APPENDIX C
EXAMPLE REMEDIAL ACTION REPORT – IN SITU SOIL AND GROUNDWATER REMEDIATION

NOTE:

The following example remedial action report is based on an actual Superfund site, but some information has been altered to illustrate the concepts of the guide. In addition, names have been changed to avoid confusion with the actual site.

Content and format of actual RA reports may vary from this example due to considerations such as project lead and support roles, availability of information, and site-specific conditions. The information presented in this example report (e.g., costs) should not necessarily be used as a technical basis for completing remedial action at an actual site (e.g., as a source of cost information).

INTERIM
REMEDIAL ACTION REPORT

LANDFILL 5 OPERABLE UNIT

FT. GRIFFEY, OHIO

September 2000

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Abstract

Landfill 5 Operable Unit
Air Sparging/Soil Vapor Extraction
Ft. Griffey, Ohio

Site Name and Operable Unit:	Landfill 5 Operable Unit
Location:	Fort Griffey, Ohio
Regulatory Oversight:	U.S. Environmental Protection Agency Region V Riverfront Air Pollution Control Agency
Contractor Oversight:	U.S. Army Corps of Engineers, Louisville District
Remedial Action Contractor:	Remediation Enhanced Developments, Inc., Cincinnati, OH
Waste Source:	Disposal of refuse and liquid waste in an unlined landfill cell during the 1950s and 1960s
Contaminants:	Dichloroethene (DCE) Trichloroethene (TCE) Tetrachloroethene (PCE) Vinyl Chloride (VC) Benzene, toluene, ethylbenzene, and xylenes (BTEX)
Technology:	Air Sparging/Soil Vapor Extraction • The full-scale system includes 5 AS wells, 6 SVE wells, 10 vadose zone piezometer (VZP) wells, and 3 dissolved oxygen sensor (DOS) wells. • An impermeable layer on the ground is used to increase the SVE wells' radii of influence. • Two parallel systems of vapor-phase granular activated carbon (GAC) are used. • SVE system operates at 0-1,290 scfm. • AS system operates at 0-210 scfm.
Cleanup Type:	Full-Scale
Purpose/Significance Of Application:	Remediation designed to treat soils suspected of being sources of groundwater contamination and to treat impacted groundwater.
Type/Quantity of Media Treated:	Approximately 60 pounds of TCE had been removed as of October 31, 1997 (based on concentrations in extracted soil gas). It is estimated that 27,800 cubic yards of soil (by SVE) and 37,400,000 gallons of groundwater (by AS) will have been treated by the end of system operation.
Period of Operation:	Pilot Test: 1/5/95 to 1/15/95 Full-Scale Operation: Ongoing
Regulatory Requirements/ Cleanup Goals:	The cleanup levels established for groundwater in the upper aquifer beneath the site are: TCE: 5 µg/L (MCL from the Federal Safe Drinking Water Act) VC: 1 µg/L (Ohio State Model Toxics Control Act Method B) Monitoring of manganese is required along the western border of South and Northwest LF5 to determine any changes in concentration. A site-specific air emission threshold limit of 2.5 parts per million volume (ppmv) TCE was also established.

Abstract

Landfill 5 Operable Unit
Air Sparging/Soil Vapor Extraction
Ft. Griffey, Ohio

Results: The concentration of TCE in the soil gas extracted by the SVE system generally decreased from 210 parts per billion by volume (ppbv) to 140 ppbv during the period of April 1, 1995 through July 27, 1995. The extracted soil gas concentration then increased to a maximum of 640 ppbv during the period of August 1, 1995 through December 27, 1999.

Costs: The total actual costs incurred for this project from Years 0-5 (1994-1999) are $1,852,104, with a capital cost of $729,294. The total project costs remaining are $2,111,483 (Years 6-15). The technology-specific unit costs for soil vapor extraction and air sparging were calculated at $65.75 per cubic yard and $18.83/1,000 gallons, respectively. These unit costs include both actual and projected costs that are applicable to each technology.

Description: Ft. Griffey occupies approximately 86,000 acres along the northern bank of the Ohio River, approximately 12 miles from Cincinnati, Ohio. Ft. Griffey began operating in 1917 and currently serves as a military reservation. Ft. Griffey is divided by I-5 into North Ft. Griffey and the Main Post.

The RI, completed in 1993 by RED, under contract with USACE, Louisville District, included an extensive landfill and soil gas survey and a groundwater investigation. The RI confirmed the presence of chlorinated hydrocarbons and aromatic hydrocarbons contamination at LF5. Elevated levels of TCE, PCE, and DCE were detected in the soil. TCE, VC and BTEX contamination was detected in the groundwater. Elevated levels of Mn were also detected in the groundwater along the western borders of South and Northwest LF5. However, the RI attributes these elevated levels to the dissolution of Mn from geologic materials in the area of LF5.

The full-scale system operation began when the startup activities were completed on July 29, 1995. The full-scale system operation is currently ongoing. The concentration of TCE in the soil gas extracted by the SVE system generally decreased from 210 parts per billion by volume (ppbv) to 140 ppbv during the period of April 1, 1995 through July 27, 1995. The extracted soil gas concentration then increased to a maximum of 640 ppbv during the period of August 1, 1995 through December 27, 1999. This increase generally corresponds to the opening of the passive injection wells after July 29, 1995, suggesting that the use of the passive injection wells enhanced the system's performance.

Ft. Griffey occupies approximately 86,000 acres along the northern bank of the Ohio River, approximately 12 miles from Cincinnati, Ohio. Ft. Griffey began operating in 1917 and currently serves as a military reservation. Ft. Griffey is divided by I-5 into North Ft. Griffey and the Main Post.

Landfill 5 (LF5) is located on North Ft. Griffey near Reese Lake and Reese Springs, which is the primary drinking water supply for the fort. The 52 acre landfill is divided into three cells - South, Northeast, and Northwest - and is located adjacent to a gravel pit (Figure 1).

From the early 1950s to the late 1960s, LF5 was reportedly used for the disposal of refuse, including domestic and light industrial solid waste and construction debris, and for the disposal of liquid waste in unlined cells. In addition, LF5 was reportedly used as a gravel quarry in the 1940s and for equipment storage and maintenance. After disposal activities ceased, the landfill was covered with native materials such as sand, gravel and soil; the landfill is currently covered with trees and grass.

PREVIOUS INVESTIGATIONS

According to the 1993 remedial investigation (RI), there were no reports of hazardous waste disposal in LF5. However, historical aerial photographs show two suspected liquid waste disposal pits located in Northeast and South LF5 and evidence of equipment maintenance activities near Northeast LF5 . Tetrachloroethene (PCE) and trichloroethene (TCE) are suspected of having been used in degreasing and equipment maintenance operations at Ft. Griffey; leaks and spills of solvents from maintenance operations on or near LF5 and disposal of solvents in unlined pits are the suspected sources of contamination.

In 1988, a limited site investigation of LF5 was conducted by Larkin Midwest Laboratory. The investigation indicated that the shallow groundwater beneath the landfill was contaminated with chlorinated hydrocarbons, aromatic hydrocarbons, and manganese (Mn). While the data were not provided in the available references, TCE was reported to have been found at concentrations ranging from 1 to 32 micrograms per liter (µg/L).

In 1991, Remediation Enhanced Developments, Inc. (RED) conducted several pre-RI activities under contract with the U.S. Army Corps of Engineers (USACE) Louisville District including a test pit investigation, a passive soil gas survey, and a preliminary ecological assessment. According to RED, the results of these activities indicated that TCE and PCE were widely distributed in the area of LF5.

The RI, completed in 1993 by RED, again under contract with USACE Louisville District, included a more extensive landfill and soil gas survey and a groundwater investigation. The RI confirmed the presence of chlorinated hydrocarbons and aromatic hydrocarbons contamination at LF5. Elevated levels of TCE, PCE, and dichloroethene (DCE) were detected in the soil. TCE, vinyl chloride (VC) and benzene, toluene, ethylbenzene, and xylene (BTEX) contamination was detected in the groundwater. Elevated levels of Mn were also detected in the groundwater along the western borders of South and Northwest LF5. However, the RI attributes these elevated levels to the dissolution of Mn from geologic materials in the area of LF5.

Low levels of BTEX were detected in the lower aquifer (<0.5 µg/L to 5.8 µg/L). However, TCE, DCE, VC, and PCE, while detected in the upper aquifer, were not detected in the lower aquifer.

Mn and iron were detected in both the upper and lower aquifers. The RI determined that the elevated levels of Mn were caused by dissolution of manganese from geologic material.

Results of groundwater quality indicator parameters measured during the RI, including increased specific conductance, dissolved metals and biochemical oxygen demand, indicated that low levels of metals and inorganic compounds were leaching from the landfill into the upper aquifer. However, the parameters were reported to rarely exceed five times their background levels. There was no evidence of leaching to the lower aquifer.

