COST AND PERFORMANCE REPORT

Thermal Desorption
at Port Moller Radio Relay Station
Port Moller, Alaska

July 1998

Prepared by:
U.S. Army Corps of Engineers
Hazardous, Toxic, Radioactive Waste
Center of Expertise

SITE INFORMATION

IDENTIFYING INFORMATION

Site Name: Port Moller Radio Relay Station (RRS)
Location: Port Moller, Alaska
Technology: Thermal Desorption
Type of Action: Remedial

TECHNOLOGY APPLICATION (1)

Period of Operation: Treatability study - 1994; full-scale operation - June through August 1995
Quantity of Material Treated During Application: 9,500 cubic yards of soil

BACKGROUND

SIC Code: 9711 (National Security)

Waste Management Practice that Contributed to Contamination: Oil spills (contamination was located primarily in an outfall ditch connected to a floor drain inside a building, near underground storage tanks [UST] and aboveground storage tanks [AST], and at drum and warehouse areas).

Site Background (14, 15):

- The Port Moller Radio Relay Station (RRS) (also referred to as the U.S. Air Force White Alice RRS, or the White Alice Communications System (WACS) site) was constructed in the late 1950s and served as a communication link between Cold Bay and Port Heiden, Alaska.

- Until 1969 a Defense Early Warning (DEW) line facility and White Alice facility were co-located at the site. From 1969 to 1978, the site functioned as an RRS. In November 1978, the site was abandoned.

- The site consists of the White Alice facility (buildings and antenna) located on a plateau at an elevation of 1,000 feet, and a fuel storage and supply facility located on the shoreline at the foot of the slope leading to the plateau.

- The site is located approximately 500 miles southwest of Anchorage on the Alaska Peninsula and is accessible only by air or water.

- In 1994, the U.S. Army Corps of Engineers (USACE) performed the following environmental remediation work at Port Moller: demolition of buildings, removal of fuel tanks, construction of a landfill for disposal of debris, installation of monitoring wells, exploration and sampling of soil and water to identify areas of contamination, and seeding of the landfill containing demolition debris and of other disturbed areas.

Remedy Selection

- Thermal desorption was selected for the application on the basis of the results of a treatability study and an engineering cost analysis. A treatability study was performed for ex situ bioremediation; that technology was found to be not feasible. A cost analysis showed that on-site thermal desorption was less expensive than off-site thermal treatment; for that reason, on-site thermal desorption was selected as the remedy for the application.

Site Investigation (14):

- A site investigation was performed from May to August, 1994. Sampling performed at 10 distinct areas at Port Moller consisted of testing for soil type, depth to groundwater, and concentrations of hydrocarbons in soil and groundwater. Chemical analysis was performed for diesel range organics (DRO); gasoline range organics (GRO); benzene, toluene, ethylbenzene, and xylenes (BTEX); total petroleum hydrocarbons (TPH); and volatile organic compounds (VOC).

- Sampling results showed that DROs were present at 3 of the 10 areas in concentrations greater than 2,000 milligrams per kilogram (mg/kg), and in 2 additional areas in concentrations higher than 200 mg/kg.

- On the basis of the results of the sampling, the 10 areas were scored against matrices identified by the Alaska Department of Environmental Conservation (ADEC), which included a quantitative analysis based on depth to subsurface water, mean annual precipitation, soil type, potential receptors, and volume of contaminated soil. Scores for the 10 areas ranged from 20 to 36 under the ADEC matrices, with 3 of the 10 areas scoring in the range of 27 to 36. These scores were used in the process of setting cleanup goals - see discussion below under performance objectives.

