DEPARTMENT OF THE ARMY
UNITED STATES ARMY AVIATION AND MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA 35898-5000

26 APR 1999

REPLY TO
ATTENTION OF

AMSAM-RA-EMP (200)

MEMORANDUM FOR Commander, U.S. Army Materiel Command,
ATTN: AMCEN-A (Mr. Krishna Ganta),
Room 4W20, 5001 Eisenhower Avenue,
Alexandria, VA 22333-0001

SUBJECT: The Final Decision Document for an Interim Remedial Action at RSA-14, Inactive Contaminated Burn Trenches, Operable Unit 14, Redstone Arsenal, Alabama

1. Enclosed is one copy of subject report.

2. The POC for this action is Ken Hewitt, Directorate of Environmental Management and Planning, DSN-788-2836 or commercial 256-842-2836.

Encl

JOE L. DAVIS
Acting Director, Directorate of
Environmental Management
and Planning

CF:
Commander, U.S. Army Environmental Center, Installation Restoration Division, ATTN: SFIM-AEC-IRP (Mr. Ross A. Mantione), Building E4480, Aberdeen Proving Grounds, MD 21010-5401 (2 copies)

FINAL

DECISION DOCUMENT

For a

INTERIM REMEDIAL ACTION SOIL VAPOR EXTRACTION TREATMENT SYSTEM

RSA-14 INACTIVE UNLINED EARTHEN OPEN BURN TRENCHES

OU-14 OPEN BURN/OPEN DEMOLISHION AREA
REDSTONE ARSENAL, ALABAMA

EPA ID NO. AL2 210 020 742

APRIL 1999

ACRONYMS

ADEM	Alabama Department of Environmental Management
AMCOM	U.S. Army Aviation and Missile Command
AR	U.S. Army Regulation
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DDT	Dichlorodiphenyltrichloroethane
DoD	Department of Defense
EPA	U.S. Environmental Protection Agency
G&M	Geraghty & Miller, Inc.
HEA	Health and Environmental Assessment
IR	Installation Restoration
IRA	Interim Remedial Action
IT	IT Corporation
mg/kg	milligrams per kilogram
msl	mean sea level
NCP	National Contingency Plan
NOV	Notice of Violation
OB/OD	Open Burn/Open Detonation Grounds
OU	Operable Unit
PRGs	Preliminary Remediation Goals
RGs	Remediation Goals
RCRA	Resource Conservation and Recovery Act
RSA	Redstone Arsenal
SARA	Superfund Amendments Reauthorization Act
SCFM	standard cubic feet per minute
SVE	soil vapor extraction
TCE	trichloroethylene
UV	ultraviolet light
VOC	volatile organic compound
VOCs	volatile organic compounds

1.0 INTRODUCTION

This decision document describes the selected action to install a soil vapor extraction (SVE) treatment system at RSA-14 Inactive Unlined Earthen Burn Trenches within operable unit (OU) 14 at Redstone Arsenal (RSA), Alabama. This interim remedial action (IRA) was chosen in accordance with the CERCLA as amended by the SARA, the NCP, RCRA, and AR 200-1, as applicable.

1.1 Site Background

RSA-14 is located adjacent to RSA-13 within OU-14. This Operable Unit (OU) occupies the closed portions of the Open Burn/Open Detonation (OB/OD) grounds on the southern edge of Redstone Aresenal that borders the Tennessee River to the west and to the south. See Operable Unit location map at the end of this document. OU-14 is also bordered to the north by wetlands and neighboring surface water bodies. This entire OU has been impacted by past Army activities that resulted in regional groundwater contamination and localized soil contamination. The cleanup actions within OU-14 are currently be addressed by interim remedial actions.

RSA-14 consists of two open trenches with identical dimensions of 300 feet by 75 feet by 10 feet. They were used to incinerate solid materials contaminated with rocket propellant. Even though this was the primary purpose of the trenches, it was suspected that the trenches were also used to incinerate waste solvents and solvent-contaminated materials. The northern trench is highly contaminated.