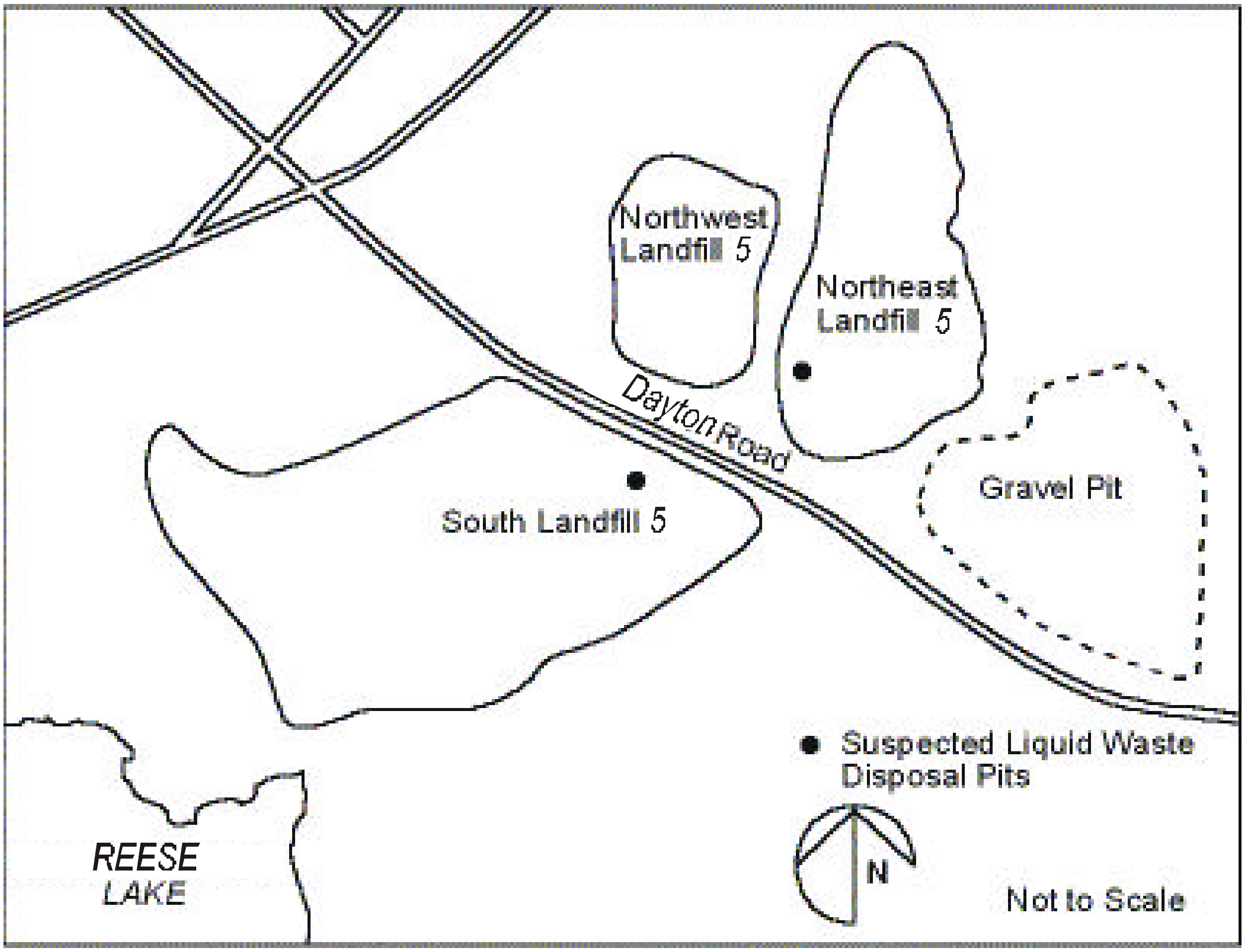

FIGURE 1
LANDFILL 5 – LOCATION OF CELLS

Based on the findings of the RI, the U.S. Environmental Protection Agency (USEPA), Region V, the U.S. Department of Defense (DoD), the Ohio Environmental Protection Agency (OEPA), and the USACE Louisville District negotiated a cleanup strategy and entered into a Federal facility agreement under Section 120 of CERCLA to address the contamination at LF5. These parties agreed to address LF5 as a single operable unit (OU) and commissioned a feasibility study (FS) in March 1993.

REMEDY SELECTION

In a record of decision (ROD) signed in October 1993, the remedy selected for LF5 included:

- Treatment of contaminated soils in areas that were suspected sources of groundwater contamination (soil hot spots) using soil vapor extraction (SVE);
- Treatment of contaminated groundwater using air sparging (AS);
- Monitoring of the upper aquifer to determine the effectiveness of the selected remedy; and,
- Maintenance of institutional controls, including access restrictions.

The groundwater AS system was to operate in conjunction with the SVE system.

The ROD also required that Mn be monitored in the groundwater in the localized areas where elevated levels were detected during the RI. The ROD specified that, if the results of the monitoring indicated that levels were not declining, then the need for remediation was to be reevaluated.

Including limited groundwater extraction and treatment in addition to AS/SVE was considered as an alternative remedy. However, AS/SVE was determined to be more cost effective than AS/SVE plus groundwater extraction and treatment while still being protective of human health and the environment.

The ROD specified four objectives for the remedy:

- To prevent exposure to contaminated groundwater;
- To restore the contaminated groundwater to its beneficial use (drinking water);
- To minimize movement of contaminants from soil to groundwater; and,
- To prevent exposure to the contents of the landfill.

No soil cleanup levels were identified. The cleanup levels established for groundwater in the upper aquifer beneath the site were:

- TCE - 5 µg/L - the Federal Safe Drinking Water Act maximum contaminant level (MCL);
- VC - 1 µg/L - the Ohio State Model Toxics Control Act Method B.

Monitoring of Mn was required along the western border of South and Northwest LF5 to determine any changes in concentration.

The remedial design (RD) for the AS/SVE system was completed in nine months and approved by USEPA October 5, 1994, for implementation of the remedial action.

The AS/SVE system was constructed between October 19 and December 29, 1994. Details of the system's construction are discussed below. Appendix A presents matrix characteristics and operating parameters.

PILOT SYSTEM

The pilot system used in this application consisted of one AS well, three SVE wells, ten vadose zone piezometer (VZP) wells, two groundwater monitoring wells, and three dissolved oxygen sensor (DOS) wells, as well as an impermeable plastic cover for the ground surface and well monitoring equipment. The AS and SVE wells were located near monitoring well LF5-MW8A, from which groundwater samples with the highest recorded TCE concentrations in the project area had been collected.

The AS well was used to inject clean air into the aquifer, using an above-ground blower, to strip volatile contaminants from the aquifer into the soil in the subsurface at the site. Dissolved oxygen (DO) concentrations in the aquifer were measured during AS using DOS wells. The DO results were used to estimate the radius of influence of the AS well during the pilot test. The SVE wells were used to extract volatile contaminants from the subsurface soil, and the VZP wells were used to measure the radius of influence of the SVE wells.

The impermeable plastic cover was used to enhance the radius of influence for the SVE wells by moving the air recharge boundary a greater distance from the SVE wells. The cover was constructed of a 20-millimeter (mil) thick layer of very low density polyethylene (VLDPE) and laid down over a cleared area. The cover had a radius of approximately 200 feet, and was covered with 4 to 6-inches of gravel to assure tight contact with the ground surface, and to allow for light vehicular traffic (pickup trucks) over the cover. All wells were drilled using a 4-inch inner diameter (ID) hollow stem auger.

Operation of the pilot system consisted of a SVE pilot test and a combined AS/SVE pilot test.

FULL-SCALE SYSTEM

The full-scale system used in this application consisted of five AS wells, six SVE wells, ten VZP wells, three groundwater monitoring wells, three DOS wells, four passive injection wells, and associated well-monitoring equipment. The passive injection wells were positioned where modeling results showed significant stagnation zones when two adjacent SVE wells were operated at the same time. The full-scale system also used the same impermeable plastic cover for the ground surface that was used in the pilot system. Two parallel systems of vapor-phase granular activated carbon (GAC) were used in the full-scale system.

Extracted vapors were first treated using a moisture (water/vapor) separator to remove entrained water, and then treated using activated carbon filter canisters (GAC), prior to discharge to the atmosphere.

The AS system consisted of an inlet particulate filter, compressor, moisture separator, and flow control valve.

The six SVE wells were piped to two parallel treatment trains, each consisting of a moisture separator, a blower, and two vapor-phase GAC canisters. These two parallel sets of equipment were operated to ensure that the system's performance would not be affected by a breakdown.

Well construction details for the full-scale system are provided below. Schematics of the SVE and AS systems, respectively, are shown in Figures 2 and 3.

