Y-12

OAK RIDGE Y-12 PLANT

MARTIN MARIETTA

Final Report from VFL Technologies
for the Pilot-Scale Thermal Treatment of
Lower East Fork Poplar Creek
Floodplain Soils

Final Report

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for
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SYSTEMS, INC.**
managing the
Oak Ridge, Y-12 Plant
Oak Ridge, Tennessee
under contract DE-AC05-84OR21400
for the
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**LOWER EAST FORK POPLAR CREEK PROJECT
THERMAL DISORPTION PILOT DEMONSTRATION
FINAL REPORT**

Prepared For:
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SEPTEMBER, 1994

LEFPC THERMAL DESORPTION PILOT DEMONSTRATION
FINAL REPORT

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DAC	Derived Air Concentration
DOT	Department of Transportation
LEFPC	Lower East Fork of the Popular Creek
LOA	Letter of Authorization
LTTD	Low Temperature Thermal Desorption
MMES	Martin Marietta Energy Systems
NFS	Nuclear Fuel Services
OSHA	Occupational Safety and Health Association
PAH	Polyaromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PPE	Personal Protective Equipment
PPM	Parts Per Million
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RWP	Radiation Work Permit
SOP	Standard Operating Procedure
SOW	Statement of Work
TCLP	Toxicity Characteristic Leaching Procedure
TLV	Threshold Level Value
TWA	Time Weighted Average
UIR	Universal Industrial Refrigeration
UPE	Universal Process Equipment
VFL	VFL Technology Corporation
VOC	Volatile Organic Compounds

SECTION 1

EXECUTIVE SUMMARY

SECTION 1

EXECUTIVE SUMMARY

1.0 EXECUTIVE SUMMARY

The Lower East Fork Poplar Creek (LEFPC) extends fourteen (14) miles through Oak Ridge, TN. The Creek sediments and surrounding floodplain soils are contaminated with mercury compounds. This project involved a comprehensive pilot demonstration on thermal desorption of these soils to validate the feasibility of the remedial technology which had been identified in previous studies.

Thermal desorption is a technology that utilizes heating or drying of soils to induce volatilization of contaminants. These contaminants are then vaporized and either incinerated or condensed in the second stage of desorption. Mercury (Hg), which was the principal contaminate of concern, was collected by condensers in a vapor collection system. This type of system insured that the toxic mercury vapors did not escape to the atmosphere.

VFL assembled a team that was comprised of three (3) companies to implement this project. Each company possessed individuals and equipment which contribute special capabilities and/or skills. The respective companies were Nuclear Fuel Services (NFS) of Erwin, TN, Universal Process Equipment (UPE) of Roosevelt, NJ, and VFL Technology Corporation of Malvern, PA. Their respective areas of responsibility are as follows:

Nuclear Fuel Services (NFS)

NFS provided the NRC approved, permitted facility where the Pilot Demo was conducted. Their high-security, permitted complex allowed the pilot demo to proceed without regulatory permitting delays. Their on-site laboratory facility provided quick analysis of test run samples in order to determine the Pilot Demo parameters.

NFS also provided the necessary training to all Project Personnel concerning the areas of Quality Assurance, Health & Safety, Sampling & Analysis, Transportation, Waste Management, Calibration, Document Control, Corrective Action, Audits, Letter of Authorization (LOA), and the Site Specific Work Plan.

NFS also provided for the collection, transportation, and analysis of the samples collected during the actual Pilot Demonstration. Analysis of the samples was performed at the NFS subsidiary lab, ECOTEK LSI of Atlanta, GA, and also at Roy F. Weston Labs of West Chester, PA.

Universal Process Equipment (UPE)

Universal Process Equipment (UPE) in conjunction with their wholly owned subsidiary, Universal Industrial Refrigeration (UIR), provided the thermal desorption equipment and the corresponding vapor collection system. UPE/UIR also provided for the necessary operators/technicians to operate the equipment necessary for the Project.

VFL Technology Corporation

VFL Technology Corporation (VFL) provided the overall Project Management, Report Preparation, and Soil Conditioning prior to the thermal desorption.

The first phase of the project involved the conversion of the soil into a more handleable, free-flowing type of material. Bench-scale treatment studies included the evaluation of no preconditioning, dewatering, homogenization, air drying, screening, and solidification with standard cementitious additives and combinations of the above. The results of the bench-scale studies showed screening and treatment with quicklime to be the most effective method of soil conditioning prior to thermal processing.

Five trial runs were conducted in the thermal desorber in order to evaluate mercury removal efficiency with respect to retention time and processing temperature. The first trial run (Run #0) was an equipment shakedown and material handling evaluation run. Run #1 was a processing efficiency run at set conditions. Run #2 evaluated an increase in temperature and increase in retention time. Run #3A evaluated an increase in production rate. Run #3B increased retention time and eliminated steam sparging from the process.

During the trial runs, production rates ranged from 120 to 240 lbs/hr. Processing temperatures ranged from 398°F (203°C) to 562°F (294°C). The retention times evaluated ranged from 94 minutes to 188 minutes.

During the trial runs, mercury concentrations in the untreated soil ranged from 203 to 531 mg/kg. Mercury concentrations in the processed soils ranged from 16 to 28 mg/kg. Mercury removal efficiency ranged from 89 to 94 percent and averaged approximately 92%.

The verification run was conducted for 10 hours and used the optimum processing scenarios generated from the trial runs. These optimized conditions were a production rate of 180 lbs/hr, processing temperature of 555°F (291°C) and retention time of 125 minutes.

For the verification run, mercury concentrations in the untreated soils ranged from 866 to 234 mg/kg. Mercury concentrations of the processed soils ranged from 19 to 29 mg/kg and averaged 22.6 mg/kg. Mercury removal efficiencies averaged 94%. This value is similar to those measured in the trial runs. Based on the available data, it appears that the residual concentration of mercury remains fairly constant; regardless of initial mercury concentration in the unprocessed soils, retention time and, to a lesser degree, processing temperature between 510°F (266°C) and 562°F (294°C).

All processed soils easily passed the TCLP Leachate criteria for mercury. One process waste was collected from the LTDD pilot processing. This waste from the condenser included an aqueous phase and a solid. These also passed the TCLP Leachate criteria after treatment.

SECTION 2

INTRODUCTION

SECTION 2

INTRODUCTION

2.0 INTRODUCTION

2.1 Project History and Background

The Lower East Fork of the Poplar Creek (LEFPC) has received industrial discharge from the Oak Ridge Y-12 Plant over the last 50 years. The large-scale use of mercury at the Y-12 Plant between 1955 and 1963 was associated with the production of lithium, enriched in the isotope for use in production of tritium for thermonuclear weapons. This lithium-6 production resulted in the release of mercury to the LEFPC through contaminated outfall water and sediments. It has been estimated that approximately 170,000 pounds of mercury remain in the floodplain soils.

The soils of the LEFPC floodplain are a high moisture content soil that consists of approximately 80% clay fines (minus #200 mesh). The soils are not a RCRA listed waste. The solids have passed the Toxicity Characteristic Leaching Procedure (TCLP) and therefore are not a RCRA characteristic hazardous waste.

The primary contaminate of concern in the soil is mercury. Mercury in the soil ranged up to 2000 parts per million (ppm) in the LEFPC.

The radioactive contaminants include uranium and neptunium. As a result of radioactive contaminants, the soils are considered radioactive material (low level). However, the soils are not considered a radioactive material per the Department of Transportation (DOT) definition.

Other minor contaminants in the LEFPC soils include arsenic, cadmium, polychlorinated biphenyls (PCB's), and polyaromatic hydrocarbons (PAH's) and radioactive contaminants.

The regulatory driver for the continuing studies of the LEFPC is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Due to the contamination of the sediment and the soil in the LEFPC, treatability studies were performed to evaluate the effectiveness of various technologies for remediation. The technologies evaluated for the contaminated soils included soil washing, solidification, stabilization and low temperature thermal desorption (LTTD). Based on conclusions of the treatability studies, LTTD was chosen as the technology of choice for a pilot-scale demonstration.

2.2 Scope of Work

VFL Technology Corporation (VFL), in partnership with Universal Process Equipment (UPE) and Nuclear Fuels Services (NFS), was awarded a contract to perform the Pilot Demonstration on the LEFPC soils on October 23, 1993. Included in the project scope of work were the following items.

- o Determine the technical feasibility of low temperature thermal desorption to remove mercury from the floodplain soil.
- o Determine the effectiveness of mercury collection from process off gases.
- o Develop an effective technique for handling and feeding the soil throughout the thermal process.
- o Determine the ability to control the process off gases in order to comply with Federal and State Clean Air Standards.
- o Determine the chemical and physical characteristics of the resultant thermally treated floodplain soil.
- o Determine the quantity and chemical characteristics of the secondary wastes generated by the process.

2.3 Performance Targets

The following performance targets were established for the pilot demonstration:

- o Reduce mercury concentration in the soils to less than 10 ppm.
- o Recover the volatilized mercury from the soil.
- o Demonstrate successful material handling of the LEFPC soils.
- o Minimize degradation of the soil structure.

2.4 VFL Project Team

VFL chose to team with two other environmental companies for the LEFPC pilot demonstration. The team members include Nuclear Fuel Systems (NFS) in Erwin, TN and Universal Process Equipment (UPE) of Roosevelt, N.J. An organizational flow chart for the VFL Team can be found on Figure 2.1.

Responsibilities of the three team members were as follows. VFL provided the overall project management, soil conditioning, soil handling and report writing. NFS provided the NRC permitted facility and personnel familiar with implementing research on radioactive and RCRA materials. UPE provided the pilot desorption unit, operators and technical support. A breakdown of the teaming responsibilities can be found on Figure 2.2.

FIGURE 2.1 ORGANIZATIONAL CHART

FIGURE 2.2 PROJECT TEAM RESPONSIBILITIES

SECTION 3

CONCLUSIONS AND RECOMMENDATIONS

SECTION 3

CONCLUSIONS AND RECOMMENDATIONS

3.0 CONCLUSIONS

Based on the results presented in this program, the pilot scale demonstration conducted in Erwin, TN was a success in that it has addressed all of the objectives established for the program.

- o The pilot demonstration showed that it was technically feasible to use Low Temperature Thermal Desorption (LTTD) to remove mercury from the floodplain soil. A significant bank of data has been generated documenting the removal of mercury from the soils at temperatures up to 560°F (293°C).
- o An effective method of handling the floodplain soils through the thermal process was demonstrated during the six (6) process runs. Bench scale treatability testing on-site allowed the pretreatment methodologies to be optimized to existing soils and process conditions. The conditioned soils fed through the process with minimal problems.
- o A successful operation of the thermal desorption equipment was demonstrated in the trial runs and the final verification run. The equipment operated efficiently with no system or component failures.
- o The chemical and physical characteristics and leachability of the soils before and after processing were identified. The process secondary wastes were also identified for both chemical characteristics and quantities.
- o Mercury volatilized in the LTTD was successfully collected during the final verification run. The mass balance calculation exclusive of the stack discharge by itself does not readily identify where the mercury was collected. However, additional monitoring on the stack and inside the pilot plant shows that mercury was removed from the floodplain soils and that it did not get discharged out the stack. With the stack release data added to the mass balance equation, the resulting mass balance/capture efficiency is much more acceptable.
- o The entire program was carried out in strict adherence to the projects' Health & Safety Plan. No accidents, incidents or injuries were recorded during the entire project.

3.2 RECOMMENDATIONS

- o Based on the results of the data package generated during the process runs, questions arise as to the viability of a target of 10 ppm. It is recommended that further studies on this data take place to evaluate whether this target is achievable at design temperatures set forth in this pilot program.
- o The LTTD system design for the pilot scale produced marginal control of dust transfer from the desorber to the scrubber condenser. During full-scale production, use of dust control systems such as a vapor dome and a dry cyclone would greatly minimize secondary waste solids generation.
- o The extraction of the mercury collected in the scrubber-condenser and associated equipment will need to be redesigned prior to full-scale operations. Whether the low extraction of mercury may in part be due to the elemental mercury settling to low spots in the unit, a heel of mercury developing on all exposed surfaces of the condenser equipment, inadequate sampling methods, or some other cause.

SECTION 4

SOIL CHARACTERIZATION

SECTION 4

SOIL CHARACTERIZATION

4.0 SOIL CHARACTERIZATION

Soil characterization tests were conducted on the LEFPC soils to provide baseline information for the pilot demonstration. Samples analyzed included split samples that were collected and submitted by Martin Marietta Energy Systems (MMES) and select samples taken by the VFL Team from the drummed soils received at the Erwin, TN facility. Soil characterization data was generated by EcoTek, LSI in Atlanta, GA and VFL at Erwin, TN.

4.1 Physical Characterization of the LEFPC Soils

The physical characteristics of the soils listed below were analyzed from the soils drums received on January 27, 1994. All 18 drums were opened and visually inspected. Drum #8 and #16 were selected as representative of the soils received based on visual observations of the soils characteristics. These soils were then analyzed for visual characteristics, odor, solids content, moisture content, particle size, bulk density and compacted density.