The trenches were constructed in the 1940s when the Gulf Chemical Warfare Depot used them for incinerating wood pallets and inert packing materials as a result of supply shipments. They have been used from the early 1940s until 1986.

The resulting ash was disposed onto the field directly to the east of RSA-14, and the flashed metal was removed and salvaged. The trenches are open on the eastern side.

1.2 Regulatory History

On 21 January 1986, RSA received a Notice of Violation (NOV) from ADEM following an inspection in 1985 of the OB/OD grounds. During the inspection, ADEM personnel observed that solvent-contaminated material was being burned on the ground surface (RSA-13) and in the trenches (RSA-14). Later that year, RSA constructed elevated burn pans (RSA-12) to thermally treat solvent-contaminated materials. The practice of open burning inert materials in the trenches continued until 1991. The trenches were cleared and abandoned.

A review of the RSA groundwater monitoring program and resulting data was conducted by the Alabama Department of Environmental Management (ADEM) to determine compliance with the Alabama Water Pollution Control Act and the Solid Waste Disposal Act, Section 4-150,.03 (b) and .04. This review was initiated as a result of the Environmental Protection Agency (EPA) correspondence of 2 October 1985 classifying the DDT landfill (RSA-107) as a solid waste management unit, and the ADEM sampling results which detected DDT, organic, and inorganic contamination in monitoring wells. This effort included an on-site inspection conducted on 21 June 1985 by Mr. Fred Mason, ADEM Geologist, with RSA representative Mr. Ron Hagler.

A review of all groundwater monitoring data submitted to ADEM since 1981 was also performed. It was noted that during the 21 June 1985 inspection of the OB/OD grounds it was observed that no groundwater monitoring wells were located around the facility. Liquids were being "poured on unprotected ground surfaces and disposed of by burning, with two other unprotected pits used to burn solid wastes" (ADEM, 21 Jan 86, NOV).

ADEM recommended RSA initiate a field investigation and plan remedial measures for cleaning up contaminated groundwater at OU-14. As quoted from the NOV, "The disposal of volatile organic compounds by pouring on unprotected ground surface and burning has possibly resulted in groundwater contamination. Soil sampling, piezometer, and monitoring wells in the soil and bedrock should be installed and monitored for organic constituents, together with a minimum of four wells in the liquids burning area to monitor the shallow water table. Bedrock wells should also be required to define the vertical extent of contamination if organics are detected in the shallow groundwater".

The NOV also required the Army to begin remedial measures for cleaning up the groundwater at OU-14. As quoted from the NOV, "Remedial measures should be planned for contaminant plumes identified by these studies. Remedial measures should include the elimination of all un-permitted pollutant discharges to groundwater, and a clean-up of existing polluted groundwater. A schedule for the implementation of these studies and any remedial measures should be submitted to ADEM within 60 days of receipt of this notice". The Army initiated funding for a RCRA Facility Investigation in 1986. Data in 1992 confirmed contamination and funds for an Interim Corrective Measure was programmed for 1993. RSA-13 was addressed first with the intention to remediate RSA-14 at a future date. By 1994, the IR Program was being managed under CERCLA and the corrective actions were renamed as IRAs. This decision document addresses the IRA for soils at RSA-14.

1.3 Site Hydrogeology and Geology

The hydrogeology in OU-14 consists of three water-bearing zones, including a residuum overburden, an upper weathered zone of the Tuscumbia Limestone (upper bedrock), and fractures and cavities in the deeper sections of the Tuscumbia Limestone (deep bedrock). Groundwater levels in the overburden mimic the topography, with the groundwater generally moving from higher elevations toward low-lying drainage areas surrounding OU-14 to the east, north, and west.

Groundwater levels at RSA-14 range from approximately 6 feet below ground surface (bgs) to 15 feet bgs. Groundwater elevations and flow in the upper weathered bedrock are similar to the overburden, indicating some degree of hydraulic connection. Water encountered in fractured and cavernous zones of the deeper Tuscumbia Limestone appears to flow to the west toward the Tennessee River.