Type of Well	No. of Wells	Depth of Well	Location of Well Screen	Screen Length (ft)	Screen Slot Openings (in)
AS	5	20 ft. below static water level (SWL); 50 ft below ground surface (BGS)	15 to 20 ft. below SWL	5	0.01
SVE	6	30 ft BGS	2 ft above seasonal high water level (SHWL) to 12 ft above SHWL	10	0.01
VZP	10	30 ft. BGS	2 ft. above SHWL to 12 ft. above SHWL	10	0.01
Groundwater monitoring	3	40 ft. BGS	1 ft. above SHWL to 7-8 ft. below SHWL	10	0.01
DOS	3	40 ft. BGS	1 ft. above SHWL to 7-8 ft. below SHWL	10	0.01
Passive injection	4	30 ft. BGS	2 ft. above SHWL to 12 ft. above SHWL	10	0.01

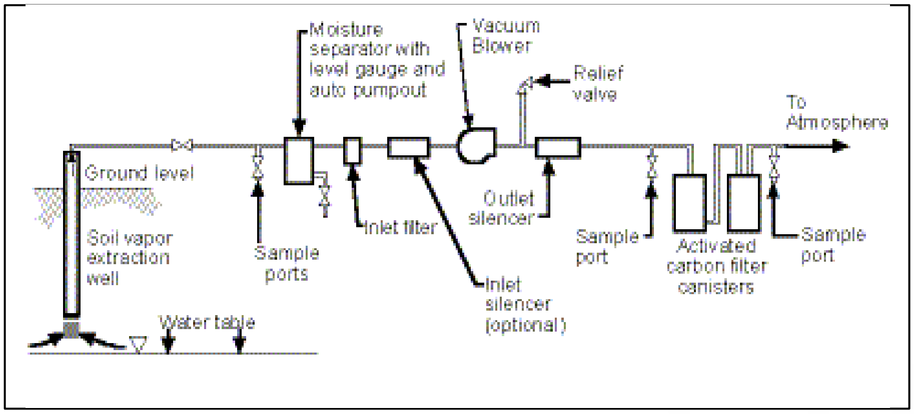

FIGURE 2
SOIL VAPOR EXTRACTION SCHEMATIC FOR LANDFILL 5

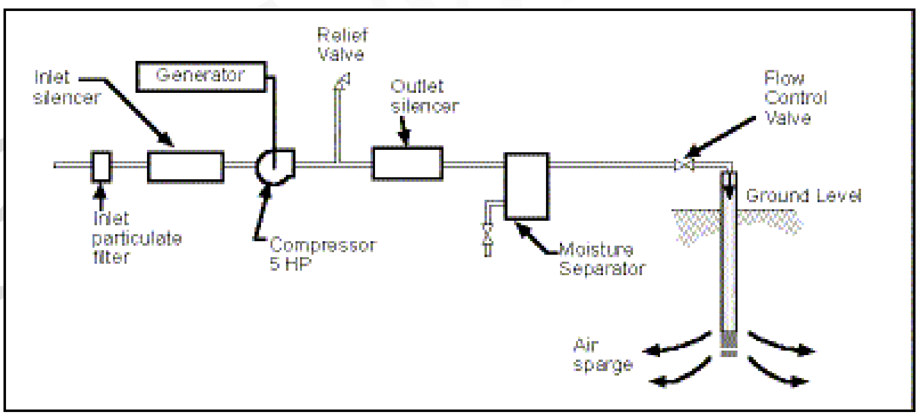

FIGURE 3
AIR SPARGING SCHEMATIC FOR LANDFILL 5

The following table includes the dates of the most significant events in the operation of the AS/SVE system at LF5.

Date	Activity
October 15, 1993	Record of decision signed
July 13, 1994	Remedial design submitted
October 5, 1994	Remedial design approved
October 19, 1994	Construction of the AS/SVE system began
December 29, 1994	Construction of the AS/SVE system completed
January 5-15, 1995	AS/SVE pilot test conducted at LF5
April 1, 1995	AS/SVE startup activities at LF5
July 29, 1995	Preliminary closeout report signed for site construction completion
September 4, 1995	Operating Properly and Successfully determination made
December 7, 1999	Data collection for Chemical Data Report #5 completed
December 27, 1999	USEPA, DoD, OEPA, and USACE representatives participated in the contract pre-final inspection and the Federal facilities agreement inspection, held simultaneously
Ongoing	AS/SVE full-scale operation

The overall performance of the AS/SVE system, as compared to the performance objectives, is discussed below.

PERFORMANCE OBJECTIVES

The ROD specified four objectives for the remedy:

- To prevent exposure to contaminated groundwater;
- To restore the contaminated groundwater to its beneficial use (drinking water);
- To minimize movement of contaminants from soil to groundwater; and,
- To prevent exposure to the contents of the landfill.

No soil cleanup levels were identified. The cleanup levels established for groundwater in the upper aquifer beneath the site were:

- TCE - 5 µg/L - the Federal Safe Drinking Water Act MCL
- VC - 1 µg/L - the Ohio State Model Toxics Control Act Method B

Monitoring of Mn was required along the western border of South and Northwest LF5 to determine any changes in concentration.

A site-specific air emission threshold limit of 2.5 parts per million volume (ppmv) TCE was calculated by USACE using Screen Model 3 and the Riverfront Air Pollution Control Agency (RAPCA) acceptable source impact levels. The air stream between the first and second carbon canisters is monitored every other week using a photoionization detector (PID). The PID breakthrough action level is 1.5 ppmv total VOCs. The breakthrough action level is used to determine when the first carbon bed needs to be removed from service.

To assess the overall performance of the system, performance monitoring is required throughout the operation of the system. The specific requirements are detailed in the compliance monitoring plan and include contaminant reduction monitoring to evaluate progress towards achieving the cleanup goals, contaminant migration monitoring to confirm that the plume is being contained, and contaminant treatment monitoring for air emissions.

TREATMENT PERFORMANCE DATA AND ASSESSMENT

The full-scale system operation began when the startup activities were completed on July 29, 1995. The full-scale system operation is currently ongoing. Performance data through December 7, 1999 were included in Chemical Data Report #5, which was the most recent document used in preparation of this report.

In general, the SVE system was operated between 0 and 1,290 standard cubic feet per minute (scfm) extracted, and the air sparging system was operated at between 0 and 210 scfm injected. The passive air injection wells initially remained closed from April 1, 1995 and July 29, 1995, after which they were opened. It was determined that the passive injection wells should remain open unless a detrimental effect could be demonstrated.

The concentration of TCE in the soil gas extracted by the SVE system generally decreased from 210 parts per billion by volume (ppbv) to 140 ppbv during the period of April 1, 1995 through July 27, 1995. The extracted soil gas concentration then increased to a maximum of 640 ppbv during the period of August 1, 1995 through December 27, 1999. This increase generally corresponds to the opening of the passive injection wells after July 29, 1995, suggesting that the use of the passive injection wells enhanced the system's performance.

Groundwater Sampling

Twenty-two rounds of groundwater sampling have been conducted (two before the remediation system was installed and four times per year for five years after the system's installation). The first round of sampling was performed during March 1994 and the last round for which data was available was performed in December 1999.

TCE was the only contaminant in groundwater consistently identified above the cleanup levels established for the site. In addition, monitoring for Mn was required.

The average TCE concentration in the contaminant reduction monitoring wells has decreased from 79 to 6.4 mg/L from March 1994 to December 1999, while the average TCE concentration in the migration monitoring wells has showed no consistent trend (average concentrations have ranged from 3.78 to 12.03 mg/L). TCE concentrations in both areas were still above the site cleanup level of 5 mg/L in December 1999.

The average total Mn concentration in the contaminant reduction monitoring wells has decreased from 11,000 mg/L in March 1994 to 8.0 mg/L in December 1999, while the average Mn concentration in the migration monitoring wells has generally decreased from 488.0 to 40.0 mg/L) during the same time period.

Vinyl chloride, the other contaminant with a cleanup level for the site, was only detected above method detection limits on one occasion (March 1997)and was never detected above site cleanup levels.

Air Emissions Sampling

Based upon the system performance testing of the AS/SVE system, the air effluent from the system was determined to be several magnitudes below the RAPCA emission action levels. Therefore, because the RAPCA emission action levels would not be exceeded during the SVE system's operation, additional air sampling was not required.

PERFORMANCE DATA QUALITY

According to the technical memorandum on the results of the pilot study, the required QA/QC samples were collected. Field duplicates, field blanks, rinsate blanks, and travel blanks were required in the final management plan for the LF5 pilot study for QA/QC of the field study sampling program. Method blanks, reagent blanks, matrix spike samples, matrix spike duplicates, duplicates, and laboratory control samples were required for laboratory QA/QC. No exceptions to the QA/QC procedures were noted in any of the field sampling or laboratory reports.

With the exception of DO data from the second quarter of 1996, no significant data quality problems were identified. This DO data were determined to be unacceptable as a result of significant fluctuations measured from the sensors. The problem did not reoccur in any of the subsequent sampling data.

