indicates offgases met the state air emissions standards

Cost Factors:
- Cost objectives were $800,000 for vitrification activities; approximately $800,000 for before-treatment activities (mobilization, site administration and preparation, sampling and analysis, and site configuration); and $90,000 for after-treatment activities (backfill and restoration, drainage structures, and demobilization)

In Situ Vitrification at the Parsons Chemical/ETM Enterprises Superfund Site, Grand Ledge, Michigan (Continued)

Description:
A full-scale soil remediation system using in situ vitrification (ISV) was conducted at the Parsons Chemical/ETM Enterprises Superfund site (Parsons). Soils and sediments at the site were contaminated with pesticides, heavy metals, phthalates, PAHs, and dioxins as a result of former agricultural chemical manufacturing processes. Dioxin levels in soil at the site were reported as high as 1.13 µg/kg. Maximum levels of other contaminants in the soil range from 0.99 mg/kg for phenanthrene to 340 mg/kg for DDT. Soil cleanup requirements were established for four constituents (chlordane, DDT, dieldrin, and mercury). In addition, the offgases from the ISV unit were required to meet state air requirements for these constituents during operation.

The ISV system used at Parsons included 9 melt cells and an air emissions control system. Contaminated soil was excavated and staged at the site due to the shallow nature of the contamination. The melt cells were installed in a treatment trench. Eight melts were completed from June 1993 to May 1994. The melts ranged in duration from 10 to 19.5 days and consumed between 559,000 and 1,100,000 kilowatt-hours of electricity per melt. Several operational problems were encountered during this period including fires and equipment problems. These problems were addressed through modifications to equipment and operating practices.

Because the melt requires approximately one year to cool before samples of the subsurface can be collected, data on the performance of the ISV will not be available until after May 1995. According to the vendor, initial results of samples taken from the surface indicate that near-surface vitrified materials contained acceptable levels of pesticides and mercury. Data on typical air emissions indicates that stack gas emissions were in compliance with state standards during operation. The cost ceiling identified in the action memorandum for this application was $1,763,000.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report presents cost and performance data for an in situ vitrification (ISV) treatment application at the Parsons Chemical/ETM Enterprises Superfund Site (Parsons) in Grand Ledge, Michigan. The Parsons site is a former agricultural chemicals mixing, manufacturing, and packaging facility. Soils and sediments at the Parsons site were contaminated with pesticides, heavy metals, and dioxins.

ISV treatment of approximately 3,000 yds^3 of contaminated soils and sediments at the Parsons site, consisting of eight melts, was completed from May 1993 to May 1994; this was notable for being the first full-scale application of ISV treatment at a Superfund site.

The melts are expected to cool by May 1995, at which time additional samples of vitrified soils are planned to be collected. Preliminary results for surface soil samples and stack gas emissions measured during the SITE Demonstration, and results for typical stack gas emissions provided by the vendor, met the soil cleanup standards and off-gas State ARARs for this application. The stack gas emissions for chlordane and 4,4'-DDT were several orders of magnitude lower than the ARARs. A volume reduction of approximately 30% for the test soil was achieved in this application, based on the results from analyses of soil dry density.

The cleanup contractor's cost ceiling for the ISV treatment application at Parson's was $1,763,000, including $800,000 for vitrification, which corresponds to $270 in costs for vitrification per cubic yard of soil treated. The estimated before-treatment costs for this application of $800,000 were high because of the need to excavate and stage the wastes prior to treatment.

SITE IDENTIFYING INFORMATION

Identifying Information:

Parsons Chemical/ETM Enterprises
Grand Ledge, Michigan
CERCLIS # MID980476907
Action Memorandum Date: 21 September 1990

Treatment Application:

Type of Action: Removal
Treatability Study associated with application? Information not available at this time
EPA SITE Demonstration Program test associated with application? Yes (see Reference 41)
Period of operation: 5/93 - 5/94
Quantity of material treated during application: 3,000 cubic yards of contaminated soils and sediments (5,400 tons) [41]

Background

Historical Activity that Generated Contamination at the Site: Mixing, manufacturing, and packaging of agricultural chemicals

Corresponding SIC Code: 2879 (Agricultural Chemicals - not elsewhere classified)

Waste Management Practice that Contributed to Contamination: Manufacturing process

Site History: The Parsons site, located near Grand Ledge, Michigan, as shown in Figure 1, is a former agricultural chemicals mixing, manufacturing, and packaging facility. Materials handled during Parsons' operation included pesticides, herbicides, solvents, and mercury-based compounds. Parsons occupied the property from April 1945 until 1979. The site is presently owned by ETM Enterprises, a manufacturer of fiberglass. [2]

SITE IDENTIFYING INFORMATION (CONT.)

Background (cont.)

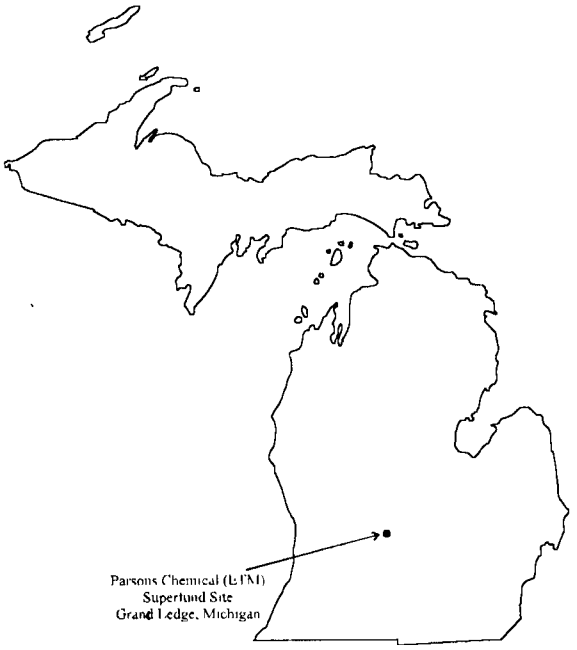

Figure 1. Site Location

Wash water from Parsons' operations was discharged through floor drains to a catch basin leading to the county drain system. The county drain system flows to an unnamed creek which ultimately empties into the Grand River. In 1979 and 1980 the Michigan Department of Natural Resources (MDNR) collected sediment samples from the unnamed creek and a ditch located on the north boundary of the site. Elevated levels of lead, mercury, arsenic, and pesticides, including dichloro-diphenyl-trichloroethane (DDT) and chlordane were detected in the samples. A hydrogeological investigation, performed during 1980, identified a septic tank and leach field system as the source of contamination. The septic tank and leach field were subsequently excavated in 1983.

Parsons was included in the Tier 3 dioxin screening under the National Dioxin Study conducted in 1984. 2,3,7,8-Tetrachlorodibenzo-p-dioxins (TCDD) was detected in the ditch sediments at the site at a concentration of 1.13 ppb at the surface and 0.56 ppb 18 inches below the surface. [2, 27]

Regulatory Context: An action memorandum, dated September 21, 1990, was approved by EPA to conduct a removal action at the Parsons site. The removal actions proposed for the site included [2]:

- Developing and implementing a site safety plan and security measures;
- Implementing a site air monitoring program;
- Characterizing, excavating, and staging all contaminated soils to facilitate the ISV process;
- Conducting a study to confirm that contaminated soils have been removed to acceptable levels;
- Treating on-site waste in a staging area utilizing ISV; and
- Completing site restoration in excavation and treatment areas.

Cleanup requirements for the site were established for near-surface vitrified materials and air emissions, as discussed below under cleanup goals and standards. [25]

Remedy Selection: Several options were considered for cleanup of the Parsons site, including ISV, incineration, and stabilization. ISV was selected as the remedy because this technology was determined to reduce volume by 20 to 30%, decrease the toxicity to near zero, and permanently immobilize the hazardous substances on the site. ISV was also identified as less expensive than on-site incineration. [2]

SITE IDENTIFYING INFORMATION (CONT.)

Site Logistics/Contacts

Site Management: Fund Lead
Oversight: EPA
On-Scene Coordinator:
Len Zintak
U.S. EPA Region 5
77 West Jackson Boulevard
Chicago, IL 60604-3507
(312) 886-4246

Treatment System Vendor:
James E. Hansen
Geosafe Corporation
2950 George Washington Way
Richland, WA 99352
(509) 375-0710

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix processed through the treatment system: Soil (in situ)

Contaminant Characterization

Primary contaminant groups: Pesticides, heavy metals; and dioxin

The maximum concentrations measured in the soil at Parsons for specific contaminants are shown in Table 1. [27]

Table 1. Maximum Contaminant Concentrations in Soil [27]

Contaminant	Maximum Concentrations in Soil (µg/kg)
g-BHC (Lindane)	78000
Bis(2-ethylhexyl) phthalate	28000
Butyl benzyl phthalate	6400
Chlordane	89000
4,4'-DDD	48000
4,4'-DDE	37000
4,4'-DDT	340000
Dieldrin	87000
Endosulfan sulfate	1300
Fluoranthene	1200
Hexachlorobenzene	2600
Mercury	34000
Methoxychlor	850
2-Methylnaphthalene	1100
Phenanthrene	990
Pyrene	1400
2,3,7,8-Tetrachloro-dibenzo-p-dioxin	1.13
Zinc	150000

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Cost or Performance

The major matrix characteristics affecting cost or performance for this technology and their measured values are presented in Table 2.

Table 2. Matrix Characteristics [4, 11]

Parameter	Value	Measurement Procedure
Soil Classification	Silty Clay	Not Available
Clay Content and/or Particle Size Distribution	Not Available	-
Moisture Content	Not Available	-
Soil Dry Density	1.48 tons/yd^3	Not Available

The soil at Parsons was reported to be difficult to work with under very wet and very dry conditions. Wet conditions caused the soil to become highly fluid and exhibit a noticeable sulfurous odor. Under dry conditions, the soil became concrete-like. The soil also had a very high moisture content, and the soil moisture contained a high level of dissolved solids. [25]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

In Situ Vitrification

Supplemental Treatment Technology:

Post-treatment (air) using quench, scrubber, and thermal oxidizer

In Situ Vitrification System Description and Operation

In situ vitrification (ISV) is an immobilization technology designed to treat media contaminated with organic, inorganic, and radioactive contaminants. The primary residual generated by ISV is the vitrified soil product. Secondary residuals generated by ISV include air emissions, scrubber liquor, carbon filters, and used hood panels. [41]

System Description

The ISV system used at Parsons consisted of 9 melt cells, as shown in Figure 2, an air emissions control system, and associated equipment. The melt cells were installed in a 16-foot deep treatment trench; each cell was 26 feet by 26 feet square. The trench was designed with a cobble wall and drain system to direct perched water that flowed into the site around the melt cells. [25]

The air emissions control system used at Parsons consisted of an off-gas collection hood, a quencher, a water scrubber, and a thermal oxidizer. The thermal oxidizer was added midway through the project to help control stack gas odors. [25]

Associated equipment used at the Parsons site included electrical transformers, capacitor tanks, natural gas metering equipment, and thermocouples and other monitoring equipment. [13]

The following technology description is an excerpt from the SITE Technology Capsule [41]:

"The ISV Technology [used at Parsons] operates by means of four graphite electrodes, arranged in a square and inserted a short distance into the soil to be treated. A schematic of the Geosafe process is presented in Figure 3.

TREATMENT SYSTEM DESCRIPTION (CONT.)

In Situ Vitrification System Description and Operation (cont.)

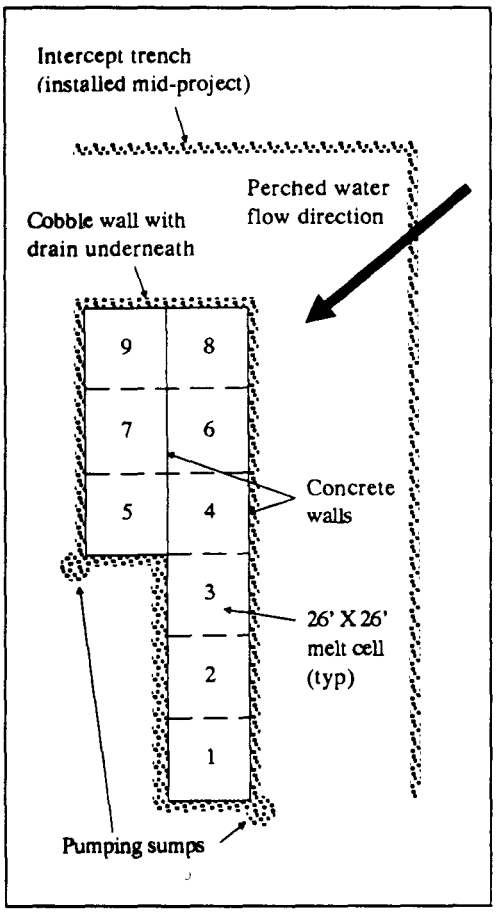

Figure 2. Plan View of Treatment Cells [25]

"ISV uses electrical current to heat (melt) and vitrify the treatment material in place. A pattern of electrically conductive graphite containing glass frit is placed on the soil in paths between the electrodes. When power is fed to the electrodes, the graphite and glass frit conducts the current through the soil, heating the surrounding area and melting directly adjacent soil.

"Molten soils are electrically conductive and can continue to carry the current which heats and melts soil downward and outward. The electrodes are allowed to progress down into the soil as it becomes molten, continuing the melting process to the desired treatment depth. One setting of four electrodes is referred to as a "melt." Performance of each melt occurs at an average rate of approximately three to four tons/hr.

"When all of the soil within a treatment setting becomes molten, the power to the electrodes is discontinued and the molten mass begins to cool. The electrodes are cut near the surface and allowed to settle into the molten soil to become part of the melt. Inorganic contaminants in the soil are generally incorporated into the molten soil which solidifies into a monolithic vitrified mass similar in characteristics to volcanic obsidian. The vitrified soil is dense and hard, and significantly reduces the possibility of leaching from the mass over the long term.

"The organic contaminants in the soil undergoing treatment are pyrolyzed (heated to decomposition temperature without oxygen) and are generally reduced to simple gases. The gases move to the surface through the dry zone immediately adjacent to the melt, and through the melt itself. Gases at the surface are collected under a stainless steel hood placed over the treatment area and then treated in an off-gas treatment system. The off-gas treatment system comprises a quencher, a scrubber, a demister, high efficiency particulate air (HEPA) filters, and activated carbon adsorption to process the off-gas before releasing the cleaned gas through a stack. A thermal oxidizer can be used following the off-gas treatment system to polish the off-gas before release to the atmosphere. A thermal oxidizer was utilized during the SITE Demonstration at the Parsons site."

System Operation

Eight melts were completed at the Parsons site from June 1993 to May 1994. As shown on Table 3, these melts ranged in duration from 10 to 19.5 days, and consumed from 559,200 to 1,100,000 kilowatt-hours of electricity per melt. The melts are expected to cool for approximately one year (i.e., until May 1995). [10-24]

TREATMENT SYSTEM DESCRIPTION (CONT.)

In Situ Vitrification System Description and Operation (cont.)

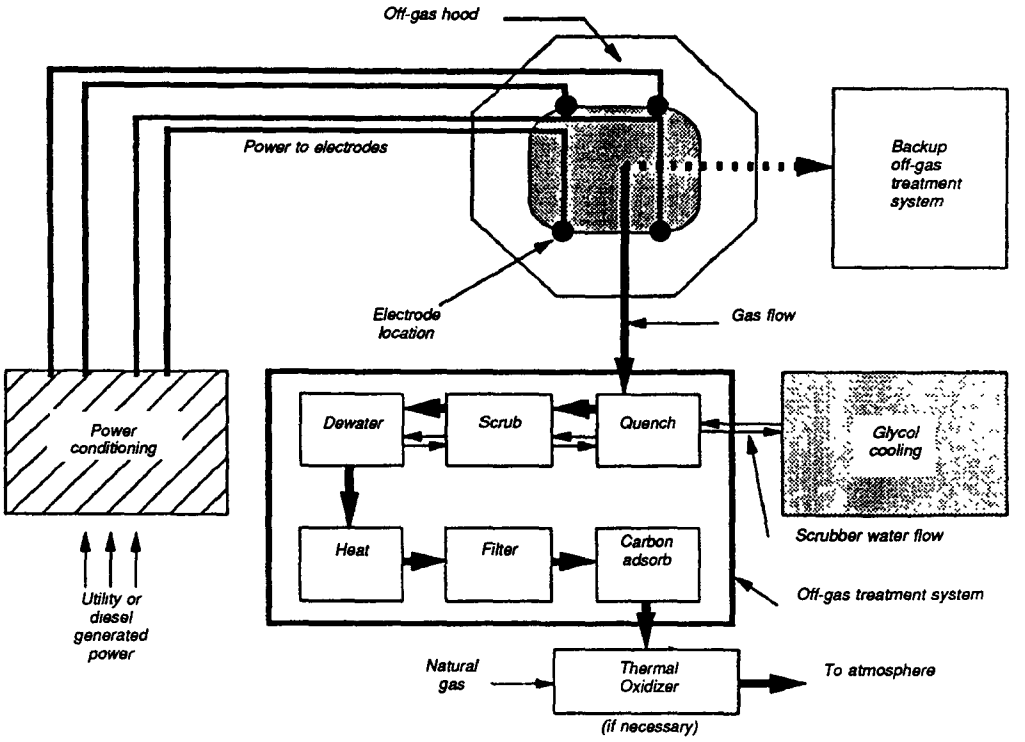

Figure 3. Geosafe In Situ Vitrification Process [41]

Table 3. Operational Data [10-24]

Melt #	Cell #	Soil Treated* (cubic yards)	Duration of Melt (days)	Power Consumed (kilowatt-hours)	Natural Gas Consumed in Thermal Oxidizer (cubic feet)
1	1 and part of 2	300	19.5	1,100,000	N/A
2	2 and part of 3	330	14	934,000	N/A
3	part of 3, 4 and 7	621	16.7	1,018,000	N/A
4	7 and part of 4, 5, and 8	672	16	996,000	N/A
5	5 and part of 4, 6, and 8	655	16	1,084,800	4,100,000
6	8 and part of 5, 7, and 9	377	10	559,200	Not Available
7	6 and part of 5, 8, and 9	575	14	836,985	Not Available
8	9 and part of 6 and 8	426	11.5	640,800	Not Available

N/A - Not applicable; thermal oxidizer not installed until after Melt #4 complete.
**Quantities shown are Geosafe estimates of contaminated and clean soil treated; total quantity of soil treated greater than 3,000 cubic yards of contaminated soil because treatment of clean soil occurred in this application.*
***SITE Demonstration Program test.*

TREATMENT SYSTEM DESCRIPTION (CONT.)

In Situ Vitrification System Description and Operation (cont.)

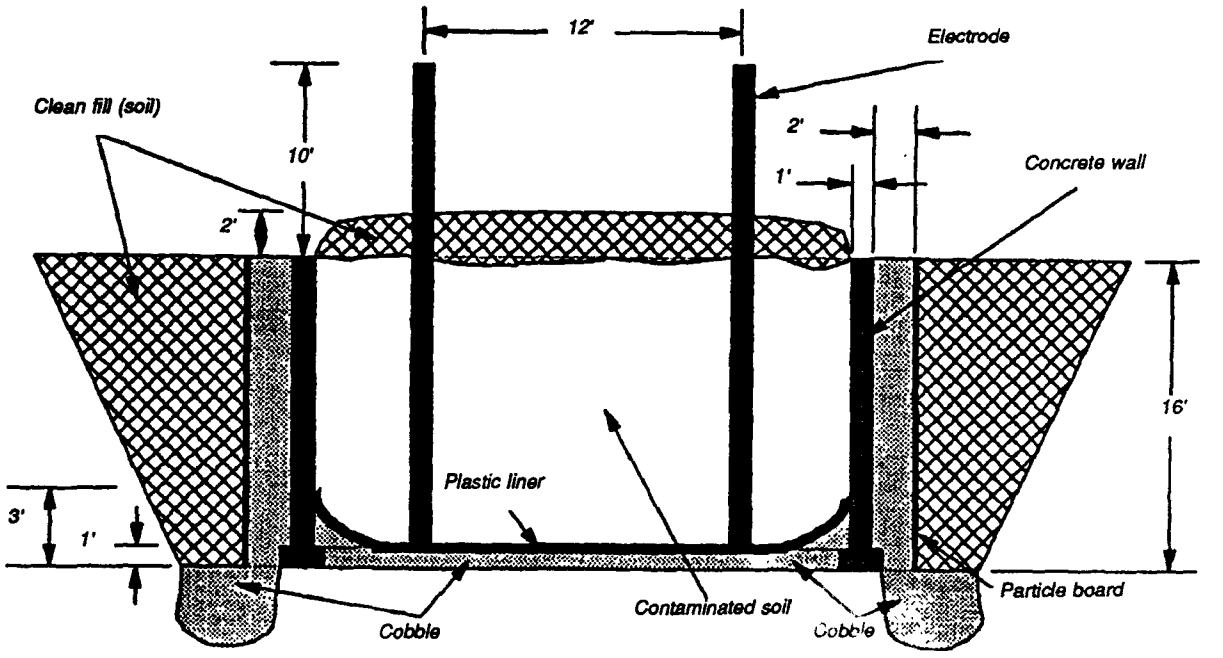

Figure 4. Side View of Typical ISV Treatment Cell [41]

The SITE Technology Capsule provides the following description of system operation at Parsons [41]:

"At the Parsons site, the original soil contamination was relatively shallow, five feet or less, and located in three main areas. To increase the economic viability of treatment at this site, the contaminated soil was excavated and consolidated into a series of nine treatment cells. The cell walls were built using concrete, cobble, and particle board as shown in Figure 4. The cells were constructed by trenching an area of the site, installing particle board and concrete forms, and pouring concrete into the forms to create the nine cell settings. A one-foot layer of cobble was placed in the bottom of each cell, and approximately two feet of cobble was used to surround the exterior of the cell forms. The use of cobble at the sides was intended as a means to retard melting out into adjacent clean soil. The bottom cobble was used to provide a drainage pathway for water that was known to be present on-site; the resultant flow of water was directed to a drainage trench. After construction, the cells were filled with contaminated soil from the site, and topped with a layer of clean soil.

