COST AND PERFORMANCE REPORT

EXECUTIVE SUMMARY

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

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

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

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

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

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Solid Waste and Emergency Response
Technology Innovation Office

SITE INFORMATION

Identifying Information

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

CERCLIS #: NJD980505341

ROD Date: 28 September 1990

Treatment Application

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

Background

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

Corresponding SIC Code: 4953: Sanitary Services—Refuse Systems

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

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

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

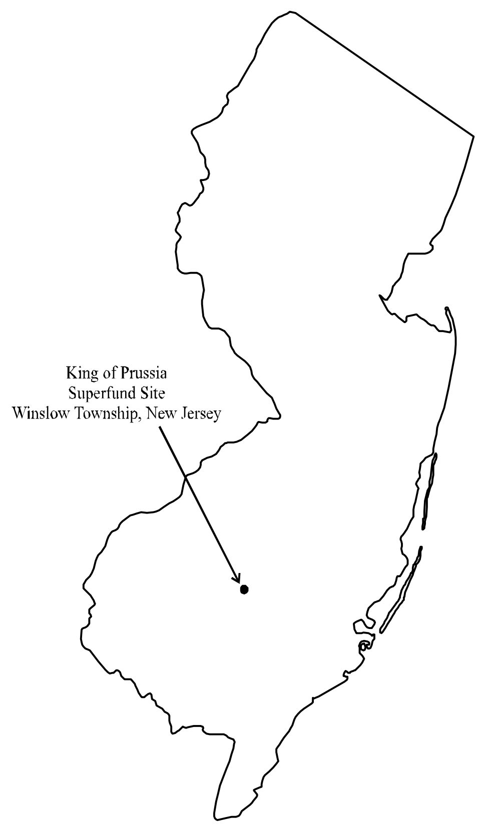

Figure 1. Site Location

SITE INFORMATION (CONT.)

Background (cont.)

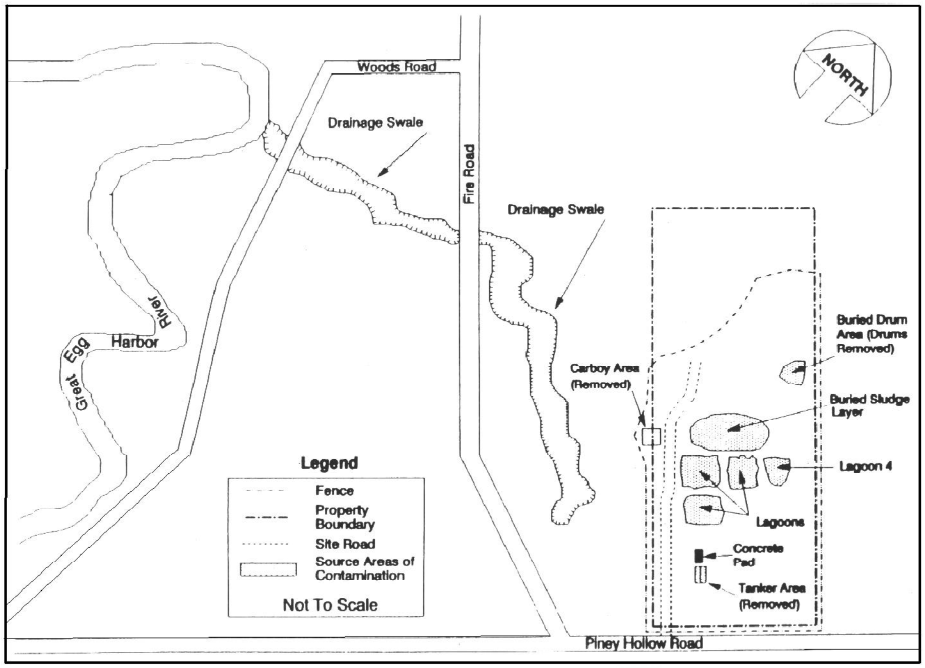

Figure 2. Site Map [9]

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

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

> *Component 1*—The metals-contaminated soils adjacent to the lagoons, the sludge in the lagoons, and the sediment in the swale. (Operable Unit One)
>
> *Component 2*—The buried drums and soils contaminated with volatile organic compounds located in the northwest section of the site. (Operable Unit Two)
>
> *Component 3*—Two tankers and their contents located near the southeast sections of the site.
>
> *Component 4*—The groundwater at the site contaminated with organics and metals. (Operable Unit Three)
>
> *Component 5*—The surface waters, sediments, and biota of the Great Egg Harbor River.