INSPECTIONS

The pre-final and the Federal facilities agreement inspections of the AS/SVE system construction were conducted simultaneously on December 27, 1999, in the presence of USEPA, DoD, OEPA, and USACE representatives.

Observations, inspections, and testing during operation of the AS/SVE treatment system found no significant operational problems affecting the performance of the remedial action.

CERTIFICATIONS

On September 4, 1995, the AS/SVE system was certified as Operating Properly and Successfully. This determination was required under the Federal facilities agreement.

HEALTH AND SAFETY

No health and safety problems were encountered during construction or operation. Modified Level D personal protective equipment (PPE) was required for all site personnel who entered the site. The equipment included coveralls, safety boots, and nitrile gloves.

The quarterly groundwater monitoring program began in March 1994. TCE concentrations in both areas were still above the site cleanup level of 5 mg/L in December 1999. The average total Mn concentration in the contaminant reduction monitoring wells has decreased from 11,000 mg/L in March 1994 to 8.0 mg/L in December 1999, while the average Mn concentration in the migration monitoring wells has generally decreased from 488.0 to 40.0 mg/L) during the same time period. Vinyl chloride, the other contaminant with a cleanup level for the site, was only detected above method detection limits on one occasion and was never detected above site cleanup levels.

It is anticipated, based on the effectiveness of the AS/SVE system, that the site cleanup level of 5 mg/L for TCE concentrations will be attained for all monitoring wells in approximately 2002 (Year 7). As specified in the ROD, after this objective has been achieved the AS/SVE system will continue to operate for an additional 3 months to ensure that the site has been remediated.

As specified in the ROD, the quarterly monitoring of groundwater will continue through 2009 (Year 15) to confirm that groundwater will not be adversely impacted by the land treatment activities.

The table below summarizes total actual project costs for the Landfill 5 operable unit RA. Appendix B provides a breakdown of these costs incurred to-date as well as a breakdown of projected costs.

Cost Item	Adjusted ROD Estimate	Actual Cost[1]	Difference
Capital Costs, Year 0 (1994)	$688,013	$729,294	+ 6 %
O&M Costs, Years 1-5 (1995-1999)	$993,522	1,102,810	+ 11 %
Periodic Costs, Year 5 (1999)	$20,000	20,000	0 %
Total Costs, Years 0-5	$1,701,535	$1,852,104	+ 9 %

[1] Costs are based on the respective years that the costs were incurred (e.g., Year 1 ended in 1995 and Year 5 ended in 1999; therefore, these costs are reported in 1995, 1996, 1997, 1998, and 1999 dollars, respectively). The ROD estimates were adjusted from 1993 dollars to the appropriate year's dollar using ENR building cost index factors.

Total projected costs for Years 6 through 15 are $2,111,483 with O&M costs of $2,057,839 and periodic costs of $53,644 using 2000 as the base year of the estimate. This compares to an adjusted ROD estimate cost of $2,006,910 for O&M (+2.5%) and $50,000 for periodic costs (+1%) for this period.

PERFORMANCE

During the operation of the treatment system in SVE-only mode, TCE concentrations were reduced from initial concentrations of 235 ppb to 110 ppb. The addition of AS to the system reduced TCE concentrations in the soil gas from initial concentrations of 110 ppb to 56 ppb.

The AS/SVE system reduced TCE concentrations in groundwater. At the three wells located near suspected hot spots of contamination, TCE concentrations were reduced from 310 ppb to 170 ppb (DOS-1), from 220 ppb to 170 ppb (DOS-2), and from 140 ppb to 23 ppb (MW8A). However, the concentrations remained above the cleanup goal of 5 ppb for TCE.

The results of Mn sampling before and after sparging indicated that Mn levels decreased in six of the eleven wells samples, but increased in five of the wells.

The following observations were made in a technical memorandum summarizing the system's operation.

- With respect to optimal air extraction rate, an extraction rate of 110 scfm is likely to capture all volatilized contaminants within about 200 feet of each extraction well.
- The radius of influence of an air injection well is about 20-30 feet.
- A pressure of approximately 8 psi was required to overcome resistance in the injection well. However, at injection pressures above 8 psi, air bubbles would be more likely to occur. At 8 psi, the air injection rate into the aquifer was about 45 scfm. The 45 scfm (8 psi pressure) was determined to be the optimal flow rate, reflecting site and conditions of injections 12 feet below static water level. The vendor noted that changes in depth of the injection well will affect the injection pressure and radius of influence.
- The major problem encountered during the pilot test was that the SVE vacuum pump did not produce a vacuum sufficient to be detected by the automated sensors. Because of schedule constraints, a larger blower could not be obtained. However, according to the vendor, adequate data was obtained from the pilot test to design the full-scale system.

While overall TCE concentrations decreased in the groundwater, there were several instances when TCE concentrations increased during operation. These increases may be attributed to the new source material (from contaminated soil) infiltrating into the groundwater.

COST

The total cost for the pilot study of the AS/SVE system at LF5 was $241,000. This amount is not included in the amounts shown in Table 8-1.

Differences between the actual costs and the adjusted ROD estimates are largely attributable to the installation of passive injections wells, a SVE system capable of sustaining a 600 scfm average volumetric airflow rate, and additional groundwater monitoring wells, and the increased groundwater sampling costs associated with the additional wells. However, as shown in

Table 8-1, the actual costs that have been incurred to this point were just 9% above the corresponding, adjusted ROD estimate.

Subsequent to original negotiations, the contaminant concentrations in system air emissions were determined to be significantly below the allowable air emission standards, and RAPCA agreed to allow USACE to eliminate the need to change the carbon units from the system and to reduce air compliance monitoring requirements. USACE is planning to reallocate money from any savings on air compliance monitoring to increase the number of system performance air tests.

Because the system operation is ongoing, the total costs to operate the system are not known at this time. Actual costs to date are shown in Table B-1, and projected additional cost to complete is shown in Table B-2.

SYSTEM OPERATION

The emphasis of vapor data collection in the future should shift to the individual extraction wells rather than the combined extracted flow. In the fifth quarter of the full-scale operation, quarterly vapor sampling from the individual wells was initiated.

Based on the testing of the untreated and the treated condensate removed by the remediation system, the potential life of the aqueous-phase carbon units was estimated to be in excess of ten million gallons.

An SVE system flow rate of less than the design maximum flow rate may be more efficient for TCE removal than continuous operation at the maximum flow rate. The vendor recommended that the system be evaluated at moderate SVE system flow rates during the ongoing optimization of the system.

The data supports the remedial investigation findings that numerous TCE hot spots exist at the site, and that the presence of TCE (and/or its degradation products) at one location may or may not be related to its presence at other locations at the site.

Studying the natural degradation of the leachate at the site may provide a more widespread picture of the fate of contamination at the site than focusing on the natural attenuation of chlorinated hydrocarbons alone.

Although the impact of the AS system on the degradation of TCE at the site had not been conclusively determined, it was recommended that the AS system continued to be operated until an impact/ benefit analysis for the system is completed.

Because one of the contaminant reduction monitoring wells upgradient of the remediation system had maintained an elevated concentration of TCE, a TCE hot spot may be located upgradient of this location beyond the influence of the remediation system. An additional AS/SVE well pair could be added to this area to increase the reach of the remediation system.

The concentrations of contaminants downgradient from the treatment system may remain above the cleanup levels for the site, even if contaminant concentrations are reduced to below cleanup levels in the treatment system area.

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1. D. Bichet, USACE. 1998. Response to questions on LF5 cost data. January 9.

2. Remediation Enhanced Developments, Inc. 1993. Final Feasibility Study Report, Landfill 5 and Solvent Refined Coal Pilot Plant, Ft. Griffey, Ohio. Prepared for USACE, Louisville District. May.

3. Remediation Enhanced Developments, Inc. 1994. AS/SVE Remedial Design, Landfill 5 Remediation, Ft. Griffey, Ohio. For USACE Contract No. DACA99-99-Z-9999-99. July 13.

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21. USACE, Louisville District. Undated. Design Analysis, Ft. Griffey, LF5, AS/SVE Final Remedial Design.

22. USACE, Louisville District. Undated. Remedial Action Workplan, Ft. Griffey, LF5, AS/SVE Final Remedial Design.

The following table details matrix characteristics that may affect cost and performance of the AS/SVE system.

MATRIX CHARACTERISTICS

Parameter	Site Condition
Soil Classification	Sandy gravel to sandy silty gravel (see Table A-3)
Particle Size Distribution	Stratigraphic units range from well sorted to unsorted (see Table A-3)
Moisture Content	9 - 12 %
Air Permeability	1.6 x 10^{-7} cm^2 (calculated using field measurements and steady state equation)
Hydraulic conductivity	232 darcies (sieve analysis) 370 darcies (computer modeling)
Effective Porosity	30%
Total Organic Carbon	580 -17,000 ppb (as measured during the pilot study)

The following table details operating parameters of the AS/SVE system.