The overburden thickness ranges from 25 to 54 feet, and consists of a surficial sandy-clay deposit approximately 10 feet to greater than 20 feet in thickness. A silty, clayey, fine-grained micaceous sand underlies the surficial clay. The grain size increases with depth and the base of the overburden consists of a silty to clayey coarse-grained sand and gravel. Confining units in the overburden are absent at OU-14. The elevation of the top of the Tuscumbia Limestone ranges from 500 feet above mean sea level (msl) to 550 feet above msl at OU-14. For the purpose of the design, the bedrock elevation was assumed to be 525 feet above msl.

1.4 Purpose of Interim Remedial Action at RSA-14

The overall objective of the SVE system is to remediate chlorinated solvent-impacted soils in the northern waste burn trench area of RSA-14. Specific objectives include limiting migration of trichloroethylene (TCE) and transformation compounds from the soils downward into the groundwater and reducing chlorinated solvent concentrations in the soils to levels that no longer threaten the underlying groundwater by extracting TCE from the soil particles and lowering the groundwater under the trench with a horizontal well.

As determined by the treatability tests at the site and the moderate soil permeability, SVE was selected as the corrective action for the site. Due to the seasonal changes in the level of the water table, a groundwater extraction system is required to de-water the trench area, which exposes more vadose zone for the SVE process. A vacuum is applied to the extraction wells to recover residual volatile organic compounds (VOCs) adsorbed to the soil particles as the groundwater table is lowered by a horizontal extraction well plumbed to the existing groundwater treatment plant. This treatment plant was designed to collect and treat groundwater from well fields at RSA-13 and RSA-14.

This interim remedial action alternative was selected by the U.S. Army Aviation and Missile Command (AMCOM) Environmental Office with support from ADEM, U.S. EPA Region IV, and the U.S. Army Corps of Engineers, Savannah District.

2.0 SITE RISK

In January 1986, RSA received a NOV from ADEM following an inspection in June 1985 of the OB/OD grounds. During the inspection, ADEM observed that solvent-contaminated material was being burned in the trenches. Later that year, RSA constructed elevated burn pans (RSA-12) to thermally treat solvent-contaminated materials. The practice of open burning inert materials in the trenches continued until 1991. The trenches were cleared and abandoned.

In 1992, Geraghty & Miller, Inc. (G&M) installed a soil boring to a total depth of 12 feet directly in the bottom of the northern trench. This boring showed levels of TCE up to 6,100 milligrams per kilogram (mg/kg) (G&M, 1992). A health and environmental assessment (HEA) was performed during Phase

I & II of the RCRA Facility Investigation. The HEA was completed to determine the possible human and environmental exposure routes to identify and evaluate the potential contaminant routes of migration. According to the HEA, VOCs, semi-volatile organic compounds, metals, and explosives were found to be present at concentrations exceeding systemic and/or carcinogenic criteria.

In 1997, IT Corporation (IT) performed a successful SVE treatability study at the site between the northern and southern trenches. Data from the direct-push soil investigation portion of the study indicated high TCE contamination (2,500 mg/kg) in the center of the northern trench. The direct-push soil investigation indicated that the southern trench had low to moderate chlorinated solvent contamination, and that the primary source of contamination was in the northern trench.

The soil IRA Preliminary Remediation Goals (PRGs) recommended for the Decision Document are risk-based and such PRGs should be protective for direct soil contact scenarios, such as soil ingestion by a construction worker, and for leaching to groundwater. Final remediation goals (RGs) cannot be established at this time because remediation system performance criteria, such as SVE asymptotic levels, have to be factored in the final RGs. Thus, the PRGs will be finalized after data from the operation of the SVE and groundwater remediation systems are available. Furthermore, development of RGs for protection of groundwater will have to consider that:

- TCE levels in groundwater are currently three to four orders of magnitude greater than federal maximum contaminant levels or risk-based levels and it will be several of years before acceptable groundwater conditions are restored;

- contaminated groundwater is also a source of subsurface soil contamination as the water table significantly fluctuates;

- the groundwater treatment system (extraction wells) will lower the water table, thereby exposing TCE-contaminated soil; and

- a compliance point for groundwater protection will need to be established.