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

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

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

SITE INFORMATION (CONT.)

Background (cont.)

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

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

Site Logistics/Contacts

Site Management: PRP Lead

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

Oversight: EPA

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

MATRIX DESCRIPTION

Matrix Identification

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

Contaminant Characterization

Primary contaminant group: Heavy metals

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

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Cost or Performance

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

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

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

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

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

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology Type

Soil Washing

Supplemental Treatment Technology Type

Screening

Technology Description

Excavation Description [7, 10]

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

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

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TREATMENT SYSTEM DESCRIPTION (CONT.)

Technology Description (cont.)

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

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

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

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

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

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

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

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

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

TREATMENT SYSTEM DESCRIPTION (CONT.)

Technology Description (cont.)

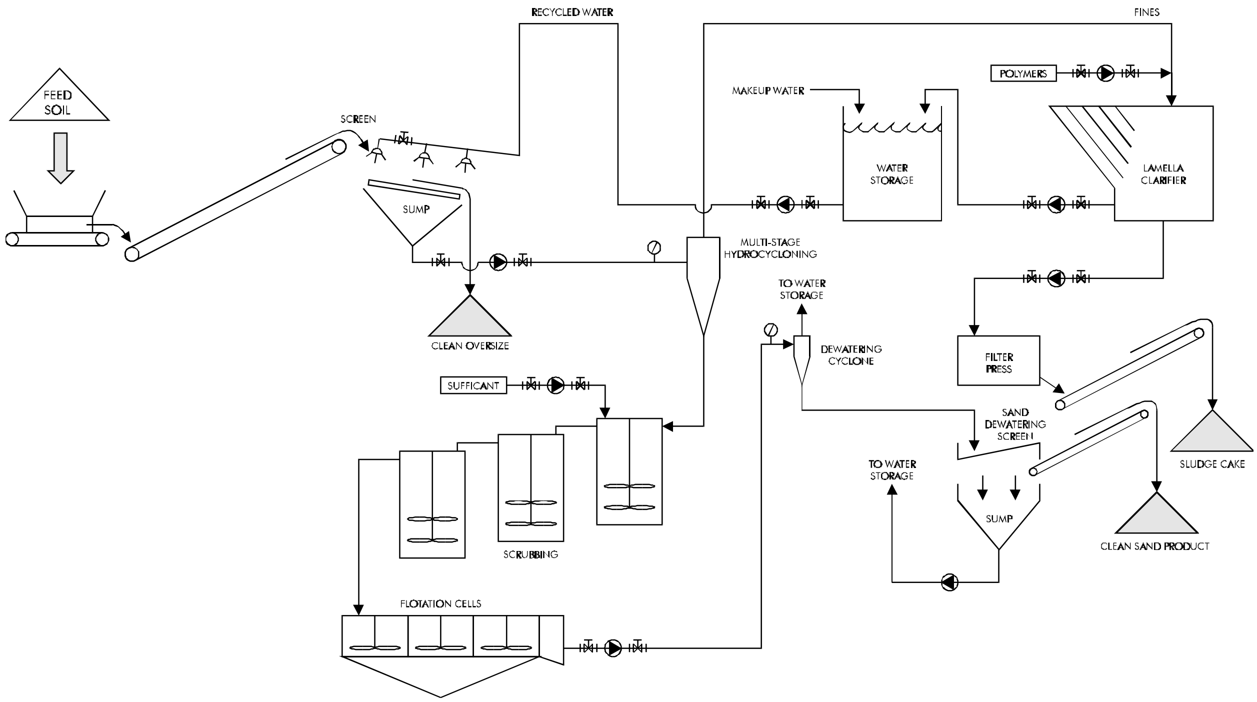

Figure 3. Soil Washing Unit Used at KOP [6]