OPERATING PARAMETERS

Operating Parameter	Value and Units
Soil Vapor Extraction System	
Air flow rate	440 - 1290 scfm
Operating vacuum	5-inches mercury vacuum at blower inlet
Operating time	Continuous
Temperature	85 – 155°F
Air Sparging System	
Air flow rate	60 - 210 scfm
Operating pressure	7 pounds per square inch (psi) (design value)
Operating time	Cyclical

The following tables present a summary of actual (Years 0-5) and projected (Years 6-15) costs and calculation of technology-specific unit costs for soil vapor extraction and air sparging. HCAS data entry sheets are attached to this appendix.

ACTUAL COSTS (1 of 2)

Site: Landfill 5
Location: Ft. Griffey, Ohio
Phase: Interim RA Report
Base Year: 1994, 1995-1999, 2000
Date: April 9, 2001

Description: The selected treatment technology consists of air sparging in combination with soil vapor extraction in the source area. Capital costs were incurred in Year 0 (1994). Actual O&M costs were incurred in Years 1 (1995) through 5 (1999). Projected O&M costs are assumed for Years 6 (2000) through 15 (2009). Periodic costs are incurred in Years 5, 10, and 15.

RA CAPITAL COSTS (Year 0):

DESCRIPTION	QUANTITY	UNIT	UNIT COST	COST	NOTES
331XX HTRW Remedial Action					
.01 Mobilization and Preparatory Work					
.01 Mob Construction Equipment & Facilities	1	EA	$2,472	$2,472	
.03 Submittals/Implementation Plans	1	EA	$13.504	$13.504	QAPP, SSHP, etc.
.05 Construct Temporary Utilities	1	EA	$1,274	$1,274	
SUBTOTAL				$17.250	
.02 Monitoring, Sampling, Testing, and Analysis					
.04 Monitoring Wells	7	EA	$2.965	$20.757	Saturated zone screen interval
.11 Geotechnical Testing	10	EA	$230	$2,300	Screen interval soil samples
.90 Vadose Zone Piezometers	10	EA	$1.577	$15.771	Installed to water table depth
.91 Dissolved Oxygen Sensor Wells	3	EA	$2.965	$8.896	Saturated zone screen interval
SUBTOTAL				$47,724	
.03 Sitework					
.02 Clearing and Grubbing	3.0	AC	$1.161	$3.482	Work area
.03 Earthwork - Stockpile Topsoil	2.420	CY	$0.51	$1.234	Strip 0.5'
SUBTOTAL				$4,717	
.13 Physical Treatment					
.32 Air Sparging (37,400 MGA)					
.90 AS Injection Wells	5	EA	$4.645	$23.225	Well depth = midpoint of aquifer
.91 AS Blower	1	EA	$5,712	$5,712	
.92 AS Piping	100	LF	$5.03	$503	Pipe, valves, fittings, etc.
.93 Electrical Hookup	1	EA	$4.949	$4.949	
.94 Startup and Testing	1	EA	$5.468	$5.468	
SUBTOTAL				$39.857	
.13 Physical Treatment					
.23 Soil Vapor Extraction (27,800 CY)					
.90 Mobilize SVE System	1	EA	$1.534	$1.534	Mobile unit
.91 Impermeable Surface Cover	125.500	SF	$0.84	$105.420	Low density polyethylene liner
.92 SVE Extraction Wells	6	EA	$3.725	$22.350	Installed to water table depth
.93 SVE Passive Injection Wells	4	EA	$2.286	$9.144	Installed to water table depth
.94 SVE System	1	EA	$93.510	$93.510	Mobile unit (600 scfm)
.95 GAC System	2	EA	$102,596	$205,192	
.96 SVE Piping	400	LF	$8.66	$3.464	Pipe, valves, fittings, etc.
.97 Electrical Hookup	1	EA	$4.949	$4.949	
.98 Startup and Testing	1	EA	$5,468	$5,468	
SUBTOTAL				$451.031	
.19 Disposal (Commercial)					
.20 Container Handling	30	Each	$60	$1.800	Transport/disposal of drums - SWLF
.90 Wastewater Discharge/Testing	200	Gallon	$1.25	$250	POTW fee - development water
SUBTOTAL				$2.050	
.20 Site Restoration					
.01 Earthwork - Spread/Compact Topsoil	2.420	Cubic Yard	$1.86	$4.501	Replace topsoil
.04 Revegetation and Planting	3.0	Acre	$1,427	$4,281	Seeding/mulch/fertilizer - work area
SUBTOTAL				$8.783	
.21 Demobilization					
.02 Removal of Temporary Utilities	1	EA	$546	$546	
.04 Demob Construction Equipment & Facilities	1	EA	$1,059	$1,059	
.06 Submittals	1	EA	$5.788	$5.788	Post-const. reports
SUBTOTAL				$7.393	
SUBTOTAL				$578.805	
Project Management				34.728	
Remedial Design				69.457	
Construction Management				46.304	
TOTAL RA CAPITAL COST (Year 0)				**$729,294**	1994

ACTUAL COSTS (2 of 2)

O&M COSTS (Years 1-5):

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
342XX HTRW O&M					
.02 Monitoring, Sampling, Testing, and Analysis					
.90 Performance Monitoring - SVE Vapor	5	YR	$22,149	$110,745	1 sample/month * 6 extraction wells
.91 Performance Monitoring - SVE Emissions	5	YR	$3,692	$18,460	1 sample/month - SVE exhaust
.92 Site Groundwater Sampling (Quarterly)	5	YR	$36,399	$181,995	Sample 8 wells/event VOCs, metals
.93 Site Groundwater Lab Analysis	5	YR	$21,839	$109,195	Analysis for above
SUBTOTAL				$420,395	
.13 Physical Treatment					
.32 Air Sparging (37,400 MGA)					
.90 Operations Labor	5	YR	$29,376	$146,880	54 manhours per month
.91 Maintenance Labor	5	YR	$3,456	$17,280	6 manhours per month
.92 Equipment Repair	1	EA	$1,000	$1,000	
.93 Utilities	5	YR	$9,254	$46,268	Electricity + fuel
SUBTOTAL				$211,428	
.13 Physical Treatment					
.23 Soil Vapor Extraction (27,800 CY)					
.90 Operations Labor	5	YR	$44,064	$220,320	82 manhours per month
.91 Maintenance Labor	5	YR	$5,184	$25,920	10 manhours per month
.92 Equipment Repair	1	EA	$1,500	$1,500	
.93 Utilities	5	YR	$13,880	$69,402	Electricity + fuel
SUBTOTAL				$317,142	
.18 Disposal (Other than Commercial)					
.90 Wastewater Discharge/Testing	8,000	GA	$1.25	$10,000	Purge & knockout water
SUBTOTAL				$958,965	
Project Management				47,948	
Technical Support				95,897	
TOTAL O&M COST (Years 1-5)				**$1,102,810**	1995-1999

PERIODIC COSTS (Year 5):

DESCRIPTION	YEAR	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Five Year Review Report	5	1	Each	$12,000	$12,000	1 report at end of Year 5
Interim RA Report	5	1	Each	$8,000	$8,000	
TOTAL PERIODIC COST (Year 5)					**$20,000**	1999

TOTAL COST (Years 0-5)	**$1,852,104**

PROJECTED COSTS

Site:	Landfill 5	**Description:**	The selected treatment technology consists of air sparging in combination with soil vapor extraction in the source area. Capital costs were incurred in Year 0 (1994). Actual O&M costs were incurred in Years 1 (1995) through 5 (1999). Projected O&M costs are assumed for Years 6 (2000) through 15 (2009). Periodic costs are incurred in Years 5, 10, and 15.
Location:	Ft. Griffey, Ohio		
Phase:	Interim RA Report		
Base Year:	1994, 1995-1999, 2000		
Date:	March 30, 2001		

O&M COSTS (Years 6-15):

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
342XX HTRW O&M					
.02 Monitoring, Sampling, Testing, and Analysis					
.90 Performance Monitoring - SVE Vapor	10	YR	$22.149	$221.490	1 sample/month * 6 extraction wells
.91 Performance Monitoring - SVE Emissions	10	YR	$3.692	$36.920	1 sample/month - SVE exhaust
.92 Site Groundwater Sampling (Quarterly)	10	YR	$18,200	$182,000	Sample 8 wells/event VOCs, metals
.93 Site Groundwater Lab Analysis	10	YR	$10.920	$109.200	Analysis for above
SUBTOTAL				$549.610	
.13 Physical Treatment					
.32 Air Sparging					
.05 Utilities	10	YR	$9.254	$92.536	Electricity + fuel
.09 Operations Labor	10	YR	$29.376	$293.760	54 manhours per month
.10 Maintenance Labor	10	YR	$3.456	$34.560	6 manhours per month
.90 Equipment Repair	1	EA	$2.000	$2.000	
SUBTOTAL				$422,856	
.13 Physical Treatment					
.23 Soil Vapor Extraction					
.05 Utilities	10	YR	$13.880	$138.804	Electricity + fuel
.09 Operations Labor	10	YR	$44,064	$440,640	82 manhours per month
.10 Maintenance Labor	10	YR	$5.184	$51.840	10 manhours per month
.90 Equipment Repair	1	EA	$3.000	$3.000	
SUBTOTAL				$634.284	
.18 Disposal (Other than Commercial)					
.90 Wastewater Discharge/Testing	16.000	GA	$1.25	$20.000	Purge & knockout water
SUBTOTAL				$1.626.750	
Contingency	10%			162.675	
SUBTOTAL				$1.789.425	
Project Management	5%			89.471	
Technical Support	10%			178.943	
TOTAL O&M COST (Years 6-15)				$2.057.839	2000