SITE LOGISTICS/CONTACTS

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MATRIX AND CONTAMINANT DESCRIPTION

MATRIX IDENTIFICATION

Soil (ex situ)

CONTAMINANT CHARACTERIZATION

Volatiles (nonhalogenated) - GRO and BTEX
Semivolatiles (nonhalogenated) - DRO and total recoverable petroleum hydrocarbons (TRPH)

CONTAMINANT PROPERTIES

- GRO, DRO, Residual Range Organics (RRO), and TRPH are indicator parameters that refer to a range of hydrocarbons and are defined by ADEC as follows:
  - GRO - hydrocarbons in the range of C_6 - C_{10} (flash point -50°F)
  - DRO - hydrocarbons in the range of C_{10} - C_{28} (flash point 110° to 190°F)
  - RRO - hydrocarbons as C_{28} and greater (flash point > 190°F)
  - TRPH - hydrocarbons as the sum of DRO, GRO, and RRO
- Properties of the contaminants are provided below for BTEX.

Property	Benzene	Toluene	Ethylbenzene	Xylenes
Chemical Formula	C_6H_6	$C_6H_5CH_3$	$C_6H_5C_2H_5$	$C_6H_{4(}(CH_3)_2$
Moleular Weight	78.11	92.14	106.17	106.17
Specific Gravity (at 20° C)	0.88	0.87	0.87	0.86 - 0.88
Vapor Pressure (mm Hg at 70° F)	79.4	23.2	10.4	5 - 9
Boiling Point (°C at 760 mg Hg)	80.1	110.6	136.2	138.3 - 144.4
Octanol-Water Partition Coefficient (K_{ow})	132	537	1,100	1,830

CHARACTERISTICS OF UNTREATED SOIL

- Based on the results of ADEC's scoring (see site investigation), soil was excavated from five areas at Port Moller for treatment by thermal desorption. Table C-1 shows the quantity of soil excavated, soil characteristics, and maximum level of contamination found in each of the five areas.

Table C-1. Characteristics of Untreated Soil [1]

Area	Soil Quantity Excavated (cubic yards)	Soil Characteristics	Maximum Level of Contamination
Outfall Ditch	1,000	A	300,000 mg/kg TRPH (1994 Investigation)
Antennas 1 and 3	600	B	6,700 mg/kg DRO (1994 Investigation)
Warehouse	1,100	C	8,400 mg/kg DRO (1995 Excavation)
Tank Rack	1,300	D	2,400 mg/kg DRO (1994 Investigation)
Tank Farm	5,500	E	11,000 mg/kg DRO (1994 Investigation)
TOTAL	**9,500**		

A - Clayey silt with subangular rocks and cobbles, moderately to strongly cohesive.
B - Sand (from backfill).
C - Sand with small amounts of gravel
D - Sand with small amounts of gravel
E - Sand (primarily)

MATRIX CHARACTERISTICS AFFECTING TREATMENT COST OR PERFORMANCE

Listed below are the major matrix characteristics affecting cost of performance for this technology and the values measured for each parameter.

Parameter	Value
Soil Classification	See Table C-1
Clay Content or Particle Size Distribution	Information not available
Soil Plasticity	Information not available
Moisture Content	11 % by mass (3)
Oil & Grease or Total Petroleum Hydrocarbons	See Table C-1
Presence of Alkaline Metal Salts	Information not available
Lower Explosive Limit	Information not available

- The soil at Port Moller is characterized as either lowland or upland. The lowland area (warehouse, tank rack, and tank farm) is a flat outwash plain of glacial sand and minor gravel that has been reworked by shoreline wave action. Typically, those deposits have little or no silt, and the sands tend to be of larger grain sizes. The upland area (outfall ditch and antennas 1 and 3) is a substantial glacial moraine, which forms the 1,000-foot plateau, and is an undifferentiated mix of silt, often with minor clay, and coarse gravel, often with large, subangular rocks. Only small amounts of sand are present in the upland area.