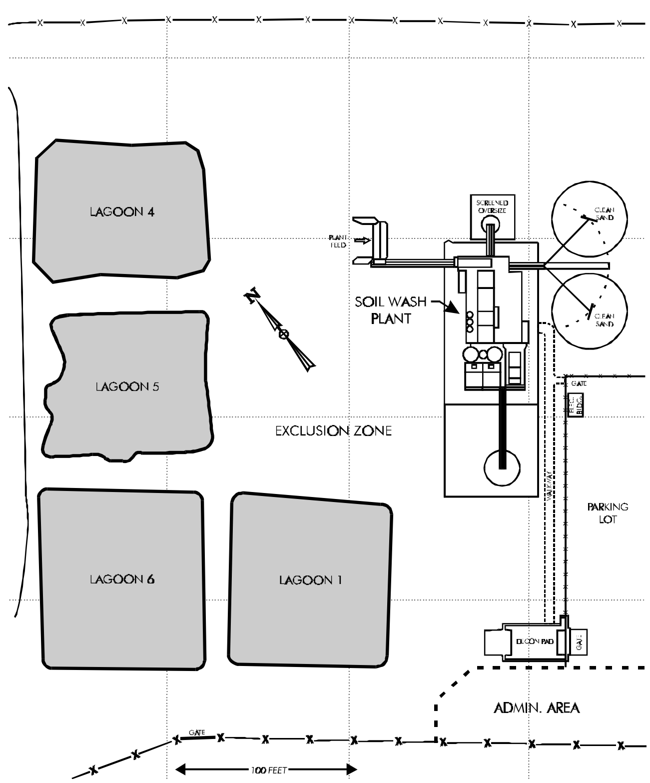

Figure 4. Remediation System Layout [12]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Technology Description (cont.)

System operation included the following processes:

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

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

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

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

TREATMENT SYSTEM DESCRIPTION (CONT.)

Operating Parameters Affecting Treatment Cost or Performance

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

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

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

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

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

Timeline

A timeline for this application is shown in Table 4.

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

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

TREATMENT SYSTEM PERFORMANCE

Cleanup Levels

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

Table 5. Soil Cleanup Levels [1]

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

Additional Information on Cleanup Levels

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

Treatment Performance Data

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

- Untreated (Feed) Soil - This sampling point represents the concentration of metals in contaminated soil after excavation and blending, but prior to screening for gross or process oversize. Determination of the chromium, copper, and nickel concentrations in the untreated soil was performed using X-ray fluorescence. The concentrations of the other eight metals shown on Table 6 were measured at an off-site laboratory using samples from the demonstration run and, because the soil from the demonstration run was collected from the same excavation trenches as for the full-scale operation, are considered to be representative of the average concentration of the untreated soil processed during the full-scale operation. These average concentrations are lower than the initial concentrations measured during the site characterization, due to blending and homogenization of the feed pile prior to its introduction to the treatment unit.

- Process (Clean) Oversize - This sampling point represents the concentration of metals in the process oversize. The process oversize is that material which was screened from the untreated soil and typically measures greater than 2 inches in diameter and consists of gravel and wood. The process oversize was ultimately redeposited at the site from the location where it was excavated. Samples for off-site analysis consisted

TREATMENT SYSTEM PERFORMANCE (CONT.)

Treatment Performance Data (cont.)

Table 6. Treatment Performance Data [9,12]

Constituent	Cleanup Level (mg/kg)	Untreated (Feed) Soil Concentration (mg/kg)		Process (Clean) Oversize Concentration (mg/kg)		Clean Sand Product Concentration (mg/kg)		Sludge Cake Average Concentration (mg/kg)
		Average	Range	Average	Range	Average	Range	
Arsenic	190	1	N/A	0.62	0.34 to 1.4	ND (0.31)	ND (0.39)	N/A
Beryllium	485	20	N/A	5.9	2.7 to 11	1.9	0.93 to 3.1	N/A
Cadmium	107	0.56	N/A	ND (0.63)	ND (0.97)	0.64	ND (0.95)	N/A
Chromium	483	660	500 to 5,000	172	81 to 310	73	37 to 94	4,700
Copper	3571	860	800 to 8,000	350	170 to 580	110	52 to 158	5,900
Lead	500	22	N/A	6.5	3.1 to 14	3.9	2.6 to 6.1	N/A
Mercury	1	0.09	N/A	ND (0.09)	ND (0.10)	ND (0.09)	ND (0.10)	N/A
Nickel	1,935	330	300 to 3,500	98	58 to 150	25	18 to 38	2,300
Selenium	4	0.36	N/A	ND (0.38)	ND (0.40)	ND (0.36)	ND (0.40)	N/A
Silver	5	0.69	N/A	ND (0.65)	ND (0.76)	ND (0.65)	ND (0.73)	N/A
Zinc	3,800	150	N/A	48	27 to 76	16	9.4 to 22	N/A

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

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

- Clean Sand Product - This sampling point represents the concentration of metals in the treated clean sand (treated soil). After screening and separation, the coarse-grained material was directed to the froth flotation unit where the contaminants were removed. The "cleaned" material was dewatered by means of a cyclone and a dewatering unit. The clean sand (treated soil) was used as backfill at the site. Twelve samples were collected for off-site analysis and consisted of daily split samples that were combined into weekly composite samples. The results of the weekly samples are presented in Appendix C, Table C-2, and summarized in Table 6.