Because of the relatively complex process required to establish RGs that are protective of the groundwater, the recommended risk-based PRG is only protective of direct contact with the soil.

PRGs for soils were developed using the human health risk scenarios, equations, and parameters presented in the approved Installation-wide Work Plan (IT, 1997). The risk-based PRGs were developed for all plausible non-residential scenarios (e.g., construction worker, groundskeeper, sportsman, and trespasser). These PRGs for TCE are presented in Table A. Based on values reported in this table, the most conservative PRG of 232 mg/kg for the groundskeeper scenario with a target risk of 1.0E-06 is recommended for RSA-14 soil remediation.

Table A
Preliminary Remediation Goals (mg/kg)
for Soils at RSA-14
Redstone Arsenal
Madison County, Alabama

Groundskeeper Scenario					
Cancer PRGs			Noncancer PRGs		
Target Risk Level			Target Risk Level		
1.00E-06	1.00E-05	1.00E-04	0.1	1	3
2.32E+02	2.32E+03	2.32E+04	5.52E+02	5.52E+03	1.66E+04

Construction Worker Scenario					
Cancer PRGs			Noncancer PRGs		
Target Risk Level			Target Risk Level		
1.00E-06	1.00E-05	1.00E-04	0.1	1	3
3.05E+03	3.05E+04	3.05E+05	2.90E+02	2.90E+03	8.71E+03

Sportsman Scenario					
Cancer PRGs			Noncancer PRGs		
Target Risk Level			Target Risk Level		
1.00E-06	1.00E-05	1.00E-04	0.1	1	3
3.41E+03	3.41E+04	3.41E+05	9.65E+03	9.65E+04	2.89E+05

At a minimum interim remediation should proceed until soil concentrations are below this PRG value. PRGs or final remediation goals that are protective of groundwater will be developed during the OU-14 Feasibility Study scheduled for completion in 1999.

3.0 REMEDIAL ALTERNATIVES

This section presents the analyses for the remedial alternatives for RSA-14. These include:

- Soil excavation, disposal, and clean soil backfill;
- SVE and off-gas treatment with carbon adsorption;
- SVE with a moving bed adsorption/desorption system;
- SVE with fluid-bed concentrator/condenser and photolytic oxidation system.
- No Action
- Institutional Controls
- Monitored Natural Attenuation

Two commonly used treatment technologies, air sparging and thermal incineration are not evaluated for the following reasons. Air sparging with SVE, using various off-gas treatment technologies typically used with SVE alone, has not been included because the existing groundwater treatment system at RSA-13 has the capacity to treat an additional 125 gallons per minute. Therefore, in situ groundwater remediation by air sparging at the northern trench brings little or no cost benefit because the groundwater will be pumped to and treated at the RSA-13 treatment plant.

Thermal incineration are not included as a remedial alternative because natural gas for supplemental fuel is not available, and a propane tank would be a safety hazard since the system is to be located adjacent to the active explosive ordnance detonation area (RSA-131). With each of the in-situ technologies, de-watering of the trench area is included due to seasonal groundwater fluctuations. De-watering is required to increase the SVE removal efficiency at the site. A horizontal well was installed in the center of the northern trench and designed to de-water the trench feature to 15 to 20 feet bgs.

Table 1 presents a summary of the capital, operating, and present value costs for the remedial alternatives. The remaining cost tables (Tables 2 through 8b) present a more detailed analysis of the capital and operating costs. These tables present supporting information regarding design parameters on which the cost estimates are based, such as preliminary performance data for treatment equipment, the number and sizes of extraction wells, analytical requirements for periodic monitoring, and labor estimates for the operation. Table 9 presents the analysis of capital and operating costs for the remaining options.