The soils ranged from a damp organic "topsoil-like material" to "red, cohesive clay" with some root structures and vegetation observed. Extraneous bits of foreign matter were also noted in the profile of the soil. Figure 4.1 shows the typical consistency of the contaminated soils in the "as received " condition.

The solids content of the received soils ranged from 74.6% to 75.4%. The average particle size of the soils was less than 1/2 inch in diameter. However, stones and other extraneous matter were noted at sizes to three (3) inches in diameter. The complete listing of the physical characteristics of the "as received" soils can be found in Table 4.1.

Table 4.1 Physical Characteristics of Soils

VISUAL - Ranged from organic topsoil to red, cohesive clay. The soils were damp and granular with some miscellaneous stone to 3", and extraneous bits of plastic, steel, etc. Root structures and some vegetation observed.

ODOR - Musty, slight decaying vegetation odor.

SOLIDS CONTENT - 74.6 - 75.4%

MOISTURE CONTENT - 32.6 - 34.0%

(Table continued on following page)

Figure 4.1

**Typical consistency of contaminated soils in
"as received" condition (note clods and vegetation)**

(Table 4.1 Continued)

PARTICLE SIZE -

Sieve Size	Drum #8		Drum #16	
	% Retained	% Pass	% Retained	% Pass
(1/2)	0	100.0	0	100
(3/8)	11.8	88.2	11	89
#4	32.2	56.0	31.2	57.8
#10	29.6	26.4	33.6	24.2
Pan	26.4	---	24.2	---

BULK DENSITY - 60.7 lbs/ft³ to 63.6 lbs/ft³ wet

COMPACTED DENSITY - 75.6 lbs/ft³ to 79.9 lbs/ft³ wet

It should be noted that the received soils were not found to be "sludge like in nature" or have a "high moisture content" as was stated in the Statement of Work (SOW).

4.2 Chemical Characterization of the LEFPC Soils

The chemical characteristics of the soils were analyzed from a duplicate set of LEFPC soil samples received on November 19, 1993. These soil samples were collected and submitted by Martin Marietta for analysis. Each of the six soil samples was analyzed for total mercury, arsenic, cadmium, polychlorinated byphenols (PCB), uranium, volatile organic compounds (VOC), and polyaromatic hydrocarbons (PAH). In addition to these analyses, pH was measured on the drummed soils received in Erwin, TN (Table 4.2).

Table 4.2 pH of Soils

pH (units) Drum #8 =	9.0
pH (units) Drum #16 =	9.5

The average concentration of mercury in the six samples was found to be 475 ppm. Additional data on the chemical characterization of the soil is found in Appendix III. A comparison of the sample results with the MMES split results are found in Table 4.3.

**Table 4.3 Comparison of LEFPC Soil Characterization Data from
EcoTek, LSI and MMES**

Analyte (total)	EcoTeck, LSI (avg ppm)	MMES (avg ppm)
Mercury	475	254
Uranium	30	17
Arsenic	10	< 20
Cadmium	9	8
PCBs	1.88	0.50

SECTION 5

PROCESS DESCRIPTION

SECTION 5

PROCESS DESCRIPTION

5.0 PROCESS DESCRIPTION

5.1 Material Pretreatment - Bench Scale Study

5.1.1 Purpose

A bench scale study was undertaken to evaluate the effectiveness of different types of material handling techniques of the LEFPC soils. The intent of this study was to address the characteristics of the soil as received and develop a material handling program specific to this material and the process being demonstrated.

The first phase of this program included physical characterization of selected soils. The results of this testing is found in Section 4.0 Soil Characterization. The second phase of this program included bench scale material handling tests. The results of the testing program were then evaluated and the best method or combination of methods was selected for use in the pilot demonstration.

The third phase of this program was to scale-up the selected methodologies from bench-scale to pilot-scale so that proper pretreatment could take place.

The following is a list of performance objectives of the bench testing program:

- o Increase the surface area of the soils.
- o Generate a dryer, more friable feedstock material.
- o Minimize the addition of reagents.
- o Improve the homogenization of the feedstock material.

5.1.2 Methodology

The bench-scale study methodology was structured around the physical characteristics of the LEFPC soils and the design of the LTTD unit to be used in the pilot demonstration.

After the initial characterization of the soils was completed, parameters were set for material handling scenarios to be utilized in the bench-scale tests. These scenarios were then conducted in the laboratory at Erwin, TN. An evaluation and decision matrix was established and executed on the results of the study based on the performance objectives.

Characterization of the soils and bench scale mixes were conducted utilizing the following equipment: five (5) quart Hobart mixer, unit weight container, ASTM sieves, Fisher convective oven, paint filters, and a certified weigh scale.

Five material pretreatment scenarios were evaluated in the bench scale study. They included homogenization, air drying, dewatering, particle size reduction, and solidification. Status quo, or no material conditioning, was also evaluated (Figure 5.1).

5.1.3 Results of the Material Pretreatment Testing.

The results of the material pretreatment testing were evaluated and unacceptable methodologies were eliminated. These included status quo, air drying, and dewatering. Acceptable pretreatment methods included homogenization, particle size reduction, and solidification.

Status Quo. The no material pretreatment option was found to be unacceptable. Material ranged from friable to clay chunks with oversize organic matter and extraneous foreign matter up to three inches in diameter.

Air Drying. The cohesive material does not lend itself to air drying. Also, the time frame and working area needed for air drying is not available for this project.

Dewatering. The material is already too dry to be considered for the option of dewatering.

Homogenization. Mechanical means of homogenization produced a more friable soil of better consistency.

Particle Size Reduction. Screening of the soils removed extraneous oversize materials and improved soil consistency. Organic matter can be shredded and reintroduced into the feed stock in order to reduce rejects from the screening process.

Solidification. Solidification with cement, fly ash and lime were evaluated. High calcium quicklime produced the best final results with a more friable material of smaller particle size and lower moisture content.

5.1.4 Conclusions and Selected Pretreatment Methodology.

Based on the results of the bench scale material pretreatment study, the following were the selected pretreatment methodologies for the pilot demonstration:

- o Pretreatment of the LEFPC soils with up to 8% high calcium quicklime to improve handleability.
- o Removal of oversize materials by screening (minus 1/2 inch maximum top size).
- o Shredding of organic matter with soil shredder.
- o Reintroduction of organic matter into the LEFPC soils.
- o Homogenization of the pretreated soils.

**FIGURE 5.1 MATERIAL HANDLING & CONDITIONING
FLOW CHART**

5.2 Material Pretreatment-Pilot Demonstration

The purpose for material pretreatment for the pilot demonstration was to develop a material handling program that would address the existing characteristics of the LEFPC soils in relationship to the conditions of the pilot demonstration processing equipment.

5.2.1 Pretreatment Equipment

Based on a bench scale study discussion in Section 5.1, material pretreatment was found to be necessary with the LEFPC soils. In order to provide the pretreatment identified in the bench scale study, special equipment was prepared for purpose of preconditioning the soils. The major components of the preconditioning equipment included the following (Figure 5.2):

- o Mix Box
- o Large Stationary Screen
- o Soil Shredder

Additional auxiliary equipment included a platform scale, Bobcat loader with drum tipper and backhoe attachment, table-top scale, and belt conveyor (Figure 5.3).

5.2.2 Controls and Calibration

The pretreatment equipment was used to condition the LEFPC soils to a specific design. Processing was accomplished through the following methodology (Figure 5.4). A Bobcat loader equipped with a drum tipper unloaded select amounts of soils onto a large stationary screen along with the specified amount of reagent (high calcium quicklime). The soil-reagent mixture was worked through the screen which passed into the mix box. Oversize from the screening operation was divided into organic (plant vegetation) and inorganic matter (metal, stones). The organic matter was shredded in a soil shredder and reintroduced into the minus 1/2 inch material. The oversized inorganic matter was put in a discard pile. The material was then completely mixed and allowed to stockpile in the mix box.

Selected amounts of soils and reagents utilized in the pretreatment were tracked using calibrated scales. Calibration of equipment was accomplished on site by VFL and NFS staff (Table 5.1). The calibration records are found in Appendix I.

Table 5.1 Equipment and Calibration

Equipment:

Calibration:

Processing Container - 4 feet x 6 feet Open Top Steel Box
Screen - 1/2" Screen Used to Remove Oversize
Soil Shredder
Bobcat loader with Drum Tripper and Backhoe Attachment
4' x 4' Platform Scale
Table-Top Scale
Conveyor with Feed Hopper Belt

Not Applicable
By VFL Staff
Not Applicable
Not Applicable
By NFS QC Staff
By NFS QC Staff
By VFL Staff

FIGURE 5.2 PRETREATMENT EQUIPMENT SKETCH

Figure 5.3 Pretreatment Equipment

Construction of soil conditioning mix box

Mixing box with conveyor and screen in place

FIGURE 5.4 SOIL PRETREATMENT FLOW CHART

5.3 Thermal Treatment Unit

5.3.1 Thermal Unit and Support Equipment

The Low Temperature Thermal Desorption unit used for the pilot demonstration is composed of two major components. They are the thermal desorber and the vapor recovery system (Fig 5.5). These components and their auxiliary equipment are discussed in the following sections.

5.3.1.1 Thermal Desorber

The thermal desorber consists of the thermal desorber (porcupine processor), the heat generation system, the feed and discharge systems. Specifications on this unit are found on Table 5.2.

The thermal desorber is a hollow shaft, cut flight paddle dryer (Figure 5.6). It is constructed with a series of hollow paddles or blades that are permanently attached to a hollow center rotor. Heat transfer fluid is circulated in the shafts, paddles, and jacket and heat is transferred through the metal walls to the process mass.

The variable speed rotors convey a fixed volume of material from the inlet, or feed end, to the product discharge end (Figure 5.7). An adjustable weir plate on the discharge end controls the operating volume of the dryer bed. Divider plates between the two sides of the desorber can be removed to increase retention time of the soils by directing the material around in a complete circle before discharge (Figure 5.8).

The desorber has the capability to allow a steam sparge into the bed of the desorber or through a port on the lid of the desorber. This unit is equipped with thermocouples, strip chart recorder, and magnahela gauge to monitor operating functions.

Table 5.2 Desorber Specifications

<u>Model No.</u> - Bethlehem 2Q1206JT Porcupine Processor
<u>Volume</u> - 8.7 ft ³ 4.4 ft ³ per side
<u>Conveys</u> - 0.7 cubic ft/hr/rpm
<u>Drive</u> - 5 hp Motor with Variable Speed Control
<u>Effective Shaft Length</u> - 6'
<u>Auger Diameter</u> - 12"
<u>Auger Pitch</u> - 1.5 degree
<u>Trough Configuration</u> - Down and Back
<u>Trough Volume</u> - 3.8 ft ³ Conveying Capacity 0.7 ft ³ /hr-RPM
<u>Steam Sparge</u> - Through Bed or Above Auger
<u>Vessel Operating Pressure</u> - Slight Vacuum
<u>Heat Transfer Surface, Rotor</u> - 56 ft ² (1/2 of area used for Run 0 and 1)
<u>Heat Transfer Surface, Jacket</u> - 20 ft ² (1/2 of area used for Run 0 and 1)
<u>Heat Transfer Fluid</u> - Dowtherm G
<u>Heater</u> - 3 Heaters Totaling 113 KW

Figure 5.5

Thermal Desorber (front view)

Thermal Desorber (top view)

FIGURE 5.6 THERMAL UNIT & SUPPORT EQUIPMENT
DESORBER - LEFT SIDE VIEW

THERMAL UNIT & SUPPORT EQUIPMENT
DESORBER - CROSS SECTION

Figure 5.7

**Internal view of Thermal Desorber
(Twin Shafts - front view)**

**Internal view of Thermal Desorber
(Desorbing Chambers - overhead view)**

FIGURE 5.8 THERMAL DESORBER-TOP VIEW

Heat Generation System. The heat generation system is a 480 volt 3 phase three heater system. The heater elements provide heat to a heat transfer fluid which is then circulated throughout the desorber via an oil pump to provide indirect fired heating of the desorber. A pressurized nitrogen blanket is applied over top of the heat generation system to allow higher oil temperatures to be run for the heat transfer fluid utilized. The heat generation system is equipped with thermocouples and thermometers for both monitoring and control of temperatures. Figures 5.9 and 5.10 show the heater generation system components.

Feed System. The feed system for the thermal desorption unit consists of a feed hopper and a rotary airlock (Figure 5.11). The rotary airlock is controlled by a variable speed motor that allows soil to enter the desorber without allowing the entrance of excess air into the desorber.

Discharge System. The discharge system for the thermal desorption unit consists of a butterfly valve and a sealed lid with a sampling port. The normal operating position for the butterfly valve is open with the lid sealed to the top of the a 55 gallon drum. During sampling, the valve is closed. This prevents air leakage into the desorber while the sampling port is open (Figure. 5.12).

5.3.1.2 Vapor Recovery System

The vapor recovery system consists of a scrubber-condenser and a cold trap. Specifications are found in Table 5.3.