PERIODIC COSTS (Years 10, 15):

DESCRIPTION	YEAR	QUANTITY	UNIT	UNIT COST	TOTAL	NOTES
Five Year Review Report	10	1	Each	$12.000	$12.000	1 report at end of Year 10
Demob SVE System 342XX.13.23.99	15	1	Lump Sum	$14,250	$14,250	Remove equipment and piping
Demob AS System 342XX.13.32.99	15	1	Lump Sum	$7.125	$7.125	Remove equipment and piping
Well Abandon 342XX.02.04.20	15	28	Each	$350	$9.800	
Contingency (% of Sum)		15%			4.676	% of construction activities
Project Mgt. (% of Sum + Cont.)		5%			1.793	% of construction + contingency
Final RA Report	15	1	Each	$4.000	$4.000	
SUBTOTAL					$41.644	
TOTAL PERIODIC COST (Years 10, 15)					$53.644	2000

TOTAL PROJECTED COST (Years 6-15)	**$2,111,483**

SOIL VAPOR EXTRACTION
TECHNOLOGY-SPECIFIC UNIT COST CALCULATION

ACTUAL CAPITAL COSTS (Year 0):	
Monitoring, Sampling, Testing, and Analysis[1]	$15,771
Physical Treatment[2]	$451,031
Disposal (Other than Commercial)[3]	$800
SUBTOTAL	$467,602
ACTUAL O&M COSTS (Years 1-5):	
Monitoring, Sampling, Testing, and Analysis[4]	$129,205
Physical Treatment[2]	$317,142
SUBTOTAL	$446,347
PROJECTED O&M COSTS (Years 6-15):	
Monitoring, Sampling, Testing, and Analysis[4]	$258,410
Physical Treatment[2]	$634,284
SUBTOTAL	$892,694
PROJECTED PERIODIC COSTS (Years 10, 15):	
Demobilize SVE System[2]	$14,250
Well Abandonment[2]	$7,000
SUBTOTAL	$21,250
TOTAL TECHNOLOGY-SPECIFIC COST	$1,827,893
Soil to be Treated (Cubic Yards)[5]	27,800
TECHNOLOGY-SPECIFIC UNIT COST (Per Cubic Yard)	**$65.75**

[1] SVE vadose zone piezometers
[2] SVE system only
[3] Disposal of SVE piezometer soil cuttings
[4] SVE performance monitoring
[5] Within zone of influence

AIR SPARGING TECHNOLOGY-SPECIFIC UNIT COST CALCULATION	
ACTUAL CAPITAL COSTS (Year 0):	
Monitoring, Sampling, Testing, and Analysis[1]	$19,172
Physical Treatment[2]	$39,857
Disposal (Other than Commercial)[3]	$1,150
SUBTOTAL	$60,179
ACTUAL O&M COSTS (Years 1-5):	
Physical Treatment[2]	$211,428
PROJECTED O&M COSTS (Years 6-15):	
Physical Treatment[2]	$422,856
PROJECTED PERIODIC COSTS (Years 10, 15):	
Demobilize AS System[2]	$7,125
Well Abandonment[2]	$2,800
TOTAL	$9,925
TOTAL TECHNOLOGY-SPECIFIC COST	$704,388
Groundwater to be Treated (MGA)[4]	37,400
TECHNOLOGY-SPECIFIC UNIT COST (Per 1,000 Gal)	**$18.83**

[1] AS monitoring wells (3), DOS wells (3), geotechnical testing
[2] AS system only
[3] Disposal of AS wells soil cuttings and development water
[4] Within treatment zone - includes flushed volume (MGA = 1,000 gallons)

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 1)

Project Information

Project Name: Landfill 5 Operable Unit

Project Number:

Project Phase (Select one)

Studies and Design	
Remedial Action	✓
Operations and Maintenance	

Project Note (Describe the project)

Soil Vapor Extraction treatment technology was utilized to remediate 27,800 cy (estimated) of contaminated soil in conjunction with Air Sparging treatment technology, which was utilized to remediate 37,400,000 gallons (estimated) of contaminated groundwater.

Contract Information

Contract Number	DACA27-94-C-0300
Managing Organization	U.S. Army Corps of Engineers
Organization Name	Louisville District
Site Owner	U.S. Army
Other ID Number	
Prime Contractor	Remediation Enhanced Developments, Inc. (RED)

Contract Type (Select one)

Cost + Award Fee	
Cost + Base + Award Fee	
Cost + Fixed Fee	✓
Cost + Incentive Award	
Fixed Price	
Not Availiable	
Other	

Procurement Type (Select one)

Two Step Sealed Bid	
Sealed Bid (IFB)	
Competitive Negotiation (RFP)	✓
Sole Source (SSC)	
Other	

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 2)

Site Information

State/Country	Ohio/USA
Installation	Ft. Griffey
Site Name	Landfill 5
Site Number	
EPA Region	V

Current Use (Select one)

Installation Operation	✓
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	
Administrative Office	
Commercial	
Other	
Unknown	

Future Use (Select one)

Installation Operation	✓
Industry Operation	
Residential	
Recreational	
Wildlife Refuge	
Waste Disposal	
Administrative Office	
Commercial	
Other	
Unknown	

Point of Contact

	Data Entry Person	POC#2	POC#3
Title/Role	Contractor Estimator		
Organization	RED, Inc.		
Name	Joe Morgan		
Address	535 Red Way		
City, State	Cincinnati, OH		
Zip	99992		
Telephone	555-111-2222		
Fax	555-111-2223		
Email	jmorgan@red.com		

Enter up to 3 POC's.

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 3)

Profile - General Characteristics

Regulatory Class		Public Concern	
CERCLA	✓	Low	✓
RCRA		High	
Other		Historical/Archoelogical	
Unknown		Yes	
National Priority List		No	✓
Yes	✓	Innovative Technology	
No		Yes	
Wetland		No	✓
Yes		Size of Exclusion Zone (Acres)	
No	✓	Size of Area (Acres)	
Flood Plain			
Yes			
No	✓		

Profile - Contaminants/Technical Approach

Site Type	**Media**	**Contaminant**	**Technical Approach**
AG Storage Tanks	Air	Nonhal VOC's	CWM/OEW Remvl
UG Storage Tanks	Equipment/Mach	Halogenated VOC's	Surf Water Control
Drums/Cont <250 GA	Groundwater	Nonhal Semi VOC's	Grnd Water Control
Unauth Disposl Area	Liquid	Halogen Semi VOC's	Air/Gas Control
Facil/Bldgs	Surface Water	Fuels	Solids Contain
Fire Train/Open Burn	Sediment	Inorganics	Liq/Sed/Sludge Cntrl
Firing Rnge/Open Det	Sludge	Low Lev Rad Waste	Drums/Tanks Remvl
Pit/Trench	Soil	High Lev Rad Waste	Biological Treatment
Surf Impnd/Lagoons	Solid/Debris	Low Rad Mixed Wst	Chemical Treatment
Lakes/Ponds/Swamp	Struct Bldg Matls	TRU Waste	Physical Treatment
Landfill	Other	CWM/OEW	Thermal Treatment
Ocean		Asbestos	Stab/Fix/Encap
Rivers/Streams		Unknown	Decon & Decommish
Spill/Emerg Resp		Other	Disposal (Not Comm)
Waste Pile			Disposal Commercial
Other			Other

Pick as many Profile combinations as necessary:

Landfill	Soil	Fuels	Physical Treatment
Landfill	Groundwater	Fuels	Physical Treatment

Historical Cost Analysis System (HCAS)
Project Data Entry Form (Sheet 4)

Cost

Start Date	10/19/1994
End Date	9/4/1995
Number of Mods	0
Reasons for Mods (Select those applicable)	
Administrative	
Changes for Time or Cost	
Changes Requested by Government Authority	
Design Deficiency	
Differing Site Conditions	
Funding Level Change	
New Federal Regulation	
Other Changes	
Suspension or Termination of Work	
Value Engineering Change	
Variations in Estimated Quantities	
Variations Not Readily Identifiable During Design	
Cost	
Award Amount	$2,900,000
Actual Amount	$3,195,695
Cost Variance	+10%

Cost Breakdown

See next sheets.