TREATMENT SYSTEM DESCRIPTION

PRIMARY TREATMENT TECHNOLOGY

Thermal desorption

SUPPLEMENTARY TREATMENT TECHNOLOGIES

Post-treatment (off-gas): oxidizer and baghouse

TIMELINE (1)

Date	Activity
1950s	Construction of Port Moller RRS was completed.
1950s to 1969	Port Moller functioned as a DEW line.
1969 to 1978	Port Moller functioned as an RRS.
November 1978	The site was abandoned.
1994 (months not specified)	Anderson Excavating and Wrecking Co. (Anderson) performed the following environmental remediation work at Port Moller: demolition of buildings, removal of fuel tanks, construction of a landfill for disposal of debris, installation of monitoring wells, exploration, and sampling of soil and water to identify areas of contamination, and seeding of landfill containing demolition debris and other disturbed areas (note that seeding was not successful).
May 1994 to August 1994	Anderson performed a site investigation, including sampling and analysis of soil and groundwater.
1994 (month not specified)	Enviros, Inc. conducted a treatability study on soil from Port Moller.
April 1995	Anderson submitted a chemical data report related to the environmental remediation activities conducted in 1994.
May 1995	Anderson mobilized to the site to implement the thermal desorption technology.
June 28, 1995 to August 24, 1995	Treatment of contaminated soil by thermal desorption was conducted.
August 1995	USACE reseeded areas that had been seeded unsuccessfully.
January 1996	Anderson Excavating and Wrecking submitted a final report on site remediation and restoration activities at Port Moller.

TREATMENT SYSTEM SCHEMATIC AND TECHNOLOGY DESCRIPTION AND OPERATION (1,2,16)

Mobilization

- In May 1994, the contractor mobilized equipment to Port Moller. The equipment included a drill rig, a compressor, asbestos abatement equipment, oil recovery equipment, excavators, loaders, trucks, generators, all-terrain vehicles (ATV), and miscellaneous support equipment required for self-sufficiency at a remote site in Alaska.

Construction

- The thermal desorption system used at Port Moller consisted of an oil-fired portable treatment unit, including a 40,000,000-British thermal unit (Btu)/hour rotary kiln (direct-fired burner and afterburner Model No. P-830H0), a 28,000,000-BTU/hour oxidizer, and a 450-filter baghouse (Model No. P1533BH). The unit was custom designed to handle the wide variety of soils to be remediated at Port Moller. The unit had a rated capacity of 70 tons per hour and was manufactured by Tarmac, Inc., of Kansas City, Missouri.

Operation

- Soil was fed to the desorber continuously after prescreening; a two-inch bar screen was used to remove oversize material. A conveyor belt with a built-in scale was used to feed the soil. After treatment in the desorber, soil was cooled by a water quench and transferred to a stockpile for clean soil. Off-gasses from the desorber were treated in a baghouse and high temperature afterburner before they were discharged to the atmosphere. Particulate matter collected in the baghouse was mixed with treated soil in the clean soil stockpile.

- Soil from the outfall ditch area was a highly cohesive clayey silt and was found to be difficult to treat separately from other soil. Some of the soil was saturated with petroleum oil lubricants (POL) at concentrations as high as 300,000 mg/kg. At times, the soil was too oily to travel up the conveyor belt that fed the treatment unit. The vendor revised the plan of operation to address that problem by blending highly contaminated soil from the outfall ditch with sandy soil from the tank rack and warehouse areas at a ratio of one part outfall ditch soil to three parts tank rack and warehouse area soil (one part clayey silt to three parts sandy soil). This soil blending was performed before treatment as a means of controlling temperatures in the rotary kiln. The vendor noted that a critical factor for controlling temperatures was maintaining an even flow of uniformly mixed soil into the unit.

- Moisture content of the soil also was found to affect operating temperatures. To address that concern, the vendor covered the soil stockpile with a tarp during heavy rains. The references available provide no additional information about the range of moisture content in the untreated soil or of the effect of elevated moisture content on the temperature of soil in the rotary kiln.

- For the major portion of the time during which the system was operated, soil temperatures in the thermal desorption unit ranged from 500 to 1,200°F (initial operations took place at temperatures in the range of 400 to 500°F).