Table 5.3 Scrubber - Condenser

Serpentine Direct Contact Condenser - Capable of Condensing 80 lbs/hr of Water
Scrubber Tank - 200 Gallon Capacity
Heat Exchanger - 35 Square Foot Surface Area
Chiller - 20 ton UIR Refrigeration Unit
Blower - Variable Speed Blower to Maintain Slight Negative Pressure on System

Scrubber-Condenser. The scrubber-condenser consists of a serpentine direct contact condenser capable of condensing 80 lbs/hr of water (Figure 5.13). The unit works by circulating cooled water through the vapor stream from the desorber. The liquor stream is circulated under pressure through a cooling interchange prior to being sprayed through the condenser serpentine. Liquid exiting the scrubber-condenser drains into the scrubber tank which serves as both a supply tank for the scrubber pump and a storage tank for the liquids produced by the condensing process (Figure 5.14).

The noncondensable gas stream that remains after the scrubber-condenser is directed through a sealed centrifugal blower and is discharged into the cold trap. This variable speed blower provides an adjustable air flow from both the scrubber-condenser and the thermal desorber to make up for any air leakage or change in processing rate to maintain a vacuum on the system.

Figure 5.9

**Hot Oil Heater Unit
Being Installed**

**Hot Oil Heater Unit
Complete**

Figure 5.10

Hot Oil Heater Expansion Tank - Original Tank

Hot Oil Heater Expansion Tank - Replacement Tank
(onsite modification)

Figure 5.11

Rotary Vane Feed\Air Lock

Feed/Air Lock Installed

Figure 5.12

Thermal Desorber - Discharge Orifice

Thermal Desorber - Sample collection at Discharge Orifice

FIGURE 5.13 SCRUBBER-CONDENSER FRONT VIEW

Figure 5.14

Serpentine Condenser (front view)

Serpentine Condenser (side view)

A plate type heat exchanger provides the transfer area for the 20 ton refrigeration unit. This, in turn, cools the liquor stream of the closed loop system of the scrubber condenser.

Cold Trap. A cold trap was added to the vapor recovery system as a final collection point for mercury prior to discharging to the building collector. The initial cold trap was composed of a collection flask submerged in a alcohol/dry ice bath. This was later replaced with a dual column dry ice trap with two 7 foot by 10 inch chambers of stacked dry ice that could be operated in series or separately (Figure 5.15 and 5.16).

5.3.2 Controls and Calibration

5.3.2.1 Controls

The LTTD contained a series of controls to maintain the desorber at the desired process settings and to collect data from each process run. Controls on the LTTD included the following:

- o Thermal Desorber Control Panel
- o Thermocouples and Thermometers
- o Temperature Controller
- o Dial Chart Recorder With Digital Readout
- o Scales
- o Steam Sparge
- o Feed Rate
- o Rotary Airlock and Butterfly Valve
- o Magnahelix Gauge

Thermal Desorber Control Panel. The control panel provided the control settings for the thermal desorber and the scrubber-condenser. The panel was composed of one and two way switches with indicator lights that control the major operations of the system (Figure 5.17).

Thermocouples and Thermometers. Thermocouples and Thermometers were located at strategic locations on the desorber and scrubber-condenser. These temperature sensing devices were used to record operating parameters of the system (Figure 5.18 and 5.19).

Temperature Controller. The temperature controller installed in the hot oil feed line to the thermal desorber regulated the oil temperature to the desorber.

Dial Chart Recorder and Digital Readout. A single pen chart recorder and digital readout was used to collect temperature data from five thermocouples located on the desorber and the heat generation system.

Scales. Platform and table scales were used for reagent addition as well as feed and product rates.

Steam Sparge. The steam sparge rate to the desorber was controlled with a regulator and orifice plate.

FIGURE 5.15 COLD TRAP ORIGINAL DESIGN (# RUN 0.1)

COLD TRAP REPLACEMENT RUN #2, 3A, 3B , & 4

Figure 5.16

Cold Trap -
Original Design
(Runs #0 & #1)

New Cold Trap - Replacement
Cold Trap (Onsite Modification -
Runs #2, #3, and Verification
Run)

Controls & Calibration

Thermal Desorber Control Panel

INDICATOR LIGHTS

FIGURE 5.18 THERMAL DESORBER
THERMOCOUPLE LOCATIONS-LEFT SIDE

RIGHT SIDE

FIGURE 5.19 THERMOMETER LOCATIONS-CONDENSER

Feed Rate. The feed rate for the thermal desorber was regulated by the pounds/minute fed into the rotary airlock.

Rotary Airlock and Butterfly Valve. The rotary airlock on the feed and the butterfly valve on the discharge valve were used to airlock materials into and out of the thermal unit while controlling leakage of air into the system.

Magnahelix Gauge. This gauge monitored the level of vacuum in the desorber and was used to adjust the blower motor in the scrubber-condenser.

5.3.2.2 Calibration

The calibration of the control devices were conducted as per the QC Plan NFS-Q-184. A list of the controls and the calibration procedures is found in Table 5.5. The calibration data is located in Appendix A.

Table 5.5 Controls and Calibration

<u>Equipment</u>	<u>Measurement</u>	<u>Calibration Procedure</u>
1. Thermocouple Type K	Feed Temperature	NFS-EC-20 REV 4 4-1-91
2. Thermocouple Type K	Discharge Temperature	NFS-EC-20 REV 4 4-1-91
3. Thermocouple Type K	Shute Temperature	NFS-EC-20 REV 4 4-1-91
4. Thermocouple Type K	Hot Oil Feed	NFS-EC-20 REV 4 4-1-91
5. Thermocouple Type K	Hot Oil Return	NFS-EC-20 REV 4 4-1-91
6. Thermocouple Type J	Hot Oil Feed (Controller)	NFS-EC-20 REV 4 4-1-91
7. Thermometer	Hot Oil Feed	NFS-EC-10 REV 4 4-1-91
8. Thermometer	Hot Oil Return	NFS-EC-10 REV 4 4-1-91
9. Thermometer	Condenser Feed	NFS-EC-10 REV 4 4-1-91
10. Thermometer	Chiller Return	NFS-EC-10 REV 4 4-1-91
11. Platform Scale	Material Weights	NFS-EC-01 REV 7 4-1-91
12. Table Scale	Material Weights	NFS-EC-01 REV 7 4-1-91
13. Temperature Chart Recorder	Recording Type K Signals	NFS-EC-12 REV 6 6-1-92
14. Temperature Controller	Hot Oil Feed	NFS-EC-12 REV 6 6-1-92

SECTION 6

PILOT DEMONSTRATION OVERVIEW

SECTION 6

PILOT DEMONSTRATION OVERVIEW

6.0 PILOT DEMONSTRATION OVERVIEW

6.1 Experimental Design and Technical Approach

The experimental design and technical approach for the LEFPC pilot demonstration was developed by VFL after review of available documents pertaining to the project. Results of the prior treatability studies (Radian Corp.) were evaluated as well as similar projects conducted by VFL.

Teaming arrangements were developed with other environmental firms to provide the level of expertise required for the pilot demonstration. A concept for the LEFPC program was developed and finalized. A work plan was written specific to the needs of the project, as well as additional required plans needed for the project.

Equipment was prepared for project, shipped and set up on site. Individual components of the process equipment were assembled and brought on line. Additional field modifications were completed prior to and during the start-up of the process.

A soil characterization of the "as received" soils was conducted. The data was evaluated and conclusions were developed with respect to the demonstration as well as full-scale operations. Bench scale material handling tests were performed on location and the results were evaluated for final pretreatment scenarios. Soils used in the pilot demonstration were conditioned with the selected pretreatment methodology to the same level as identified in the bench-scale study.

A dry run of all system components was carried out prior to the start of the trial runs. Once the equipment was checked out and both the QA audit and the readiness review was completed, the trial runs were begun.

The trial runs included a shakedown run (Run #0) which brought all systems on line with LEFPC soils being processed. Following the shakedown run, Run #1 was conducted which was a repeat of initial conditions after adjustments had been made to the scrubber-condenser unit. The upper limits of the temperature range for the thermal desorption unit were evaluated during this run.

Run #2 was conducted with baffles removed between the two chambers of the desorber in order to evaluate increased retention time of the soil in relation to the mercury removal. A revised cold trap was installed at this time to improve collection efficiency of the vapor recovery system.

Trial Run #3A was carried out to evaluate increased through-put and production rate. Run #3B included a decrease in feed rate and removal of the steam sparge to the desorber.

The results of the five (5) trial runs were evaluated and the parameters for the final verification run were selected. Analysis of the data from the 5 trial runs showed that a combination of longer retention time, highest bed temperature, slightly reduced feed rate, and no steam sparging appeared to be the optimum processing conditions at that time. The final verification run (Run #4) duplicated as close as possible the conditions set forth in trial run #3B.

The final verification run was conducted under strict parameter control for an actual run time of ten (10) hours after a product steady state was reached. Samples were collected and shipped to approved laboratories for analysis.

The Pilot Demonstration was completed with the evaluation of all pertinent data and writing of the Final Report for the project.

6.2 Methodology and Execution

6.2.1 Sampling and Analysis

The objectives of the Sampling and Analysis program are identified in the Sampling and Analysis Plan procedure number NFS-M-055. Major objectives of the sampling and analysis program include the following:

- o To insure that all sampling and analyses are performed in accordance with U.S. EPA SW-846 guidelines.
- o To provide data used to judge the effectiveness of the VFL thermal desorption pilot process for the removal of mercury from LEFPC floodplain soil.
- o To determine if the process produces secondary wastes exhibiting toxicity characteristics under TCLP procedure in 40 CFR Part 261.
- o To quantify the release of hazardous materials to the air.

The sampling program for the LEFPC pilot demonstration was conducted in accordance with the Sampling and Analysis Plan. Samples were collected from identified locations on the equipment process train and the building stack (Figure 6.1). The samples were collected and placed in proper containers by trained technicians using the proper sampling devices as per NFS-M-055. Chain of Custodies were used in the collection and transfer of samples to the approved laboratories. Documentation is found in Appendix II.

Analysis of the soil samples for the final verification run were carried out by Roy F. Weston of West Chester, PA and EcoTek LSI of Atlanta, GA. Both laboratories are approved CLP laboratories. Samples were prepared and analyzed in accordance with U.S. EPA SW-846 guidelines at Analytical Quality Levels (AQL) III and IV. A summary of the sample collection and analysis are found in Table 6.1.

TABLE 6.1 SUMMARY OF SAMPLE COLLECTION AND ANALYSIS

Sample Description	Est. No. of Samples	Preservation Required	Analyte of Interest	Preparation Method [1]	Analytical Method [1]	Special Instructions
Soil Feed into Desorber	8	4C	Hg	7471	7471	Samples Sent Off-site to Ecotek LSI with: One Sample Analysed at AQL IV; Remaining Samples Analysed at Level III
			As	3050	7060	
			Cd	3050	7131	
			PCB	3500	8080	
			VOC	5030	8240	
			PAH	3500	8270	
			Dioxin [4]	3500	8280	
			Full TCLP	1311	[3]	
			U	[2]	[2]	
Soil Product from Desorber	8	4C	Gross A/B	[2]	[2]	Samples Sent Off-site to Ecotek LSI with: One Sample Analysed at AQL IV; Remaining Samples Analysed at Level III
			Hg	7471	7471	
			As	3050	7060	
			Cd	3050	7131	
			PCB	3500	8080	
			VOC	5030	8240	
			PAH	3500	8270	
			Dioxin [4]	3500	8280	
			Full TCLP	1311	[3]	
Condensate (HgS Sludge)	7	4C	U	[2]	[2]	
			Gross A/B	[2]	[2]	
			Hg	7471	7471	
			S	7471	6010	
			VOC	5030	8240	
			PCB	3500	8080	
			PAH	3500	8270	
			Full TCLP	1311	[3]	
			Gross A/B	[2]	[2]	
Condensate (Liquid Phase)	7	4C	Hg	7470	7470	
			S	7470	6010	
			VOC	5030	8240	
			PCB	3500	8080	
			PAH	3500	8270	
			Gross A/B	[2]	[2]	
Vent Gas	7	4C	Hg	7470	7470	Contents of Cold-Trap Dissolved in Methanol Prior to Preservation
			VOC	5030	8240	
			PCB	3500	8080	
			PAH	3500	8270	
			Gross A/B	[2]	[2]	

NOTES:

[1]-SW-846

[2]-Ecotek LSI SOP'S

[3]-Reference Table 2

[4]-Analysis Performed at Roy F. Weston, Inc.

FIGURE 6.1 SAMPLING AND ANALYSIS

6.2.2 Quality Assurance Program

The purpose of the quality assurance program is to insure all information, data, and decisions resulting from the pilot demonstration are technically valid and properly documented. The Quality Assurance Plan for the LEFPC Thermal Desorption Pilot Demonstration NFS-Q-184 was prepared for this project to address the applicable elements/criteria included in EPA's QAMS-005/80, dated December 29, 1980 and DOE's Order 5700.6C, dated August 21, 1991.

The Quality Assurance Plan establishes control systems that were followed throughout the pilot demonstration. A list of the control systems are located in Table 6.2.

The Quality Assurance Manager was responsible for verifying that the Quality Assurance program was carried out properly and that records were adequately maintained. Appendix II "Quality Assurance" contains the following records: training and qualifications of personnel, assessment/audit reports, corrective action responses, analytical data reports (certificates), and QA manager reports.