"During the treatment of the first few cells, problems with the cell design were observed. The intense heat that was melting the soil was also thermally decomposing the particle board forms. Analysis of water samples collected from the diversion system surrounding the cells identified volatiles (benzene), phenolics, and epoxies that were released by this decomposition. The cobble outside of the cells created porous paths in the vicinity of treatment, thereby increasing the likelihood of vapors escaping the area outside the hood and causing irregular melt shapes.

"Geosafe responded by excavating the area outside of the remaining treatment cells and removing the particle board forms. A refractory ceramic material with insulating and reflective properties was placed adjacent to the exterior of the concrete cell walls. This helped to control the melt shape, limit fugitive vapor emissions, and restrict the melt energy inside the cell boundaries. . . . . It should be noted that the use of cobble in treatment cell construction was unique to the Parsons site where the configuration and flow of the on-site groundwater dictated its application.

TREATMENT SYSTEM DESCRIPTION (CONT.)

In Situ Vitrification System Description and Operation (cont.)

"Utility requirements for this technology include electricity, natural gas (if a thermal oxidizer is used), and water. As expected, electricity is a major consideration when implementing ISV. Total power to the electrodes during treatment is approximately three MW; the voltage applied to each of the two phases during steady state processing averages around 600 volts while the current for each phase averages approximately 2,500 amps."

Operating Parameters Affecting Treatment Cost or Performance

The major operating parameters affecting cost or performance for this technology and the values measured for each are presented in Table 4.

Table 4. Operating Parameters [10-24]

Parameter	Value	Measurement Procedure
Soil Treated	300-672 cubic yards per melt	Vendor estimate
Melt Duration	10-19.5 days per melt	-
Power Consumption	559,200-1,100,000 kWh/melt	-

Timeline

A timeline for this application is shown in Table 5.

Table 5. Timeline [1, 10-26]

Start Date	End Date	Activity
3/89	-	Parsons added to NPL
9/90	-	Action memorandum signed
10/90	4/91	Site preparation work completed (excavation and staging of 3,000 cubic yards into ISV treatment cells)
3/91	-	Operational acceptance test terminated due to fire
5/93	6/93	Mobilization of equipment and personnel to site
6/93	9/93	ISV treatment conducted
9/93	11/93	ISV treatment suspended for 9 weeks pending discussions about scrubber solution disposition, stack gas odors, groundwater disposition, and melt shape
11/93	12/93	ISV treatment continued
1/94	-	Thermal oxidizer installed to control stack gas odors
2/94	5/94	ISV treatment continued
3/94	4/94	SITE Demonstration Program test (Melt #6)
5/94	expected '95	Decontamination, dismantling, and demobilization conducted

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

Cleanup requirements were established for soils remaining on site and for off-gasses from the ISV unit, as shown below in Table 6.

Table 6. Cleanup Requirements [25, 28]

Contaminant	Soil CleanupStandards (mg/kg)	Off-Gas State ARAR (lbs/hr)
Chlordane	1	25
4,4'-DDT	4	0.01
Dieldrin	0.08	0.00028
Mercury	12	0.00059

Treatment Performance Data

Although final treatment performance data are not yet available, preliminary data for this application include results from total waste analysis and TCLP analysis of vitrified soil for pesticides and metals, and from analyses of stack gas emissions. Table 7 shows selected results from the SITE Demonstration for vitrified soil and stack emissions in melt #6. During the SITE Demonstration, three samples of vitrified soil were collected from the surface of Cell 8, and analyzed for pesticides and metals (total and TCLP). Stack gas emissions were also tested for total hydrocarbons (THC) and carbon monoxide (CO). During the SITE Demonstration, THC and CO were each measured at less than 10 ppmv. [41]

Table 8 shows typical stack gas emission performance data as reported by the vendor.

Additional samples of vitrified soil are planned to be collected after the melts cool (expected by May 1995).

Table 7. Selected Results from the SITE Demonstration Program for Melt #6 [41]

	Before-Treatment Soil		After-Treatment Surface Soil		Stack Gas Emissions	
Contaminant	Total (µg/kg)	TCLP (µg/L)	Total (µg/kg)	TCLP (µg/L)	Concentration (µg/m³)	Mass (lbs/hr)
Chlordane	<80	<0.5	<80	<0.5	<1.38	<0.000011
4,4'-DDT	2,400-23,100	0.12-0.171	<16	<0.1	<0.28	<0.0000022
Dieldrin	1,210-8,330	6.5-10.2	<16	<0.1	<0.28	<0.0000022
Arsenic	8,380-10,100	NA	717-5,490	<4-30.5	<0.269	<0.000001293
Chromium	37,400-47,600	NA	12,500-14,600	<10-17.1	2.081-3.718	0.0000148-0.0000267
Lead	<50,000	NA	<5,000-21,00	<50-4,290	<3.891	<0.0000282
Mercury	2,220-4,760	NA	<40	<0.2-0 23	12.9-17.7	0.0000989-0.000125

NA - Not analyzed.

Table 8. Typical Stack Gas Emissions [25]

Contaminant	State ARAR (lbs/hr)	Stack Gas Emission (lbs/hr)
Chlordane	25	<0.00000011
4,4'-DDT	0.01	<0.000022
Dieldrin	0.00028	<0.000022
Mercury	0.00059	0.00012

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment

The treatment performance data in Table 7 shows that the surface soil samples and stack gas emissions measured during the SITE Demonstration met the soil cleanup standards and off-gas State ARARs for this application. In addition, the typical stack gas emission data provided by the vendor, as shown in Table 8, show compliance with the State ARARs. The data in Table 8 show that the stack gas emissions for chlordane and 4,4'-DDT were several orders of magnitude lower than the ARARs.

The data in Table 7 show a reduction in total waste analysis concentrations from levels as high as 23,100 μg/kg to levels less than 11 μg/kg for chlordane, 4,4'-DDT, and dieldrin in surface soil samples. Concentrations of metals in a TCLP extract are shown to be reduced from as high as 21,000 μg/L to levels less than 5,000 μg/L.

Additional data from the SITE Demonstration show a volume reduction of approximately 30% for the test soil, based on the results from analyses of soil dry density.

Performance Data Completeness

Limited data are available at this time to characterize the results of the ISV application at Parsons. Data available at this time are for stack gas emissions, and for surface soil samples collected during the SITE Demonstration. Additional sampling of the vitrified soil is planned for after the melt cools (approximately May 1995).

Performance Data Quality

Soil sampling and analysis for the SITE Demonstration was conducted following EPA SW-846 analytical methods. No exceptions to the methods were noted in the available references. The SITE Technology Capsule, however, identified a possibility that other, non-EPA approved, methods may provide more accurate determinations for metals in vitrified materials.

TREATMENT SYSTEM COST

Procurement Process

EPA contracted with Geosafe Corporation to construct and operate the ISV system at the site. Geosafe used several subcontractors to implement specific aspects of the operation.

Information about the competitive nature of the procurement process is not available at this time. [10]

Treatment System Cost

Although final cost information is not yet available, preliminary treatment system cost information is available from EPA, as presented in Tables 9-12. An action memorandum identified cost ceilings for this application totalling $3,466,967, including $1,763,000 for the cleanup contractor, as shown in Table 9. [1] In negotiating the contract with Geosafe, EPA established objectives for nine cost elements, as shown in Tables 10-12. The delivery order for Geosafe specified a ceiling value of $1,690,305. The reason for the discrepancy between the $1,763,000 and $1,690,305 values is not available at this time. [24]

In order to standardize reporting of costs among projects, costs are shown in Tables 10-12 according to the format for an interagency Work Breakdown Structure (WBS). The WBS specifies 9 before-treatment cost elements, 5 after-treatment

TREATMENT SYSTEM COST (CONT.)

Treatment System Cost (cont.)

cost elements, and 12 cost elements that provide a detailed breakdown of costs directly associated with treatment. Tables 10, 11, and 12 present the cost elements exactly as they appear in the WBS, along with the specific activities, and unit cost and number of units of the activity (where appropriate), as provided in the Contract Negotiation Cost Objectives. [31]

Table 9. Cost Ceilings Shown in Action Memorandum [1]

Cleanup Contractor	$1,763,000
Contingency (15%)	$264,450
Subtotal	$2,027,450
TAT	$716,000
Extramural subtotal	$2,743,450
Extramural Contingency	$411,517
Total for Extramural Costs	$3,154,967
U.S. EPA Direct Costs	$120,000
EPA Indirect Costs	$192,000
TOTAL for Intramural Costs	$312,000
TOTAL for Removal Project	3,466,967

Table 10. Before-Treatment Cost Elements [Adapted from 31]

Cost Element	Cost Objective
Mobilization and Preparatory Work	
- Mobilization	$150,000
- Site Administration	$220,000
- Site Preparation	$4,000
Monitoring, Sampling, Testing, and Analysis	
- Soil	$80,000
- Glass	$10,000
- Air	$130,000
- Water	$25,000
Site Work	
- Uncontaminated Soil	$80,000
- Contaminated Soil	$100,000

Table 11. Treatment Cost Elements [31]

Cost Element	Cost Objective
Operation (short-term - up to 3 years)	
- Vitrification	$800,000

TREATMENT SYSTEM COST (CONT.)

Treatment System Cost (cont.)

Table 12. After-Treatment Cost Elements [Adapted from 31]

Cost Element	Cost Objective
Site Restoration	
- Backfill and Grade	$80,000
- Seeding	$4,500
- Drainage Structures	$2,500
Demobilization	$77,000

Cost Data Quality

Limited data are available at this time to assess the cost for this treatment application. The cost data shown in this report were provided by EPA as contract negotiation cost objectives.

Vendor Input

The vendor stated that the costs for the application at Parsons were unusually high, and expects that the costs for future applications will be lower. Key factors affecting costs for ISV include: [41]

- Cost of the local price of electricity;
- Depth of processing;
- Soil moisture content; and
- Treatment volume.

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- The cleanup contractor's cost ceiling for the ISV treatment application at Parsons was $1,763,000, including $800,000 for vitrification operations, which corresponds to $270 in costs for vitrification per cubic yard of soil treated.
- The before-treatment costs for this application of $800,000 were high because of the need to excavate and stage the wastes prior to treatment.

Performance Observations and Lessons Learned

- The surface soil samples and stack gas emissions measured during the SITE Demonstration, and the typical stack gas emission results provided by the vendor, met the soil cleanup standards and emissions standards for this application.
- Typical stack gas emissions for chlordane and 4,4'-DDT were several orders of magnitude lower than the ARARs.
- Based on the results of the SITE demonstration:

  1. The total waste analysis concentrations in surface soil samples were reduced from levels as high as 23,100 μg/kg to levels less than 11 μg/kg for chlordane, 4,4'-DDT, and dieldrin.
  2. Concentrations of metals in a TCLP extract of surface soil samples were reduced from as high as 21,000 μg/L to levels less than 5,000 μg/L.
  3. A volume reduction of approximately 30% for the test soil was achieved in this application, based on the results from analyses of soil dry density.

OBSERVATIONS AND LESSONS LEARNED (CONT.)

Other Observations and Lessons Learned

- Additional sampling of the vitrified soil is planned for after the melt cools (approximately May 1995).

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Analysis Preparation

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Thermal Desorption at the Pristine, Inc. Superfund Site Reading, Ohio

Case Study Abstract

Thermal Desorption at the Pristine, Inc. Superfund Site Reading, Ohio

Site Name:
Pristine, Inc. Superfund Site

Location:
Reading, Ohio

Contaminants:
Chlorinated Aliphatics, Pesticides, Polynuclear Aromatic Hydrocarbons (PAHs), and Metals
- VOCs up to 0.14 ppm
- SVOCs up to 130 ppm
- 4,4'-DDT ranging from 0.11 ppm to 8.2 ppm
- Lead ranging from 26 ppm to 1,100 ppm

Period of Operation:
November 1993 to March 1994

Cleanup Type:
Full-scale cleanup

Vendor:
Joseph Hutton
SoilTech ATP System, Inc.
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

Technology:
Thermal Desorption
- Rotary kiln desorber with proprietary sand seals
- Retort zone temperature 1,009.9-1,034.1°F
- Air emissions controlled using cyclones, baghouse, scrubbers, fractionator, condenser, and gas-oil-water separator
- Water treated on site using oil/water separation, hydrogen peroxide oxidation, sand filtration, and carbon adsorption

Cleanup Authority:
CERCLA
- ROD Date: 3/30/90
- PRP Lead

SIC Code:
4953W - Waste Management; Refuse Systems (Waste Processing Facility, Miscellaneous)

Point of Contact:
Tom Alcamo
Remedial Project Manager
U.S. EPA - Region 5
230 South Dearborn Street
Chicago, IL 60604
(312) 886-7278

Waste Source:
Storage-Drums/Containers; Waste Treatment Plant

Type/Quantity of Media Treated:
Soil
- Approximately 12,800 tons treated
- 12-25% moisture; pH of 1-2 for some feed soils

Purpose/Significance of Application:
This application is notable for treating soils with a wide range of pH and moisture conditions.

Regulatory Requirements/Cleanup Goals:
- Soil - Numeric cleanup goals identified for 11 constituents, including PAHs, pesticides, dioxin, benzene, and chlorinated aliphatics; cleanup goals ranged from 0.99 to 3,244 µg/kg
- Air - Total Dioxins/Furans: <30 mg/dscm, particulates: 0.015 gr/dscf, and four other stack gas emission parameters

Results:
Soil - Cleanup goals for all constituents were met in all soil piles tested; 6 of 11 constituents removed to levels at or below detection limit
Air - Stack gas requirements met for dioxin/furan emissions and particulates

Cost Factors:
No data available

Case Study Abstract

Thermal Desorption at the Pristine, Inc. Superfund Site Reading, Ohio (Continued)

Description:
Pristine, Inc. performed liquid waste disposal operations at the site from 1974 to 1981. Spills and on-site disposal of treated wastes led to soil contamination. Soils at the Pristine site were contaminated with volatile and semivolatile organics, polynuclear aromatic hydrocarbons (PAHs), pesticides, and metals. The soils also contained greater than 2% of elemental sulfur. This application was notable for treating soil with a wide range of pH and moisture conditions.

SoilTech's 10 ton/hr mobile Anaerobic Thermal Processor (ATP) system was used for treating the contaminated soil at the Pristine site. The SoilTech ATP system included a feed system, the ATP unit (rotary kiln thermal desorber), a vapor recovery system, a flue gas treatment system, and a tailings handling system. Wastewater from the vapor recovery system was treated in an on-site wastewater treatment system. The ATP system was operated at the Pristine site from November 1, 1993 until March 4, 1994 and was used to treat approximately 12,800 tons of contaminated soil.

The ATP System treated contaminants in soil to levels below the cleanup goals. Levels of 6 of the 11 target constituents were reduced to concentrations at or below the reported detection limits. All stack gas air emission performance standards were met in this application, with occasional spikes of THC over the 20 ppm performance standard. Average throughput was approximately 6.5 tons/hr, and average on-line availability was approximately 62 percent.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report presents cost and performance data for a thermal desorption treatment application at the Pristine, Inc. Superfund Site, located in Reading, Ohio. Pristine, Inc. performed liquid waste disposal operations at the site from 1974 to 1981 and operated as a sulfuric acid manufacturing facility prior to 1974. As a result of spills and on-site disposal of wastes, soils at the Pristine site became contaminated with volatile and semivolatile organics, polynuclear aromatic hydrocarbons (PAHs), pesticides, and inorganic metals. The soils also contained high levels of elemental sulfur (greater than 2%).

SoilTech's 10 ton/hr mobile Anaerobic Thermal Processor (ATP) system was used for treating contaminated soil at the Pristine site. The ATP system included a feed system, the ATP unit (rotary kiln thermal desorber), a vapor recovery system, a flue gas treatment system, and a tailings handling system. Wastewater from the vapor recovery system was treated in an on-site wastewater treatment system.

The ATP system was operated at the site from November 1, 1993 until March 4, 1994 and was used to treat approximately 12,800 tons of contaminated soil. The ATP System treated contaminants in soil to levels below the cleanup goals. Levels of six of the 11 target constituents were reduced to concentrations at or below the reported detection limits. All stack gas air emission performance standards were met in this application. Average throughput was approximately 6.5 tons/hr, and average on-line availability was approximately 62 percent, in this application. This application was notable for treating soil with a wide range of pH and moisture conditions. Treated soil was backfilled on site.

No information on treatment system cost was available at the time of this report.

SITE IDENTIFYING INFORMATION

Identifying Information

Pristine, Inc. Superfund Site
Reading, Ohio
CERCLIS #: OHD076773712
ROD Date: 30 March 1990

Treatment Application

Type of Action: Remedial
Treatability Study Associated With Application? No
EPA SITE Program Test Associated With Application? No
Period of Operation: November 1993 to March 1994
Quantity of Material Treated During Application: Approximately 12,800 tons of soil

Background

Historical Activity that Generated Contamination at the Site: Liquid waste storage, disposal, and treatment operations

Corresponding SIC Code: 4953 W - Waste Management; Refuse Systems (Waste Processing Facility, miscellaneous)

Waste Management Practice that Contributed to Contamination: Storage - Drums/ Containers; Waste Treatment Plant

Site History: Pristine, Inc., a former liquid waste disposal facility that operated from 1974 to 1981, is located on a 3-acre site in Reading, Ohio, as shown in Figure 1. Prior to 1974, the Pristine site was the location of a sulfuric acid manufacturing facility. Between

SITE INFORMATION (CONT.)

Background (cont.)

Figure 1. Site Location [1]

1974 and 1981, the Pristine facility accepted a variety of bulk and drummed liquid waste products, including acids, solvents, pesticides, and PCBs. The types of wastes stored at Pristine are shown in Table 1. These wastes were treated by acid neutralization or incineration, and disposed on site. In December 1977, the Ohio Environmental Protection Agency modified Pristine's operating permit to require that Pristine reduce the amount of waste maintained at the site to the equivalent of no more than 2,000 drums. [1, 2, and 3]

In 1979, an on-site inspection of Pristine's facilities by the Ohio EPA found 13 bulk storage tanks that each contained from 500 to 10,000 gallons of liquid waste material and as many as 10,000 drums on site. As a result of state enforcement actions, which cited Pristine's failure to comply with the terms of its waste incinerator operating permit and violations of water pollution control regulations, Pristine, Inc. ceased disposal activities at the site in 1981. Samples taken on and near the Pristine site during Remedial Investigation/Feasibility Study (RI/FS) indicated that soils and sediment at the site were contaminated with volatile organic compounds (VOCs), semivolatile organic compounds, including polynuclear aromatic hydrocarbons (PAHs), pesticides, compounds, and inorganic metals. [1,2]

Regulatory Context: A Record of Decision (ROD) was signed in December 1987 and amended in 1990. An Explanation of Significant Differences (ESD) amended the 1990 ROD and specified thermal desorption to remediate site soils. Thermal desorption was selected based on its ability to remove PAHs and pesticides from the site soil. [4,5,6]

Site Logistics/Contacts

Site Management: PRP Lead

Oversight: EPA

Remedial Project Manager:
Mr. Tom Alcamo
USEPA Region 5
230 South Dearborn Street
Chicago, Illinois 60604
(312) 886-7278

Vendor:
Mr. Thomas J. Froman
Project Engineer
Canonie Environmental Services Corp. (prime contractor)
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

Mr. Joseph H. Hutton
SoilTech ATP Systems, Inc. (subcontractor)
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

SITE INFORMATION (CONT.)

Background (cont.)

Table 1. Types of Wastes Stored at Pristine [3]

Mixed paint sludges	Sodium
Acid-contaminated soil	Adipoyl chloride
Neutralized acid sludge	Kepone
DDT and other pesticides	Acetomethoxane (originally listed as dioxin)
Contaminated soap, cosmetics, corn syrup, and fatty acids	Inorganic peroxides
Dimethyl sulfate	Tetrahydrofuran
Hydrazine	Amines
Flammable solvents	Biological waste
Cyanide wastes	Pharmaceutical waste
Chlorinated solvent sludge	Freons
Sulfuric and nitric acid	Adhesives
PCB-contaminated solvents	Mercaptans
Ink solvent	Alcohols
Neutralized acid	Cadmium and plating waste
PCB-contaminated soybean oil	Phenolic plastics and resins
Sulfuric acid sludge	Phosphorus
Chrome wastes	Picric acid
Scrubber process wastes	Laboratory packs

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix processed through the treatment system:

Soil (ex situ), sediment (ex situ)

Contaminant Characterization

Primary contaminant groups:

Volatiles, semivolatiles (primarily polynuclear aromatic hydrocarbons), pesticides, metals, and sulfur.

To characterize soils for thermal desorption, composite samples were collected from twelve separate areas across the Pristine site. Concentrations of volatile organics ranged from non-detect to 140 parts per billion (ppb), semivolatile organics ranged from non-detect to 130 ppm, lead ranged from 26 parts per million (ppm) to 1,100 ppm, and 4,4'-DDT ranged from 110 ppb to 8,200 ppb. Samples analyzed for PCBs were all non-detect. One composite sample was collected from the area near the former waste incinerator and analyzed for dioxins and furans. Laboratory analytical results for this sample indicated that concentrations of furans ranged from 26.7 parts per trillion to 722 parts per trillion, and concentrations dioxins ranged from 3.0 parts per trillion to 792 parts per trillion. [9]

The soil was also determined to contain sulfur in excess of 2% by weight. [20]

MATRIX DESCRIPTION (CONT.)

Contaminant Characterization (cont.)

Table 2 presents the concentrations of 17 contaminants in the untreated soil that was fed to the desorber during the three-day proof-of-process test. [16, 20]

Table 2. Feed Soil Concentrations [16,20]

Constituent	Number of Samples	Minimum Concentration (µg/kg)	Maximum Concentration (µg/kg)
Benzo(a)anthracene	3	530 J	1,100
Benzo(a)pyrene	3	420 J	750
Benzo(b)fluoranthene	3	980	1,900
Benzo(k)fluoranthene	3	290 J	440
Chrysene	3	790	890
Dibenzo(a,h)anthracene	3	ND (380)	ND (770)
Indeno(1,2,3-cd)pyrene	3	290 J	370 J
Aldrin	3	ND (460)	ND (2,300)
4,4'-DDT	3	3,200	4,800
Dieldrin	3	160 J	ND (2,300)
2,3,7,8-TCDD (equivalent)	4	9.93 E-04	1.06 E-02
Benzene	3	ND (6)	ND (6)
Chloroform	3	3 J	ND (6)
1,2-Dichloroethane	3	5 J	8
1,1-Dichloroethene	3	ND (6)	ND (6)
Tetrachloroethene	3	11	70
Trichloroethene	3	ND (6)	6

J - Result is an estimated value below the reporting limit.
ND - Not detected (detection limit shown in parentheses).