- At times, soil temperatures were less than 500°F. This occurred when unusually wet or fine-grained soil, or soil having an elevated concentration of contaminants, was introduced into the unit. The lower soil temperatures, which occurred primarily at the beginning of the application, were minimized after the vendor began mixing soil from different areas at the site.

- During treatment of highly contaminated soil (estimated to be over 100,000 mg/kg), the vendor reported that because combustible vapors were being desorbed from the soil in quantities sufficient to sustain the oxidizer's operation, the external fuel supply to the oxidizer could be "virtually shut off."

- During the operation of the unit, particulate matter, carbon monoxide (CO), and oxygen (O_2) levels in the exhaust gas from the oxidizer were monitored continuously and recorded. No analytical data on the results of this monitoring were included with available references.

- Water was obtained from an infiltration trench near the treatment unit and was used to cool the soil and control dust.

- Approximately 9,500 cubic yards of excavated soil were treated at Port Moller.

- The references available provide no information about the percentage of time the system was operational.

OPERATING PARAMETERS AFFECTING TREATMENT COST OR PERFORMANCE (1, 16)

Listed below are the major operating parameters affecting cost or performance for this technology and the values measured for each parameter.

Parameter	Value
Residence Time	Information not available
System Throughput	40-60 tons per hour at 10% moisture
Soil Temperature	500 to 1200°F (see text)

Closure

- After treatment, soil was used to backfill and contour the tank rack, warehouse, and tank farm excavations. In 1994, the USACE attempted to revegetate (seed) the landfill containing demolition debris and other disturbed areas at Port Moller with a mix of red fescues, rye grass, and Kentucky bluegrass. This initial seeding was not successful. In August 1995, after thermal desorption had been completed, USACE reseeded the areas with a different seed mix. Grass was growing vigorously in all areas within three weeks of the reseeding. The seed mix used in 1995, recommended by the Plant Materials Center in Palmer, Alaska, consisted of bering hair grass, arctared red fescue, and Gruening alpine bluegrass. The seed was spread with 20-20-10 (N-K-P) fertilizer at 12.5 pounds per 1,000 square feet. The Plant Materials Center recommended this mixture for soil at Port Moller having a pH ranging from 5.2 to 5.9.

- Seven acres at Port Moller were reseeded: the warehouse and tank rack area (one acre); the tank farm and operations area (one acre); and the landfill, an abandoned road to the reservoir, the outfall ditch, and the antenna area (5 acres).

TREATMENT PLAN (3)

- In 1994, Enviros, Inc. performed a treatability study of three remediation technologies using soil collected from the diesel tank farm, the gasoline and diesel tank area, and the waste drain outfall. The treatability study was performed to evaluate the effectiveness, at a bench scale, of thermal desorption, soil washing, and bioremediation. In addition, the treatability study provided a detailed soil characterization, including specific gravity, hydrocarbon speciation, pH, nutrients and microorganisms present, particle size distribution, and soil classification. Thermal desorption was tested on three soil samples representing different concentrations of hydrocarbons in the untreated soil. The results of the treatability study showed that, of the three technologies tested, thermal desorption achieved the lowest concentration of hydrocarbons (measured by EPA Method 418.1 Modified) in the treated soil (220 mg/kg at 750°F). The results of treatment of the three soil samples by thermal desorption are summarized below by treatment temperature.

Table TS-1. Results of Treatability Study of Thermal Desorption [3]

Treatment Temperature	Concentration of Hydrocarbons (mg/kg, dry weight)		
	Sample #1	Sample #2	Sample #3
No treatment	4,000	11,600	205,000
225°F	1,100	2,500	193,000
450°F	280	920	185,000
750°F	60	190	220

- In its recommendations, the vendor of the treatability study noted that soil treated by thermal desorption met the required cleanup levels for the site and that the performance of thermal desorption was not as dependent on site conditions (for example, relatively short summer season and inclement weather) as soil washing or bioremediation.