Table 6.2 Established Control Systems

Training and Qualifications
Document Control
Instructions and Procedures
Control of Purchased Items and Services
Identification and Control of Items
Control of Process
Inspection
Test Control
Control of Measuring and Testing Equipment
Handling Storage and Shipment
Inspection, Test and Operating Status
Control of Non Conformance Items and Corrective Action
Processing Controls
Quality Assurance Records and Reports
Assessments/Audits

6.2.3 Data Management

The management of data generated from the LEFPC Pilot Demonstration followed the protocol stated in the Work Plan, Sampling and Analysis Plan, Quality Assurance Plan, and Letter of Authorization (LOA). Changes to these plans were documented in the field change records No. 1 to 6. The Quality Assurance Department was responsible for verifying that the data management was conducted as specified. The major components of the data management program are listed below.

Project Log Book. Information from the LTTD Pilot Demonstration Project was recorded in a hardbound laboratory notebook at the time of data generation. This produced a data base that was used for analysis and result interpretation. This data was then utilized for report writing.

Centralized Filing Location (Locked Fireproof File Cabinet). Data management included a central location of all information for the project. All information was confined to one four (4) drawer fireproof locked file cabinet. Any in use data, such as the lab book, was returned to the this location at the end of the work shift.

Sampling and Analysis. Samples from the pilot demonstration were entered in the log book and the sampling log as per NFS-M-055. At a minimum, information recorded included:

- o Sample Type
- o Observations
- o Collector(s)
- o Date and Time
- o Sample Identification Number
- o Analysis Required

Chain of custodies and container labeling followed SW-846 guidelines.

Document Review. Review of documents followed procedures as specified in the Quality Assurance Plan. Changes or modifications to the controlled documents required signatures by all team members as well as the normal required sign-offs.

Data Distribution Control. The distribution of documents and data was controlled through the document control procedure No. NFS-RM-008.

6.2.4 Deviations from the Work Plan.

Deviations from the work plan that occurred during the pilot demonstration are listed in below:

- o **Hepa Filter.** A high efficiency particulate filter (HEPA) was installed in the building ventilation system. This was done for added protection to minimize discharge from the building.

- o **Cold Trap.** The existing alcohol-dry ice bath cold trap was replaced with a larger dry-ice cold trap due to the original cold trap being undersized for the volume of scrubber off gas actually produced.

- o **Heat Transfer Fluid.** The heat transfer fluid used in the thermal desorber was Dowtherm G rather than Thermonal 75. This was due to the physical properties of the Dowtherm G being more acceptable to the process.

- o **Wipe tests.** Wipe tests were performed before the start of any tests before the final verification run and after the final verification run to assure cleanliness of the desorber. Wipes were conducted on the thermal desorber, the transfer pipe and the condenser.

- o **Desorber Clean-out.** The desorber was cleaned out by using a liquid wash rather than a brush clean due to the brush cleaning not being satisfactory.

o **Air Monitoring at Building Discharge.** Air monitoring was conducted at the building stack when conditions indicated that mercury might be passing the cold trap.

o **Deletion of Steam Sparge.** On one of the trial runs and the final verification run the steam sparge was not used because steam sparging did not enhance mercury removal.

o **Removal of Crossover Plates.** The crossover plates between the two sides of the desorber were removed for runs #2 and #4 to increase retention time of the soils in the desorber.

o **Reduced Variability in Temperature.** Due to limitations of the heat transfer fluid and a larger span between transfer fluid and the bed temperature, less temperature settings were accomplished.

o **Reduction in Soil Quantity Utilized.** Less soil was used for the complete project due to lower feed rates for the trial runs and the final verification run. Feed rates estimated prior to the pilot demonstration were more aggressive than the rates used for the actual demonstration.

SECTION 7

PILOT SCALE TRIAL RUNS

SECTION 7

PILOT SCALE TRIAL RUNS

7.0 PILOT SCALE TRIAL RUNS

7.1 Objectives

The primary objectives of the pilot scale trial runs were to evaluate the effectiveness of the LTDD equipment for the removal of mercury and mercury compounds from the LEFPC soils. Through a series of process runs and laboratory testing, thermal desorption processing was evaluated. The information gained from the trial runs would then be used in defining the best parameters to be used for the final verification run.

The program developed for the trial runs was divided into two phases. The first phase included pilot scale material handling and conditioning while the second phase consisted of pilot scale processing through the thermal desorber.

7.1.1 Material Handling and Conditioning

The objective of the material handling and conditioning phase for the pilot scale trial runs was to take the methodology developed in the VFL Bench Scale Material Pretreatment Study (see Section 5.1) and set pilot scale conditioning parameters. The methodology utilized for the pilot scale runs included conditioning the soils with quicklime, screening oversize, shredding of organic matter, and homogenization. This pretreatment methodology would be carried out in similar proportions for all subsequent process runs.

7.1.2 Pilot Scale Processing

The objectives of the pilot scale processing through the thermal desorber were to define the operating conditions and requirements for the final verification run. This was carried out through a series of five (5) trial runs. During these runs, operating parameters were evaluated with their relationship to mercury removal. These operating parameters included the following:

Feed Rate. The LEFPC conditioned soils were fed through the desorber at different feed rates. Results of the trial runs were used to evaluate processing speed verses mercury removal.

Retention Time. Retention time is a factor of the feed rate into the desorber. Results were again used to evaluate processing speed verses mercury removal. The retention time calculation is located in Appendix VII.

Soil Temperature (Bed Temperature). The temperature that the soil reaches in the thermal desorber was evaluated for mercury removal from the conditioned LEFPC soils.

Steam Sparge Rate. The need for a steam sparge was evaluated for mercury removal from the LEFPC soils. The steam sparge rate calculation is located in Appendix VII.

7.2 Operations

Five trial runs were carried out on the LEFPC floodplain soils. General operating conditions are listed below.

Conditioning. The LEFPC soils were all conditioned prior to the trial runs. The soils were conditioned equally with 2% high calcium quicklime and screened to minus 1/2 inch. The oversize material was separated and the organic matter portion of the oversized material was shredded and reintroduced into the minus 1/2 inch material. The material was then homogenized and allowed to stockpile. The final product was a friable soil-like material. Table 7.1 lists oversize rejected from the conditioning process.

TABLE 7.1 Soil Screening - Oversize Rejects

<u>Drum #</u>	<u>Net Weight (lb)</u>	<u>Oversize (lb)</u>	<u>% Oversize</u>
8	338	----	----
16	364	----	----
20	363	----	----
--	---	47 ¹	4.4
12	421	12	2.8
28	486	12	2.5
19	400	8	2.0
13	416	8	1.9
14	432	11	2.5
11	455	9	2.0
23	442	8	1.8
27	424	14	3.3
9	404	8	2.0
			Average 2.8%
¹	Total of Drum 8, 16, and 20.		

Operating Times. The time of run for the trial runs ranged from 2 hours to 6 hours in duration. The warm-up time of the equipment was typically 2.5 hours. The cool down time of the equipment was 1.5 hours to 400°F (204°C) and 18 to 24 hours to ambient.

Process Temperatures. The bed temperatures (soil temperatures) ranged from 398°F (203°C) to 562°F (294°C) and the hot oil temperatures varied from 685°F (363°C) to 690°F (366°C). The bed temperature averaged 149°F (65°C) below the hot oil temperature of the hot oil heater.

Process Rates. The soil feed rates ranged from 120 pounds/hour to 240 pounds/hour. The corresponding retention times in the thermal desorber ranged from 94 minutes to 188 minutes in length.

Steam Sparge. A steam sparge was used on four (4) of the runs and not used on one (1) of the runs. The steam was either introduced into the desorber bed or the top of the desorber lid.

Sampling and Analysis. Sampling was conducted on the feed material in to the desorber and the product from the desorber. The condenser water and the cold trap were also sampled. The samples were analyzed at the on-site laboratory for total mercury and sulfides. Laboratory data packages are located in Appendix IV.

Equipment Cleanliness. Equipment was cleaned between each run in preparation for the following run. Procedures for cleaning were as noted in the VFL Work Plan except a liquid wash was used rather than brush cleaning.

Process Liquids Treatment. Any process waters and cleanup waters were properly collected, stored, and treated at NFS Waste Water Treatment Plant prior to disposal.

7.3 Process Monitoring

The monitoring of the process of the five (5) trial runs included the setup of the equipment controls to initial specified conditions and monitoring of data generated on conditions of the operating system.

Run #0 (Shakedown Run). This run was set up to evaluate the workings of the thermal desorption system as a whole with conditioned soils being processed. The feed rate was set at an average rate with the hot oil temperature on the highest setting (Table. 7.2). During this shakedown run fugitive emissions of mercury were detected in the work areas. Because these levels were below Permissible Exposure Limits (PEL) for employee safety and health, the decision was made to immediately curtail the run prior to completion.

The LTDD system went through a normal shutdown. Samples were collected and analyzed and the system was prepared for the next run. Sources of the fugitive emissions were identified as being from leaks in connections of condenser vent lines and the seal in the blower motor. Corrections were made to these problems prior to initiating the succeeding process run.

Material bed depth loading was evaluated after completion of this run. Figure 7.1 shows discharge orifice with flange removed.

Run #1 (Repeat Run). This run was initiated to evaluate the same conditions as Run #0, however, carrying the process to completion. Run #1 was completed successfully and all data was gathered. The processed material from this run was sampled and analyzed.

After this run, questions developed on the efficiency of the previously used cold trap. It appeared that the cold trap was undersized for the application. A field fabricated cold trap was installed to rectify this situation.

Environmental concerns also developed relating to stack emissions from the building. The issue was resolved after conversations with the Air Pollution Control Agency for the State of Tennessee before the initiation of the following trial run.

TABLE 7.2 DESORBER SETTINGS

	Test 0 4/25/94	Test 1 4/29/94	Test 2 5/5/94	Test 3A 5/10/94	Test 3B 5/10/94
Steam	19 lbs/hr (1)	19 lbs/hr (1)	19 lbs/hr (1)	19 lbs/hr (1)	0 lbs/hr (2)
Auger Speed	3 rpm	3 rpm	3 rpm	9 rpm	9 rpm
Hot Oil Supply (°F-°C)	690-366	690-366	685-363	689-365	690-366
Dryer Jacket (°F-°C)	-	620-327	614-323	621-327	622-328
Vapor Temp Out (°F-°C)	-	339-171	306-152	Not Available	Not Available
Condenser Water Temp (°F-°C)	-	77-25	70-21	75-24	76-24
Temp Cold Trap (°F-°C)	32-0	32-0	39-4(3)	50-10(3)	48-9(3)
Feed Rate (lbs/hr)	120	120	120	240	180
Crossover Plate	In	In	Out	Out	Out
Steam Sparge	Yes	Yes	Yes	Yes	No
Retention Time (min)	94	94	188	94	125
Bed Temperature (°F-°C)	-	398-203	530-277	510-266	562-294

(1) = Bottom Charge
(2) = Top Charge
(3) = Modified Cold Trap

Figure 7.1

**Discharge Orifice - Flange removed for
material bed depth/loading evaluation
(shakedown run)**

Run #2 (Increased Retention Time). The results of Run #1 showed that mercury was being desorbed at a high level, however, the target of 10 ppm in the final product had not been achieved. With the temperature of the desorber already operating at the highest allowable setting based on heat transfer fluid limits, retention time of the soils in the desorber was considered as the next variable. The crossover plates between the two sections of the desorber were removed allowing for a doubling of the retention time in the desorber. All other control settings remained the same.

Run # 3A (Increased Feed Rates). Review of the operations data and laboratory analysis for mercury from the last trial run showed no significant improvement in removal with the increase of the retention time. Run #3A evaluated higher feed rates with a doubling of the pounds/hour from the previous run. The auger speed was increased to allow for higher feed rates. All other control settings were left static.

Run #3B (Decreased Retention Time, No Steam Sparge). The second segment of Run #3 included evaluating the need for a steam sparge while adjusting the feed rate to the mean of the two previous runs. The steam sparge was shut off and the thermal unit was allowed to achieve a steady state prior to initiating this segment of Run #3. No other control settings on the thermal desorber were adjusted.

7.4 Results and Interpretation

The trial run results for mercury removal from the LEFPC soils can be found in Table 7.3. The average Hg concentration of the feed material for the five (5) trial runs ranged from 362 mg/kg to 213 mg/kg. The average Hg concentration in the processed soils ranged from 28 to 20 mg/kg. The percent removal varied from 89% for Run #1 to 94% for Run #3B. Mass balances for mercury were not conducted for the trial runs.

TABLE 7.3 Trial Run-Results

<u>Run#</u>	<u>Feed Mean (ppm Hg)</u>	<u>Product Mean (ppm Hg)</u>	<u>% Removal</u>
Run 0	248	28	89
Run 1	330	24	93
Run 2	213	20	91
Run 3A	262	21	92
Run 3B	362	20	94

With the data derived from the five (5) trial runs, interpretations were made that would be utilized for selecting the system setup matrix for the final verification run. The interpretations are as follows:

- o Conditioning performed on the LEFPC soils is satisfactory. Conditioned soils fed well with minimal problems associated with the feed system.