3.1 Option 1: Soil Excavation, Disposal, and Clean Soil Backfill - Table 2

Option 1 includes excavating of the contaminated soil, disposal to a hazardous waste landfill or incinerator, and backfilling the excavated trench with clean backfill. An excavator or backhoe will be used to remove contaminated soil of approximately 157,500 cubic feet, or (5,833 cubic yards, or 8,663 tons (equivalent to a 175-by-75-by-12 foot area). Soil without free liquids can be disposed of in a hazardous waste landfill. Soil with free-phase liquids must be disposed of by a hazardous waste incinerator. After the edges of the open trench are below the volatile organic compound (VOC) soil contamination limits, clean backfill will be placed, but not compacted, back in the excavated trench area with a front-end loader or bulldozer. Routine groundwater monitoring performed outside the scope of this task will monitor attenuation of the dissolved VOC contamination plume. The remediation time for Option 1 is estimated to be 4 to 6 weeks, depending on coordination of subcontractors and mode of soil disposal. The total net present value of this option has the highest cost with approximately $2,346,400 minimum (landfill) and $4,251,900 maximum (incinerator).

3.2 Option 2: SVE With Vapor-Phase Carbon Adsorption - Tables 3, 4a, 4b

Option 2 involves implementing SVE (four vertical wells and four monitoring wells) and using carbon adsorption as the off-gas treatment technology. SVE removes VOCs above the water table by inducing air flow through areas of contamination by application of a vacuum. The air flow volatilizes and removes VOCs and supplies oxygen to support biodegradation. Proper air flow is ensured by properly spacing vapor extraction points, and by locating the contamination horizon and screening the vapor extraction wells accordingly. The treatability test performed in February 1997 indicated that SVE was the best and most effective technology to remove soil contamination from the trench area. The treatability test determined that the radius of influence for an SVE well was approximately 30 feet, and the volume of air for four SVE wells to cover the soil contamination would result in a total system volume of up to 250 standard cubic feet per minute (SCFM).

The SVE system blower is expected to be a 30 to 40 horsepower, positive displacement, rotary lobe vacuum blower (15-inch mercury vacuum maximum). A soil sample was taken at approximately 6 feet bgs and resulted in TCE contamination of 2,500 mg/kg. Also, in August 1997, static VOC readings were taken by a flame ionization detector from boreholes in the trench that yielded readings up to 3.7 percent total VOC. It is estimated that extraction wells placed in the trench will produce up to 20,000 part per million by volume VOC in the extracted soil vapor for the first few weeks of operation. At this concentration, it is expected that up to 112 pounds per hour of VOC will be extracted by the SVE system, and an estimated 268,000 and 340,500 pounds of granular activated carbon will be required for the first 2 months and first year, respectively. The carbon consumption is based on an exponential decrease in the VOC vapor concentration in which large amounts of carbon usage will decrease quickly over a few months of operation.

The remediation duration for Option 2 is estimated to be 3 years. The total net present value of this option is $1,759,200.

3.3 Option 3, SVE With Moving Bed Adsorption System - Tables 5, 6a, 6b

Option 3 involves implementing SVE (four vertical wells and four piezometers) and using a moving bed adsorber/desorber as the off-gas treatment technology. SVE removes VOCs above the water table as previously described. The moving bed adsorption/desorption system is an on-site regenerable adsorption technology especially suited to treat halogenated VOCs in dilute air streams. The system consists of an adsorber, desorber, and a service module. A given volume of adsorption media (resin) is continuously cycled between the adsorber and desorber via gravity, rotary air-lock valves, and a pneumatic conveyance system.

The contaminated air stream passes horizontally through the resin contained in the thin, rectangular adsorption bed. The resin, moving slowly down the adsorption bed, captures the VOCs contained in the air stream. The "spent" resin discharges from the adsorber to the pre-heated desorber through a rotary air-lock valve. The adsorption bed is designed to achieve the mandated requirements for release of "clean air," typically 95 to 99 percent VOC removal efficiency.