TREATMENT SYSTEM PERFORMANCE

PERFORMANCE OBJECTIVES (2)

- The cleanup goals for the application were based on the results of negotiations with ADEC.

- The negotiated cleanup goals for the application consist of the following:

  DRO - 200 mg/kg
  GRO - 200 mg/kg
  TRPH - 200 mg/kg
  BTEX - 15 mg/kg

- ADEC first proposed Matrix Level A cleanup criteria that include a concentration of DRO of 100 mg/kg. However, during the negotiation, it was agreed that the cleanup goal for DRO be increased from 100 to 200 mg/kg. USACE Alaska District indicated that the application of that criterion would ensure that the site would be restored to levels that are environmentally acceptable, at considerable cost savings to the government over application of the Level A criterion. USACE Alaska District had estimated that the additional testing and slower production needed to meet a cleanup goal of 100 mg/kg for DRO would have increased the project cost by 48 percent.

- The air quality permit issued by the state of Alaska required that the emissions meet the following limits: particulate matter, 0.05 grains per dry standard cubic foot (gr/dscf); and CO, 100 parts per million volume (ppmv) and 2.39 pounds per hour.

TREATMENT PERFORMANCE DATA AND ASSESSMENT (1, 16)

- Table TPD-1 summarizes the results of analyses of samples collected during the operation of the thermal desorption system at Port Moller. Listing the results by specific sample numbers and groups of sample numbers, the table shows sampling date, soil temperature, and results of analysis for before- and after-treatment for DRO, GRO, TRPH, and BTEX. At Port Moller, 118 samples of treated soil were collected. Samples were collected at a frequency of one per 50 tons for the first 250 tons, one per 100 tons for the next 4,000 tons (approximately), and one per 200 tons for the remaining 5,000 tons (approximately).

- Matching samples of untreated soil were available for only 8 of the 118 samples of treated soil (those samples were mostly those collected at lower soil temperatures - e.g., 350 to 400°F). In the case of soil temperatures shown as more than (>) or less than (<) a certain value, the references available do not indicate the exact soil temperature.

- Only three samples of after-treatment soil contained concentrations of contaminants higher than the applicable cleanup goals (samples 253, 258, and 277). For sample 253, collected at a soil temperature of <350°F, the concentration of DRO was 210 mg/kg, and the concentration of TRPH was 242 mg/kg. For sample 277, collected at a soil temperature of 350°F, the concentration of DRO was 258 mg/kg, and the concentration of TRPH was not reported. Both of the samples were treated again in the desorber at higher temperatures and subsequently achieved the cleanup goals.

- For sample 258, collected at a soil temperature of >500°F, the concentration of DRO was 122 mg/kg, and the concentration of TRPH was 206 mg/kg. The concentration of TRPH was 3 percent higher than the applicable cleanup goal; however, according to USACE, the sample was not retreated, probably because the TRPH concentration was relatively close to the cleanup level (206 versus 200 mg/kg), and because it was believed that the difference was within the range of error for the analytical method used.

Table TPD-1. Thermal Desorption Treatment Performance Data, Port Moller [1]

Sample No. (95PMS R-)	Date	Soil Temperature (ºF)	Before Treatment (mg/kg)				After Treatment (mg/kg) (Cleanup Goal)			
			DRO	GRO	TRPH	BTEX	DRO (200)	GRO (200)	TRPH (200)	BTEX (15)
191/192	6/28/95	>400	564	6	NR	0.06	45	ND	NR	ND
193/194	6/29/95	>400	735	22	NR	0.43	45	ND	NR	ND
195/196	6/29/95	>400	546	5	NR	ND	132	ND	NR	ND
197/198	6/29/95	>400	5,590	NR	6,800	NR	150	NR	120	NR
199/200	6/29/95	>400	6,500	NR	6,800	NR	122	ND	87	ND
201/202	6/29/95	>400	487	NR	NR	NR	49	ND	NR	ND
203/204	6/30/95	750	6,340	NR	10,700	NR	41	NR	74	NR
207-210, 212-216	6/30-7/2/95	400 to >400	NR	NR	NR	NR	12-112	ND	ND-94	ND
217-252	7/2-7/19/95	>500	NR	NR	NR	NR	23-160	ND-23	26-175	ND
253	7/20/95	<350	NR	NR	NR	NR	210	ND	242	ND
254-275	7/20-8/2/95	>500 to 550	NR	NR	NR	NR	23-140	NR	54-206	NR
276/277	8/2/95	350	1,080	NR	NR	NR	258	NR	NR	NR
283-430	8/3 - 8/24/95	>600 to 1,200	NR	NR	NR	NR	ND-160	NR	ND-178	NR