- o Mercury can be effectively removed with bed temperatures from 400°F (204°C) to 560°F (293°C). Temperature did not appear to be a large factor in the desorption process in the working range of the trial runs (Figure 7.2).
- o The feed rates through the desorber were acceptable to 240 pounds/hour. Feed rates trials beyond 240 pounds /hour were not attempted during the trial runs.
- o Soil retention times in the desorber do not appear to be a major factor in mercury removal in the ranges of the trial runs.
- o The steam sparge did not enhance mercury removal. There is apparently enough steam generated during the thermal process to mitigate any advantages to steam addition.
- o The processing equipment operated efficiently with no material buildup, clogging, or sticking in the desorber.

**FIGURE 7.2 COMPARISON OF Hg LEVELS IN SOIL BEFORE AND AFTER
DESORPTION**

SECTION 8

PILOT SCALE FINAL VERIFICATION RUN

SECTION 8

FINAL VERIFICATION RUN

8.0 FINAL VERIFICATION RUN

8.1 Objectives

The test objectives of the Final Verification Run were to simulate full-scale conditions by processing a large quantity of contaminated soil for an extended period of time under the optimum processing conditions developed during the previous trial runs.

8.2 Operations

Data developed through previous runs is used to select operating parameters for the final verification run. Critical parameters include the following:

- o Feed Rate of the Soils
- o Retention Time in the Thermal Desorber
- o Bed Temperature (Soil Temperature)
- o Steam Sparge Rate

Material Handling and Conditioning. All LEFPC soils used for the final verification run are to be conditioned as identified in the bench scale treatability study and conducted for the trial runs (Figure 8.1).

Material Processing. Provide operation of the LTDD system for 8 hours continuous operation.

Sampling and Analysis. Collect soil feed and product samples from the process as per the Sampling and Analysis Plan. Collect samples from the different waste streams for analysis. Provide proper sample tracking and shipping to approved laboratories. Provide analysis as required in accordance with U.S. EPA SW-846 guidelines at the designated levels required.

Data Collection. Collect and record data from all operating sources. Record any other pertinent information.

Cleanliness Verification. Prior to and after the final verification run, verify cleanliness of the desorber system by conducting wipe tests on the major components.

Figure 8.1

Typical consistency of conditioned soils prior to Thermal Desorbtion (shredded, screened and lime treated)

Consistency of conditioned soil before Thermal Desorbtion (left) and after Thermal Desorbtion (right)

Air Monitoring for the Environment. During the verification run, monitor the discharges from the building to ascertain levels of mercury released.

Air Monitoring for Employee Safety. Monitor the work environment for employee safety and health.

The final verification was conducted on May 12 and 13, 1994. After review of all pertinent data from the previous runs, the final run was developed using setup conditions similar to trial run #3B.

8.3 Process Monitoring

Operating Times. The warm-up time for the desorber was 2 hours and 25 minutes. The loading time for the soil into the desorber was 2 hours. Actual run time was 10 hours and 30 minutes. A cool-down period of 1 hour and 30 minutes was needed to reach 400°F (204°C) hot oil temperature. A total of 18 to 24 hours was needed to bring the unit to ambient conditions.

Material Handling and Conditioning. The 1770 lbs of soil fed into the desorber had been conditioned with lime as per the trial runs. The soil collected from the desorber was placed in 55 gallon drums.

Operating Conditions. The processing conditions for the final verification run are as noted. The bed temperature for the soil was 555°F (291°C) with a hot oil temperature of 690°F (366°C). The process rate was set at 180 pounds/hour which produced a retention time of 125 minutes in the desorber. There was no steam sparge for the final verification run.

Sampling and Analysis. Sampling and analysis were conducted as per the Sampling and Analysis plan. The feed and product were sampled every hour for 8 sampling intervals with a hour and a half stagger between collection of the first feed and the first product sample. The total sampling period was 9 hours and 30 minutes (Figure 8.2).

The scrubber-condenser and the cold trap were sampled at the end of the process run. A summary of the required testing is located in Appendix VIII.

Samples collected also included split samples of all the soil samples which were sent to MMES for evaluation.

Field Observations. The final verification run was generally uneventful. An anomaly in the operation was a jam in the feed hopper to the thermal desorption unit. This entailed a 20 minute delay in the feed to the desorber while the jam was removed. There were no other delays to the verification run. A summary of the process monitoring is located in Table 8.1.

Figure 8.2

Sampling & Analysis
Sample collection
during a processing run

Sampling & Analysis
Packaging of samples
for off site analysis

TABLE 8.1 FINAL VERIFICATION RUN-PROCESS
MONITORING

	Test 4
	5/12/94
Steam	0 lbs/hr (2)
Auger Speed	9 rpm
Hot Oil Supply (°F-°C)	689-365
Hot Oil Return (°F-°C)	663-351
Dryer Jacket (°F-°C)	623-328
Vapor Temp Out (°F-°C)	332-167
Condenser Water Temp (°F-°C)	78-26
Temp Cold Trap (°F-°C)	54-12(3)
Feed Rate (lbs/hr)	180
Crossover Plate	Out
Retention Time	122
Bed Temperature (°F-°C)	555-291

- (1) = Bottom Charge
 (2) = Top Charge
 (3) = Modified Cold Trap

8.4 Results and Interpretation

8.4.1 Chemical Analysis of the Raw and Processed LEFPC Soils

Arsenic. Arsenic analyzed in the feed and the product indicated a 31% increase in concentration (Table 8.3). This increase is believed to be related to the loss of water and organic material from the LEFPC process soils. The TCLP analysis of the processed soils showed concentrations well below the RCRA unit.

Mercury. Analysis of the pre and post sampling of the LTTD process indicate a removal rate of 94.1% (Table 8.2). This data compares reasonably well with the results of trial run #3B. It must be noted that the duplicate sample analyzed on the feed material was significantly higher than the rest of the data points (Table 8.3).

Table 8.2 Final Verification Run - Results

<u>Run #</u>	<u>Feed Mean (ppm Hg)</u>	<u>Product Mean (ppm Hg)</u>	<u>Removal</u>
Final Run	403.2	23.8	94

Cadmium. The analysis of cadmium in soils before and after treatment indicates a concentration of cadmium of 71% over the feed material. Again, this increase in concentration is believed to be in part related to the loss of water and organic material from the processed material. TCLP analysis of the processed soils showed cadmium concentrations well below RCRA units, as was observed in the analysis.

Uranium. Table 8.4 lists the uranium data for the analysis of samples before and after LTTD processing. The slight enrichment in the LTTD soils may be related directly to the process or may be a sampling anomaly.

Gross Alpha and Beta. Alpha and Beta showed slight increases from the feed material to the final product of 4.9% and 2.3% respectively.

PCBs. PCBs analyzed in the feed material and the product were determined by EPA Method 8080. Table 8.5 gives the results which indicate that Aroclor 1260 is the only significant analyte detected in the unprocessed soils. This Aroclor was not generally detected in the processed soils except for sample 1661B-223 where both Aroclor 1260 and 1242 were detected. Surrogate recovery was outside QC limits on this sample which may limit the usefulness of this data. PCB emissions may be a concern in full scale.

Volatile Organics. The trace amounts of volatile organics found in the feed and product were either in estimated amounts or were also identified in the associated blank (Table 8.6). This limits the usefulness of this data.

Semivolatile Organics. Table 8.7 lists the results of semivolatile organics for the feed and product from the LTTD pilot demonstration.

**TABLE 8.3 TOTAL METALS AND TCLP METALS
FINAL VERIFICATION RUN**

Description	TCLP								Total			
	As	Ba	Cd	Cr	Pb	Hg	Se	Ag	As	Cd	Hg	
Feed 1	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	8 *	327	
Feed 2	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	5 *	12 *	413	
Feed 3	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	0.15	(0.05) *	5 *	12 *	385	
Feed 4	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	4 *	84 *	866	
Feed 4	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	5 *	10 *	234	
Feed 5	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	14 *	394	
Feed 6	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	6 *	11 *	305	
Feed 7	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	5 *	13 *	405	
Feed 8	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	5 *	9 *	300	
Prod 1	(0.1)	16	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	10 *	29	
Prod 2	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	10 *	25	
Prod 3	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	10 *	23	
Prod 4	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	9 *	24	
Prod 4	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	9 *	24	
Prod 5	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	10 *	24	
Prod 6	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	10 *	24	
Prod 7	(0.1)	(5)	0.02	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	9 *	19	
Prod 8	(0.1)	(5)	(0.01)	(0.05)	(0.05)	(0.005)	(0.1)	(0.05) *	7 *	10 *	23	
Cond. Solids	(0.1)	(5)	0.04	(0.05)	(0.05)	0.24	(0.1)	(0.05)	7 *	13 *	1,950	
Cold Trap	-	-	-	-	-	-	-	-	-	-	135	
Cond. Liq	-	-	-	-	-	-	-	-	-	-	3	

NOTE: ### = Below PQL; PQL = Practical Quantification Limits; * = Estimated values due to results of QC samples
Total metals exposed in mg/kg except cold trap and condenser mg/l
TCLP metals are in mg/kg

**TABLE 8.4 ALPHA, BETA, & NATURAL URANIUM
FINAL VERIFICATION RUN**

Analyte (pCi/g or pCi/mL)	Feed									Condenser Liquid
	1	2	3	4	4 Dup	5	6	7	8	
Total U	34.7	23.7	33.4	31.3	41.8	38.5	36.4	38.5	39.0	-
Gross Alpha	48.1	37.0	36.5	27.4	41.4	42.1	30.9	32.2	34.4	337.0
Gross Beta	42.6	40.1	51.6	41.1	38.4	46.4	43.7	35.7	45.8	139.0

Analyte (pCi/g or pCi/mL)	Product									Cold Trap
	1	2	3	4	4 Dup	5	6	7	8	
Total U	37.3	35.2	40.3	35.2	35.2	37.6	38.8	37.0	39.0	-
Gross Alpha	41.1	36.2	38.1	49.4	38.1	35.8	38.7	28.8	40.9	(104.0)
Gross Beta	55.2	42.7	32.0	46.8	42.5	44.4	44.4	47.2	39.0	(167.0)

NOTE: (###) = Below PQL

TABLE 8.5 PCB'S
FINAL VERIFICATION RUN

Analyte (ppb)	Feed									Condenser Solids	Condenser Liquid
	1	2	3	4	4 Dup	5	6	7	8		
Aroclor 1016	(42.3)	(34.2)	(41.5)	(44.3)	(41.1)	(42.3)	(51.4)	(42.3)	(42.2)	(53.0)	(1.0)
Aroclor 1221	(84.6)	(68.4)	(83.0)	(88.6)	(82.3)	(84.5)	(103.0)	(84.5)	(84.4)	(106.0)	(2.0)
Aroclor 1232	(42.3)	(34.2)	(41.5)	(44.3)	(41.1)	(42.3)	(51.4)	(42.3)	(42.2)	(53.0)	(1.0)
Aroclor 1242	(42.3)	(34.2)	(41.5)	(44.3)	(41.1)	(42.3)	(51.4)	(42.3)	(42.2)	1,310.0	(1.0)
Aroclor 1248	(42.3)	(34.2)	(41.5)	(44.3)	(41.1)	(42.3)	(51.4)	(42.3)	(42.2)	(53.0)	(1.0)
Aroclor 1254	(42.3)	(34.2)	(41.5)	(44.3)	(41.1)	(42.3)	(51.4)	(42.3)	(42.2)	(53.0)	(1.0)
Aroclor 1260	751.0	689.0	1,020.0	824.0	854.0	920.0	1,300.0	666.0	873.0	1,450.0	(1.0)

Analyte (ppb)	Product									Cold Trap
	1	2	3	4	4 Dup	5	6	7	8	
Aroclor 1016	(33.1)	(33.3)	(32.9)	(33.3)	(33.4)	(33.2)	(33.3)	(33.2)	(33.4)	(100.0)
Aroclor 1221	(66.2)	(66.6)	(65.8)	(66.7)	(66.7)	(66.4)	(66.5)	(66.4)	(66.7)	(200.0)
Aroclor 1232	(33.1)	(33.3)	(32.9)	(33.3)	(33.4)	(33.2)	(33.3)	(33.2)	(33.4)	(100.0)
Aroclor 1242	(33.1)	(33.3)	(32.9)	(33.3)	(33.4)	(33.2)	(33.3)	(33.2)	(33.4)	(100.0)
Aroclor 1248	(33.1)	(33.3)	(32.9)	(33.3)	(33.4)	(33.2)	(33.3)	(33.2)	(33.4)	(100.0)
Aroclor 1254	(33.1)	(33.3)	(32.9)	(33.3)	(33.4)	(33.2)	(33.3)	(33.2)	(33.4)	(100.0)
Aroclor 1260	(33.1)	(33.3)	(32.9)	(33.3)	(33.4)	(33.2)	(33.3)	(33.2)	(33.4)	(100.0)