The HCAS Cost Breakdown is structured in accordance with the February 1996 "HTRW Remedial Action Work Breakdown Structure (RA WBS)" and "HTRW O&M Work Breakdown Structure (O&M WBS)".

The next sheets show the RA WBS and O&M WBS to the Third Level as required for the HCAS cost report portion of the "RA Report".

The costs reported shall be "Burdened Costs", meaning that contractor markups, general requirements, overhead, and profit shall be included in the costs.

The complete RA WBS and O&M WBS to the Fourth Level is at:
http://www.FRTR.gov/cost/ec2/wbs1.html

The HCAS 3.1 software can be downloaded from:
http://www.FRTR.gov/cost/ec2/index.html

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
33XXX				**HTRW CONSTRUCTION ACTIVITIES**				
331XX				**HTRW REMEDIAL ACTION (Capital and Operating)**				
	01			**MOBILIZATION AND PREPARATORY WORK**				
	01	01		Mobilization of Construction Equipment and Facilities	1	EA	2,472	2,472
	01	02		Mobilization of Personnel		EA		
	01	03		Submittals/Implementation Plans	1	EA	13,504	13,504
	01	04		Setup/Construct Temporary Facilities		EA		
	01	05		Construct Temporary Utilities	1	EA	1,274	1,274
	01	06		Temporary Relocations of Roads/Structures/Utilities		EA		
	01	07		Construction Plant Erection		EA		
	01	08		Institutional Controls		EA		
	01	09		Alternate Water Supply		EA		
	01	10		Population Relocation		EA		
	01	9X		Other (Use Numbers 90-99)				
	02			**MONITORING, SAMPLING, TESTING, AND ANALYSIS**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling		EA		
	02	04		Monitoring Wells	7	EA	2,965	20,755
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing	10	EA	230	2,300
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-Site Laboratory Facilities		EA		
	02	14		Off-Site Laboratory Facilities		EA		
	02	9X		Other (Use Numbers 90-99)	1	LS	24,667	24,667
	03			**SITEWORK**				
	03	01		Demolition		SY		
	03	02		Clearing and Grubbing	3	ACR	1,161	3,482
	03	03		Earthwork	2,420	CY	0.51	1,234
	03	04		Roads/Parking/Curbs/Walks		SY		
	03	05		Fencing		LF		
	03	06		Electrical Distribution		LF		
	03	07		Telephone/Communication Distribution		LF		
	03	08		Water/Sewer/Gas Distribution		LF		
	03	09		Steam and Condensate Distribution		LF		
	03	10		Fuel Line Distribution		LF		
	03	11		Storm Drainage/Subdrainage		LF		
	03	12		Permanent Cover Structure Over Containment Area		SF		
	03	13		Development of Borrow Pit/Haul Roads		ACR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	03	14		Fuel Storage Tanks (New)		EA		
	03	9X		Other (Use Numbers 90-99)				
	04			**ORDNANCE AND EXPLOSIVE - CHEMICAL WARFARE**				
	04	01		Ordnance Removal and Destruction		ACR		
	04	9x		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF		
	05	02		Floodwalls		SF		
	05	03		Levees		LF		
	05	04		Terraces and Benches		LF		
	05	05		Channels/Waterways (Soil/Rock)		LF		
	05	06		Chutes or Flumes		LF		
	05	07		Sediment Barriers		LF		
	05	08		Storm Drainage		LF		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	12		Earthwork		CY		
	05	13		Erosion Control		ACR		
	05	14		Development of Borrow Pit/Haul Roads		ACR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA		
	06	02		Subsurface Drainage/Collection		LF		
	06	03		Slurry Walls		SF		
	06	04		Grout Curtain		SF		
	06	05		Sheet Piling		SF		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	09		Development of Borrow Pit/Haul Roads		ACR		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF		
	07	02		Gas/Vapor Collection Well System		EA		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asphalt		ACR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	07		Development of Borrow Pit/Haul Roads		ACR		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Pump System		ACR		
	09	08		Development of Borrow Pit/Haul Roads		ACR		
	09	9x		Other (Use Numbers 90-99)				
	10			**DRUMS/TANKS/STRUCTURES/MISCELLANEOUS**				
	10	01		Drum Removal		EA		
	10	02		Tank Removal		EA		
	10	03		Structure Removal		SF		
	10	04		Asbestos Abatement		SF		
	10	05		Piping and Pipeline Removal		LF		
	10	06		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	10	07		Miscellaneous Items		ACR		
	10	08		Contaminated Paint Removal		SF		
	10	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Sequencing Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Construction of Permanent Plant Facility		EA		
	11	9x		Other (Use Numbers 90-99)				

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	**12**			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic Oxidation, UV Ozone,		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process (BCDP)		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Construction of Permanent Plant Facility		EA		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		
	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction	27,800	CY	16.22	451,031
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging	37,400	MGA	1.07	39,857
	13	50		Construction of Permanent Plant Facility		EA		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Construction of Permanent Plant Facility		EA		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		
	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Construction of Permanent Plant Facility		EA		
	15	9x		Other (Use Numbers 90-99)				
	16			**RESERVED FOR FUTURE USE**				
	17			**DECONTAMINATION AND DECOMMISSIONING (D&D)**				
	17	01		Pre-Decommissioning Operations		SF		
	17	02		Facility Shutdown Activities		SF		
	17	03		Procurement of Equipment and Material		SF		
	17	04		Dismantling Activities		SF		
	17	05		Research and Development (R&D)		SF		
	17	06		Spent Fuel Handling		SF		
	17	07		Hot Cell Cleanup		SF		
	17	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
331XX	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Construction of Permanent Disposal Facility		EA		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees and Taxes		TON		
	18	23		Mixed Waste Storage Fees and Taxes		TON		
	18	9x		Other (Use Numbers 90-99)				
	19			**DISPOSAL (COMMERCIAL)**				
	19	20		Container Handling	30	EA	60	1,800
	19	21		Transportation to Storage/Disposal Facility		TON		
	19	22		Disposal Fees and Taxes		TON		
	19	23		Mixed Waste Storage Fees and Taxes		TON		
	19	9x		Other (Use Numbers 90-99)	1	LS	250	250
	20			**SITE RESTORATION**				
	20	01		Earthwork	2,420	CY	1.86	4,501
	20	02		Permanent Markers		EA		
	20	03		Permanent Features		EA		
	20	04		Revegetation and Planting	3	ACR	1,427	4,281
	20	05		Removal of Barriers		EA		
	20	9x		Other (Use Numbers 90-99)				
	21			**DEMOBILIZATION**				
	21	01		Removal of Temporary Facilities		EA		
	21	02		Removal of Temporary Utilities	1	EA	546	546
	21	03		Final Decontamination		EA		
	21	04		Demobilization of Construction Equipment and Facilities	1	EA	1,059	1,059
	21	05		Demobilization of Personnel		EA		
	21	06		Submittals	1	EA	5,788	5,788
	21	07		Construction Plant Takedown		EA		
	21	9x		Other (Use Numbers 90-99)				
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				578,801