Matrix Characteristics Affecting Treatment Cost or Performance

Table 3 presents the major matrix characteristics affecting cost or performance for this application.

Table 3. Matrix Characteristics [9, 20]

Parameter	Value	Measurement Procedure
Soil Classification	Silty clays with some sand	Not available
Clay Content and/or Particle Size Distribution	Not available	—
Bulk Density	53-104 lbs/ft^3	Not available
Lower Explosive Limit	Not available	—
Moisture Content	15-20%	Not available
pH	1-2 for some feed soils	Not available
Oil and Grease or Total Petroleum Hydrocarbons	Not available	—

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Thermal desorption

Supplemental Treatment Technology

Post-treatment (air) - cyclone, quench, baghouse, carbon adsorption, condenser, and gas-oil-water separators.

Post-treatment (water) - oil/water separation (using a gravity separator, a coalescing plate system, an oleophilic membrane packing, and a dissolved air flotation system), hydrogen peroxide oxidation, sand filtration, and activated carbon filtration.

SoilTech ATP Thermal Desorption System Description and Operation

System Description

The SoilTech Anaerobic Thermal Processor, shown in Figure 2, is a mobile treatment system consisting of six main process units, including a soil pretreatment system, a feed system, an anaerobic thermal processor unit, a vapor recovery system, a flue gas treatment system, a tailings handling system, and a wastewater treatment system. [14, 17, 20]

The feed system consists of two feed hoppers and a conveyor belt. One feed hopper contains the contaminated soil and the other contains clean sand. The sand is fed to the ATP unit during system startup and shutdown periods, and acts as a heat carrier. [14, 18]

The ATP unit is a rotary kiln which contains four separate internal zones separated using proprietary sand seals. As shown in Figure 3, these include the preheat, retort, combustion, and cooling zones. The feed enters the preheat zone where it is heated to approximately 450°F and mixed, vaporizing water, volatile organics, and some semivolatile organics. The solids then enter the retort zone where they are heated to a target temperature range of 950 to 1,200°F, causing vaporization of heavy oils and some thermal cracking of hydrocarbons, resulting in the formation of coked solids and decontaminated solids. The solids from the retort zone then enter the combustion zone where coked solids are combusted. A portion of the decontaminated solids are recycled to the retort zone via a recycle channel. The recycling of these solids helps to maintain an elevated temperature in the retort zone. The decontaminated solids remaining in the combustion zone enter the cooling zone where they are cooled to a specified exit temperature. [14, 18]

The vapor recovery system consists of two parallel systems. One system condenses water and vapors from the preheat zone of the ATP unit and consists of a cyclone, a condenser, and a gas-oil-water separator. The other system condenses water and vapors from the retort zone and consists of two cyclones, a scrubber, a fractionator, a condenser, and a gas-oil-water separator. Condensed water from the vapor recovery system is treated in an on-site wastewater treatment system which consists of the following processes:

- Oil/water separation (using a gravity separator, a coalescing plate system, an oleophilic membrane packing, and a dissolved air flotation system);
- Hydrogen peroxide oxidation;
- Sand filtration; and
- Carbon adsorption.

The flue gas treatment system consists of a cyclone with fines conveyor, flue gas quencher chamber, baghouse with dust conveyor, acid gas scrubber, and activated carbon unit. This system removes particulates and trace hydrocarbons from the flue gas exiting the combustion zone of the ATP. Fines from the baghouse and cyclone are mixed with the treated solids exiting the ATP unit. The treated flue gas is released to the atmosphere. [14, 18]

TREATMENT SYSTEM DESCRIPTION (CONT.)

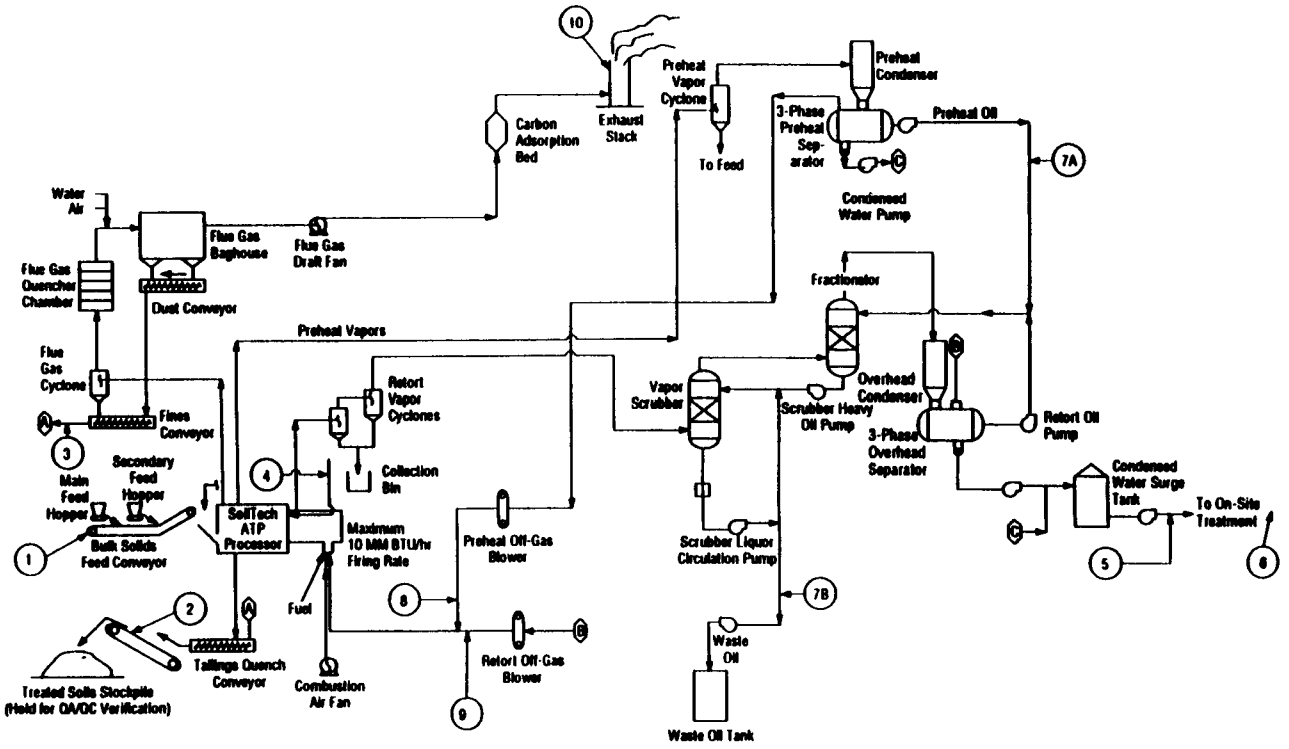

Figure 2. ATP Schematic [19]

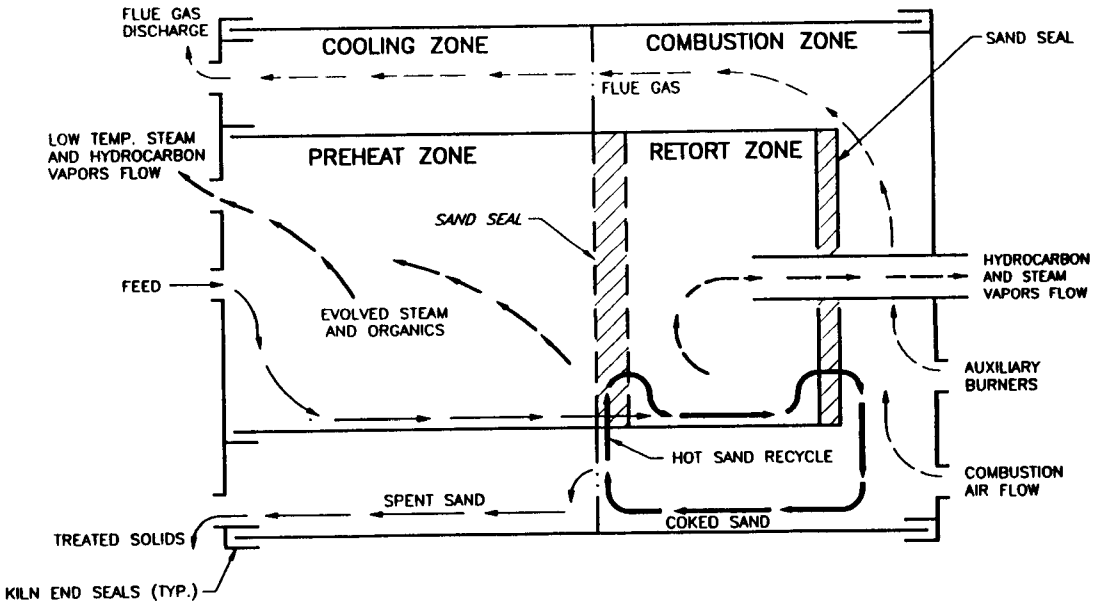

Figure 3. Simplified Sectional Diagram Showing the Four Internal Zones [14]

TREATMENT SYSTEM DESCRIPTION (CONT.)

SoilTech ATP Thermal Desorption System Description and Operation (cont.)

The tailings (treated solids) handling system is used to cool and remove treated solids from the ATP. The treated solids exiting the ATP are quenched with process and scrubber water and transported to storage piles using belt and screw conveyors. [14, 18]

Treated soil was backfilled on site. The soil was placed in trenches that were used for a soil vapor extraction system. The vendor stated that this area will be capped. [21, 22]

The primary innovative features of this ATP unit are the four internal zones and the use of proprietary sand seals at each end of the retort zone which are designed to maintain an oxygen-free environment in the retort zone. The oxygen-free environment in the retort zone helps to prevent the oxidation of hydrocarbons and coke. [14, 18]

System Operation

SoilTech conducted a proof-of-process performance test prior to full-scale operation to demonstrate compliance with soil treatment cleanup goals and stack gas emission performance standards. Four test runs (sampling windows) were completed during the proof-of-process test. [20]

Sulfur dioxide (SO_2) control was a particular concern in this application because of concerns with SO_2 emissions and the impact of SO_2 on corrosion of process equipment and on the pH of aqueous condensate streams. Several SO_2 control methods were used during the proof-of-process and full-scale operations, including lime (calcium oxide) addition, caustic solution, desorption, recovery of elemental sulfur under anaerobic conditions, and wet scrubbing of ATP flue gasses. [20]

During full-scale operation of the ATP system, 12,839 tons of soil and sediment were treated. Average throughput was approximately 6.5 tons/hr, and average on-line availability was approximately 62 percent. The wastewater from this system was treated and discharged to a sanitary sewer. [17,20]

Operating Parameters Affecting Treatment Cost or Performance [14,20]

Table 4 lists the major operating parameters affecting cost or performance for this technology. Values measured for these parameters during the proof-of-process period are included in this table. Automatic waste feed shutoff controls were used for key operating parameters, including retort and combustion zone temperatures and preheat, retort, and combustion zone pressures.

The data collected during the proof-of-process period indicated that the ATP system met all established performance criteria for flue gas stack emissions and for treated soil. Based on these results, EPA approved the continued operation of the ATP system at these target operating conditions.

Table 4. Operating Parameters [14, 20]

Parameter	Value	Measurement Procedure
Preheat and Retort Zone Residence Time	Approximately 5 minutes	Engineering design calculations
Preheat Zone Temperature	411 9-446 1°F	Thermocouples in preheat zone
Retort Zone Temperature	1,009 9-1,034.1°F	Thermocouples in retort zone
Combustion Zone Temperature	1,386.0-1,412.0°F	Thermocouples in combustion zone
Cooling Zone Temperature	623 8-688 8°F	Thermocouples in cooling zone
System Throughput	7.84-10 tons/hr	Weight of untreated solids measured using a truck scale
Preheat Zone Pressure	-0 10 inches water column	Pressure to electrical transducer
Retort Zone Pressure	-0.12 inches water column	Pressure to electrical transducer
Combustion Zone Pressure	-0.08 inches water column	Pressure to electrical transducer
Stack Gas Exit Temperature	135°F	Thermocouples in stack
Stack Gas Flow Rate	8,200 acfm @ 450°F	Orifice Plate Flowmeter

TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

The timeline for this application is presented in Table 5.

Table 5. Timeline [4, 5, 14]

Start Date	End Date	Activity
12/82	---	Pristine added to National Priorites List
---	'87	RI/FS conducted
12/87	---	ROD signed
3/90	---	ROD amended
11/93	3/94	Thermal desorption completed
11/93	11/93	Three day proof-of-process test conducted

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

An Explanation of Significant Differences (ESD), which amended the 1990 ROD, identified the cleanup goals shown in Table 6 for treatment of on-site soils and sediments at the site.

Table 6. Cleanup Goals [6]

Constituent	Cleanup Goal (µg/kg)
Total Carcinogenic PAHs*	1,000
Aldrin	15
DDT	487
Dieldrin	6
2,3,7,8-TCDD (Equivalent)**	0.990
Benzene	116
Chloroform	2,043
1,2-Dichloroethane	19
1,1-Dichloroethane	285
Tetrachloroethane	3,244
Trichloroethane	175

**Total Carcinogenic PAHs are defined as the total of benzo(a)anthracene, benz(a)pyrene, benz(b)fluoranthene, benz(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.*

***Cleanup goal for 2,3,7,8-TCDD (Equivalent) taken from Treated Soil Analytical Results. [16]*

While the ROD and ESD did not specify stack gas emission standards, standards for stack gas emissions were established for the proof-of-process period during project planning. Table 7 lists performance standards for stack gas emissions. In addition, a Destruction and Removal Efficiency (DRE) of 99.99% was required to be demonstrated for PAHs and pesticides in this application. [20]

TREATMENT SYSTEM PERFORMANCE (CONT.)

Cleanup Goals/Standards (cont.)

Table 7. Proof-of-Process Tests Stack Gas Emissions Performance Standards [20]

Parameter	Performance Standard
Particulates	0.015 grains per dry standard cubic foot (gr/dscf) corrected to 7% oxygen
Opacity	≤20%
Total Dioxin and Furan Emissions	<30 nanograms (ng)/dscm @ 7% O_2
Hydrogen Chloride	≤4 lbs/hr
Total Hydrocarbons (THC)	≤20 ppm corrected to 7% O_2
Sulfur Dioxide	16.6 gm/sec

Treatment Performance Data [16, 20]

Table 8 summarizes the results of the analysis of treated soil from 40 of the 44 piles. Data on the minimum and maximum constituent concentrations are presented; data on analysis by soil pile is included in Appendix A. Sampling was performed between November 1, 1993 and March 4, 1994. No data were reported for four of the piles (nos. 34-37).

Table 8. Treatment Performance Data [16]

Contituent	Number Soil Piles Analyzed	Cleanup Goal (µg/kg)	Minimum Concentration (µg/kg)	Maximum Concentration (µg/kg)
Benzo(a)anthracene	40	ND (370)	ND (370)	ND (400)
Benzo(a)pyrene	40	ND (370)	ND (370)	ND (400)
Benzo(b)fluroanthene	40	ND (370)	ND (370)	ND (400)
Benzo(k)fluroanthene	40	ND (370)	ND (370)	ND (400)
Chrysene	40	ND (370)	ND (370)	ND (400)
Dibenzo(a,h)anthracene	40	ND (370)	ND (370)	ND (400)
Indeno(1,2,3-cd)pyrene	40	ND (370)	ND (370)	ND (400)
Total Carcinogenic PAHs	40	1000	ND	ND
Aldrin	40	15	ND (4.3)	ND (4.9)
4,4'-DDT	40	487	ND (8.6)	9.6
Dieldrin	40	6	ND (4.0)	4.8
2,3,7,8-TCDD (equivalent)	40	0.99	0.000028	0.0123
Benzene	40	116	ND (5)	9
Chloroform	40	2043	ND (5)	9
1,2-Dichloroethane	40	19	ND (5)	ND (6)
1,1-Dichloroethane	40	285	ND (5)	ND (6)
Tetrachloroethane	40	3244	ND (5)	ND (6)
Trichloroethane	40	175	ND (5)	ND (6)

ND - Not detected (detection limit shown in parentheses).

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (cont.)

Performance standards and analytical results for selected parameters in stack gas emissions during the proof-of-process tests as presented in Table 9. Air modelling using the ICST-2 model, was conducted to assess ground level concentrations of specific metals and other compounds.

Table 9. Stack Gas Emissions Results from Proof-of-Process Tests [20].

Parameter	Performance	Analytical Results
Particulates	0.015 grains per dry standard cubic foot (gr/dscf) corrected to 7% oxygen	<0.00078 gr/dscf @ 7% O_2
Opacity	≤20%	≤20%
Total Dioxin and Furan Emission	<30 nanograms (ng)/dscm @ 7% O_2	0.26 ng/dscm @7% O_2 (window no.1); 2,3,7,8-TCDD equivalent = 0.013 ng/dscm @ 7% O_2
Hydrogen Chloride	≤4 lbs/hr	0.00851 - 0.0144 lbs/hr
Total Hydrocarbons (THC)	≤20 ppm corrected to 7% O_2	5.6 - 8.8 ppm (occasional spikes over 20 ppm*)
Sulfer Dioxide	16.6 gm/sec	<1 gm/sec

**Waste feed to the ATP was discontinued when THC concentrations exceeded 20 ppm. THC spikes (above 20 ppm) were attributed by the vendor to burner malfunction causing uncombusted propane fuel to be emitted from the stack*

To assess compliance with the 99.99% DRE for PAHs and pesticides during the proof-of-process period, surrogate organic compounds were added to the feed soil in window numbers 2, 3, and 4 of the proof-of-process test. 1,2,3-Trichlorobenzene was used as a surrogate to represent PAHs, and chloromethylbenzene (benzyl chloride) was used as a surrogate for pesticides. The results of the testing showed a 99.99% (four-nines) DRE for 1,2,3-trichlorobenzene in windows 2 and 3 (six-nines in window 4) and 99.999% (five-nines) DRE for benzyl chloride in windows 2, 3, and 4.

Performance Data Assessment

A review of the treatment performance data in Table 8 indicates that the cleanup goals for all constituents were met for the 40 piles of treated soil that were analyzed. The performance data show that the technology removed six of the 11 targeted constituents to levels at or below the detection limit. Only 4,4'-DDT, dieldrin, 2,3,7,8-TCDD (equivalent), benzene, and chloroform remained in the treated soil above the detection limit, at maximum concentration levels of 4.8 to 9.6 µg/kg.

For the seven PAH constituents analyzed, this technology was effective in removing these constituents to the reported detection limit (400 µg/kg).

A review of the stack gas emissions sampling results, presented in Table 9, show that during the proof-of-process tests, all stack gas emissions performance standards were met. Occasional THC spikes were measured at levels greater than the performance standard of 20 ppm. The vendor attributed these THC spikes to burner malfunction which caused uncombusted propane fuel to be emitted from the stack.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Completeness

Treatment performance data are available for assessing the concentrations of individual constituents in 40 of 44 soil piles treated, and for assessing the concentrations in feed soil and stack gas air emissions from the proof-of-process test.

Performance Data Quality

Project specifications were prepared for this application by Conestoga-Rovers Associates (CRA). The remedial action was monitored by CRA for the PRPs.

Soil samples were analyzed using SW-846 Methods 8270, 8080, 8290, and 8240. No exceptions to the QA/QC objectives were noted by the vendor for this application.

TREATMENT SYSTEM COST

Procurement Process

The PRPs contracted with Canonie Environmental Services Corp. to thermally treat soil and sediment at this site. Canonie contracted with SoilTech to perform the thermal treatment portion of the project. Conestoga-Rovers Associates was selected by the PRPs to monitor the remedial action. [20] No additional information is available on the competitive nature of the procurement process.

Treatment System Cost

No information was available on treatment system cost at the time of this report's preparation.

Vendor Input

According to the treatment vendor, in general, the costs for treatment using the SoilTech ATP system vary depending on the character of the waste material, with treatment costs ranging from $150 to $250 per ton for a 10 ton/hr ATP system. The factors identified by the vendor that affect costs include:

- Moisture content of feed material;
- Particle size;
- Hydrocarbon content;
- Material handling characteristics; and
- Chemical characteristics.

Vendor estimates for mobilization and demobilization costs for a 10-ton per hour system range from $700,000 to $1.5 million. [17]

OBSERVATIONS AND LESSONS LEARNED

Performance Observations and Lessons Learned

- Thermal desorption using the ATP system was effective in treating contaminants in soil at the Pristine site to levels below the cleanup goals. In addition, levels of six of the 11 targeted constituents were reduced to concentrations at or below the reported detection limits.
- Thermal desorption using the ATP system was also effective in reducing levels of seven additional constituents to the reported detection limit of 400 µg/kg.
- All stack gas air emission performance standards were met in this application, including standards for particulates, opacity, dioxins and furans, hydrogen chloride, THC, and SO_2. Surrogate compounds were used to verify compliance for a 99.99% DRE

OBSERVATIONS AND LESSONS LEARNED (CONT.)

Performance Observations and Lessons Learned

for PAHs and pesticides (1,2,3-trichlorobenzene for PAHs and chloromethylbenzene for pesticides).

- Occasional THC spikes were measured at levels greater than the performance standard; the vendor attributed these spikes to burner malfunction.

Other Observations and Lessons Learned

- Because SO_2 control was a particular concern in this application, several methods were used to control SO_2 during this application, including chemical addition and wet scrubbing.

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Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Radian Corporation under EPA Contract No. 68-W3-0001.