The resin that flows down the desorption chamber is heated by conduction to a known temperature required to revolatilize or desorb the VOCs from the resin. The desorbed VOCs are removed from the chamber by a small vacuum blower. The vapors are routed to the service module and subsequently condensed by mechanical refrigeration. Outlet vapor with minor levels of VOCs from the condenser will be recycled back to the adsorption bed for further destruction efficiency.

The regenerated resin is pneumatically conveyed from a hopper located at the bottom of the desorber to a cooling section located above the adsorber. Through an air-liquid heat exchanger and chiller, the resin is collected prior to re-introduction to the adsorber. The rotational speed of the rotary air lock valves determines the rate of resin flow through the entire system.

The remediation duration for Option 3 is estimated to be 3 years. The total net present value of this option is $1,587,100.

3.4 Option 4: SVE with Fluid Bed Concentrator/Condenser and Photolytic Oxidation System - Tables 7, 8a, 8b

Option 4 involves implementing SVE (four vertical wells and four piezometers) and using a fluid bed concentrator/condenser and photolytic oxidation system as the off-gas treatment technology. SVE removes VOCs above the water table as previously described. The concentrator increases the TCE to the 50 or 60 percent level before delivery to the condenser. The TCE, and other compounds, will readily transfer into a liquid phase with almost 100 percent recovery during the condensing operation.

The concentrator uses an adsorption/desorption process to achieve an increase in VOCs while simultaneously decreasing the flow rate by an equal mass balance. Activated carbon or specialty adsorbents may be used as the filter media. The fluid-bed concentrator is designed to achieve the mandated requirements for release of "clean air," typically 95 to 99 percent VOC removal efficiency.

A small amount of indirect steam is used to remove the chemicals below the adsorbent media during the desorption phase, so that concentrations of the TCE and other compounds can be increased beyond the limits typically mandated by the lower explosive limit. The steam effects oxygen and allows the system to reach higher concentrations safely.

A typical remedial cleanup involves a variety of halogenated and nonhalogenated compounds. The condensate requires a double decant to recover lighter and heavier fractions that are not miscible in water.

If the site has noncondensible compounds (typically low molecular weight chemicals), then the photolytic destruction unit will treat this stream and further enhance total removal/destruction efficiency for the process. Ultraviolet (UV) light breaks the molecular bonds, converts the halogenated compounds into stable salts, and releases hydrochloric acid gas that will be neutralized and produces nonhazardous byproducts, such as carbon dioxide and water. This is a 1 to 2 cubic feet per minute flow, therefore, only one UV reactor is required. The unit is integrated with a small scrubber and programmable logic controller controls.

The condensate from the concentrator's desorption and the humidity condenser sections will contain volatile organic components. The free-phase organic layer (concentrated TCE, as an example) will be pumped to a storage tank for off-site disposal. The water stream will be discharged to the RSA-13 groundwater treatment plant.

The remediation time for Option 4 is estimated to be 3 years. The total net present value of this option is $1,446,000.

3.5 Option 5: No Action

The No Action alternative excludes all remedial measures, including any existing institutional controls. No activities would be initiated at RSA-13. The NCP requires this evaluation because it provides a baseline from which to compare the developed alternatives. With no treatment undertaken, Option 5 does not reduce contaminant toxicity, mobility, or volume "through treatment". Likewise, no treatment-related residuals are generated. All existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in Table A. No actions or controls are initiated to manage this risk, and therefore this alternative affords no long-term protection of human health and the environment. With no action taken, no short-term impacts are caused.

The technical feasibility of implementing Option 5 is considered high, because it does not require any activities to be either initiated or continued (with the exception o a site evaluation report that must be submitted to the EPA whenever wastes are left in place at a site). The administrative feasibility of implementing this alternative is considered low, because it provides no increased protection, and is therefore unlikely to receive regulatory approval.

Option 5 alternative has no capital costs associated with it, since it does not require any activities to be initiated. Because contaminants are left in place, a site evaluation report must be submitted to the EPA every 5 years. The estimated cost of this report is about $4,000/year.