NOTE: (###) = Below PQL

**TABLE 8.6 VOA'S
FINAL VERIFICATION RUN**

Analyte (ppb)	Feed										Condenser Solids	Condenser Liquid
	1	2	3	4	4 Dup	5	6	7	8			
Chloromethane	(12)	(13)	(13)	(62)	(62)	(13)	(12)	(12)	(13)	(80)	(10)	
Bromomethane	(12)	(13)	(13)	(62)	(62)	(13)	(12)	(12)	(13)	(80)	(10)	
Vinyl chloride	(12)	(13)	(13)	(62)	(62)	(13)	(12)	(12)	(13)	(80)	(10)	
Chloroethane	(12)	(13)	(13)	(62)	(62)	(13)	(12)	(12)	(13)	(80)	(10)	
Methylene chloride	14 B	33 B	41 B	120 B	120 B	54 B	58 B	58 B	66 B	71 B	33 B	
Acetone	110 J	1,100	2,100 J	1,200	990	1,000 J	910 J	6,000 J	970	320 J	72,000 J	
Carbon disulfide	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
1,1-Dichloroethene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
1,1-Dichloroethane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
1,2-Dichloroethene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Chloroform	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
1,2-Dichloroethane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
2-Butanone	33 J	180	280	240 J	190 J	300	280	270	170	240 J	22,000 J	
1,1,1-Trichloroethane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Carbon Tetrachloride	(6)	4 J	6 J	(31)	(31)	14 J	13	6 J	15	(40)	(5)	
Vinyl Acetate	(62)	(63)	(64)	(310)	(310)	(63)	(62)	(62)	(64)	(400)	(50)	
Bromodichloromethane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
1,2-Dichloropropane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
cis-1,3-Dichloropropene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Trichloroethene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Dibromochloromethane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
1,1,2-Trichloroethane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Benzene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	42	120	
Trans-1,3-dichloropropene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Bromoform	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
4-Methyl-2-pentanone	(62)	(63)	(64)	(310)	(310)	(63)	(62)	(62)	(64)	(400)	260	
2- Hexanone	(62)	(63)	(64)	(310)	(310)	(63)	(62)	(62)	(64)	(400)	290	
Tetrachloroethene	(6)	(6)	(6)	(31)	(31)	3 J	2 J	3 J	4 J	(40)	(5)	
1,1,2,2-Tetrachloroethane	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Toluene	(6)	8	12	21 J	18 J	17 J	15	16	17	85	110	
Chlorobenzene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	(5)	
Ethlybenzene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	19 J	13	
Styrene	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	(40)	32	
Xylenes	(6)	(6)	(6)	(31)	(31)	(6)	(6)	(6)	(6)	69	44	
2-Chloroethyl vinyl ether	(12)	(13)	(13)	(62)	(62)	(13)	(12)	(12)	(13)	(80)	(10)	

NOTE: J = Estimated Value; (###) = Below PQL; B = Analyte was found in associated blank as well as in sample

TABLE 8.6 VOA'S (Continued)
FINAL VERIFICATION RUN

Analyte (ppb)	Product										Cold Trap									
	1	2	3	4	4 Dup	5	6	7	8											
Chloromethane	(25)	(52)	(50)	37	J	(50)	(50)	(50)	(50)	(50)	(5,000)									
Bromomethane	(25)	(52)	(50)	(50)		(50)	(50)	(50)	(50)	(50)	(5,000)									
Vinyl chloride	(25)	(52)	(50)	(50)		(50)	(50)	(50)	(50)	(50)	(5,000)									
Chloroethane	(25)	(52)	(50)	(50)		(50)	(50)	(50)	(50)	(50)	(5,000)									
Methylene chloride	33	B	190	B	330	B	390	B	100	B	150	B	260	B	230	B	240	B	18,000	B
Acetone	420		500	J	820	J	660	J	690	J	2,500	J	13,000	J	6,800	J	8,400	J	36,000	J
Carbon disulfide	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
1,1-Dichloroethene	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
1,1-Dichloroethane	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
1,2-Dichloroethene	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
Chloroform	(13)		(26)		(25)		(25)		(25)		(25)		7	J	(25)		(25)		17,000	
1,2-Dichloroethane	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
2-Butanone	110	J	570		1,100		840		200		380	J	270		(500)		290	J	260,000	
1,1,1-Trichloroethane	(13)		(26)		(25)		(25)		(25)		(25)		6	J	(25)		(25)		(2,500)	
Carbon Tetrachloride	(13)		(26)		73		61		6	J	(25)		(25)		(25)		(25)		(2,500)	
Vinyl Acetate	(130)		(260)		(250)		(250)		(250)		(250)		(250)		(250)		(250)		(25,000)	
Bromodichloromethane	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
1,2-Dichloropropane	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
cis-1,3-Dichloropropene	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
Trichloroethene	(13)		(26)		(25)		(25)		(25)		(25)		10	J	(25)		(25)		(2,500)	
Dibromochloromethane	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
1,1,2-Trichloroethane	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
Benzene	(13)		92		160		200		45		85		82		31		77		(2,500)	
Trans-1,3-dichloropropene	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
Bromoform	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
4-Methyl-2-pentanone	(130)		(260)		92	J	(250)		(250)		(250)		(250)		(250)		(250)		(25,000)	
2- Hexanone	(130)		(260)		58	J	(250)		(250)		(250)		(250)		(250)		(250)		(25,000)	
Tetrachloroethene	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
1,1,2,2-Tetrachloroethane	(13)		(26)		(25)		(25)		(25)		(25)		6	J	(25)		(25)		(2,500)	
Toluene	13		260		450		570		130		210		75		21	J	34		(2,500)	
Chlorobenzene	(13)		(26)		(25)		18	J	(25)		(25)		(25)		(25)		(25)		(2,500)	
Ethlybenzene	(13)		20	J	24	J	21	J	10	J	13	J	7	J	(25)		(25)		(2,500)	
Styrene	(13)		(26)		(25)		(25)		(25)		(25)		(25)		(25)		(25)		(2,500)	
Xylenes	(13)		57		85		120		36		46		26		(25)		11	J	(2,500)	
2-Chloroethyl vinyl ether	(25)		(52)		(50)		(50)		(50)		(50)		(50)		(50)		(50)		(5,000)	

NOTE: J = Estimated Value; (###) = Below PQL; B = analyte was found in the associated blank as well as in sample

TABLE 8.7 SEMIVOLATILES

Compound Name	Feed	Product
	Result (ug/kg)	Result (ug/kg)
Phenol	13000	6400
bis(2-Chloroethyl)ether	(530)	(20)
2-Chlorophenol	(530)	(20)
1,3-Dichlorobenzene	(530)	(20)
1,4-Dichlorobenzene	(530)	(20)
Benzyl alcohol	(1100)	140
1,2-Dichlorobenzene	(530)	(20)
2-Methylphenol	1900	790
bis(2-Chloroisopropyl)ether	(530)	(20)
4-Methylphenol	4000	1200
N-Nitroso-di-n-propylamine	(530)	(20)
Hexachloroethane	(530)	(20)
Nitrobenzene	(530)	(20)
Isophorone	(530)	(20)
2-Nitrophenol	(530)	(20)
2,4-Dimethylphenol	(530)	230
Benzoic Acid	(2700)	2000
bis(2-Chloroethoxy)methane	(530)	(20)
2,4-Dichlorophenol	(530)	(20)
1,2,4-Trichlorobenzene	(530)	(20)
Naphthalene	5500	88
4-Chloroaniline	(1100)	(40)
Hexachlorobutadiene	(530)	(20)
4-Chloro-3-methylphenol	(1100)	(40)
2-Methylnaphthalene	4700	26
Hexachlorocyclopentadiene	(530)	(20)
2,4,6-Trichlorophenol	(530)	(20)
2,4,5-Trichlorophenol	(530)	(20)
2-Chloronaphthalene	(530)	(20)
2-Nitroaniline	(2700)	(100)
Dimethylphthalate	(530)	(20)
Acenaphthylene	860	4.7
2,6-Dinitrotoluene	(530)	(20)
3-Nitroaniline	(2700)	(100)
Acenaphthene	560	(20)
2,4-Dinitrophenol	(2700)	(100)
4-Nitrophenol	(2700)	(100)
Dibenzofuran	1900	(20)
2,4-Dinitrotoluene	(530)	(20)
Diethylphthalate	(530)	(5.0)
4-Chlorophenyl-phenylether	(530)	(20)

TABLE 8.7 SEMIVOLATILES (Continued)

Compound Name	Feed	Product
	Result (ug/kg)	Result (ug/kg)
Fluorene	(530)	(20)
4-Nitroaniline	(2700)	(100)
4,6-Dinitro-2-methylphenol	1300	(100)
N-Nitrosodiphenylamine	1800	9.2
4-Bromophenyl-phenylether	(530)	(20)
Hexachlorobenzene	(530)	(20)
Pentachlorophenol	(2700)	(100)
Phenanthrene	6000	4.8
Anthracene	1400	(20)
Di-n-butylphthalate	(530)	5.4
Fluoranthene	5300	(20)
Pyrene	3900	(20)
Butylbenzylphthalate	650	(20)
3,3'-Dichlorobenzidine	(1100)	(40)
Benzo(a)anthracene	(530)	(20)
Chrysene	1200	(20)
bis(2-Ethylhexyl)phthalate	2900	(20)
Di-n-octylphthalate	(530)	(20)
Benzo(b)fluoranthene	(530)	(20)
Benzo(k)fluoranthene	(530)	(20)
Benzo(a)pyrene	(530)	(20)
Indeno(1,2,3-cd)pyrene	(530)	(20)
Dibenzo(a,h)anthracene	(530)	(20)
Benzo(g,h,i)perylene	(530)	(20)

J = Estimated Value

(###) = Below PQL

Semivolatile PAH Organics. Trace amounts of PAH organics were identified in the feed material. Some PAHs in estimated amounts were also identified in the product (Table 8.8).

Dioxins. The dioxins appear to have been volatilized during the LTDD process. Further studies should be directed toward this subject (Table 8.9).

8.4.2 Physical Characteristics of LTDD Soils

The soils processed through the LTDD unit had the following characteristics. The soils were light brown talcum powder type material with a distinct burned odor. The soils were bone dry (100% Solids) and had a bulk density of 63.0 lbs/ft³ and a pH (units) of 12.0.

8.4.3 TCLP Analytical on Soils

TCLPs were analyzed for both the feed and the product for the 40 toxicity characteristic parameters (Table 8.10 through 8.12). No results were over the maximum contamination concentrations.

8.4.4 Secondary Waste Generation

The secondary wastes generated during the thermal desorption process were from the scrubber-condenser and the cold trap. Both secondary waste streams were in the form of a liquid (Table 8.13).

Scrubber-Condenser. The scrubber-condenser is the location where the majority of the mercury volatilized in thermal desorber was expected to condense out. Condensate from the scrubber-condenser was sampled as a liquid slurry and allowed to settle. Both the liquid phase and the solid phase were analyzed for mercury. Approximately 45 gallons of this material was collected over the length of the process run. Approximately 150 gallons is required for make up water regardless of process batch size or processing duration.

Cold Trap. Mercury that was noncondensable at the operating temperature of the condenser was collected in the cold trap. The contents of the cold trap were sampled using a methanol wash. Approximately 2500 ml. of this liquid was collected in the cold trap during the process run.

Table 8.13 Secondary Waste Generation vs. Feed Material

Feed Material	1770 lbs
Secondary Wastes ¹	385.5 lbs
% Secondary Waste Generated	22% by weight of feed material

¹ Derived from 2500 ml from cold trap and 45.3 gal from scrubber condenser

TABLE 8.8 PAH'S
FINAL VERIFICATION RUN

Analyte (ppb)	Feed								
	1	2	3	4	4 Dup	5	6	7	8
Napthalene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)
2-Methylnapthalene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)
Acenapthylene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)
Acenapthene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)
Fluorene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)
Phenanthrene	570 J	420 J	540 J	540 J	500 J	700 J	650 J	470 J	470 J
Anthracene	84 J	70 J	81 J	76 J	76 J	100 J	91 J	52 J	97 J
Fluoranthene	1,600	1,000	1,100	1,200	1,100	1,300	1,600	1,200	1,300
Pyrene	1,300	1,000	1,200	1,300	1,200	1,400	1,600	1,000	1,100
Benzo(a)anthracene	700 J	530 J	600 J	(880)	(830)	(840)	740 J	500 J	540 J
Chysene	780 J	560 J	620 J	(880)	(830)	(840)	840 J	520 J	620 J
Benzo(b)fluoranthene	1,100	610	860	(880)	(830)	(840)	(1,000)	720	(840)
Benzo(k)fluoranthene	320 J	320 J	270 J	(880)	(830)	(840)	(1,000)	230 J	(840)
Benzo(a)pyrene	800 J	(690)	(830)	(880)	(830)	(840)	(1,000)	570 J	(840)
Indeno(1,2,3-cd)pyrene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)
Dibenzo(a,h)anthracene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)
Benzo(g,h,i)perylene	(840)	(690)	(830)	(880)	(830)	(840)	(1,000)	(850)	(840)