Summary of Analytical Results for the Treated Soil Piles at the Pristine Superfund Site [16]
Data reported in ug/kg for all constituents

Pile Number		1	2	3	4	5	6	7	8	9	10	11
Sample Date	Cleanup	1 Nov 93	8 Nov 93	9 Nov 93	11 Nov 93	12 Nov 93	15 Nov 93	17 Nov 93	18 Nov 93	20 Nov 93	25 Nov 93	29 Nov 93
EPA Method	Goals	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270
Benzo(a)anthracene		370 U	370 U	380 U	380 U	380 U	380 U	370 U	380 U	380 U	370 U	370 U
Benzo(a)pyrene		370 U	370 U	380 U	380 U	380 U	380 U	370 U	380 U	380 U	370 U	370 U
Benzo(b)fluoranthene		370 U	370 U	380 U	380 U	380 U	380 U	370 U	380 U	380 U	370 U	370 U
Benzo(k)fluoranthene		370 U	370 U	380 U	380 U	380 U	380 U	370 U	380 U	380 U	370 U	370 U
Chrysene		370 U	370 U	380 U	380 U	380 U	380 U	370 U	380 U	380 U	370 U	370 U
Dibenzo(a,h)anthracene		370 U	370 U	380 U	380 U	380 U	380 U	370 U	380 U	380 U	370 U	370 U
Indeno(1,2,3-cd)pyrene		370 U	370 U	380 U	380 U	380 U	380 U	370 U	380 U	380 U	370 U	370 U
Total PAHs	1000	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
EPA Method		8080	8080	8080	8080	8080	8080	8080	8080	8080	8080	8080
Aldrin	15	4.5 U	4.5 U	4.6 U	4.6 U	4.5 U	4.6 U	4.4 U	4.5 U	4.5 U	4.5 U	4.5 U
4,4'-DDT	487	8.9 U	9.1 U	9.2 U	9.1 U	9 U	9.3 U	8.9 U	9.1 U	9 U	9 U	9 U
Dieldrin	6	4.5 U	4.5 U	4.6 U	4.6 U	4.5 U	4 U	4.4 U	4.5 U	4.5 U	4.5 U	4.5 U
EPA Method		8290	8290	8290	8290	8290	8290	8290	8290	8290	8290	8290
2,3,7,8-TCDD (Equivalent)	0.99	0.0123	0.00221	0.00371	0.0013 U	0.00126 U	0.000575	0.000635	0.0000277	0.000275	0.00104	0.000105 U
EPA Method		8240	8240	8240	8240	8240	8240	8240	8240	8240	8240	8240
Benzene	116	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	9	6 U	5 U
Chloroform	2043	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	5 U	6 U	5 U
1,2-Dichloroethane	19	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	5 U	6 U	5 U
1,1-Dichloroethene	285	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	5 U	6 U	5 U
Tetrachloroethene	3244	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	5 U	6 U	5 U
Trichloroethene	175	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	5 U	6 U	5 U

BDL - Below detection limit
N/A - Not available
Data Qualifiers:
U - Constituent was not detected above the detection limit specified. The detection limit is influenced by several factors, including initial sample size, dilution factor, matrix interferences, and instrument response; therefore, the detection limit may vary from sample to sample.

Summary of Analytical Results for the Treated Soil Piles at the Pristine Superfund Site [16]
Data reported in ug/kg for all constituents

Pile Number		12	13	14	15	16	17	18	19	20	21	22
Sample Date	Cleanup	30 Nov 93	2 Dec 93	3 Dec 93	6 Dec 93	7 Dec 93	12 Dec 93	14 Dec 93	17 Dec 93	20 Dec 93	20 Dec 93	22 Dec 93
EPA Method	Goals	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270
Benzo(a)anthracene		360 U	390 U	380 U	380 U	370 U	380 U	400 U	380 U	370 U	380 U	380 U
Benzo(a)pyrene		360 U	390 U	380 U	380 U	370 U	380 U	400 U	380 U	370 U	380 U	380 U
Benzo(b)fluoranthene		360 U	390 U	380 U	380 U	370 U	380 U	400 U	380 U	370 U	380 U	380 U
Benzo(k)fluoranthene		360 U	390 U	380 U	380 U	370 U	380 U	400 U	380 U	370 U	380 U	380 U
Chrysene		360 U	390 U	380 U	380 U	370 U	380 U	400 U	380 U	370 U	380 U	380 U
Dibenzo(a,h)anthracene		360 U	390 U	380 U	380 U	370 U	380 U	400 U	380 U	370 U	380 U	380 U
Indeno(1,2,3-cd)pyrene		360 U	390 U	380 U	380 U	370 U	380 U	400 U	380 U	370 U	380 U	380 U
Total PAHs	1000	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
EPA Method		8080	8080	8080	8080	8080	8080	8080	8080	8080	8080	8080
Aldrin	15	4.3 U	4.7 U	4.5 U	4.6	4.5 U	4.6 U	4.8 U	4.7 U	4.5 U	4.4 U	4.5 U
4,4'-DDT	487	8.6 U	9.4 U	9.1 U	9.2	9.1 U	9.2 U	9.6	9.3 U	8.9 U	8.9 U	9 U
Dieldrin	6	4.3 U	4.7 U	4.5 U	4.6	4.5 U	4.6 U	4.8	4.7 U	4.5 U	4.4 U	4.5 U
EPA Method		8290	8290	8290	8290	8290	8290	8290	8290	8290	8290	8290
2,3,7,8-TCDD (Equivalent)	0.99	0.000405	0.000562	0.000296	0.000225	0.0000715	0.000208	0.0000859	0.000204	0.000434	0.00016	0.000514
EPA Method		8240	8240	8240	8240	8240	8240	8240	8240	8240	8240	8240
Benzene	116	7	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
Chloroform	2043	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	9
1,2-Dichloroethane	19	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
1,1-Dichloroethene	285	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
Tetrachloroethene	3244	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
Trichloroethene	175	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U

BDL - Below detection limit
N/A - Not available
Data Qualifiers:
U - Constituent was not detected above the detection limit specified. The detection limit is influenced by several factors, including initial sample size, dilution factor, matrix interferences, and instrument response; therefore, the detection limit may vary from sample to sample.

Summary of Analytical Results for the Treated Soil Piles at the Pristine Superfund Site [16]
Data reported in ug/kg for all constituents

Pile Number		23	24	25	26	26 (Dup.)	27	28	29	30	31	32	33
Sample Date	Cleanup	3 Jan 94	3 Jan 94	5 Jan 94	10 Jan 94	10 Jan 94	12 Jan 94	14 Jan 94	17 Jan 94	18 Jan 94	20 Jan 94	24 Jan 94	31 Jan 94
EPA Method	Goals	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270
Benzo(a)anthracene		380 U	390 U	400 U	380 U	380 U	400 U	370 U	410 U	400 U	370 U	380 U	380 U
Benzo(a)pyrene		380 U	390 U	400 U	380 U	380 U	400 U	370 U	410 U	400 U	370 U	380 U	380 U
Benzo(b)fluoranthene		380 U	390 U	400 U	380 U	380 U	400 U	370 U	410 U	400 U	370 U	380 U	380 U
Benzo(k)fluoranthene		380 U	390 U	400 U	380 U	380 U	400 U	370 U	410 U	400 U	370 U	380 U	380 U
Chrysene		380 U	390 U	400 U	380 U	380 U	400 U	370 U	410 U	400 U	370 U	380 U	380 U
Dibenzo(a,h)anthracene		380 U	390 U	400 U	380 U	380 U	400 U	370 U	410 U	400 U	370 U	380 U	380 U
Indeno(1,2,3-cd)pyrene		380 U	390 U	400 U	380 U	380 U	400 U	370 U	410 U	400 U	370 U	380 U	380 U
Total PAHs	1000	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
EPA Method		8080	8080	8080	8080	8080	8080	8080	8080	8080	8080	8080	8080
Aldrin	15	4.5 U	4.7 U	4.7 U	4.6 U	4.6 U	4.8 U	4.6 U	4.9 U	4.8 U	4.5 U	4.6 U	4.5 U
DDT	487	9 U	9.4 U	9.3 U	9.2 U	9.2 U	9.1 U	9.1 U	9.7 U	9.8 U	9 U	9.1 U	9 U
Dieldrin	6	4.5 U	4.7 U	4.7 U	4.6 U	4.6 U	4.8 U	4.6 U	4.9 U	4.8 U	4.5 U	4.6 U	4.5 U
EPA Method		8290	8290	8290	8290	8290	8290	8290	8290	8290	8290	8290	8290
2,3,7,8-TCDD (Equivalent)	0.99	.000413	0.0000705	0.000595	0.000733	0.000415	0.000114	0.000189	0.0000542	0.0000436	0.00023	0.00138	0.000679
EPA Method		8240	8240	8240	8240	8240	8240	8240	8240	8240	8240	8240	8240
Benzene	116	6 U	5 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
Chloroform	2043	6 U	5 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
1,2-Dichloroethane	19	6 U	5 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
1,1-Dichloroethene	285	6 U	5 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
Tetrachloroethene	3244	6 U	5 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U
Trichloroethene	175	6 U	5 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U	6 U

BDL - Below detection limit
N/A - Not available
Data Qualifiers:
U - Constituent was not detected above the detection limit specified. The detection limit is influenced by several factors, including initial sample size, dilution factor, matrix interferences, and instrument response; therefore, the detection limit may vary from sample to sample.

Summary of Analytical Results for the Treated Soil Piles at the Pristine Superfund Site [16]
Data reported in ug/kg for all constituents

Pile Number		34	35	36	37	38	39	40	41	42	42 (Dup.)	43	44
Sample Date	Cleanup	N/A	N/A	N/A	N/A	22 Feb 94	22 Feb 94	22 Feb 94	26 Feb 94	28 Feb 94	28 Feb 94	1 March 94	4 March 94
EPA Method	Goals	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270	8270
Benzo(a)anthracene		N/A	N/A	N/A	N/A	0.38 U	0.38 U	0.38 U	0.36 U	0.38 U	0.38 U	0.37 U	0.37 U
Benzo(a)pyrene		N/A	N/A	N/A	N/A	0.38 U	0.38 U	0.38 U	0.36 U	0.38 U	0.38 U	0.37 U	0.37 U
Benzo(b)fluoranthene		N/A	N/A	N/A	N/A	0.38 U	0.38 U	0.38 U	0.36 U	0.38 U	0.38 U	0.37 U	0.37 U
Benzo(k)fluoranthene		N/A	N/A	N/A	N/A	0.38 U	0.38 U	0.38 U	0.36 U	0.38 U	0.38 U	0.37 U	0.37 U
Chrysene		N/A	N/A	N/A	N/A	0.38 U	0.38 U	0.38 U	0.36 U	0.38 U	0.38 U	0.37 U	0.37 U
Dibenzo(a,h)anthracene		N/A	N/A	N/A	N/A	0.38 U	0.38 U	0.38 U	0.36 U	0.38 U	0.38 U	0.37 U	0.37 U
Indeno(1,2,3-cd)pyrene		N/A	N/A	N/A	N/A	0.38 U	0.38 U	0.38 U	0.36 U	0.38 U	0.38 U	0.37 U	0.37 U
Total PAHs	1000	N/A	N/A	N/A	N/A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
EPA Method		8080	8080	8080	8080	8080	8080	8080	8080	8080	8080	8080	8080
Aldrin	15	N/A	N/A	N/A	N/A	4.6 U	4.5 U	4.6 U	4.3 U	4.5 U	4.5 U	4.4 U	4.4 U
DDT	487	N/A	N/A	N/A	N/A	9.1 U	9 U	9.2 U	8.6 U	9.1 U	9.1 U	8.8 U	8.9 U
Dieldrin	6	N/A	N/A	N/A	N/A	4.6 U	4.5 U	4.6 U	4.3 U	4.5 U	4.5 U	4.4 U	4.4 U
EPA Method		8290	8290	8290	8290	8290	8290	8290	8290	8290	8290	8290	8290
2,3,7,8-TCDD (Equivalent)	0.99	N/A	N/A	N/A	N/A	0.00024 U	0.0000659 U	0.000175 U	0.000152 U	0.000136	0.00021	0.0000629	0.000144
EPA Method		8240	8240	8240	8240	8240	8240	8240	8240	8240	8240	8240	8240
Benzene	116	N/A	N/A	N/A	N/A	6 U	6 U	6 U	5 U	6 U	6 U	5 U	5 U
Chloroform	2043	N/A	N/A	N/A	N/A	6 U	6 U	6 U	5 U	6 U	6 U	5 U	5 U
1,2-Dichloroethane	19	N/A	N/A	N/A	N/A	6 U	6 U	6 U	5 U	6 U	6 U	5 U	5 U
1,1-Dichloroethene	285	N/A	N/A	N/A	N/A	6 U	6 U	6 U	5 U	6 U	6 U	5 U	5 U
Tetrachloroethene	3244	N/A	N/A	N/A	N/A	6 U	6 U	6 U	5 U	6 U	6 U	5 U	5 U
Trichloroethene	175	N/A	N/A	N/A	N/A	6 U	6 U	6 U	5 U	6 U	6 U	5 U	5 U

BDL - Below detection limit
N/A - Not available
Data Qualifiers:
U - Constituent was not detected above the detection limit specified. The detection limit is influenced by several factors, including initial sample size, dilution factor, matrix interferences, and instrument response; therefore, the detection limit may vary from sample to sample.

Thermal Desorption at the T H Agriculture & Nutrition Company Superfund Site Albany, Georgia

Case Study Abstract

Thermal Desorption at the T H Agriculture & Nutrition Company Superfund Site, Albany, Georgia

Site Name:
T H Agriculture & Nutrition Company Superfund Site

Location:
Albany, Georgia

Contaminants:
Halogenated Organic Pesticides
- Dieldrin, toxaphene, DDT, lindane

Period of Operation:
July 1993 to October 1993

Cleanup Type:
Full-scale cleanup

Vendor:
Mark Fleri
Williams Environmental Services, Inc.
2076 West Park Place
Stone Mountain, GA 30087
(404) 498-2020

Technology:
Thermal Desorption
- Rotary dryer desorber
- Temperature of soil exiting heating chamber ranged from 833 to 1,080°F
- Soil residence time 15 minutes
- Offgases - routed through a baghouse, a water quenching unit, a reheater, and a vapor phase carbon adsorption bed

Cleanup Authority:
CERCLA (Removal Action) and State: Georgia
- Unilateral Administrative Order - 3/92
- PRP Lead

SIC Code:
2879 (Pesticides and Agricultural Chemicals, Not Elsewhere Classified)

Point of Contact:
R. Donald Rigger
On-Scene Coordinator
U.S. EPA Region IV
345 Courtland Street, N.E.
Atlanta, GA 30365
(404) 347-3931

Waste Source:
Manufacturing Process

Type/Quantity of Media Treated:
Soil
- 4,300 tons
- Bulk density - 125.8 to 129.7 lbs/ft^3; moisture content - 13 to 19%; pH - 5.7 to 6.2; particle size distribution - up to 2.38 mm; TOC - 0.2 to 0.23 mg/kg

Purpose/Significance of Application:
First full-scale application of thermal desorption under the Superfund program to remediate soil contaminated with a mixture of organochlorine pesticides.

Regulatory Requirements/Cleanup Goals:
Cleanup goals identified in March 1992 Unilateral Administrative Order and October 1992 Treatability Variance for proof-of-process performance test and full-scale treatment
- Total OCL pesticides < 100 mg/kg and 4 constituents (DDT, toxaphene, BHC-alpha, BHC-beta) > 90% measured reduction in concentration; air emissions - stack gas total hydrocarbons < 100 ppmv
- Additional air emissions limits during proof-of-process test - Georgia Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions

Results:
- The cleanup goals for soil were met for both total OCL pesticides and individual constituents
- Air emission standards were achieved during both the proof-of-process test and during the full-scale remediation
- Average OCL pesticides concentration in treated soil was 0.51 mg/kg
- Average removal efficiencies for individual constituents were greater than 98%

Thermal Desorption at the T H Agriculture & Nutrition Company Superfund Site, Albany, Georgia (Continued)

Cost Factors:
- Estimated Total Treatment Cost - $849,996 (including solids preparation and handling, mobilization, startup, system operation, and demobilization)
- Estimated Before-Treatment Costs - $252,582 (including mobilization and preparatory work, monitoring, sampling, testing, and analysis, including the treatability study)

Description:
The T H Agriculture & Nutrition (THAN) Company Superfund site in Albany, Georgia was used from the 1950s to 1982 for pesticide formulation and storage. As a result of these operations, soils at the site were contaminated with pesticides, primarily organochlorine (OCL) pesticides and the site was placed on the National Priorities List (NPL) in 1989. In March 1992, EPA issued a Unilateral Administrative Order to THAN for removal of contaminated soil and debris. Contaminated soil with concentrations of OCL pesticides greater than 1,000 mg/kg was excavated and stockpiled.

Thermal desorption was used at THAN to treat approximately 4,300 tons of stockpiled soil contaminated with OCL pesticides. The thermal desorption unit consisted of a rotary kiln thermal desorber operated at 833 to 1,080°F (soil exit temperature) and a 15-minute residence time. An interlock (waste feed cutoff) process control system was used in this application to maintain operation of the unit within allowable limits. The system was operated from July to October 1993. Thermal desorption achieved the specified cleanup levels for OCL pesticides and air emission rates. Total OCL pesticide concentrations in the treated soil ranged from 0.009 to 4.2 mg/kg with an average concentration of 0.5 mg/kg. Average removal efficiencies for the four target OCL pesticides were greater than 98%.

The total estimated treatment cost for this application was approximately $850,000. The proof-of-process performance test results provided information on operating conditions and air emissions that were used for the full-scale treatment application. In addition, the bench-scale treatability study provided data to support a treatability variance request by THAN, approved by EPA in October 1992, to place treated soils on site.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report presents cost and performance data for a thermal desorption treatment application at the T H Agriculture & Nutrition (THAN) Company Superfund site in Albany, Georgia. Stockpiled soil contaminated with organochlorine (OCL) pesticides was treated as part of a removal action. This project is notable for being the first full-scale thermal desorption treatment application of soil containing a mixture of OCL pesticides at a Superfund site. In addition, an interlock process control system was used to monitor process parameters.

The THAN site, used from the 1950s to 1982 for pesticide formulation and storage, was placed on the National Priorities List (NPL) in 1989. In March 1992, EPA issued a Unilateral Administrative Order (UAO) to THAN for a soil and debris removal action at the site. An estimated 4,300 tons of soil with concentrations of total OCL pesticides equal to or greater than 1,000 mg/kg was excavated and stockpiled at the site. Initially, the stockpiled soil was to be transported to an off-site incinerator for treatment. However, because the actual volume of stockpiled soil was over four times the initial estimate of 1,000 tons, on-site thermal desorption, with subsequent placement of treated soils on-site, was used.

The UAO established a treatment goal of less than 100 mg/kg for total OCL pesticides in the treated subsurface soil. A Treatability Variance (TV), received in October 1992, allowed the treated soil to be placed on site after treatment and required a minimum reduction of 90% in concentration of specific OCL pesticides. Air emission limitations for the thermal desorber stack gas were established through negotiation with EPA.

The full-scale thermal desorption system operated from July to October 1993 and was used to treat approximately 4,300 tons of contaminated soil. Total OCL pesticide concentrations in the treated soil at THAN ranged from 0.009 to 4.2 mg/kg during the full-scale operation, with an average concentration of 0.5065 mg/kg. Average removal efficiencies achieved for the four target OCL pesticides were greater than 98 percent.

Prior to full-scale operation, a process shakedown and proof-of-process performance test were conducted to verify the effectiveness of the operating conditions. In addition, a shakedown pretest was conducted to evaluate the materials handling portion of the system.

Based on a petition for reimbursement, the cost for thermal desorption at THAN was approximately $1.1 million, including approximately $850,000 in costs directly attributed to treatment activities (corresponding to $200/ton of soil treated).

SITE INFORMATION

Identifying Information

T H Agriculture & Nutrition Company Superfund Site
Albany, Georgia

Action Memorandum Date: Not available

Treatment Application

Type of Action: Removal
Treatability Study Associated with Application? Yes (See Appendix A)
EPA SITE Program Test Associated with Application? No
Duration of Action: *March 1992 - February 1994*
Period of Operation: July to October 1993
Quantity of Soil Treated During Application: 4,318 tons

SITE INFORMATION (CONT.)

Background

Historical Activity that Generated Contamination at the Site: Agricultural Pesticides Formulation and Storage

Corresponding SIC Code: 2879 (Pesticides and Agricultural Chemicals, Not Elsewhere Classified)

Waste Management Practice that Contributed to Contamination: Manufacturing process

Site History: The 7-acre T H Agriculture & Nutrition Company (THAN) facility is located in Albany, Georgia, as shown in Figure 1. From the mid-1950s until 1967, the site was used by other companies for the storage and formulation of pesticides. Typical activities for formulating pesticides included preparation of dry and liquid formulations, and blending pesticides with solvents. THAN purchased the site in 1967 and continued pesticide formulation operations until 1978. The site was used by THAN as a storage and distribution center until 1982. [3]

In 1982, the Georgia Environmental Protection Division (GEPD) determined that the soil and groundwater at the site were contaminated primarily with OCL pesticides and solvents as a result of site activities. The site was placed on the National Priorities List (NPL) in March 1989. [3]

Regulatory Context: In response to a UAO issued by EPA in March 1992 for a soil and debris removal action, THAN excavated soil from areas where a 50 mg/kg concentration in surface soils and 100 mg/kg concentration in subsurface soils of total OCLs was exceeded. A total of 29,000 tons of contaminated soil and debris were excavated from these areas. Approximately 4,300 tons of excavated soil was stockpiled on site for further treatment. Initially the stockpiled soil was to be transported to an off-site incinerator for treatment. However, because the actual volume of stockpiled soil was over four times greater than the initial estimate of 1,000 tons, on-site thermal desorption, with subsequent placement of treated soils on-site, was used. The stockpiled soil was identified as containing listed hazardous wastes with RCRA waste codes P037 (dieldrin), P123 (toxaphene), U061 (DDT and metabolites), U129 (lindane), and U239 (xylenes). The remaining 24,700 tons were disposed off-site. [3]

Figure 1. Site Location

A TV, received from EPA Region 4 on October 27, 1992, set treatment standards for on-site thermal desorption of the stockpiled soils and approved a plan to place and cover thermally treated soils on site with a minimum of 2 feet of clean soil. In addition, air emissions limits were established for the thermal desorber stack gas. [3]

Prior to approval of the full-scale remediation work plan, THAN was required to show proof-of-process in a performance test. A shake-down pretest was performed to evaluate the materials handling portion of the system. The proof-of-process performance test was run in July 1993. Based on the proof-of-process performance test results, EPA Region 4 provided the required approval to conduct full-scale treatment activities in August 1993. Full-scale treatment activities began in August 1993 and concluded in October 1993. Demobilization of the unit was completed in January 1994. [4, 8, 9]

SITE INFORMATION (CONT.)