Laboratory testing methods were not available
NR = Not reported.
ND = Not detected; detection limit not provided.

- While data on the actual air emissions from the Port Moller application were not available, the RPM provided emissions data for a similar application show that actual emissions were: particulate matter, 0.0046 gr/dscf; CO, 0.29 ppmv; and CO, 0.016 pounds per hour. According to the RPM, this similar application met the state's requirements for air emissions.

Material Balance: No quantitative material balance was completed for this application because of the limited amount of performance data available from matched samples of untreated and treated soil.

Links to Operating Conditions: The data provided in Table TPD-1 show the link between soil temperature and treatment performance. As the data show, when soil temperatures were lower than 400°F concentrations of contaminants in the treated soil were higher than the limits established as the cleanup goals for DRO and TRPH.

Removal Efficiencies: No quantitative analysis of removal efficiencies could be completed for the application because of the limited amount of performance data available from matched samples of untreated and treated soil.

PERFORMANCE DATA QUALITY

- The sampling and analysis program conducted at Port Moller included use of quality control procedures, such as quality assurance (QA) and quality control (QC) samples. The vendor noted no exceptions to QA or QC procedures for the application.

TREATMENT SYSTEM COST

PROCUREMENT PROCESS

- USACE, through its Richardson Resident Engineer (RRE) Office in Anchorage, Alaska, administered the environmental remediation activities at Port Moller. Anderson performed the environmental remediation activities in support of the RRE under USACE Contract No. DACA-94-D-0003. (1)

- USACE Alaska District used an indefinite quantity, unit price, delivery order-type contract to procure a contractor for the application. The contract included a 10-page list of unit prices that covered all work items to be needed at the site, ranging from equipment mobilization to individual analytical tests. The prices were established by staff of USACE Alaska District. The contract was advertised through a request for proposals (RFP), and bidders were instructed to submit separate items addressing technical qualifications and costs. For costs, the bidders were instructed to submit bids as a percentage of the government-established unit prices. USACE Alaska District received five proposals, with bids ranging from 89 to 105 percent of the unit prices. Anderson was selected on the basis of five rating factors that ranked bidders by technical expertise and cost. Anderson's bid included a cost of 93.9 percent of the government-established unit prices. (2)

- USACE Alaska District used the contracting approach described above to address its concerns about the difficulty of accurately defining the quantity of contaminated soil for a thermal desorption project. Under the contract developed by USACE Alaska District, the contractor was required to determine the extent of contamination during the site investigation phase of the work in 1994 and use the unit prices in the contract to determine the total cost to USACE for treating contaminated soil.

TREATMENT SYSTEM COST (2, 7)

- The environmental remediation activities at Port Moller were conducted under three delivery orders (DO). DO 1, under which work was performed in 1994, included mobilization and demobilization, operation of a contractor's camp, testing, site delineation, removal and closure of underground and aboveground storage tanks, asbestos abatement, general demolition, and landfilling; costs under DO 1 were $4,043,463.

- DO 2, under which work was performed in 1994, included sampling, testing, excavation, hauling, and stockpiling of contaminated soil; treatability studies; and revegetation; costs under DO 2 were $415,175.