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
34XXX				**HTRW POST CONSTRUCTION AND FINANCIAL CLOSEOUT ACTIVITIES**				
341XX				**FISCAL/FINANCIAL CLOSE ACTIVITIES**				
342XX				**HTRW OPERATION AND MAINTENANCE (POST CONSTRUCTION)**				
	02			**MONITORING, SAMPLING, TESTING, AND ANALYSIS**				
	02	01		Meteorological Monitoring		EA		
	02	02		Radiation Monitoring		EA		
	02	03		Air Monitoring and Sampling		EA		
	02	04		Monitoring Wells	28	EA	350	9,800
	02	05		Sampling Surface Water/Groundwater/Liquid Waste		EA		
	02	06		Sampling Soil and Sediment		EA		
	02	07		Sampling Asbestos		EA		
	02	08		Sampling Radioactive Contaminated Media		EA		
	02	09		Laboratory Chemical Analysis		EA		
	02	10		Radioactive Waste Analysis		EA		
	02	11		Geotechnical Testing		EA		
	02	12		Geotechnical Instrumentation		EA		
	02	13		On-site Laboratory Facilities		EA		
	02	14		Off-site Laboratory Facilities		EA		
	02	9X		Other (Use Numbers 90-99)	1	LS	970,005	970,005
	03			**SITEWORK**				
	03	04		Roads/Parking/Curbs/Walks		SY/YR		
	03	05		Fencing		LF/YR		
	03	06		Electrical Distribution		LF/YR		
	03	07		Telephone/Communication Distribution		LF/YR		
	03	08		Water/Sewer/Gas Distribution		LF/YR		
	03	09		Steam and Condensate Distribution		LF/YR		
	03	10		Fuel Line Distribution		LF/YR		
	03	11		Storm Drainage/Subdrainage		LF/YR		
	03	12		Permanent Cover Structure Over Contaminated Area		SF/YR		
	03	14		Fuel Storage Tanks (New)		EA/YR		
	03	9X		Other (Use Numbers 90-99)				
	05			**SURFACE WATER COLLECTION AND CONTROL**				
	05	01		Berms/Dikes		LF/YR		
	05	02		Floodwalls		SF/YR		
	05	03		Levees		LF/YR		
	05	04		Terraces and Benches		LF/YR		
	05	05		Channels/Waterways (Soil/Rock)		LF/YR		
	05	06		Chutes or Flumes		LF/YR		
	05	07		Sediment Barriers		LF/YR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	05	08		Storm Drainage		LF/YR		
	05	09		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	05	10		Pumping/Draining/Collection		MGA		
	05	11		Transport to Treatment Plant		MGA		
	05	13		Erosion Control		ACR/YR		
	05	9X		Other (Use Numbers 90-99)				
	06			**GROUNDWATER COLLECTION AND CONTROL**				
	06	01		Extraction and Injection Wells		EA/YR		
	06	02		Subsurface Drainage/Collection		LF/YR		
	06	03		Slurry Walls		SF/YR		
	06	04		Grout Curtain		SF/YR		
	06	05		Sheet Piling		SF/YR		
	06	06		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		
	06	07		Pumping/Collection		MGA		
	06	08		Transport to Treatment Plant		MGA		
	06	9x		Other (Use Numbers 90-99)				
	07			**AIR POLLUTION/GAS COLLECTION AND CONTROL**				
	07	01		Gas/Vapor Collection Trench System		LF/YR		
	07	02		Gas/Vapor Collection Well System		EA/YR		
	07	03		Gas/Vapor Collection at Lagoon Cover		SY/YR		
	07	04		Fugitive Dust/Vapor/Gas Emissions Control		ACR/YR		
	07	9x		Other (Use Numbers 90-99)				
	08			**SOLIDS COLLECTION AND CONTAINMENT**				
	08	01		Contaminated Soil Collection		CY		
	08	02		Waste Containment, Portable (Furnish/Fill)		CY		
	08	03		Transport to Treatment Plant		CY		
	08	04		Radioactive Specific Waste Containment (Furnish/Fill)		CY		
	08	05		Capping of Contaminated Area/Waste Pile (Soil/Asph		ACR/YR		
	08	06		Nuclear Waste Densification (Dynamic Compaction)		CY		
	08	9x		Other (Use Numbers 90-99)				
	09			**LIQUIDS/SEDIMENTS/SLUDGES COLLECTION AND CONTAINMENT**				
	09	01		Dredging/Excavating		CY		
	09	02		Industrial Vacuuming		CY		
	09	03		Waste Containment, Portable (Furnish/Fill)		MGA		
	09	04		Transport to Treatment Plant		MGA		
	09	05		Radioactive Specific Waste Containment (Furnish/Fill)		MGA		
	09	06		Pumping/Draining/Collection		MGA		
	09	07		Lagoons/Basins/Tanks/Dikes/Pump System		ACR/YR		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	09	9x		Other (Use Numbers 90-99)				
	11			**BIOLOGICAL TREATMENT**				
	11	01		Activated Sludge (Seq Batch Reactors)		MGA		
	11	02		Rotating Biological Contactors		MGA		
	11	03		Land Treatment/Farming (Solid Phase Biodegradation)		CY		
	11	04		In-Situ Biodegradation/Bioreclamation		CY		
	11	05		Trickling Filters		MGA		
	11	06		Biological Lagoons		MGA		
	11	07		Composting (Soil Pile Bioremediation)		CY		
	11	08		Sludge Stabilization - Aerobic		CY		
	11	09		Sludge Stabilization - Anaerobic		CY		
	11	10		Genetically Engineered Organisms (White Rot Fungus)		CY		
	11	11		Slurry Biodegradation		CY		
	11	12		Bioventing		SF		
	11	13		Bioslurping		SF		
	11	14		Biopile (Heap Pile Remediation)		CY		
	11	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	11	9x		Other (Use Numbers 90-99)				
	12			**CHEMICAL TREATMENT**				
	12	01		Oxidation/Reduction (Catalytic)		MGA		
	12	02		Solvent Extraction		MGA		
	12	03		Chlorination		MGA		
	12	04		Ozonation		MGA		
	12	05		Ion Exchange		MGA		
	12	06		Neutralization		MGA		
	12	07		Chemical Hydrolysis		MGA		
	12	08		Ultraviolet Photolysis (UV Oxidation)		MGA		
	12	09		Dehalogenation (Catalytic Dechlorination)		CY		
	12	10		Alkali Metal Dechlorination		CY		
	12	11		Alkali Metal/Polyethylene Glycol (A/PEG)		CY		
	12	12		Base-Catalyzed Decomposition Process		CY		
	12	13		Electrolysis		MGA		
	12	14		Vapor Recovery/Reuse (Internal Combustion Engine)		CF		
	12	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	12	9x		Other (Use Numbers 90-99)				
	13			**PHYSICAL TREATMENT**				
	13	01		Filtration/Ultrafiltration		MGA		
	13	02		Sedimentation		MGA		
	13	03		Straining		MGA		
	13	04		Coagulation/Flocculation/Precipitation		MGA		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	13	05		Equalization		MGA		
	13	06		Evaporation		MGA		
	13	07		Air Stripping		MGA		
	13	08		Steam Stripping		MGA		
	13	09		Soil Washing (Surfactant/Solvent)		CY		
	13	10		Soil Flushing (Surfactant/Solvent)		CY		
	13	11		Solids Dewatering		CY		
	13	12		Oil/Water Separation		MGA		
	13	13		Dissolved Air Floatation		MGA		
	13	14		Heavy Media Separation		CY		
	13	15		Distillation		MGA		
	13	16		Chelation		MGA		
	13	17		Solvent Extraction		MGA		
	13	18		Supercritical Extraction		MGA		
	13	19		Carbon Adsorption - Gases		CF		
	13	20		Carbon Adsorption - Liquids		MGA		
	13	21		Membrane Separation - Reverse Osmosis		MGA		
	13	22		Membrane Separation - Electrodialysis		MGA		
	13	23		Soil Vapor Extraction	27,800	CY	34.74	965,676
	13	24		Shredding		CY		
	13	25		Aeration		CY		
	13	26		Advanced Electrical Reactor		CY		
	13	27		Low Level Waste (LLW) Compaction		CY		
	13	28		Agglomeration		CY		
	13	29		In-Situ Steam Extraction		MGA		
	13	30		Filter Presses		MGA		
	13	31		Lignin Adsorption/Sorptive Clays		CY		
	13	32		Air Sparging	37,400	MGA	17.15	641,409
	13	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	13	9x		Other (Use Numbers 90-99)				
	14			**THERMAL TREATMENT**				
	14	01		Incineration		CY		
	14	02		Low Temperature Thermal Desorption		CY		
	14	03		Supercritical Water Oxidation		MGA		
	14	04		Molten Salt Destruction		CY		
	14	05		Radio Frequency Heating		CY		
	14	06		Solar Detoxification		CY		
	14	07		High Temperature Thermal Desorption		CY		
	14	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	14	9x		Other (Use Numbers 90-99)				
	15			**STABILIZATION/FIXATION/ENCAPSULATION**				
	15	01		Molten Glass		CY		

WBS Number				DESCRIPTION	QTY	UOM	UNIT COST	COST $
342XX	15	02		In-Situ Vitrification		CY		
	15	03		In-Situ Pozzolan Process (Lime/Portland Cement)		CY		
	15	04		Pozzolan Process (Lime/Portland Cement)		CY		
	15	05		Asphalt-Based Encapsulation		CY		
	15	06		Radioactive Waste Solidification (Grouting/Other)		CY		
	15	07		Sludge Stabilization (Aggregate/Rock/Slag)		CY		
	15	50		Post Construction O&M of Permanent Plant Facility		EA/YR		
	15	9x		Other (Use Numbers 90-99)				
	18			**DISPOSAL (OTHER THAN COMMERCIAL)**				
	18	01		Landfill/Burial Ground/Trench/Pits		CY		
	18	02		Above-Ground Vault		CY		
	18	03		Underground Vault		CY		
	18	04		Underground Mine/Shaft		CY		
	18	05		Tanks		MGA		
	18	06		Pads (Tumulus/Retrievable Storage/Other)		CY		
	18	07		Storage Bldgs/Protective Cvr Structures/Other Bldgs &		CY		
	18	08		Cribs		CY		
	18	09		Deep Well Injection		MGA		
	18	10		Incinerator		CY		
	18	15		Post Construction O&M of Permanent Disposal Fac		EA/YR		
	18	20		Container Handling		EA		
	18	21		Transportation to Storage/Disposal Facility		TON		
	18	22		Disposal Fees & Taxes		TON		
	18	23		Mixed Waste Storage Fees & Taxes		TON		
	18	9x		Other (Use Numbers 90-99)	1	LS	30,000.00	30,000
	9X			**OTHER (Use Numbers 90-99)**				
				TOTAL AMOUNT $				2,616,890