Site Logistics/Contacts

Site Management: PRP Lead

Oversight: EPA

On-Scene Coordinator:
R. Donald Rigger
U.S. Environmental Protection Agency
Region 4
345 Courtland Street, N.E.
Atlanta, Georgia 30365
(404) 347-3931

Contractor:
Mark Fleri
Project Manager
Williams Environmental Services, Inc.
2076 West Park Place
Stone Mountain, Georgia 30087
(404) 498-2020

Project Oversight:
William L. Troxler, P.E.
Focus Environmental, Inc.
9050 Executive Park Drive, Suite A-202
Knoxville, Tennessee 37923
(615) 694-7517

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Soil (ex situ)

Contaminant Characterization

Primary Contaminant Groups: Halogenated Organic Pesticides

THAN conducted an RI between December 1990 and September 1991 including soil, groundwater, and other media sampling. Constituents identified at the site included organochlorine (OCL) pesticides, organophosphorus (OP) pesticides, polychlorinated biphenyls (PCBs), chlorinated herbicides (CHs), volatile and semivolatile organics, as well as inorganics. [3] The OCL pesticide constituents were analyzed using EPA Method 8080.

Matrix Characteristics Affecting Treatment Cost or Performance

Listed below in Table 1 are the major matrix characteristics affecting cost or performance, and the values measured for each.

Specific particle size distribution data were measured for the stockpiled soil and are provided below in Table 2. The soil was described as containing large clumps of clay. The impact of high clay content material on the system operation is discussed in the *Thermal Desorption System Description and Operation* section of this report.

Table 1. Matrix Characteristics [13]

Parameter	Value	Measurement Method
Soil Classification	Not Provided	-
Clay Content and/or Particle Size Distribution	See Table 2	-
Bulk Density	125.8 to 129.7 lbs/ft^3	Not Available
Lower Explosive Limit	Not Available	-
Moisture Content	13 to 19%	ASTM D2216
pH	5.7 to 6.2	ASA #9
Total Organic Carbon (TOC)	0.2 to 0.23%	Not Available
Oil and Grease or Total Petroleum Hydrocarbons	Not Available	—

Table 2. Particle Size Distribution of Stockpiled Soil [13]

Particle Size (millimeters)	Distribution (percent)
0 - 0.074	0.8 - 1.2
0.074 - 0.149	5.6 - 8.0
0.149 - 0.297	18.4 - 20.4
0.297 - 0.590	21.2 - 22.0
0.590 - 1.19	12.2 - 12.4
1.19 - 2.38	36.8 - 41.0

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology Type

Thermal Desorption

Supplemental Treatment Technology Types

Pretreatment (Solids): Screening
Post-Treatment (Air): Baghouse, Quench, Air Cooler, Induced Draft Fan, Carbon Adsorption, Condenser
Post-Treatment (Solids): Quench
Post-Treatment (Water): Carbon Adsorption

Thermal Desorption Treatment System Description and Operation [8, 10]

The Williams Environmental Services, Inc. Thermal Desorption Processing Unit (TPU) #1, used to treat soils at the THAN site and shown in Figure 2, consisted of a feed system, a countercurrent rotary desorber, and a cooling system for the treated soil. Off-gasses were routed through a baghouse, a water quenching unit, a reheater, and a vapor phase carbon adsorption bed, as shown in Figure 2. Quench water was routed through a liquid-phase carbon adsorption bed. Treated solids from the system were mixed with baghouse fines and redeposited on site. Off-gases were vented to the atmosphere through a stack, after treatment in the air pollution control (APC) unit. The activated carbon beds were regenerated off site.

An interlock process control system was utilized to maintain operation of the TPU #1 system within allowable limits. In the event that any of the limits were breached, the interlock system was designed to automatically shut down the feed system. Parameters monitored on either an instantaneous or rolling average included the elements listed in the following table. Cutoff conditions for the interlock system are also shown below on Table 3.

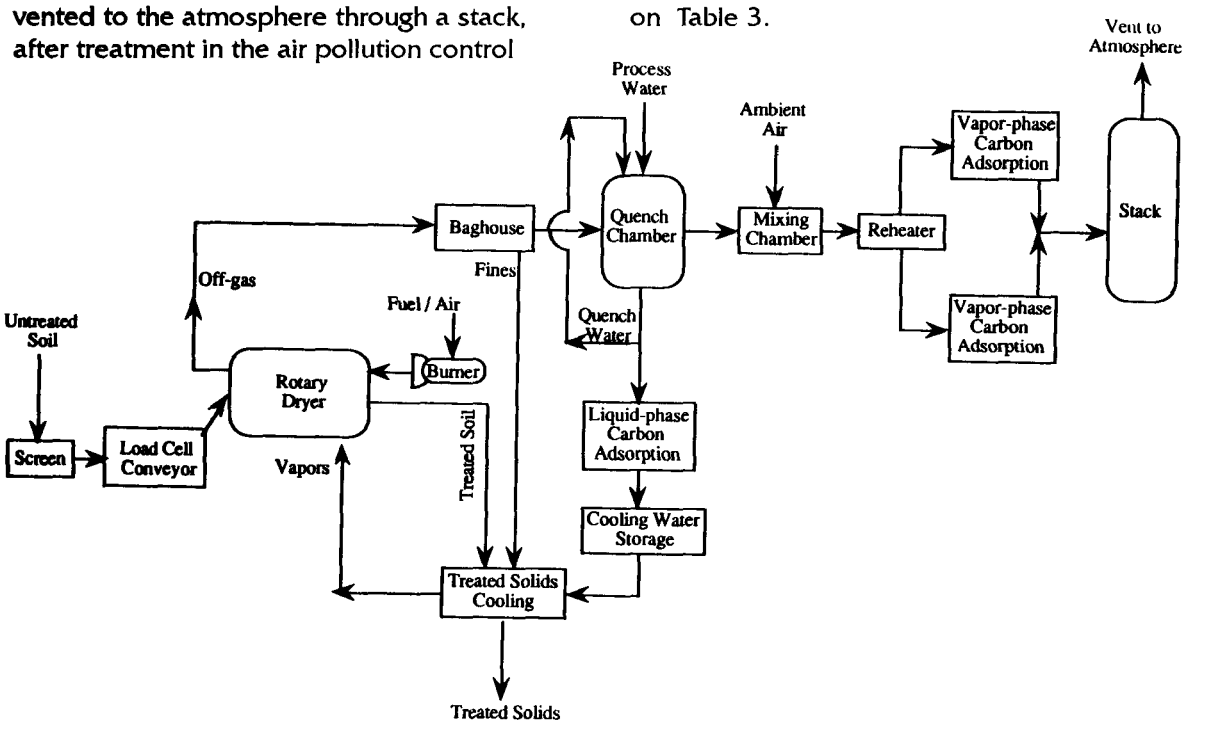

Figure 2. Williams Environmental Services, Inc. Thermal Desorption Unit, TPU #1 Used at THAN Facility, Albany, Georgia [8]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Thermal Desorption Treatment System Description and Operation (cont.)

Table 3. Interlock System Cutoff Conditions [9]

Interlock System Process Parameter	Cutoff Condition	Type of Monitoring and/or Cutoff
Minimum Desorber Exit Gas Temperature	250°F	1-minute time delay
Maximum Desorber Exit Gas Temperature	510°F	Instantaneous, vent opens, automatic waste feed shutoff
Maximum Soil Feed Rate	7.8 tons/hour	20-minute rolling average
Minimum Treated Soil Exit Temperature	875°F	20-minute delay
Minimum Quench Recycle Liquid Pressure	5 psi	5-minute time delay
Maximum Quench Exit Gas Temperature	200°F	Instantaneous, vent opens, automatic waste feed shutoff
Minimum Baghouse Differential Pressure	1-inch water column	Instantaneous
Power Failure	—	Instantaneous, vent opens
Maximum Stack Gas Total Hydrocarbons	100 ppmv	20-minute rolling average

A process change was made prior to full-scale treatment activities based on automatic cutoffs during the proof-of-process performance test. Insufficient fan capacity triggered several cutoffs based on the maximum rotary dryer pressure of 0.00 inches of water; the fan was replaced prior to conducting full-scale treatment activities.

The TPU #1 feed system consisted of a shaker screen, a conveyor belt, and an automated load cell that was connected to the interlock system. The shaker screen removed clay clumps and other material greater than 3/4 inch in size from the soil stockpile. These clay clumps were crushed using a front-end loader and re-introduced into the desorber.

The TPU #1 soil treatment unit consisted of a countercurrent flow rotary dryer, a propane-fired burner unit, a primary mover unit, and a soil quench system. The desorber was a direct-fired, rotating, inclined cylindrical drum 5 feet in diameter and 22 feet in length, and was constructed from a combination of carbon steel and stainless steel. The primary burner was rated at 21,000,000 Btu/hr and fired with propane in air. A centrifugal fan maintained a negative pressure through the desorber with an average flow of 15,056 actual cubic feet per minute (acfm). The burner gas enhanced the volatilization and transport of organic contaminants from the soil. Desorption was enhanced by the drum's rotation as well as internal flights that lifted and spilled soils in the heated regime of the dryer. Actual soil exit temperatures during the performance test were measured between 833 and 1,085°F. Treated soils exited at the burner end of the unit via a screw conveyor where they were mixed with fines from the baghouse and quenched with process water to suppress dust emissions. A negative pressure was maintained throughout the transport system to capture vapors from the quenching process. The screw conveyor discharged the treated solids to a stacking conveyor for stockpiling. The treated soil was deposited on site.

The TPU #1 exhaust gas treatment system consisted of a baghouse, a quench chamber, a mixing chamber, a reheater, an induced draft fan, and a vapor-phase carbon adsorption system. The off-gases were fed into a pulse jet baghouse, which consisted of an enclosed series of fine-mesh cloth filters to remove particulates. The baghouse operated at temperatures up to 500°F and a maximum air-to-cloth ratio of 5:1. The baghouse fines were discharged from the hoppers via a conveyor system to the treated soils transport unit. The baghouse off-gases were then quenched by flash evaporation of water in a quench chamber, which cooled the gas to the adiabatic saturation temperature of 165°F. The exhaust gas from the quench unit was passed through a demister, and then cooled to 140°F by

TREATMENT SYSTEM DESCRIPTION (CONT.)

Thermal Desorption Treatment System Description and Operation (cont.)

mixing with ambient air. To control potential condensation, the gases were then reheated to 150°F and fed through a parallel dual-bed (12,000 pounds per bed) carbon adsorption system. The treated off-gases were then vented to the atmosphere through a 45 foot vertical stack.

A portion of the quench water was recycled back to the spray nozzles in the spray tower at a rate of approximately 30 gpm. This recycle was monitored for pH and for the presence of acid gases. Caustic soda (50% NaOH) was added when neutralization was necessary. The remaining quench water was treated with a liquid-phase carbon adsorption system and then stored for use in cooling treated soils. Both the liquid- and vapor-phase carbon adsorption beds were regenerated off site at Westates Carbon in Parker, Arizona.

Prior to full-scale system operation, a shakedown pretest and proof-of-process performance test were conducted using 268 tons of the stockpiled soil. The shakedown pretest was used to evaluate the materials handling portion of the system. During the pretest, large clumps of clay were found in the soil stockpile, and were identified as a potential problem for obtaining good heat transfer in the desorber. A shaker screen was added to the system to limit materials to 3/4 inch in size prior to the proof-of performance test. [8]

The proof-of-process performance test was conducted at the THAN facility on July 22, 23, and 25, 1993. Four runs were conducted on approximately 152 tons of the stockpiled soils to demonstrate that the soil could be treated to the target levels while not exceeding air emissions set for the remediation. On average, the soil feed rate was 8.3 tons per hour, soil temperature was 1,000°F, and the exhaust temperature was 319°F. The results indicated that all treated soil target levels could be met while not exceeding the air standards.

Full-scale treatment activities at the THAN facility began on August 12, 1993, and continued until October 1993. Sampling and analysis of soils beneath the stockpile area and in the area around the thermal desorption system occurred after the full-scale treatment was completed to verify that all soils on site above EPA's action levels had been treated.

The treated soils were placed on site as was stipulated in the treatability variance. Personal protective equipment, debris, and construction waste were landfilled at a Chemical Waste Management facility in Carlyss, Louisiana. Demobilization of the unit was completed in January 1994.

Operating Parameters Affecting Treatment Cost or Performance [8 and 10]

Listed below in Table 4 are the major operating parameters affecting cost or performance for thermal desorption and the values measured for each during this treatment application.

Table 4. Operating Parameters [8, 10]

Parameter	Value
Stack Gas Air Flow Rate	15,056 acfm (average)
Heating Chamber Maximum Operating Pressure	0.0 inches water column
Soil Residence Time per Pass	15 minutes
Number of Passes	1
System Throughput	7.29 to 9 5 tons/hour
Temperature of Soil Exiting Heating Chamber	833 to 1,080°F
Heating Chamber Exhaust Gas Temperature	284 to 332°F
Baghouse Differential Pressure	1.8 to 2.2 inches water column
Maximum Quench Exhaust Temperature	200°F
Minimum Quench Recycle Liquid Pressure	5 psig
Carbon Adsorption Inlet Gas Temperature	141 to 150°F
Minimum APC System Purge Rate	1 gpm
Minimum APC System Water Supply Pressure	20 psig

TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

A timeline for this application is shown in Table 5.

Table 5. Timeline [8]

Start Date	End Date	Activity
Mid-1950s	1982	Pesticide formulating and storage operations conducted at site.
October 1982	1989	GEPD conducted initial site visits and identified soil and groundwater contamination. THAN conducted studies to evaluate the nature and extent of contamination.
July 1984	September 1984	Removed and disposed of 10,400 tons of soil and debris at a hazardous waste landfill.
March 1989	—	THAN placed on National Priorities List.
March 1992	—	EPA issed a Unilateral Administrative Order for removal action.
April 1992	—	Disposal of 24,700 tons of soil and debris at a hazardous waste landfill.
June 1992	—	Bench-scale treatability study for thermal desorption.
October 1992	—	Treatability Variance granted.
July 1993	—	Full-scale Proof-of-Process Performance Test.
August 1993	October 1993	Full-scale treatment activity.
January 1994	—	Demobilization completed.

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

Cleanup goals for the thermal desorption application at THAN were identified in a March 1992 UAO. An October 1992 TV provided additional treatment requirements for the soil, and negotiations with EPA established air emission standards for the project. The treatment requirements for both the proof-of-process performance test and full-scale treatment activities are shown below in Table 6. [9, 11, 12] The constituents included in the parameter "Total OCL Pesticides" include aldrin, alpha-BHC, beta-BHC, delta-BHC, lindane, chlordane, DDT, DDD, DDE, dieldrin, endosulfan I, endosulfan II, endrin, and toxaphene. [3]

Table 6. Treatment Requirements [9, 11, 12]

Constituent/Parameter	Soil Cleanup Goal	Source	Required During Proof-of-Performance Test	Required During Full-Scale Treatment Activity
4,4'-DDT	>90% measured reduction in concentration	Treatability Variance	✓	✓
Toxaphene	>90% measured reduction in concentration	Treatability Variance	✓	✓
BHC-alpha	>90% measured reduction in concentration	Treatability Variance	✓	✓
BHC-beta	>90% measured reduction in concentration	Treatability Variance	✓	✓
Total OCL Pesticides	<100 mg/kg	Unilateral Administrative Order and Treatability Variance	✓	✓

TREATMENT SYSTEM PERFORMANCE (CONT.)

Cleanup Goals/Standards (Cont.)

Air emission standards for stack gas THC, HCl, and particulates were established in negotiations with EPA, as shown in Table 7.

Table 7. Air Emission Standards [8]

Constituent/Parameter	Air Emission Standards	Source	Required During Proof-of-Performance Test	Required During Full-Scale Treatment Activity
Stack Gas Total Hydrocarbons	100 ppmv	Negotiations with EPA	✓	✓ (operating parameter)
HCl Mass Emission Rate	<4 lbs/hr	Negotiations with EPA	✓	
Stack Gas Particulates	<0.08 gr/dscf	Negotiations with EPA	✓	
Toxaphene	As shown on Figure 3	Georgia Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions	✓	
4,4'-DDT	As shown on Figure 4	Georgia Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions	✓	

Additional Information on Goals [3, 9]

Soil cleanup goals were developed in two stages. A goal of 100 mg/kg for total OCL pesticides on a dry-weight basis was first provided in the UAO. Additional goals for measured reductions in concentration of target constituents were then developed for a TV based on *Superfund LDR Guide #6B - Obtaining a Soil and Debris Treatability Variance for Removal Actions* (Directive 9347.3-06BFS). Soil cleanup goals required to be demonstrated during the proof-of-process performance test and full-scale treatability activity included a minimum reduction of 90% in concentration of BHC (alpha and beta), 4,4'-DDT, and toxaphene; and less than 100 mg/kg total OCL pesticides in the treated soil. Since the stockpile had been characterized and 90% reduction had been achieved during the performance test, no feed samples were required for collection or analysis during the full-scale operation, provided that the system operated within the proposed operating conditions agreed upon by THAN and EPA.

Air emission standards were developed through negotiations with EPA. Stack gas particulates and HCl emission rate limits were based on requirements in 40 CFR Part 264.343 (which provides standards for incinerator emissions). A THC emission limit of 100 ppmv based on a 60-minute rolling average was developed by EPA using the following assumptions:

1. Feed soil containing approximately 1% total organic material, such as humic materials;
2. A stack gas flow rate of 56,420 lbs/hr (dry basis), or 1,947 mols/hr; and
3. The APC system achieving a removal efficiency of between 93% and 96% for non-methane hydrocarbons.

Air emissions standards for toxaphene and DDT were developed based on compliance with Georgia's Guidelines for Ambient Impact Assessment of Toxic Air Pollutant Emissions. The attached graphs (Figures 3 and 4) showing acceptable ambient concentrations for toxaphene and DDT were developed based on site-specific air emission modeling conducted at the THAN site. The concentrations shown on the graphs are a

TREATMENT SYSTEM PERFORMANCE (CONT.)

Additional Information on Goals [3, 9] (Cont.)

function of THAN's operating schedule and air pollution control equipment removal efficiency. For example, at the maximum operating schedule of 24 hours per day, 7 days per week, the required removal efficiency shown on Figure 3 for toxaphene is 96 percent.

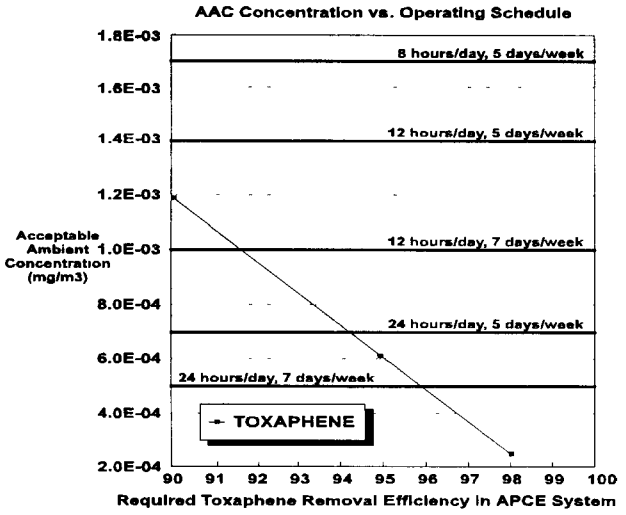

Figure 3. Toxaphene AAC Values vs. Operating Schedule

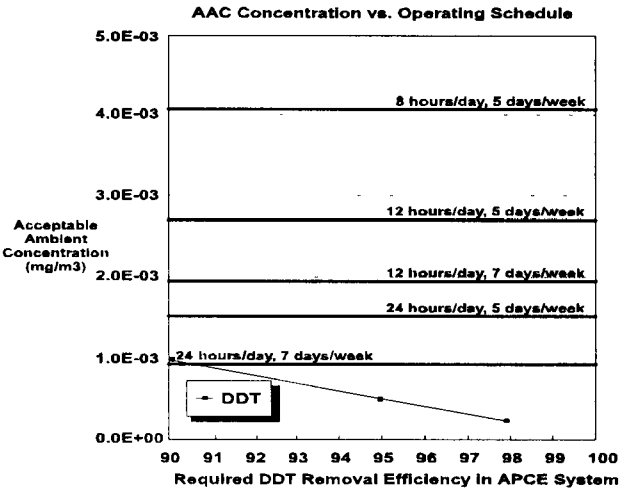

Figure 4. DDT AAC Values vs. Operating Schedule

Treatment Performance Data [8]

Performance data for the thermal desorption treatment application at THAN include proof-of-process performance test data results and full-scale treatment activity data results. These data are presented in the following tables.

Soil data were obtained during the proof-of-process performance test by collecting process samples of untreated and treated soil. One composite sample was collected per run, consisting of grab samples collected at approximately 15-minute intervals during treatment operations. The samples were collected using procedures in EPA SW-846, "Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods." Each composite sample was analyzed using EPA Method 8080 for OCL pesticides.

Data presented in Table 8 represent the averages of the four composite samples collected during the four runs conducted during proof-of-process performance test.

Air emissions data for stack gas OCL pesticides from the proof-of-process performance test were obtained through sampling activities conducted using EPA's Modified Method 5 Sampling Train. Stack gas particulates and HCl were measured using EPA's Method 5 Sampling Train, and stack gas total hydrocarbon concentrations were monitored with a continuous emission monitoring (CEM) system using EPA Method 25A. Data were collected during each of the four runs from the proof-of-process performance test, and are presented in Table 9.

Soil data were obtained during the full-scale treatment activities by collecting and compositing samples of treated soils and are presented in Table 10. A total of 18 composite samples were collected and analyzed for OCL pesticides using EPA Method 8080.

Average untreated soil concentrations presented in Table 10 are values from the proof-

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (cont.)