Analyte (ppb)	Product								
	1	2	3	4	4 Dup	5	6	7	8
Napthalene	(330)	(330)	(330)	46 J	(330)	(330)	(330)	(330)	(330)
2-Methylnapthalene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Acenapthylene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Acenapthene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Fluorene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Phenanthrene	45 J	(330)	46 J	39 J	(330)	(330)	(330)	(330)	(330)
Anthracene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Fluoranthene	89 J	47 J	130 J	86 J	69 J	57 J	37 J	54 J	72 J
Pyrene	(330)	(330)	42 J	(330)	(330)	(330)	(330)	(330)	(330)
Benzo(a)anthracene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Chysene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Benzo(b)fluoranthene	100 J	70 J	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Benzo(k)fluoranthene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Benzo(a)pyrene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Indeno(1,2,3-cd)pyrene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Dibenzo(a,h)anthracene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)
Benzo(g,h,i)perylene	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)	(330)

NOTE: J = Estimated Value; (###) = Below PQL

TABLE 8.9 DIOXINS

Description	2,3,7,8-TCCD	Total TCCD	Total PECCD	Total HXCCD	Total HPCCD	OCCD	2,3,7,8-TCDF	Total TCDF	Total PECDF	Total HXCDF	Total HPCDF	OCDF
Feed 1	U	U	U	.6 J	5.0	11	U	U	.5 J	1.4	2.6	1.5
Feed 2	U	U	U	.8 J	6.0	12	U	U	.5 J	1.7	2.9	1.6
Feed 3	U	U	U	.8 J	5.4	12	U	U	.5 J	1.8	2.8	1.5
Feed 4	U	U	U	.9 J	6.0	13	U	.1 J	.5 J	1.9	3.1	1.7
Feed 5	U	U	U	.6 J	6.0	12	U	.1 J	.5 J	1.6	3.2	2.0
Feed 5	U	U	U	.7 J	5.0	10	U	U	.4 J	1.6	2.8	1.8
Feed 6	U	U	U	.5 J	5.6	13	U	U	.4 J	1.6	3.3	2.4
Feed 7	U	U	U	.6 J	5.4	12	U	U	.5	1.7	3.1	2.1
Feed 8	U	U	U	.7 J	5.5	12	U	U	2.7	2.7	3.2	1.6
Prod 1	U	U	U	U	U	.3 J	U	.2 J	U	U	U	U
Prod 2	U	U	U	U	U	.4 J	U	U	U	U	U	U
Prod 3	U	U	U	U	U	.2 J	U	U	U	U	U	U
Prod 4	U	U	U	U	U	.3 J	U	U	U	U	U	U
Prod 4	U	U	U	U	U	.3 J	U	U	U	U	U	U
Prod 5	U	U	U	U	U	.3 J	U	U	U	U	U	U
Prod 6	U	U	U	U	U	.3 J	U	U	U	U	U	U
Prod 7	U	U	U	U	U	U	U	U	U	U	U	U
Prod 8	U	U	U	U	U	U	U	U	U	U	U	U

Results Expressed in (ng/g)

J = Estimated Value

U = Not Detected

2,3,7,8 - TCCD = Tetrachlorinated Dibenzo-p-Dioxins

Total TCCD = Total Tetrachlorinated Dibenzo-p-Dioxins

Total PECCD = Total Pentachlorinated Dibenzo-p-Dioxins

Total HXCCD = Total Hexachlorinated Dibenzo-p-Dioxins

Total HPCDD = Total Heptachlorinated Dibenzo-p-Dioxins

OCCD = Octachlorinated Dibenzo-p-Dioxins

2,3,7,8 TCDF = Tetrachlorinated Dibenzofurans

Total TCDF = Total Tetrachlorinated Dibenzofurans

Total PECDF = Total Pentachlorinated Dibenzofurans

Total HXCDF = Total Hexachlorinated Dibenzofurans

Total HPCDF = Total Heptachlorinated Dibenzofurans

OCDF = Octachlorinated Dibenzofurans

**TABLE 8.10 VOA TCLP
FINAL VERIFICATION**

Analyte	Feed									Condenser Solids	Condenser Solids
	1	2	3	4	4 Dup	5	6	7	8		
Benzene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	0.11
Carbon Tetrachloride	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Chlorobenzene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Chloroform	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	0.03	J (0.050)
1,2-Dichloroethane	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
1,1-Dichloroethene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Methyl ethyl ketone	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	21.00
Tetrachloroethene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Trichloroethene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Vinyl chloride	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)

Analyte	Product									Cold Trap
	1	2	3	4	4 Dup	5	6	7	8	
Benzene	(0.050)	0.07	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	0.05
Carbon Tetrachloride	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	0.12
Chlorobenzene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Chloroform	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	17.00
1,2-Dichloroethane	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
1,1-Dichloroethene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Methyl ethyl ketone	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	19.00
Tetrachloroethene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Trichloroethene	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
Vinyl chloride	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)

NOTE: J = Estimated Value; (###) = Below PQL; Results expressed in mg/l

TABLE 8.11 TCLP SEMIVOLATILES
FINAL VERIFICATION RUN

Analyte (ppm)	Feed									Condenser Solids	Condenser Liquid
	1	2	3	4	4 Dup	5	6	7	8		
1,4-Dichlorobenzene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2-Methlyphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	0.79
3-Methlyphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	-
4-Methlyphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	1.20
Total Methylphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	-
Hexachloroethane	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Nitrobenze	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Hexachlorobutadiene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2,4,6,-Trichlorophenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2,4,5,-Trichlorophenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2,4-Dinitrotoluene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Hexachlorobenzene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Pentachlorophenol	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.100)
Pyridine	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	0.49	-

Analyte (ppm)	Product									Cold Trap
	1	2	3	4	4 Dup	5	6	7	8	
1,4-Dichlorobenzene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2-Methlyphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
3-Methlyphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	-
4-Methlyphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Total Methylphenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	-
Hexachloroethane	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Nitrobenze	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Hexachlorobutadiene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2,4,6,-Trichlorophenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2,4,5,-Trichlorophenol	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
2,4-Dinitrotoluene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Hexachlorobenzene	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.100)	(0.020)
Pentachlorophenol	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.100)
Pyridine	0.03 J	0.04 J	(0.100)	(0.100)	0.09 J	0.05 J	0.04 J	0.06 J	0.06 J	-

NOTE: J = Estimated Value; (###) = Below PQL

**TABLE 8.12 TCLP HERBICIDES & PESTICIDES
FINAL VERIFICATION RUN**

Analyte (ppm)	Feed								
	1	2	3	4	4 Dup	5	6	7	8
Herbicides:									
2,4-D	(0.010)	0.01	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
2,4,5-TP (Silvex)	(0.020)	(0.002)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Pesticides:									
Gamma-BHC	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)
Heptachlor	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)
Heptachlor epoxide	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)
Endrin	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)
Methoxychlor	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)
Chlorodane	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)
Toxaphene	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)

Analyte (ppm)	Product								
	1	2	3	4	4 Dup	5	6	7	8
Herbicides:									
2,4-D	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
2,4,5-TP (Silvex)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Pesticides:									
Gamma-BHC	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)
Heptachlor	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)
Heptachlor epoxide	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)	(0.00025)
Endrin	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)	(0.00050)
Methoxychlor	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)	(0.00250)
Chlorodane	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)	(0.00500)
Toxaphene	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)	(0.02500)

NOTE: (###) = Below PQL

8.4.5 Mass Balance Calculations for Mercury

Calculations for the mass balance of mercury for the LTTD final verification run took into account the following data sources: Concentrations of mercury in the LTTD feed material, concentrations of mercury in the final product, mercury collected in the condenser-scrubber, and mercury collected in the cold trap. In addition the stack discharge from the building was included in the calculation.

Based on analysis of the data sources excluding the stack discharge, the recovery of mercury was only 39.7% (Table 8.14). This low number is due in part to the inability to remove all mercury from the scrubber-condenser system during sampling. Also, the sampling methodology utilized to sample the scrubber-condenser may have led to some collection inefficiency of elemental mercury from the system. Sampling methodology included circulating and agitating the scrubber condenser-water with a double diaphragm pump and a paddle mixer. An aliquot of this liquid was then collected for analyses of the liquid and solid fractions. Elemental mercury collected in this scrubber-condenser water may not have been adequately placed into suspension due to its density and thus samples may not have been representative of the mercury removed.

Table 8.14 Results of Off Gas Collection of Mercury

Mass Balance Calculations		
	<u>Hg (Grams)</u>	<u>Capture of Volatilized Hg (%)</u>
Soil In	172.3	
Soil Out	11	
Cold Trap	0.9	< 1
Scrubber	50.2	31.1
Stack Discharge	2.29	1.4
Hg Recovered	64.39	39.7
Hg Unaccounted For	107.9	60.1

A better mass balance is achieved when environmental monitoring data for the stack discharge from the building is utilized. Based on calculations of the discharge from the building (Appendix VII) the collection efficiency of the process equipment was 98.6% (Table 8.15). The use of this data is valid because Building 110-B, where all the processing took place, contains a specially designed ventilation system that keeps the enclosure at a negative pressure. All discharge occurs through a roof stack where the monitoring took place. The building filtration system which is designed for particulate capture only was not taken into account for this mass balance calculation.

Table 8.15 Results of Off Gas Collection of Mercury - Mass Balance Using Environmental Monitoring Data

	<u>Hg (Grams)</u>	<u>%</u>
Hg Volatilized from Soils	161.3	---
Hg Discharged from Stack	2.29	---
Collection Efficiency of System (1)	158.7	98.6

(1) Based on Stack Emissions Data

8.4.6 Final Verification Run Interpretations and Conclusions

The following interpretations and conclusions can be drawn from the evaluation of the data and results collected from the LTTD Final Verification Run.

Thermal Desorption Feasibility. The use of LTTD for the LEFPC soils is a feasible technology. High levels of mercury were able to be removed with this process.

Successful Operation of the Thermal Desorption Equipment. The equipment adequately handled the soils of the LEFPC. No significant problems were noted to the major components during the process run.

Successful Removal of Mercury from the Soils. 94% of the mercury in the soil feed was removed through the thermal desorption process. A longer retention time and a steam sparge are not factors in obtaining a higher removal rate (Figure 8.3).

Removal of Mercury in the Soils to 23.9 mg/kg. This level does not meet target, however, it is very consistent with the levels noted in the trial runs. Much higher desorber temperatures will be needed to achieve a lower soil mercury level and would, therefore, eliminate the advantages of LTTD.

Successful Collection of Vaporized Mercury. Mercury vaporized during the final verification run was successfully collected. Loss out the stack amounted to only 2.29 grams over a 9.83 hour period.

Secondary Wastes Evaluation. Two secondary wastes were generated during the processing. This included a scrubber-condenser liquor that contained some solids in a liquid from the cold trap. The scrubber-condenser liquor was composed of the process condensables condensed at the operating temperature of the condenser and any solids that were scrubbed from the process off gases. The cold trap liquid was composed of additional condensables that were collected from the dry ice cold trap. Total secondary wastes from the final verification accounted for approximately 46 gallons of liquid.

**FIGURE 8.3 COMPARISON OF Hg LEVELS IN SOIL BEFORE AND AFTER
DESORPTION**

SECTION 9

DEMOBILIZATION

SECTION 9

DEMOBILIZATION

9.0 DEMOBILIZATION

9.1 Decontamination and Disposal

The decontamination and disposal of the LEFPC LTDD process materials is still under way at this time. Table 9.1 shows the tasks, percent complete and expected completion dates as of the date of this report.

Table 9.1 Decontamination and Disposal Status Report

<u>Task</u>	<u>Status (%) Complete</u>	<u>Completion Date</u>
Decontaminate equipment	100%	5/94
Verify decontamination	100%	6/94
Ship equipment off-site	100%	6/94
Treat secondary wastes (liquids)	100%	7/94
Treat secondary wastes (soils)	100%	7/94
Receive approval that soils meet TCLP	100%	7/94
Discharge secondary wastes (liquids)	100%	7/94
Receive approvals for shipment of soils to MMES	In Progress	9/94 (1)
Ship soils to MMES	0%	9/94 (1)

(1) Estimated

9.1.1 Procedures

Upon completion of the final verification run, the thermal desorber unit and all potentially contaminated equipment went through a thorough decontamination. This involved disassembling of some of the processing components to allow for better cleaning.

Equipment decontamination entailed removal of all materials from the parts of the thermal unit. A water wash was then performed followed by a bleach wash. A water rinse and a cleaning solution wash were then followed by a final water rinse (Figure 9.1).

9.1.2 Execution

Secondary liquid wastes were collected and treated on site by NFS in their waste water treatment plant. Liquid wastes included process water from the condenser and wash water from the decontamination process. The treatment process for the water included pH adjustment and

Figure 9.1

Decon Operations - Thermal Desorber interior being washed

Decon Operations - floor cleaning

amalgamation. A flocculation agent was then added for phase separation. The liquid was analyzed to meet discharge limits prior to the release to NFS's waste water treatment plant for further treatment and discharge. See Appendix VIII for the secondary waste stream management information.

The thermally desorbed soils were collected for return to MMES. Testing was performed for full TCLP and Paint Filter prior to shipment. Soil and secondary waste shipments to MMES are still pending.

9.1.3 Confirmatory Analysis

Prior to release of the equipment for shipment, confirmatory testing was performed for radiation and mercury. Equipment survey included both transferable and fixed radiation. Three (3) mercury wipe samples were taken at various locations on the thermal unit, the crossover pipe and the condenser. The results of the confirmatory testing and associated limits are located in Appendix VIII.