- Sludge Cake - This sampling point represents the concentration of metals in the sludge cake. After screening and separation, the fine-grained material was filtered. The filter (sludge) cake was disposed off site as a nonhazardous waste. Samples of the filter cake were analyzed on site using XRF for chromium, copper, and nickel, and off site for TCLP metals. No results from the TCLP analysis are contained in the references available at this time.

Performance Data Assessment

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

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TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment (cont.)

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

Performance Data Completeness

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

Performance Data Quality

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

TREATMENT SYSTEM COST

Procurement Process

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

Treatment System Cost

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

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

Cost Data Quality

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

OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

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

Performance Observations and Lessons Learned

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

OBSERVATIONS AND LESSONS LEARNED (CONT.)

Performance Observations and Lessons Learned (cont.)

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

Other Observations and Lessons Learned

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

REFERENCES

1. U.S. EPA, *Superfund Record of Decision*, King of Prussia, New Jersey, September 1990.
2. Remedial Action Plan (Proposed), ERM, Inc. (undated).
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Analysis Preparation

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APPENDIX A—TREATABILITY STUDY RESULTS

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

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Objectives

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

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

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

Treatability Study Test Description [5]

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

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

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

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

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

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

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

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

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APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Performance Data

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

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

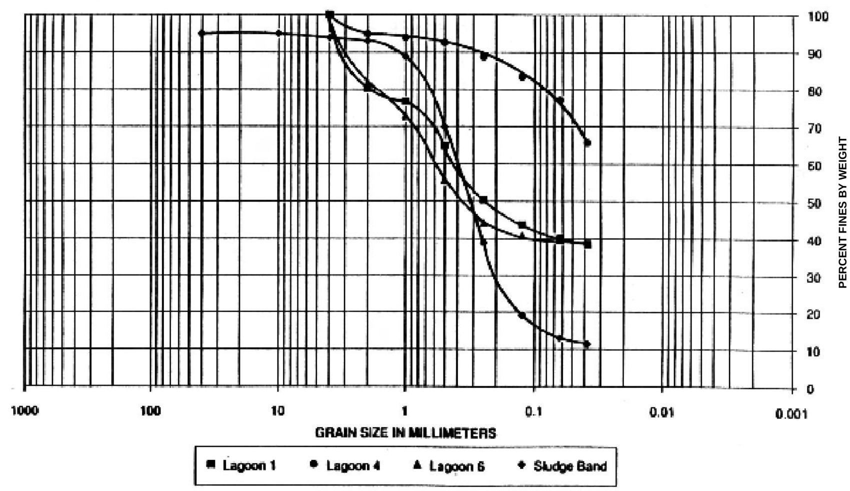

Figure A-1. Particle Size Distribution Curves

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

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

**Calculated*

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

APPENDIX A—TREATABILITY STUDY RESULTS (CONT.)

Treatability Study Observations and Lessons Learned

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

APPENDIX B—DEMONSTRATION RUN RESULTS

Demonstration Run Objectives

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

Demonstration Run Description

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

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

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

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

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

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

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

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APPENDIX B—DEMONSTRATION RUN RESULTS (CONT.)

Demonstration Run Description (cont.)

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

Demonstration Run Results

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

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

(all mg/kg)

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

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

APPENDIX B—DEMONSTRATION RUN RESULTS (CONT.)

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

(all mg/kg)

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

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

(all mg/kg)

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

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

APPENDIX B—DEMONSTRATION RUN RESULTS (CONT.)

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

IEA Analyses Only

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

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

Demonstration Run Observations and Lessons Learned

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

APPENDIX C—FULL-SCALE ANALYTICAL RESULTS

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

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

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

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

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

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

COST AND PERFORMANCE REPORT

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

Prepared By:

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

March 1995

NOTICE

Preparation of this report has been funded wholly or in part by the U.S. Environmental Protection Agency under Contract Number 68-W3-0001. It has been subject to administrative review by EPA headquarters and Regional staff and by the technology vendor. Mention of trade names for commercial products does not constitute endorsement or recommendation for use.