Table 8. Proof-of-Process Performance Test Soil Data [8]

Constituent/Parameter	Cleanup Goal	Average Untreated Soil Concentration (mg/kg)	Average Treated Soil Concentration(b) (mg/kg)	Range of Percent Removal (%)	Average Percent Removal (%)(c)
Aldrin	N/A	Not available(a)	<0.017	Not available	>98.64
BHC-alpha	>90% measured reduction in concentration	1.9	<0.017	>92.6 to >99.7	97.84
BHC-beta	>90% measured reduction in concentration	4.5	<0.017	>92.4 to 99.81	97.89
BHC-delta	N/A	Not available(a)	<0.017	Not available	>98.28
Lindane (BHC-gamma)	N/A	Not available(a)	<0.017	Not available	>98.50
Chlordane-alpha	N/A	Not available(a)	<0.017	Not available	>98.50
Chlordane-gamma	N/A	Not available(a)	<0.017	Not available	>98.50
Dieldrin	N/A	Not available(a)	<0.033	Not available	>98.34
4,4'-DDD	N/A	Not available(a)	<0.033	Not available	>98.50
4,4'-DDE	N/A	9.48	2.94	0.0 to 98.98(d)	Not available(d)
4,4'-DDT	>90% measured reduction in concentration	212.6	<0.017	>99.6 to >99.99	99.89
Endosulfan	N/A	9.33	<0.033	Not available	>99.65
Endosulfan II	N/A	Not available(a)	<0.017	Not available	>98.64
Endrin	N/A	Not available(a)	<0.033	Not available	>98.64
Toxaphene	>90% measured reduction in concentration	257.7	<1.70	>97.0 to 99.72	98.98
Total OCL Pesticides	<100 mg/kg	Not available	4.01	Not available	Not available

N/A = Not Applicable.
(a)An average of the four proof-of-process samples was not calculated because one or more of the constituents was "not detected" in the untreated soil sample.
(b)Concentrations represent the average value of treated soil composite samples.
(c)Average of the four percent removals calculated for each sample collected during four proof-of-performance test runs.
(d)Analytical results indicated that 4,4'-DDE concentration increased in Run #3. Therefore, the percent removal shown as 0.0% for Run #3, and an average percent removal was not calculated.

Table 9. Proof-of-Process Performance Test Air Emissions Data [8, 14]

Constituent/Parameter	Air Emission Standard	Average Emission Rate or Concentration	Range of Emission Rates or Concentrations
Stack Gas Total Hydrocarbons	100 ppmv	11.9 ppmv	2.9 to 35.5 ppmv
HCl Mass Emission Rate	<4 lbs/hr	0.12 lbs/hr	0.12 to 0.13 lbs/hr
Stack Gas Particulates	<0.08 gr/dscf	0.0006 gr/dscf	0.0005 to 0.0007 gr/dscf
Toxaphene(a)	1.48 $\mu g/m^3$	0.045 $\mu g/m^3$	Not available
4,4'-DDT(a)	2.96 $\mu g/m^3$	ND	Not available

ND = Not Detected.
(a) Allowable Ambient Air Concentrations were developed based on Georgia's Guidelines for Ambient Impact Assessment of Toxic Air Pollutant Emissions. Stack emissions calculated from the measured ambient concentrations of toxaphene and 4,4'-DDT were all ND.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (cont.)

Table 10. Full-Scale Treatment Activity Soil Performance Data [8]

Constituent/Parameter	Soil Cleanup Goal	Average Untreated Soil Concentration(a) (mg/kg)	Average Treated Soil Concentration (mg/kg)	Range of Percent Removal (%)(c)	Average Percent Removal (%)(c)
Aldrin	N/A	Not available(b)	<0.0365	Not available	Not available
BHC-alpha	90% measured reduction in concentration	1.9	<0.0399	>91.19 to >99.96	>98.97
BHC-beta	90% measured reduction in concentration	4.5	<0.0383	>96.22 to >99.98	>99.57
BHC-delta	N/A	Not available(b)	<0.0376	Not available	Not available
Lindane (BHC-gamma)	N/A	Not available(b)	<0.0365	Not available	Not available
Chlordane-alpha	N/A	Not available(b)	<0.0365	Not available	Not available
Chlordane-gamma	N/A	Not available(b)	<0.0365	Not available	Not available
Dieldrin	N/A	Not available (b)	<0.0703	Not available	Not available
4,4'-DDD	N/A	Not available(b)	<0.0703	Not available	Not available
4,4'-DDE	N/A	9.48	<0.4413	Not available	>97.67
4,4'-DDT	90% measured reduction in concentration	212.6	<0 0710	>99.85 to >99.99	>99.98
Endosulfan	N/A	9.33	<0.0365	Not available	>99.80
Endosulfan II	N/A	Not available(b)	<0 0703	Not available	Not available
Endrin	N/A	Not available(b)	<0.0703	Not available	Not available
Toxaphene	90% measured reduction in concentration	257.7	<3 6456	>93.40 to >99.97	>99.29
Total OCL Pesticides	<100 mg/kg	Not available	0.5065	Not available	Not available

N/A = Not Applicable.

(a)Untreated soil concentrations shown were measured during the proof-of-process performance test (see Table 8), because sampling and analysis of untreated soil was not required during full-scale treatment activities.

(b)An average of the four proof-of-process performance test samples was not provided because one or more of the concentrations was "not detected."

(c)Percent removal calculations used one-half (0.5) of the detection limit. Data used for these calculations are presented in Appendix B.

of-process performance test. Sampling and analysis of untreated soil was not required during full-scale treatment activities, as specified in EPA's letter of approval following the proof-of-process performance test. Treated soil concentrations shown in Table 3 represent the average concentration of the 18 samples collected. Average percent removal was calculated by averaging the 18 separate values for percent removal of that constituent. The average treated soil concentration of total OCL pesticides of 0.5065 mg/kg represents the average of concentrations that ranged from 0.009 mg/kg to 4.2 mg/kg.

A complete data set for the 18 samples collected and analyzed during the full-scale treatment activity is provided in Appendix B.

Air emissions data, other than monitoring of THC in stack gas, were not required to be collected during the full-scale treatment activities. Because THAN met the treatment and emission standards during the proof-of-process performance test, EPA was satisfied that the established operating parameters would ensure attainment of the additional air emission goals during full-scale treatment activities.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment

The cleanup goal of 100 mg/kg total OCL pesticides in treated soils at the THAN site was achieved by the thermal desorption system. The average total OCL pesticides concentration in the treated soil was 0.5065 mg/kg during the full-scale treatment activities.

Average removal efficiencies measured during full-scale treatment activities of the thermal desorption system (averaged from 18 composite sample results) were greater than 98.97% for BHC-alpha, 99.57% for BHC-beta, 99.98% for 4,4'-DDT, and 99.29% for toxaphene. The individual sample removal efficiencies ranged from 91.19% to 99.99%. The treatment goal of 90% reduction of concentration established in the TV was achieved for the specified constituents.

The proof-of-process performance test results indicated that air emissions from the thermal desorption system achieved the air emission standards for particulate concentrations and HCl emission rates, Acceptable Ambient Concentrations for 4,4'-DDT and toxaphene developed from Georgia's Air Toxics Guidelines, and EPA-approved THC concentrations in the stack gas.

Performance Data Completeness

Performance data available from the thermal desorption treatment application at the THAN facility include soil performance test data from the proof-of-process performance test and the full-scale treatment activities, and air emissions data from the proof-of-process performance test. These data characterize the treated soil matrix for OCL pesticides from the full-scale treatment activities. In the proof-of-process performance test, constituent concentrations for OCL pesticides in untreated soil are matched with treated soil concentrations, and linked to specific operating conditions.

Performance Data Quality

All samples were analyzed using EPA-approved methods and data validation procedures. A QA/QC review was performed by Woodward-Clyde consultants for THAN and by Roy F. Weston, Inc for EPA. The results of this review indicated no technical data quality concerns. One deviation from EPA Method 8080 was noted; a wide-bore GC column was used instead of a packed GC column.

A single-point calibration was first conducted on toxaphene but was then reported with good agreement for a five-point calibration.

TREATMENT SYSTEM COST

Procurement Process

Eight vendors were contacted by THAN regarding the thermal desorption project. THAN evaluated the cost estimates provided by each vendor for mobilization/demobilization and per ton treatment, and also evaluated the vendor's treatability study experience, the vendor's experience treating hazardous waste (rather than petroleum contamination), vendor availability, equipment types, and anticipated processing rates. Based on this assessment, THAN contracted with Williams Environmental and prepared the detailed work plans for the project.

TREATMENT SYSTEM COST (CONT.)

Treatment System Cost

Treatment system costs were obtained from a Petition for Reimbursement submitted by THAN to EPA, as shown below in Tables 11 and 12. In order to standardize reporting of costs across projects, costs are shown in Tables 11 and 12 according to the format for an interagency Work Breakdown Structure (WBS). No costs were reported for the following elements in the WBS: liquid preparation and handling; training; cost of ownership; dismantling; site work; surface water collection and control; groundwater collection and control; air pollution/gas collection and control; solids collection and containment; liquids/sediments/ sludges collection and containment; drums/tanks/structures/miscellaneous demolition and removal; decontamination and decommissioning; disposal (other than commercial); disposal (commercial); site restoration; or demobilization (other than treatment unit).

Table 11. Treatment Cost Elements [15]

Cost Elements (Directly Associated with Treatment)	Cost (dollars)	Actual or Estimated ((A) or (E))*
Solids Preparation and Handling (equipment retrofit)	30,000	E
Vapor/Gas Preparation and Handling (equipment purchase, puffs)	4,885	E
Pads/Foundations/Spill Control (asphalt pad)	26,373	E
Mobilization/Set Up (mobilization)	50,000	E
Startup/Testing/Permits (performance test)	30,000	E
Operation (short-term; up to 3 years) (soil processing, air monitoring services, thermal treatment oversight, final report)	698,738	E
Demobilization (demobilization)	10,000	E
TOTAL TREATMENT COST	**849,996**	**E**

Average Cost per Ton: $849,996 ÷ 4,318 tons = $200/ton of soil treated

**Cost data were submitted by THAN in a Petition for Reimbursement, and have not been evaluated by EPA as of June 15, 1994.*

Table 12. Before -Treatment Cost Elements [15]

Cost Elements	Cost (dollars)	Actual or Estimated ((A) or (E))*
Mobilization and Preparatory Work (Focus' and Williams' work plan preparation, modeling)	148,263	E
Monitoring, Sampling, Testing, and Analysis (treatability study; Enseco engineering; untreated soil, treated soil, process water analyses, and puff air sample analyses; and respirable dust analyses)	104,319	E

**Cost data were submitted by THAN in a Petition for Reimbursement, and have not been evaluated by EPA as of June 15, 1994.*

Cost Data Quality

An assessment of cost data quality has not been completed to date. Cost data were submitted by THAN in a Petition for Reimbursement, and have not been evaluated by EPA Region 4 as of June 15, 1994.

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- Based on a petition for reimbursement, the cost for thermal desorption at THAN was approximately $1.1 million, including approximately $850,000 for activities directly attributed to treatment of 4,318 tons of soil.

Performance Observations and Lessons Learned

- The cleanup goal of 100 mg/kg total OCL pesticides in treated soils at the THAN site was achieved by the thermal desorption treatment system. The average total OCL pesticides concentration in the treated soil was 0.5065 mg/kg during the full-scale treatment activities.
- Average removal efficiencies measured during full-scale treatment activities of the thermal desorption system (averaged from 18 composite sample results) were greater than 98.97% for BHC-alpha, 99.57% for BHC-beta, 99.98% for 4,4'-DDT, and 99.29% for toxaphene. The individual sample removal efficiencies ranged from 91.19% to 99.99%. The cleanup goal of 90% reduction of concentration established in the TV was achieved for the specified constituents.
- The proof-of-process performance test results indicated that air emissions from the thermal desorption system achieved the air emission standards for particulate concentrations and HCl emission rates, Acceptable Ambient Concentrations for 4,4'-DDT and toxaphene developed from Georgia's Air Toxics Guidelines, and EPA-approved THC concentrations in the stack gas.
- The proof-of-process performance test successfully demonstrated that certain operating conditions (e.g., system throughput and soil exit temperature) would meet the soil treatment goals and air emission standards established for treating soil from the THAN site. Sufficient data were collected during the test to gain EPA's approval to conduct full-scale treatment activities.
- The bench-scale treatability study accurately predicted a removal efficiency of greater than 90% with effective removal of decomposition products.
- The bench-scale treatability study provided data required to support a treatability variance request submitted by THAN to EPA Region IV. The Treatability Variance, approved by EPA Region IV in October 1992, allowed THAN to place the treated soils on site. The treatability study also provided necessary data to select the thermal desorption temperature used in the full-scale treatment application.

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3. Williams Environmental Services, Inc. *Thermal Desorption Work Plan THAN Facility, Albany, GA.* Prepared for THAN. Stone Mountain, GA. July 1993.

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13. Data sets provided by John P. Cleary, P.E. from THAN, November 22, 1994.
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Analysis Preparation

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response, Technology Innovation Office. Assistance was provided by Radian Corporation under EPA Contract No. 68-W3-0001.

APPENDIX A—TREATABILITY STUDY RESULTS [2]

Treatability Study Objectives

Treatability Study Duration:
6/11/92 to 6/12/92

The purpose of the bench-scale treatability test was to determine the feasibility of treating OCL pesticide-contaminated soils from the THAN site using thermal desorption (i.e., achieving greater than 90% removal) and to evaluate the effects of varying temperature and residence time on pesticide removal efficiency to determine optimum operating range.

Treatability Study Test Description

The test was conducted by Williams Environmental Services at Deep South Laboratories in Homewood, Alabama. Contaminated soils from the THAN site (100 grams per batch) were treated in static trays at various residence times and temperatures. The trays were shallow pans. The pans were placed in a muffle furnace with nitrogen used as a purge gas to eliminate organic vapor saturation in the furnace. Fifteen OCL pesticides and two OP pesticides were targeted for analysis in determining the treatment removal effectiveness of thermal desorption using soils from the THAN site.

The ranges selected for the operating parameters used were based on known operating parameter limits of the rotary dryer and the physical characteristics (boiling point and

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Test Description (cont.)

volatility) of the OCL pesticides present in the THAN site soils. The following temperatures were tested: 500°F, 700°F, and 900°F. An initial temperature of 212°F was used to simulate the entrance of the soil into the rotary dryer, where the water in the soils are first vaporized. The temperature was then increased at a rate equivalent to the temperature gradient present in the rotary dryer. Residence times of 36 and 51 minutes were selected on the basis of the rotary dryer's normal operating range of 15 to 45 minutes.

	Pesticide Removal Efficiency (%)	
Test Temperature (°F)	36-Minute Residence Time(a)	51-Minute Residence Time(a)
500	>86.85	>90.28
700	>99.89	>99.90
900	>99.91	>99.91

(a)Residence time at target soil treatment temperature was six minutes for both scenarios. [8,9]

Treatability Study Performance Data

At a residence time of 36 minutes, pesticide removal efficiencies were greater than 99% at 700°F and 900°F. At 500°F, the pesticide removal efficiency was less than 90%. However, at a residence time of 51 minutes, pesticide removal efficiencies greater than 90% were achieved at all three test temperatures. Removal efficiencies were greater than 99% at 700°F and 900°F and greater than 90% at 500°F. At a temperature of 500°F, concentrations of 4,4'-DDE were greater in the post-treatment soils than in the pre-treatment soils. The vendor attributed this increase to thermal decomposition of 4,4'-DDT. It was determined that at the higher temperatures this additional decomposition product was removed as well.

Treatability Study Lessons Learned

The treatability test showed that thermal desorption was feasible for treatment of pesticide-contaminated soils at the THAN site. These results were further validated in the full-scale remediation where the cleanup goals were met using thermal desorption.

APPENDIX B—FULL-SCALE TREATMENT ACTIVITY SOIL DATA [8]

Sample ID	aldrin (ug/kg)	alpha BHC (ug/kg)	beta BHC (ug/kg)	delta BHC (ug/kg)	gamma BHC (ug/kg)	alpha Chlordane (ug/kg)	gamma Chlordane (ug/kg)	4'4' DDD (ug/kg)	4'4' DDE (ug/kg)	4'4' DDT (ug/kg)	Dieldrin (ug/kg)	Endosulfan I (ug/kg)	Endosulfan II (ug/kg)	Endrin (ug/kg)	Toxaphene (ug/kg)	Total(a) OCL Pesticides (ug/kg)
816-TS-P	<6.8	<6.8	<6.8	<6.8	<6.8	<6.8	<6.8	<13	70	<13	<13	<6.8	<13	<13	<680	70
817-TS-P	<6.8	<6.8	<6.8	<6.8	<6.8	<6.8	<6.8	<13	53	<13	<13	<6.8	<13	<13	<680	53
819-TS-P	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<3.3	<3.3	<3.3	<3.3	<1.7	<3.3	<3.3	<170	ND
829-TS-P-1	<6.8	<6.8	13	<6.8	<6.8	<6.8	<6.8	<13	600	27	<13	<6.8	<13	<13	<680	640
830-TS-P	<34	<34	<34	<34	<34	<34	<34	<66	260	<66	<66	<34	<66	<66	<3400	260
902-TS-P-1	<6.8	<68	30	<6.8	<6.8	<6.8	<6.8	<13	490	19	<13	<6.8	<13	<13	<680	1010
906-TS-P-1	<68	<68	<68	<68	<68	<68	<68	<130	820	<130	<130	<68	<130	<130	<6800	820
909-TS-P-1	<68	<68	<68	<68	<68	<68	<68	<130	480	<130	<130	<68	<130	<130	<6800	480
911-TS-P-1	<8 5	<8.5	<8.5	<8.5	<8 5	<8.5	<8.5	<16	57	<16	<16	<8.5	<16	<16	<850	57
913-TS-P-1	<3.4	<3.4	6.1	<3.4	<3.4	<3.4	<3.4	<6.6	36	<6.6	<6.6	<3.4	<6.6	<6.6	<340	42
915-TS-P-1	<1 7	<1.7	2.4	<1.7	<1.7	<1.7	<1.7	<3.3	20	2.1	<3.3	<1.7	<3.3	<3.3	<170	25
917-TS-P-1	<6.8	<6.8	<6.8	<6.8	<6.8	<6.8	<6.8	<13	96	<13	<13	<6.8	<13	<13	<680	96
919-TS-P-1	<1.7	<1.7	<1.7	<1 7	<1.7	<1.7	<1.7	<3 3	13	<3.3	<3.3	<1.7	<3.3	<3.3	<170	13
1005-TS-P1	<17	<17	<17	<17	<17	<17	<17	<33	11	<33	<33	<17	<33	<33	<1700	11
1005-TS-P2	<340	<340	<340	<340	<340	<340	<340	<660	4200	<660	<660	<340	<660	<660	<34000	4200
1006-TS-P1	<68	<68	<68	<68	<68	<68	<68	<130	670	<130	<130	<68	<130	<130	<6800	670
1017-TS-P1	<8 5	<8 5	<8.5	29	<8.5	<8.5	<8.5	<16	55	9.5	<16	<8.5	<16	<16	<850	55
1020-TS-P1	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1 7	<3.3	8.8	<3.3	<3.3	<1.7	<3.3	<3.3	<170	9
No. of Sample	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	
Minimum	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<3.3	<3.3	<3.3	<3.3	<1.7	<3.3	<3.3	<170.0	
Average	<36.5	<39 9	<38.3	<37.6	<36 5	<36.5	<36.5	<70.3	<441.3	<71.0	<70.3	<36.5	<70.3	<70.3	<3645.6	
Maximum	<340	<340	<340	29	<340	<340	<340	<660	4200	27	<660	<340	<660	<660	<34000	
Standard Deviation	77.2	77.2	76.7	77.0	77 2	77 2	77 2	149.8	948 1	149 6	149.8	77.2	149.8	149.8	7724.2	

(a)Total OCL pesticides are calculated from detected values only.

Thermal Desorption/Dehalogenation at the Wide Beach Development Superfund Site Brant, New York

Case Study Abstract

Thermal Desorption/Dehalogenation at the Wide Beach Development Superfund Site, Brant, New York

Site Name:
Wide Beach Development Superfund Site

Location:
Brant, New York

Contaminants:
Polychlorinated Biphenyls (PCBs)
- Stockpiled soil contained 10 to 5,000 mg/kg PCBs
- Material feed to thermal desorber contained 11 to 68 mg/kg PCBs

Period of Operation:
October 1990 to September 1991

Cleanup Type:
Full-scale cleanup

Vendor:
Joseph Hutton
SoilTech ATP System, Inc.
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

Technology:
Thermal Desorption/Dehalogenation
- Rotary kiln desorber with proprietary sand seals
- Retort zone temperature 1,160°F
- Preheat and retort zone residence time 30-40 minutes
- Alkaline polyethylene glycol (APEG) sprayed onto contaminated soil to dechlorinate PCBs
- Air emissions controlled using cyclones, baghouse, scrubbers, fractionator, condenser, gas-oil-water separator, and carbon adsorption
- Water treated on site using filtration, oxidation, settling, air stripping, and carbon adsorption

Cleanup Authority:
CERCLA and State: New York (per interagency agreement between EPA and USACE)
- ROD Date: 9/30/85
- Fund Lead

SIC Code:
Not applicable

Point of Contact:
Herb King (RPM)
U.S. EPA Region 2
26 Federal Plaza
New York, NY 10278
(212) 264-1129
Joe Salvatore
USACE c/o 914 TAG, Bldg. 322
Niagara Falls Int'l. Airport
Niagara Falls, NY 14304
(716) 297-8531

Waste Source:
Road Oiling - Application of PCB-containing waste oils to the roadways for dust control

Type/Quantity of Media Treated:
Soil
- 42,000 tons treated
- 18.3% moisture; 12.8% clay; 30.3% silt; pH of 7.7

Purpose/Significance of Application:
The Wide Beach project is notable for being the first full-scale treatment application using SoilTech's ATP system in conjunction with APEG dechlorination to treat soil at a Superfund Site contaminated with PCBs.