9.1.4 Waste Disposal

Soils and secondary wastes were handled in accordance with the Waste Management Plan (NFS-M-057). Soils were drummed for return to MMES pending approvals for shipment. Liquids were collected and treated prior to discharge at NFS's onsite waste water treatment facility.

9.2 Equipment Dismantling and Removal

Equipment dismantling began shortly after completion of the final verification run. Final dismantling was completed on May 26, 1994. Final confirmatory analysis was conducted on the thermal desorption equipment on May 31, 1994. The thermal unit and all associated hardware was shipped offsite on June 16, 1994. The status of the equipment dismantling and removal is 100% complete.

SECTION 10

HEALTH AND SAFETY

SECTION 10

HEALTH & SAFETY

10.0 HEALTH AND SAFETY

This section is a overview of the employee safety program for the LEFPC pilot demonstration project. Health and Safety documentation is located in Appendix IX of this report.

10.1 Personal Protective Equipment (PPE)

Personal Protective Equipment was utilized as specified in the Radiation Work Permit (RWP) and the Health and Safety Plan Procedure # NFS-M-058. The protective equipment included smocks, shoe covers, disposable gloves, disposable Tyvek suits, coveralls, respirators, and etc. Protective equipment was required in the exclusion zones where there was a potential for exposure to the soils during the pilot demonstration (Fig. 10.1).

10.2 Training

All workers working on the LEFPC project received training on the related health and safety documents. The training was accomplished through training classes and/or self study. Worker sign-off on all training received was required prior to performing work on the project. The list of training required is included in Table 10.1.

Table 10.1 Project Training Requirements

Work Plan
Sampling & Analysis Plan
Quality Assurance Plan
Health and Safety Plan
Waste Management Plan
Transportation Plan
Letter of Authorization (LOA)
Radiation Work Permit (RWP)
8 Hour Site Specific Safety and Health Training
Lockout/Tagout (Figure 10.2)
Hazardous Waste Operations & Emergency Response (HAZWOPER)*
First Aid and CPR*

Note* Not mandatory for project, however, all VFL employees and many team members had completed this training.

Figure 10.1

**Health & Safety - Personal Protective Equipment
During Operations (Level C)**

Figure 10.2

Health & Safety Procedures - Lock Out/Tag Out

Health & Safety Procedures - Lock Out/Tag Out

10.3 Work Zones

Exclusion zones were established in the areas where there was potential for exposure to the soils during the pilot run. These areas included the drum handling area, the soil conditioning area, and the soil processing area. These areas were delineated by banner tape and warning signs excluding unauthorized personnel from entry. Protective equipment was worn as per the RWP based on the type of contaminants present and the expected levels of contamination.

10.4 Decontamination

Decontamination was required for anyone entering the exclusion zone during the pilot run. Decontamination included proper doffing of PPE and washing of hands and face before eating, drinking and smoking. In addition, all personnel were required to perform a complete personal survey for alpha contamination using a hand held detector before leaving the work zone.

10.5 Medical Monitoring

Medical monitoring for personnel working on the project included a physical for certification that they could wear protective equipment and respirators. The majority of the team members were already included in a corporate medical monitoring program with their respective employers.

10.6 Monitoring for Employee Safety

Monitoring in the workplace for employee safety and health was composed of monitoring for radioactive materials and mercury vapors. Monitoring included both real-time and time-weighted average monitoring.

10.6.1 Radioactivity Monitoring

Monitoring for radioactive contaminants was accomplished with both stationary monitors, dosimeter badges and personal air pumps.

Alpha contamination on the skin and clothing was monitored using an Eberline Model RM-20-1 monitor. Employees working in the control zone of the building performed a complete survey before being allowed to leave the area.

Thermo luminescent dosimeter badges were worn by all employees working in the facility. These badges monitored Beta/Gamma radiation exposure. Monitoring results for external radiation dosimetry indicated that all results were non-detectable for deep, shallow, and lens of eye dose equivalents. According to the requirements of 10 CFR 20, monitoring was not required for this work, however, facility procedures require that all personnel entering the plant protected areas, are required to be monitored for external radiation exposure.

Air monitoring for employee time weighted average exposure to Alpha radiation utilized MSA Flowlite pumps and sampling media. The air samples results ranged from 0.0 to 1.6 DAC-hrs. The average result for the period was 0.7 Derived Air Concentration (DAC)-hrs. The results are well below the NFS investigation limit of 8 DAC-hrs. This data is summarized in Table 10.2.

Table 10.2 Radioactivity - Time Weighted Average (Derived Air Concentration)

March 21 to May 17, 1994

<u>Location</u>	<u>Number of Samples</u>	<u>Mean Value mg/m³</u>	<u>Standard Deviation</u>	<u>Sample Range DAC-Hr</u>	<u>Limit DAC-Hrs</u>
Employee Lapel Sampler	11	.67	.65	0-1.6	8

10.6.2 Mercury Vapor Monitoring

Both real time and time weighted monitoring were carried out during the pilot demonstration. Both types of monitoring were conducted using a Jerome Instrument Corporation Mercury Vapor Analyzer, Model 411. In addition to the Jerome mercury vapor meter, Drager Tubes were also utilized for real time monitoring.

A summary of the real time monitoring for Run #4 using the Jerome meter is listed on Table 10.3. Based on this monitoring, the action level of 0.05 mg/m³ was not exceeded during this run.

Table 10.3 Mercury Vapor - Real Time Run #4

<u>Date</u>	<u>Location</u>	<u>Number of Samples</u>	<u>Mean Value mg/m³</u>	<u>Standard Deviation</u>	<u>Sample Range mg/m³</u>	<u>Limit mg/m³</u>
5/12/94 to 5/13/94	Work Area	25	0.0104	.0087	0.00 to .032	0.05

The Jerome instrument, with Jerome sampling pumps and collection tubes, was utilized to conduct time weighted average monitoring. Sampling times of 45 to 745 minutes were drawn to evaluate employee exposure rates. The data is summarized in Table 10.4. No overexposures were indicated by the collected data.

Table 10.4 Mercury Vapor - Time Weighted Average

March 22 to May 12, 1994

<u>Location</u>	<u>Number of Samples</u>	<u>Mean Value mg/m³</u>	<u>Standard Deviation</u>	<u>Sample Range mg/m³</u>	<u>Limit mg/m³</u>
Employee Lapel Sampler	11	1.9×10^{-4}	5.9×10^{-4}	9.2×10^{-8} to 2.0×10^{-3}	0.05

10.7 Environmental Monitoring

The primary environmental hazard associated with this project was potential release of radiological constituents or mercury vapor to the environment through air emissions. Environmental monitoring for the LEFPC project consisted of air stack monitoring for radioactive particulate and mercury emissions.

10.7.1 Radioactive Particulate Monitoring

A stationary air stack sampler located in the Building 110B main air discharge stack was used to monitor radioactive particulate emissions during pilot operations. Results from the stack samples collected are shown in Appendix I. These results indicate compliance with 10 CFR Part 20 limits.

10.7.2 Mercury Vapor Emissions

Stack monitoring results during the initial pilot demonstration runs indicated that mercury vapors were being discharged through the Building 110B main scrubber stack. Since this stack was not permitted for mercury emissions, processing operations were not restarted until this issue could be resolved.

The Tennessee State Air Pollution Control Agency was notified by phone (see Appendix I for telephone memorandum to State). A continuation was authorized for the Pilot Demonstration provided that the mercury concentration in the gaseous effluent from the stack did not exceed 0.05 mg Hg / cubic meter.

Monitoring of the stack was performed with a Jerome Mercury Vapor Meter. This hand held monitor was used to monitor the mercury concentration in the off-gas stack during the pilot scale testing operations. Results of mercury vapor monitoring indicates that the TLV was not exceeded during any of the process runs. The results of the stack readings are shown in Table 10.5.

Table 10.5 Stack Emissions During Verification Run

<u>Date</u>	<u>Time</u>	<u>Mean Value</u> <u>(mg Hg/m³)</u>	<u>No. of</u> <u>Samples</u>	<u>Standard</u> <u>Deviation</u>	<u>Sample Range</u> <u>(mg Hg/m³)</u>	<u>Thermal Desorber</u> <u>Cold Trap Temp.</u>	
						<u>(°F)</u>	<u>(°C)</u>
5/12/94	1445	0.0292	21	0.0031	0.026 to 0.036	39	4
5/12/94	1555	0.0159	21	0.0056	0.008 to 0.025	45	7

10.8 OSHA Reportables

During the pilot demonstration program, no OSHA reportable injuries or illnesses were reported among the participating member teams.

SECTION 11

TRANSITION TO FULL-SCALE DESORPTION

SECTION 11

TRANSITION TO FULL SCALE DESORPTION

11.0 TRANSITION TO FULL-SCALE DESORPTION

There are commercially available thermal treatment systems with dryers and condenser vapor collection equipment that are very similar to that employed in VFL's pilot demonstration. The principal difference involves capacity of soil or sludge that the desorber will process in an hour.

For the full scale remediation, VFL suggests use of the multiple porcupine dryers with a single shaft of 66 inches diameter and an internal trough of 24 feet. This dryer provides heat transfer through the jacket and through the central rotor and its many ridges or "porcupines".

Although each of these dryers can process up to 20 tons per hour, the need to first vaporize the water and then to raise the temperature several hundred degrees higher imposes a limitation on the treatment rate. Based on available data, it is anticipated that each thermal desorption unit can process 7 tons per hour. With 6 units operating in parallel on a 24 hour per day schedule, the anticipated desorption rate is 708 tons each work day. This calculation assumes 70% productivity, a figure which allows for maintenance and repairs. The round-the-clock operations is necessary because of economic factors associated with high temperature drying.

Six desorption units were incorporated into this projection because this scale of treatment allows more optimal utilization of the heavy equipment and operators involved with excavation, desorption feed, truck loading, transportation, and backfill. Although the project might use fewer desorbers, the unit cost will increase rapidly, particularly when other labor categories are included in the analysis.

The Request for Proposal specifications listed a volume of contaminated soil at 4,500,000 cubic feet. This volume equates with 167,000 cubic yards. Since in place density readings of the soil are not available, it is assumed that each cubic yard of clayey soil has a weight of 1.55 tons.

The budgetary estimate of full scale thermal desorption costs provided below is based on 258,850 tons of soil for treatment. At a processing rate of 708 tons per day, 365 work days will be required for treatment. This equates to 18 months, exclusive of mobilization, demobilization and reports.

Pricing includes the condenser/wet scrubber vapor collection system for each unit. These desorbers will be placed on a bermed pad and will operate under a roof to facilitate all weather productivity. Carbon filtration using specially impregnated carbon that can adsorb elemental mercury and mercuric sulfide will polish the air to meet emission standards.

The desorbers will be fed from a stockpile of soil that is situated on a lined, bermed pad. A front end loader will transfer the soil to a screen to ensure that only small diameter soil will enter the desorber through the conveyor system.

Soil leaving the desorber will be rehydrated automatically and transferred by a stacking conveyor that allows multiple piles to cool and pass confirmatory testing before loading onto dump trucks for backfill operations.

11.1 Assumptions/Conditions

In addition to the volume and productivity estimates previously described, several other assumptions were employed for parameters governing this budgetary estimate for full-scale cleanup.

- o Soil moisture content of 25%
- o No costs for disposal or reclamation of condensate generated by the desorption vapor collection system. This condensate will include water which can be used to rehydrate the soil, mercury compound precipitate that will sink to the bottom of the separator, and an organic, lighter-than-water fraction.
- o No pricing for reconstitution of post-desorption soil or for new topsoil/revegetation.
- o Excludes any expenditures to dispose of radiologically contaminated desorbers, conveyors, or other hardware/equipment, and replacement value for any radioactive equipment, if condition results.
- o Excludes all chemical and physical testing, as the requirements are currently unknown.
- o Excludes costs of payment and performance bonds for contractor, if required.
- o Haul road improvements are unknown, and therefore, not included.
- o Estimate listed uses 1994 prices and inflation should be considered into subsequent budgets.
- o The costs associated with excavation and backfill are excluded due to our unfamiliarity of site specific conditions.

11.2 Budgetary Estimate

The following budgetary cost is anticipated for the thermal desorption portion of the Lower East Fork Poplar Creek Project: \$25,000,000.00 (Table 11.1). The pricing reflects an anticipated quantity of 167,000 cubic yards, or 258,850 tons of soil for treatment. This equates to \$96.58/ton for the estimate conditions.

Table 11.1 Budgetary Estimate Breakdown

<u>Item</u>	<u>Cost (million dollars)</u>
Mobilization/Demobilization	1.5
Health & Safety	1.5
Process Equipment Cost	5.0
Labor	4.3
Fuel	3.0
Mobile Equipment	2.5
General & Administration	1.0
Miscellaneous	2.0
Overhead & Profit (20%)	4.2
<hr/>	
TOTAL	25.0

Figure 11.1 provides a flow diagram for the proposed full scale process.

**FIGURE 11.1 PROPOSED FULL SCALE
PROCESS FLOW DIAGRAM**