- DO 3, under which work was performed in 1995, included mobilization and demobilization; operation of a contractor's camp; operation by the contractor of a field laboratory, including sampling and testing; and thermal treatment of soil contaminated with POL; costs under DO 3 were $3,919,736.

- The costs of DO 3 (thermal desorption activities) were categorized according to an interagency remedial action work breakdown structure (WBS) that includes specific cost elements for before-treatment activities, cost elements for activities directly attributed to treatment, and cost elements for after-treatment activities. Under the WBS, the costs for DO 3 were categorized as shown in Table C-1.

Table C-1. Summary of Costs for Thermal Desorption Activities at Port Moller, Alaska, Categorized According to the WBS (7)

Activity	Cost ($)	Comment
Mobilization and demobilization	594,038	Before- and after-treatment activities
Contractor's camp	31,590	Before-treatment activity
Operation by the contractor of a field laboratory	37,033	Before-treatment activity
Thermal treatment of soil contaminated with POL	3,325,000	Activity directly attributed to treatment

COST SENSITIVITIES

- As discussed above, the costs of thermal desorption at Port Moller were affected by the cleanup goals established by ADEC, the concentrations of contaminants in the soil, the moisture content of the soil, and the quantity of soil to be treated. The references available provide no additional information about specific factors of the application that affected costs.

- In addition, because of the remote location of the site, mobilization and demobilization costs were relatively high.

REGULATORY/INSTITUTIONAL ISSUES

- This project was managed under the Formerly Used Defense Sites (FUDS) Program and the Installation Restoration Program (IRP), with USACE serving as lead agency. In that role, USACE solicited review comments, as appropriate, from the U.S. Air Force and ADEC.

OBSERVATIONS AND LESSONS LEARNED

COST OBSERVATIONS AND LESSONS LEARNED

- USACE Alaska District took an innovative approach to procuring a remediation contractor for the application. That approach was based on the use of unit prices established by the government for specific activities associated with the remediation and solicitation of bids as a percentage of the unit prices.
- USACE Alaska District developed an innovative contract based on the use of unit prices to provide flexibility in determining the total cost to the government of remediating contaminated soil at Port Moller. For a thermal desorption project, it is difficult to estimate accurately the quantity of contaminated soil to be treated. For the Port Moller contract, costs were based on the use of unit prices. The contractor was required to determine the quantity of contaminated soil during the site investigation phase of the work and use the unit prices in the contract to determine the total cost to USACE for treating the contaminated soil. USACE Alaska District indicated that that approach required close coordination between the government and the contractor and saved years of time that otherwise would have been spent delineating the contaminated areas at the site.
- The actual cost of the thermal desorption of soil contaminated with POL at Port Moller was $3,325,000 (for activities directly attributed to treatment), or $350 per cubic yard of soil treated (9,500 cubic yards treated).

PERFORMANCE OBSERVATIONS AND LESSONS LEARNED

- The thermal desorption unit used at Port Moller achieved the cleanup goals after three months of operation. Untreated soil contained concentrations of DRO as high as 6,500 mg/kg, and concentrations of TRPH as high as 10,700 mg/kg. Concentrations of DRO in treated soil were less than 200 mg/kg, for soil treated at temperatures of 400 to 1,200°F.
- Of the 118 soil samples, 115 (97 percent) achieved the cleanup goals after one pass through the desorption unit. The three samples that did not achieve the cleanup goal after one pass were treated at relatively low soil temperatures (less than 400°F). Those samples were retreated and subsequently achieved the cleanup goals.
- Air emissions testing was conducted at this site (17), but no data were available for review. However, analytical data from an application similar to that at Port Moller met the state's requirements for air emissions.