Regulatory Requirements/Cleanup Goals:
- Soil - PCBs: 2 mg/kg
- Air - PCBs: 3.33 x 10^{-5} lbs/hr, PEG: 4.16 x 10^{-5} lbs/hr, particulates: 0.05 gr/dscf

Thermal Desorption/Dehalogenation at the Wide Beach Development Superfund Site, Brant, New York (Continued)

Results:
- Soil - PCB concentrations reduced from up to 68 to less than 2 mg/kg
- Air - Stack gas requirements met for PCBs, PEG, and particulates; dioxin/furan emissions equivalent to a 2,3,7,8-TCDD concentration of 0.707 ng/dscm

Cost Factors:
- Actual total costs for cost elements directly associated with treatment - $11,600,000 (including solids preparation and handling, startup, equipment, and operation)
- Before-treatment costs - $908,000 (including mobilization/preparatory work, monitoring)
- After-treatment costs - $3,400,000 (disposal)

Description:
Contamination of soil at the Wide Beach Development Superfund site (Wide Beach) resulted from the spraying of waste oil containing polychlorinated biphenyls (PCBs) over the roadways in the community to control dust. In response to a 1985 Record of Decision and a 1988 interagency agreement between EPA and the U.S. Army Corps of Engineers (USACE), SoilTech's mobile anaerobic thermal processor (ATP) system was used in conjunction with alkaline polyethylene glycol (APEG) dechlorination from October 1990 to September 1991 to treat contaminated soil at Wide Beach. Approximately 42,000 tons of stockpiled soil contaminated with PCBs, mainly Arochlor 1254, at concentrations ranging from 10 to 5,000 mg/kg, were treated at Wide Beach. The USACE specified that the concentration of PCBs in soil treated at Wide Beach should not exceed 2 mg/kg. The Wide Beach project is notable for using full-scale treatment application using SoilTech's ATP system in conjunction with APEG dechlorination to treat soil at a Superfund Site contaminated with PCBs.

During the full-scale treatment of soils at Wide Beach, samples of untreated soil were occasionally collected from the feed conveyor of the ATP system. The concentrations of PCBs measured in these samples ranged from 11 to 68 mg/kg, with an average PCB concentration of 24 mg/kg. Samples of the treated soil were collected either from the treated solids staging area or the tailings conveyor of the ATP system. The concentrations of PCBs measured in these samples were generally less than or near the detection limit (approximately 0.5 mg/kg) and all samples were below the 2 mg/kg cleanup level during the treatment application. A lack of structural integrity in the treated soils led to a need for off-site disposal.

The cost for this full-scale application was $11,600,000, for costs directly associated with treatment. The level of dechlorination achieved by the ATP/APEG process was measured during a demonstration test conducted prior to full-scale operation of the system. The demonstration test results indicated that the ATP/APEG process dechlorinated 76 percent of the PCBs that entered the ATP system during the test. However, this figure does not account for dechlorination from recycling residual oil through the system. In addition, an EPA SITE Demonstration was conducted during the full-scale operation in May of 1991. The SITE Demonstration results indicated that 98 percent of the PCBs that entered the ATP system were dechlorinated.

COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

This report presents cost and performance data for a thermal desorption/dehalogenation treatment application at the Wide Beach Development Superfund site (Wide Beach) in Brant, New York. Contamination of soil at the Wide Beach site resulted from the spraying of waste oil containing polychlorinated biphenyls (PCBs) over the roadways in the community to control dust. A Record of Decision (ROD), signed in 1985, required excavation, stockpiling, and treatment of soil from areas including roadways, drainage ditches, and residential yards where concentrations of PCBs were greater than 10 mg/kg. In response to the ROD and a 1988 interagency agreement between EPA and the U.S. Army Corps of Engineers (USACE), SoilTech's mobile anaerobic thermal processor (ATP) system was used in conjunction with alkaline polyethylene glycol (APEG) dechlorination to treat contaminated soil at this site. The USACE specified that the concentration of PCBs in soil treated at Wide Beach should not exceed 2 mg/kg.

The system was operated from October 1990 to September 1991. Approximately 42,000 tons of stockpiled soil contaminated with PCBs, mainly Arochlor 1254, at concentrations ranging from 10 to 5,000 mg/kg, were treated. The Wide Beach project is notable for being the first full-scale treatment application using SoilTech's ATP system in conjunction with APEG dechlorination to treat soil at a Superfund site contaminated with PCBs.

The SoilTech ATP system used at Wide Beach consisted of a feed system, the ATP unit (a rotary kiln thermal desorber), a vapor recovery system, a flue gas treatment system, a tailings handling system, and a module for preparing reagents used for the APEG dechlorination process. Wastewater from the vapor recovery system was treated on-site and then disposed of at an off-site treatment facility. Waste oil from the vapor recovery system containing PCBs was dechlorinated using APEG and then recycled as carrier oil in the vapor recovery system. An EPA SITE Demonstration, conducted during the full-scale operation in May of 1991, indicated that 98 percent of the PCBs that entered the ATP system were dechlorinated.

The thermal description system at Wide Beach achieved the specified soil cleanup standards. Concentration of PCBs in treated soil samples were generally at or below the reported detection limit of 0.5 mg/kg. However, treated soils could not be used as backfill, because they were not as cohesive as the excavated soil, and were disposed of off site as nonhazardous waste.

The costs for the treatment application at Wide Beach, excluding costs for construction of a concrete pad for the ATP unit and for off-site disposal of the treated soil, were $11,600,000.

SITE INFORMATION

Identifying Information

Wide Beach Development Superfund Site,
Brant, New York
CERCLIS #: NY0980652259
ROD Date: September 30, 1985

Treatment Application

Type of Action: Remedial
Demonstration Test Associated with Application? Yes (see Appendix A and Reference 4)
EPA SITE Program Test Associated with Application? Yes (see Reference 9)
Period of Operation: October 1990 to September 1991
Quantity of Soil Treated During Application: 42,000 tons

Background

Historical Activity That Generated Contamination at the Site: Spraying of waste oil over roadways for dust control. [7]
Corresponding SIC Codes: Not applicable
Waste Management Practice that Contributed to Contamination: Road Oiling - Application of PCB-containing waste oils to the roadways for dust control.

Site History: The Wide Beach Development Superfund Site (Wide Beach) is a 55 acre, lake-side community located in Brant, New York, as shown on Figure 1. From 1964 until 1978, waste oil containing polychlorinated biphenyls (PCBs) was applied to the roadways in the community to control dust. Soil from the roadways was excavated during the installation of a 1-mile sanitary sewer trench in the community during 1980. Excavated soil was used as fill in several residential yards. [7]

An Erie County Department of Environment and Planning investigation of an odor complaint led to the discovery of 19 drums in a wooded area in the Wide Beach Development community. Two of the drums contained waste oil contaminated with PCBs. Further investigation revealed that PCBs were present in soil from roadways and residential yards, in vacuum cleaner dust from residential homes, and in water from residential wells. The Wide Beach Development site was placed on the National Priorities List in September 1983. [7]

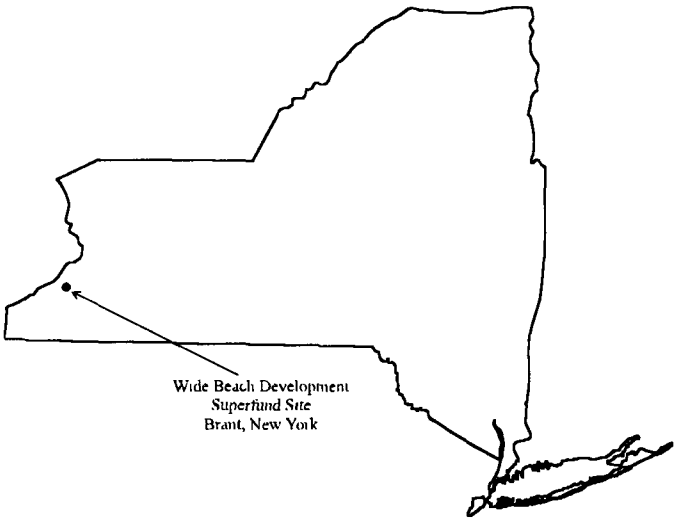

Figure 1. Site Location

A remedial investigation and feasibility study (RI/FS) was conducted from 1984 to 1985. [18] The RI/FS results indicated that:

- PCBs (mainly Arochlor 1254) were the major contaminants;
- The highest PCB concentrations were detected in soils from the roadways, drainage ditches, driveways, and front yards;
- Concentrations of PCBs in water from residential wells were in the parts per billion range or less;
- PCBs were transported mostly by surface water:
- Contaminated soils would act as a long-term source of PCBs; and
- Human exposure to PCBs was possible through ingestion of contaminated vegetation and/or soil, inhalation, and dermal absorption.

Based on these results, EPA implemented a removal action, which was conducted from June to July 1985. The removal action included paving roadways, drainage ditches, and driveways, shampooing and vacuuming rugs, replacing air conditioner and furnace filters in residential homes, and installing

SITE INFORMATION (CONT.)

Background (cont.)

particulate filters in residential wells to prevent further exposure of the public to PCBs. [7]

Long-term remedial measures were subsequently specified in a 1985 Record of Decision (ROD). Remedial measures were conducted from 1986 until 1991.

Several activities took place relative to the implementation of the ROD requirement of chemical treatment for contaminated soil at Wide Beach.

From May 1986 to February 1989, Ebasco Services, Inc., and Galson Research Corporation conducted bench- and pilot-scale treatability studies to determine the suitability of potassium polyethylene glycol (KPEG) dechlorination as a chemical treatment process. These studies were completed using a batch process, including blending of contaminated soil with KPEG for at least 12 hours, centrifugation of the mixture to recover the dechlorination reagents, and then washing of the soil. [8]

In December 1988, EPA and the United States Army Corps of Engineers (USACE) signed an interagency agreement for the procurement of a remedial action (RA) contractor and management and administration of the RA contract by the USACE. The RA contract developed by the USACE specified that all excavated soils must be treated using a chemical treatment process. Additionally, the contract specified that the concentration of PCBs in soil treated with this process should not be greater than 2 mg/kg and specified that all work be performed in conformance with applicable Federal, State, and local requirements. [8]

In October 1989, Kimmins Thermal Corporation (Kimmins) was awarded the RA contract for the Wide Beach site. Kimmins subsequently submitted a Value Engineering Change Proposal in February 1990 suggesting the use of a continuous process consisting of treatment of soil using SoilTech's Anaerobic Thermal Process (ATP) combined with EPA's APEG dechlorination process, instead of the batch KPEG process, for remediating soil at the Wide Beach site. The ATP/APEG process was preferred by Kimmins because the APEG process could be accelerated by the combination of vigorous mixing and higher temperatures in the ATP unit. This process was subjected to a demonstration test in September 1990 and stack gas testing on October 4 and 5, 1990. Based on the results of these tests the ATP/APEG process was found to be acceptable to EPA and the USACE. The soil remediation at the Wide Beach site using the ATP/APEG process was conducted from October 1990 to September 1991. [8]

Regulatory Context: The September 1985 ROD identified the following long-term remedial measures for the site [7]:

- Excavation and chemical treatment of contaminated soil from roadways, drainage ditches, driveways, yards, and wetlands containing PCB concentrations greater than 10 mg/kg;
- Sampling for PCBs in soils from residential yards, sewage in a lift station near the site, and sediments in disconnected septic systems to accurately define the extent of PCB contamination;
- Pilot-scale testing to determine an effective treatment scheme for chemically treating the PCB-contaminated soils;
- Backfilling the treated soil into the excavated areas;
- Treatment of water from the sewer trench;
- Construction of a hydraulic barrier at the end of the sewer trench;
- Disposal of contaminated asphaltic material and reuse of uncontaminated asphaltic material for repaving roadways and driveways; and
- Repaving roadways and driveways.

SITE INFORMATION (CONT.)

Site Logistics/Contacts

Site Management: Fund - Lead (remedial design activities)
USACE - Lead (Contract Administration)

Oversight: EPA

Remedial Project Manager:
Herb King
USEPA, Region 2
26 Federal Plaza
New York, NY 10278
(212) 264-1129

U.S. Army Point of Contact:
Joe Salvatore (primary contact for this application)
USACE
c/o 914 TAG, Building 322
Niagara Falls International Airport
Niagara Falls, NY 14304
(716) 297-8531

Treatment Vendor:
Joseph Hutton
SoilTech ATP Systems, Inc.
800 Canonie Drive
Porter, IN 46304
(219) 926-8651

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Soil (ex situ)

Matrix Characteristics Affecting Treatment Cost or Performance [9]

The major matrix characteristics affecting cost or performance for this technology and their measured values are presented in Table 1.

Table 1. Matrix Characteristics [9,28]

Parameter	Value	Measurement Procedures
Soil Classification	Silt/Loam	Not Reported
Bulk Density*	2.10 g/cm	Not Reported
Clay Content	12.8%	ASTM D-421/422
Silt Content	30.3%	ASTM D-421/422
Moisture Content	18.3%	ASTM D-2116
pH*	7.7	Not Reported
Particle Size Distribution* (cumulative % by weight finer)		
4.75 mm	85.9	
2.0 mm	76.2	Not Reported
0.425 mm	68.0	
0.075 mm	48.6	
0.005 mm	18.8	
Lower Explosive Limit	Not Available	—
Oil and Grease or Total Petroleum Hydrocarbons	Not Available	—

**These values are the average results for three composite samples of the contaminated feed collected during the three test runs of the SITE Demonstration conducted in May 1991. These values are from the SITE Demonstration only, during which 104 of the 42,000 tons of contaminated soil from Wide Beach were tested.*

Contaminant Characterization

Primary contaminant groups: PCBs

The concentration of PCBs measured in the soils stockpiled for treatment ranged from approximately 10 to 5,000 mg/kg. PCB concentrations measured in the material fed to the ATP unit ranged from 11 to 68 mg/kg. PCBs were measured in the untreated (stockpiled) soil using EPA Method 8080. [16, 19]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology Type

Thermal Desorption/Dehalogenation

Supplemental Treatment Technology Types [9]

Post-treatment (air): The ATP system used at Wide Beach included two off-gas treatment systems.

The flue gas treatment system, designed to treat gases from the combustion zone of the ATP unit, included the following technologies:

- Cyclone;
- Baghouse;
- Acid gas scrubber; and
- Carbon adsorption.

The vapor recovery system, designed to treat gases from the preheat and retort zones of the ATP unit, consisted of the following technologies:

- Cyclone;
- Scrubber;
- Fractionator;
- Condenser; and
- Gas-oil-water separator.

Post-treatment (water): The condensed water from the vapor recovery system was treated in an on-site wastewater treatment system utilizing sand filtration, clay and anthracite coal filtration, primary oxidation, gravity settling, secondary oxidation, air stripping, and carbon adsorption.

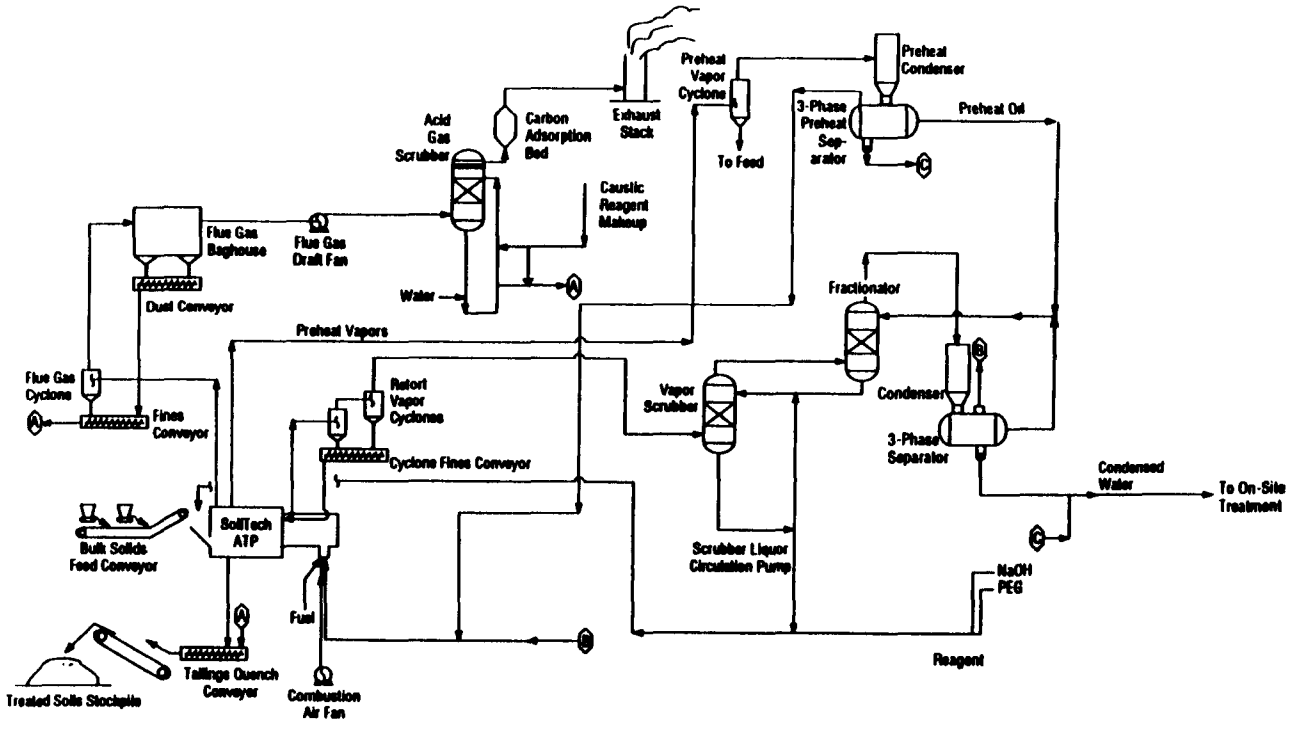

Figure 2. ATP Schematic [9]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Supplemental Treatment Technology Types [9] (cont.)

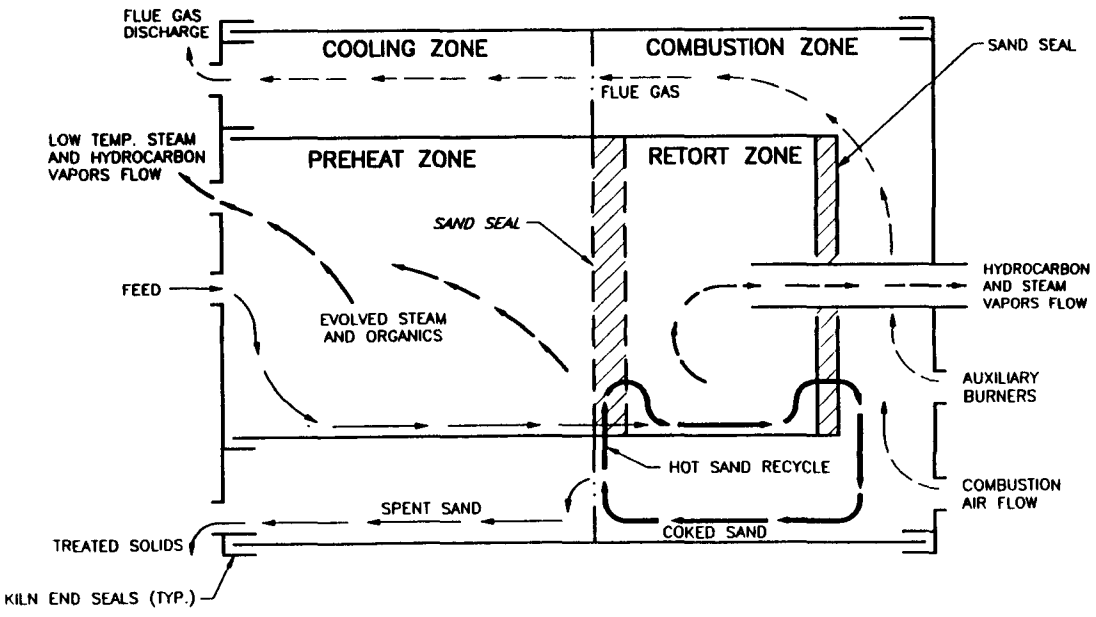

Figure 3. Simplified Sectional Diagram Showing the Four Internal Zones [9]

ATP/APEG Process Description and Operation [7,9,27,28]

The SoilTech Anaerobic Thermal Processor mobile treatment system shown in Figure 2 consisted of six main process units including a soil pretreatment system, a feed system, an anaerobic thermal processor, a vapor recovery system, a flue gas treatment system, and a tailings handling system. In addition, the system used at Wide Beach included a reagent preparation module.

APEG reagent and carrier oil solution was sprayed onto the contaminated soil as it entered the ATP unit. APEG reagent was prepared in a module consisting of a reagent storage area, reagent mixing tank, reagent and carrier oil blending tank, and feed pumps. Reagents were mixed and heated in the reagent mixing tank. The reagent solution was then blended with carrier oil in the reagent and carrier oil blending tank.

The feed system consisted of two feed hoppers and a conveyor belt. One feed hopper contained the contaminated soil and the other contained clean sand. The sand served as a heat carrier and was fed to the ATP unit during system startup and shutdown periods.

The ATP unit is a rotary kiln containing four separate internal zones - the preheat, retort, combustion, and cooling zones (shown in Figure 3). The feed entered the preheat zone where it was heated and mixed, vaporizing water, volatile organics, and some semivolatile organics. The heated solids then entered the retort zone where they were further heated, causing vaporization of heavy oils and some thermal cracking of hydrocarbons, resulting in the formation of coked solids and decontaminated solids. The coked and decontaminated solids from the retort zone then entered the combustion zone where coked solids were combusted. A portion of the decontaminated solids were recycled to the retort zone via a recycle channel. The recycling of these solids helped to maintain an elevated temperature in the retort zone. The decontaminated solids remaining in the combustion zone entered the

TREATMENT SYSTEM DESCRIPTION (CONT.)

ATP/APEG Process Description and Operation [7,9,27,28] (cont.)

cooling zone where they were cooled to an appropriate exit temperature.

The primary innovative features of the ATP unit are the four internal zones and the use of proprietary sand seals at each end of the retort zone which are designed to maintain an oxygen-free environment in the retort zone, and to prevent the oxidation of hydrocarbons and coke.

The vapor recovery system consisted of two parallel systems. One system condensed water and vapors from the preheat zone of the ATP unit. This system consisted of a cyclone, a condenser, and a gas-oil-water separator. The other system condensed water and vapors from the retort zone and consisted of two cyclones, a fines conveyor, a scrubber, a fractionator, a condenser, and a gas-oil-water separator.