OTHER OBSERVATIONS AND LESSONS LEARNED

- The USACE Construction Branch Chief responsible for the Port Moller thermal desorption application identified the following lessons learned related to thermal treatment of soil contaminated with POL through the experiences gained at Port Moller (2):

Topic Area	Lessons Learned
Characteristics of the matrix	• Uniformity is essential in the feed material. Blend soil aggressively to avoid clumps of peat and clay and remove rocks. Disperse pockets of extremely highly contaminated soil to avoid flare-ups in the plant. • Take measures to decrease the moisture content of the stockpile. Keep the stockpile compact in areal extent. Cover the stockpile. Work from a building or structure if possible, especially in high winds and heavy rain.
Skills of the contractor and government oversight personnel	• During operation of the system, experienced, skilled personnel, including the plant operator, the feed operator, and the millwright, must monitor the system. • An experienced geologist must manage field screening for excavation, collecting samples of feed material and remediated soil for certification of remediation. Rigorous management of field screening during excavation to ensure proper segregation of contaminated and clean layers of soil is a crucial element in maintaining cost control and requires diligent oversight by the government. • The contractor must establish a strong support network of suppliers, including the plant manufacturer, emissions control equipment manufacturer, the air emissions consultant, and personnel of general equipment parts service centers. • The complexity of the electronic control equipment requires very specialized technical support personnel, including an electrician, an electrical engineer, a computer programmer, and an air emissions technician. The technical consultants must be available instantly to respond to equipment failures and must be prepared to travel to the plant to troubleshoot the equipment and perform repairs.
Quality control and standard operating procedures (SOP)	• Rigorous QC and supervision of materials handling to avoid costly mistakes is important. Remediated soil must be stockpiled according to a well-designed plan to avoid the need to move it more than necessary before it is approved for backfilling. • The contractor must demonstrate to the government that it has established a rigorous SOP for maintenance of equipment. Failure to check high-wear points, fines-accumulation points, fuel supply, and other features of the plant otherwise would cause costly breakdowns and delays. • The contractor must establish a procedure for handling material that, for a variety of reasons, must be reprocessed. Designate a location for stockpiling such material, which could include cobbles that are screened out before the contaminated soil enters the dryer unit. If lumps of clay, peat, or asphalt enter the coarse-screened stockpile, the material must be rescreened at the contractor's expense. If remediated soil fails to meet the cleanup criteria established by ADEC, it must be retreated. Failure to address the need to retreat some material in advance will cause delays.

Topic Area	Lessons Learned
Analytical requirements	• The support of an analytical laboratory is essential. Regulators are likely to recommend sampling every 50 tons of processed soil. If the system is performing properly, it is advisable to notify regulators that a greater increment, such as 250 tons, will be used. USACE must take the initiative to maintain control of cost and technical aspects of projects. Further, excessive-sampling overtaxes the laboratory's production capacity and diminishes its ability to provide rapid turnaround when necessary
Air quality	• Compliance with the requirements of an air emissions permit requires sophisticated combustion control equipment, as well as dependable air monitoring equipment for continuous monitoring of emissions. It is essential a consultant be available under contract to monitor emissions and oversee quarterly reporting to ADEC's Air Quality Program. • Access to USACE HTRW CX is an essential resource for USACE resident office managers. Thermal desorption remediation equipment is complicated and must meet strict air emissions criteria. Mr. Ed Mead of CEMRD-ET-HE reviewed requirements and provided copies of relevant U.S. Environmental Protection Agency (USEPA) publications and assisted in calculating air emissions for reporting to ADEC.
Payment procedures	• The government and the contractor must establish the procedure for measurement for payment that will be used. To do so requires continual measurement of the quantity, density, and weight of the soil. The typical form of measurement for process equipment is the use of a calibrated belt scale. Belt scales require frequent calibration checks by the contractor and witnessed by a representative of the government. To avoid confrontations during the project, the procedure must be simple and clearly understood by both parties. Since all equipment has limitations and failures occur, a backup procedure for measurement for payment is necessary. To minimize the risks to both parties, it must be agreed in advance that the government and the contractor will maintain a system of multiple checks, independent measurement of all excavations and of all stockpiles of segregated, contaminated, and remediated soil. Frequent calculations of mass balance should be performed to ensure that parties are in agreement.

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