At Wide Beach, condensed water from the vapor recovery system was treated in an on-site wastewater pretreatment system which consisted of the following treatment processes: sand filtration; clay and anthracite coal filtration; primary oxidation using sodium hypochlorite; settling; secondary oxidation with sodium hypochlorite; air stripping; and carbon adsorption. The wastewater discharged from this system was further treated in an off-site commercial treatment system.

The waste oil from the vapor recovery system containing PCBs was dechlorinated using APEG and then recycled as carrier oil in the vapor recovery system. At the end of the project, waste oil remaining in the vapor recovery system was disposed off site.

The flue gas treatment system consisted of a cyclone, fines conveyor, baghouse, dust conveyor, acid gas scrubber and activated carbon unit. This system removed particulates and trace hydrocarbons from the flue gas exiting the combustion zone of the ATP. Fines from the baghouse and cyclone were mixed with the treated solids exiting the ATP unit. The treated flue gas was released to the atmosphere.

The tailings (treated solids) handling system was used to cool and remove treated solids from the ATP. The treated solids exiting the ATP were quenched with process and scrubber water and transported to storage piles using belt and screw conveyors.

The ROD specified that the treated solids were to be used to backfill the excavated areas of the site; however, the treated solids exhibited less cohesiveness than the excavated soil and were not suitable for backfilling. The loss of cohesion was possibly due to the high silt and clay content and the presence of expansive interlayered illite/smectite clay.

At Wide Beach, the ATP unit was operated continuously (24 hours a day and 7 days a week) excluding system down time to repair the mechanical problems discussed below (approximately two months) and to perform routine maintenance (approximately three days per month).

During the treatment application at Wide Beach, the unit was shut down for approximately two months because the inner kiln of the ATP unit cracked due to heat and mechanical stresses during operation. During that time, the geometry and metallurgy of the inner kiln was modified, the burner system was redesigned to reduce heat stresses, and a second drive system was installed to reduce the mechanical stresses on the existing drive system. After making these modifications, the inner kiln did not crack again during the remainder of the treatment application at Wide Beach.

During treatment, problems were encountered with steel debris interfering with the retort zone sand seal in the ATP unit. Also, conglomerated soil was clogging the feed hopper. A soil pretreatment system was added to shred large pieces of conglomerated soil and remove steel debris. The pretreatment system consisted of an asphalt grinder for crushing soil conglomerates to feed particle sizes of less than 2 inches and a magnet for removing steel debris from stockpiled, contaminated soil.

TREATMENT SYSTEM DESCRIPTION (CONT.)

ATP/APEG Process Description and Operation [7,9,27,28] (cont.)

Prior to the demonstration test conducted in September 1990, SoilTech discovered that a number of the filter bags in the baghouse were torn due to excessive wear from previous operations. During the test, SoilTech tied off the damaged bags. SoilTech indicated that the baghouse had adequate capacity to operate with the damaged bags off-line. After discovering that the particulate emissions had exceeded the NYDEC air permit level during the demonstration test, SoilTech determined that several damaged bags had not been tied off. SoilTech subsequently replaced all of the filter bags in the baghouse prior to stack gas testing requested by the USACE and conducted the tests on October 4 and 5, 1990. The average particulate emissions measured during the October 1990 stack gas tests (0.03 gr/dscf, based on three stack gas tests) were less than one-tenth the average particulate emissions measured during the September 1990 stack gas tests (0.32 gr/dscf, based on two stack gas tests).

Operating Parameters Affecting Treatment Cost or Performance

The major operating parameters affecting treatment cost or performance for this technology and their values measured during this treatment application are presented in Table 2.

Table 2. Operating Parameters [9,25]*

Parameters	Value	Measurement Method
Operating Pressure	Negative Pressure	Not Available
Preheat and Rtort Zone Residence Time	30 - 40 minutes	Not Available
Retort Zone Temperature	1,160 F	Thermocouples in the Retort Zone
Combustion Zone Temperature	1,293 F	Thermocouples in the Combustion Zone
Cooling Zone Temperature	434 F	Thermocouples in the Cooling Zone
System Throughput	Not Available	Not Avaialble

**The values presented in Table 2 are the average results for the three test runs of the SITE Demonstration. According to the USACE, these values were held fairly constant during the entire course of the soil remediation at Wide Beach. [9,25]*

Other parameters measured during the SITE Demonstration were the stack gas flow rate (5,275 standard cubic feet per minute (scfm)) and the preheat and retort zone off-gas flow rates (203 and 109 actual cubic feet per minute (acfm), respectively). [9]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

The timeline for this application is presented in Table 3.

Table 3. Timeline

Start Date	End Date	Activity
September 30, 1985	—	ROD signed
May 1986	February 1989	Treatability Studies of KPEG conducted
September 7, 1990	September 8, 1990	Demonstration test of the ATP/APEG process performed
October 4, 1990	October 5, 1990	Stack gas tested for particulate emissions.
October 1990	September 1991	Full-scale operation of the ATP/APEG process
December1990	January 1991	System shut down - the inner kiln of the ATP unit cracked due to thermal and mechanical stresses. The geometry and metallurgy of the inner kiln was imporved to allow use of combustion zone temperature up to 1,500 F.
May 1991	—	SITE Demonstration conducted

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals Standards

The Remedial Action (RA) contract developed by USACE specified a maximum concentration of 2 mg/kg for PCBs in treated soil and that all remediation work be performed in conformance with applicable Federal, State and local requirements. [17]

Applicable Federal, State, and local requirements include air emission requirements for stack gases. The New York Department of Environmental Conservation (NYDEC) specified the following stack emission requirements for the ATP unit used at Wide Beach [4]:

- PCBs: 3.33×10^{-5} pounds per hours (lb/hr);
- Polyethylene glycol (PEG): 4.16×10^{-5} lb/hr; and
- Particulates: 0.05 gr/dscf.

The ROD specified that contaminated soils from roadways, drainage ditches, driveways, yards, and wetlands containing more than 10 mg/kg of PCBs were to be excavated and chemically treated.

The RA contract required a PCB cleanup level of 2 mg/kg be verified by collecting one sample from the treated soil staging area for every 100 tons of soil treated. These samples were collected by inserting a stainless steel tube into the staging pile. [17, 19]

Treatment Performance Data

Table 4 summarizes the analytical results for PCBs (measured in an on-site laboratory using EPA Method 8080) in untreated and treated soil during the treatment application at Wide Beach. [19, 24]

Results for stack gas emissions of PCBs, PEG, and particulates are presented in Appendix A.

Although no treatment standard or action level was set for dioxins/furans in stack gas emissions, these constituents were measured in the SITE Demonstration. [28] Table 5 shows dioxin and furan stack gas emissions measured during the SITE Demonstration. [9]

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (Cont.)

Table 4. PCB Results [19, 24]

	Range of PCB Concentrations (mg/kg)	Number of Data Points	Number of Detects	Number of Detects Greater than 2 mg/kg
Untreated soil	11-68	42	41	41
Treated soil	ND(0.4)-21	520	196	0

ND = Not detected. Number in parenthesis is the reported detection limit.

Table 5. Dioxin and Furan Stack Gas Emissions [9]

Compound	Stack Gas (ng/dscm)
Tetrachlorinated dibenzo-p-dioxins (TCDD)	0.14
Tetrachlorinated dibenzofurans (TCDF)	4.8
Pentachlorinated dibenzo-p-dioxins (PeCDD)	0.96
Pentachlorinated dibenzofurans (PeCDF)	0.72
Hexachlorinated dibenzo-p-dioxins (HxCDD)	0.17
Hexachlorinated dibenzofurans (HxCDF)	0.077
Heptachlorinated dibenzo-p-dioxins (HpCDD)	0.25
Heptachlorinated dibenzofurans (HpCDF)	0.032
Octachlorinated dibenzo-p-dioxins (OCDD)	2.34
Octachlorinated dibenzofurans (OCDF)	0.032
TOTAL	9.52*

**Total stack gas concentration of 9.52 ng/dscm is equivalent to a 2,3,7,8-TCDD concentration of 0.707 ng/dscm.*

Performance Data Assessment

The concentrations of PCBs in treated soil samples ranged from less than the reported detection limit (generally equal to 0.4 to 0.5 mg/kg) to 1.8 mg/kg. The concentrations of PCBs in treated soil samples were generally less than or equal to the detection limit of 0.4 to 0.5 mg/kg.

The level of dechlorination in the ATP unit was measured during the demonstration test conducted in September 1990 (see Appendix A), and the SITE Demonstration conducted in May 1991. The level of dechlorination was determined by comparing the quantity of PCBs entering the ATP system to the quantity of PCBs discharged from the ATP system via all effluent streams - the treated solids, stack gas, condensed water, and vapor scrubber oils, and assuming that the difference in mass of PCBs is attributed to dechlorination. During the demonstration test, 4.3 pounds of PCBs entered the system and 1.05 pounds of PCBs were discharged, corresponding to a 76 percent dechlorination level (i.e., 76 percent of the mass of PCBs entering the system were dechlorinated). However, this figure does not account for dechlorination from the recycle of residual oil through the system. During the SITE Demonstration, 0.321 lb/hr of PCBs were fed to the ATP system and 0.00678 lb/hr of PCBs were discharged from the ATP system, corresponding to a 98 percent dechlorination level. [4, 9]

During the Demonstration Test, stack gas emission requirements were met for PCBs, PEG, and particulates.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Completeness

The performance data are suitable for characterizing the concentrations of PCBs in untreated and treated soil, and for comparing treatment performance with system design and operation. The demonstration test and the SITE Demonstration test include paired, representative untreated and treated soil samples.

Performance Data Quality

Approximately 10% of the treated soil samples collected during the treatment application at Wide Beach were split for analysis in both the on-site laboratory and the USACE's New England Division laboratory. The on-site laboratory results generally compared well with the USACE results. In some instances the on-site laboratory results below 1 mg/kg PCBs showed a negative bias when compared to the USACE laboratory results; however, none of the data were rejected by the USACE. [20-23]

TREATMENT SYSTEM COST

Procurement Process

EPA and the USACE signed an interagency agreement for the procurement of an RA contractor. The interagency agreement specified that the USACE would be responsible for management and administration of the RA contract. The USACE retained Kimmins Thermal Corporation to manage the remedial construction and treatment activities at the site. Kimmins subcontracted SoilTech, Inc., to treat the excavated contaminated soil at Wide Beach using the ATP/APEG dechlorination process. [8]

Treatment Cost

Tables 6, 7, and 8 present the costs for the Thermal Desorption/Dehalogenation application at the Wide Beach Development Superfund Site. In order to standardize reporting of costs across projects, costs are shown in Tables 6, 7, and 8 according to the format for an interagency Work Breakdown Structure (WBS). The WBS specifies 9 before-treatment cost elements, 5 after-treatment cost elements, and 12 cost elements that provide a detailed breakdown of costs directly associated with treatment. Tables 6, 7, and 8 present the cost elements exactly as they appear in the WBS, along with the specific activities, and unit cost and number of units of the activity, as provided by EPA in the draft Applications Analysis Report.

In preparing the Applications Analysis Report, EPA obtained actual cost data from Soil Tech for treating 42,000 tons of soil at Wide Beach [9]. As shown in Table 6, the cost data show a total of $11,600,00 for cost elements directly associated with treatment of the soil (i.e., excluding before- and after-treatment cost elements). This total treatment cost corresponds to $280 per ton of soil treated. In addition, Tables 7 and 8 show that a total of $908,000 for before-treatment and $3,400,000 for after-treatment costs were incurred. There were no costs in this application for the following elements in the WBS: Liquid Preparation and Handling, Vapor/Gas Preparation and Handling, Pads/Foundations/

TREATMENT SYSTEM COST (CONT.)

Treatment Cost (Cont.)

Spill Control, Training, Operation (Long-term - over 3 years), Site Work, Surface Water Collection and Control, Groundwater Collection and Control, Air Pollution/Gas Collection and Control, Solids Collection and Containment, Liquids/Sediments/Sludges Collection and Containment, Drums/Tanks/Structures/ Miscellaneous Demolition and Removal, Decontamination and Decommissioning, Disposal (Other than Commercial), Site Restoration, and Demobilization.

*Table 6. Costs Directly Associated with Treatment [9]**

Cost Elements	Cost (dollars)
Solids Preparation and Handling	
—residuals and waste handling and transporting	736,000
Startup/Testing/Permits	
—permitting and regulatory	200,000
—startup	133,000
Operation (short-term - up to 3 years)	
—labor	3,800,000
—supplies and consumables	1,194,000
—utilities	913,000
—equipment repair and replacement	1982,000
Cost of Ownership	
—capital equipment	2,153,000
Demobilization	481,000
TOTAL TREATMENT COST	**11,600,000**

Calculated Cost per Ton of Soil Treated: $280 per ton
**Additional information on estimated costs is available in Reference 26.*

Table7. Before -Treatment Cost Elements

Cost Elements	Cost (dollars)
Mobilization and Preparatory Work —transport of ATP unit to site —initial setup —installing infrastructure for utilities —setup of decontamination facilities	588,000
Monitoring, Sampling, Testing, and Analysis	320,000

Table 8. After -Treatment Cost Elements [9]

Cost Elements	Cost (dollars)
Disposal (commercial)	3,400,000*

** Calculated from a disposal cost of $80/ton x 42,000 tons of soil treated.*

TREATMENT SYSTEM COST (CONT.)

Cost Data Quality

Treatment cost information shown in Table 6 represents actual costs of the treatment application and was obtained from the treatment vendor. No qualifications to the cost information were provided by the vendor. [9]

Vendor Input [27,28]

According to the treatment vendor, in general, the costs for treatment using the SoilTech ATP system vary depending on the character of the waste material, with treatment costs ranging from $150 to $250 per ton for a 10-ton per hour ATP system. The factors identified by the vendor that affect costs include:

- Moisture content of feed material;
- Particle size;
- Hydrocarbon content;
- Material handling characteristics; and
- Chemical characteristics.

Vendor estimates for mobilization and demobilization costs for a 10-ton per hour system range from $700,000 to $1.5 million. In the three Superfund projects completed by the SoilTech ATP System since the Wide Beach project, no off-site disposal of treated solids has been required. In addition, treatment costs have been reduced by as much as 17% as a result of improved process efficiency.

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

- The cost for treatment of 42,000 tons of soil at Wide Beach was $11,600,000, or approximately $280/ton. This value includes treatment chemical costs, but does not include costs for a concrete pad for the ATP unit. Off-site disposal of treated soil from Wide Beach was $80/ton.

Performance Observations and Lessons Learned

- The SoilTech ATP System achieved the 2 mg/kg cleanup level for PCBs in soil. The concentrations of PCBs in treated soil were generally at or below the reported detection limit (0.5 mg/kg). These results were consistent with those shown in the demonstration test.
- Treatment of 42,000 tons of soil was completed in a one year period.
- During the demonstration test, stack gas emission requirements were met for PCBs, PEG, and particulates.
- The SITE Demonstration results indicated that about 98 percent of the PCBs were dechlorinated. This value is greater than the level of dechlorination calculated from the demonstration test results (76 percent, see Appendix A).

Other Observations and Lessons Learned

- The system was shut down for about two months when the inner kiln of the ATP unit cracked due to mechanical and heat stresses during operation. The geometry and metallurgy of the inner kiln, and the burner and drive systems for the ATP unit were modified so that the unit could withstand temperatures of up to 1,500° C in the combustion zone.
- A soil pretreatment system was added to the treatment system after the system was shut down to remove steel debris which interfered with the retort zone sand seal and conglomerated soil lodged in the feed hopper.

OBSERVATIONS AND LESSONS LEARNED (CONT.)

Other Observations and Lessons Learned (Cont.)

- The fiberglass woven bags used in the flue gas treatment system baghouse abraded when the bags were cleaned with an air pulse system. SoilTech later replaced the fiberglass woven bags with stronger felted glass bags which are more durable at higher temperatures. The modified bags did not abrade when the ATP system was later used to treat soil and sediment at the Outboard Marine Corporation Superfund Site.
- The treated solids could not be backfilled at the site because they were not as cohesive as the excavated soil. The vendor indicated that the loss of cohesion in the solids after treatment was possibly due to the high silt and clay content and the presence of expansive illite/smectite clay. While off-site disposal of treated soils was necessary for this application, no off-site disposal has been necessary in the three Superfund projects conducted since Wide Beach which used the SoilTech ATP system.
- The SITE Demonstration and a New York State Department of Environmental Conservation study indicated that the thermal and chemical treatment of soils at Wide Beach may have adversely affected the ability of the treated soils to support vegetation for the following reasons:
  - the average concentration of nitrogen was reduced from 733 in the untreated soil to 40 mg/kg in the treated solids during the SITE Demonstration;
  - the treated solids contained an elevated concentration of soluble salts due to the addition of the APEG reagents; and
  - the pH of the treated soil required adjustment.
- Additional information provided by the RPM and Contracting Officer concerning the procurement and contracting processes at the Wide Beach Development site (and other sites) is provided in Reference 30. Reference 30 is available from the U.S. EPA National Center for Environmental Publications and Information (NCEPI), P.O. Box 42419, Cincinnati, OH 45242; (fax orders only) (513) 489-8695.

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1. Appendix D: Pilot Study Testing Report: KPEG Processing of Soils, Galson Remediation Corp; Final Design Report, Remedial Design, Ebasco Services, February 1989.
2. Lab Scale Testing Report, KPEG Processing of Wide Beach Development Site Soil, Galson Remediation Corp., September 30, 1988.
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Analysis Preparation

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APPENDIX A—DEMONSTRATION TEST

Demonstration Test Purpose

The purpose of this test was to:

- Demonstrate that SoilTech's Anaerobic Thermal Processor (ATP) system combined with dechlorination chemistry could achieve treatment of polychlorinated biphenyl (PCB)-contaminated soil from the Wide Beach site to a cleanup level of less than 2 mg/kg PCBs.
- Demonstrate that the New York Department of Environmental Conservation (NYDEC) air emission standards could be achieved by the ATP system.
- Demonstrate that the concentrations of metals, herbicides, semivolatile organics, pesticides, and volatile organics measured in the Toxicity Characteristic Leachate Procedure (TCLP) extracts from the treated solids are less than the Toxicity Characteristic (TC) limits.
- Demonstrate that dechlorination of PCBs is occurring during the treatment process.
- Demonstrate that an average feed rate of 8 tons per hour is attainable by the ATP system.

Demonstration Test Description

The treatment system used for the full-scale remediation of soil at the Wide Beach site was used for the demonstration test, as described in the ATP/APEG Process Description and Operation section of this report.

The demonstration scale test was conducted on September 7 and 8, 1990 and consisted of two phases. The first phase included processing of approximately 62 tons of contaminated soil through the treatment system and occurred during the first ten hours of the test. The second phase included the processing of clean sand feed while recycling recovered oils containing PCBs with the dechlorination reagents. The second phase occurred during the last 11 hours of the demonstration. The purpose of the second phase was to collect data which showed that dechlorination was occurring during the treatment process by isolating the dechlorination of PCBs contained in the recycled water and oil.

Demonstration Test Performance Data [4]

As shown in Tables A-1 and A-2, the demonstration scale test results indicated that the site cleanup goal for PCBs in soil (less than 2 mg/kg) and stack gas emissions requirements were achieved using the ATP dechlorination treatment system.

Analyses of the TCLP extracts from the treated solids indicated that metals, herbicides, semivolatile organics, pesticides, and volatile organics were not present in the extracts above the TC limits. Additionally, total petroleum hydrocarbons were not detected in the

Table A-1. Removal of PCBs from Contaminated Soil [4]

Concentration of PCBs in the Contaminated Feed Composite Sample (mg/kg)	Concentration of PCBs in the Treated Solids Composite Sample (mg/kg)	Cleanup Goal for PCBs in Soil (mg/kg)	Percent Removal (%)
25	<0.06	<2.0	>99

APPENDIX A—DEMONSTRATION TEST (CONT.)

Demonstration Test Performance Data [4] (Cont.)

Table A-2. Stack Gas Emissions [4]

Constituent	Requirement	Maximum Emission Levels
PCB (lb/hr)	3.33×10^{-5}	1.0×10^{-5}
PEC (lb/hr)	4.16×10^{-5}	4.0×10^{-5}
Particulates (gr/dscf)	0.05	0.04

treated solids (detection limit equal to 4.6 mg/Kg).

The occurrence of dechlorination was quantified by analyzing PCB material balance data for the demonstration test. During the first phase of the demonstration, approximately 4.3 pounds of PCBs were fed into the treatment system, 0.0151 pounds were discharged in the treated soils and stack emissions, and 1.03 pounds accumulated in the system (in process oil and water). The percentage of PCBs introduced into the treatment system that were dechlorinated is calculated by the following equation:

$$\text{Percentage of PCBs dechlorinated} = \frac{\text{PCBs introduced (pounds)} - \left[\text{PCBs discharged (pounds)} + \text{PCBs accumulated in the system}\right]}{\text{PCBs introduced (pounds)}} \times 100$$

These results indicate that approximately 76 percent of the PCBs introduced into the system were dechlorinated during the first phase of the demonstration test.

During the first phase of the demonstration test, recovered oils were commingled with oils produced during the pretest run and reagent fuel. This increased the volume of oil to be recycled during the second phase. As a result, only 20% of the recovered oils could be recycled during the test. Consequently, the second phase of the demonstration test could not provide conclusive evidence of dechlorination of the recycled oils.

During the first phase of the demonstration test, 61.66 tons of contaminated soil were treated in the ATP system in 7.62 hours. This corresponds to an average feed rate of 8.1 tons per hour (tph). The maximum feed rate during the first phase of the demonstration test was 8.92 tph for approximately 1.5 hours.

Demonstration Test Lessons Learned

- The SoilTech ATP/dechlorination system achieved the site cleanup goal for PCBs in soil (less than 2 mg/Kg) during the demonstration test. PCBs were reduced from 25 mg/kg to less than the 0.06 mg/kg reported detection limit.
- Metals, herbicides, semivolatile organics, pesticides and volatile organics in the TCLP extracts for the treated solids were measured at concentrations which were less than the TC limits.
- PCB material balance data indicated that approximately 76 percent of the PCBs introduced into the treatment system were dechlorinated in the first phase of the demonstration test. This figure underestimates the ability of the system to dechlorinate PCBs because it does not take into account the recycling of residual oil through the system.
- The ATP system maintained an average operating rate of 8.1 tph during the first phase of the demonstration test.

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