3.6 Option 6: Institutional Controls

Institutional controls are legal or barrier restrictions on the use of land at an environmentally contaminated site that are designed to reduce the dangers from releases or threatened releases of environmental contaminants. Option 6 may be used in conjunction with engineered remedial actions or as the sole remedy when active measures are determined to be impracticable. Under Option 6, the remedial technologies and process options to be implemented include access restrictions, groundwater use restrictions, and monitoring.

With no treatment undertaken, Option 6 does not reduce contaminant toxicity, mobility, or volume "through treatment". Likewise, no treatment-related residuals are generated. All existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in Table A. However, actions and controls are initiated to manage human health risks, and therefore this alternative does provide long-term protection of human health. No actions or controls are initiated which provide long-term protection of the environment. The technical feasibility of implementing

Option 6 is considered high, because the required activities, monitoring, and site control, are easily implemented and will continue to be in the future. It provides increased protection of human health, but no increased protection to the environment. The administrative feasibility of implementing this alternative is considered moderate.

The estimated capital costs for Option 6 consist of administrative actions for controlling access to work areas, restricting future property use, and restricting installation of new groundwater wells used for a drinking water supply. The capital costs also include a Public Education Program to increase public awareness of hazards and remedial actions through press releases, presentations, and the posting of signs. These activities should cost approximately $80,000. The estimated annual operation and maintenance costs related to environmental monitoring should total about $118,000. This cost includes monitoring the groundwater from each aquifer at locations upgradient and downgradient of the source areas, and monitoring surface water and sediment in the wetlands areas.

3.7 Option 7 Monitored Natural Attenuation

Under this option, the general response actions to be implemented include all institutional controls (Option 6) activities together with monitored natural attenuation (MNA). MNA achieves the reduction of contaminant concentrations through any combination of the following natural processes which occur in the absence of engineering actions, including, biodegradation, dilution, volatilization, adsorption, chemical reactions, and phytoremediation. MNA differs from Option 5 and Option 6 in that it requires thorough documentation of the roles, if any, being played by the natural processes previous mentioned. Field tests, analytical data, and modeling are necessary to demonstrate the viability of this alternative. If found to be viable and implement-able, the effectiveness of Option 7 must also be verified through environmental sampling, monitoring, and modeling (NRC, 1993). MNA alternative does reduce contaminant toxicity, mobility, and volume through the naturally-occurring treatment processes listed above. However, because those processes have not been quantified and modeled, the degree to which they are occurring or may occur is unknown. Likewise, types, quantities, and risks of any residuals created by those processes are unknown. At the cessation of Option 7, the residual amount of existing waste which would be left untreated is unknown. Any change in the magnitude of risk posed is also unknown.

The technical feasibility of implementing Option 7 is considered high, because the required activities (e.g., monitoring, modeling, and site control) are easily implemented currently and will continue to be in the future. The administrative feasibility of implementing this alternative is considered moderate for the following reasons: existence of inadequate data and modeling; unknown increase in protection to the environment; and approval by regulatory agencies may not be possible.

The capital costs for Option 7 include conducting a biofeasibility study and collecting the field samples necessary for this study. These costs should total approximately $70,000. Once implemented, this alternative requires extensive field sampling and monitoring to demonstrate its effectiveness. This demonstration sampling program can be defined after the biofeasibility study is completed. Option 7 will require more sampling and monitoring than Option 6. Therefore, annual costs for Option 7 will be at least $80,000.

3.8 Selected Remedy

The excavation and clean backfilling option has the shortest cleanup time, but the highest cost. So, Option 1 was not recommended. The SVE with a moving bed adsorption/desorption system (Option 3) has initial flow restrictions (55 SCFM) because the system cannot handle the start-up VOC concentrations. The cost of Option 3 is still higher than the SVE with the fluid-bed concentrator/condenser and photolytic oxidation alternative (Option 4).

Option 4 has the lowest overall cost within Options 1 through 4. However, this technology was not chosen to treat the off-gas from the SVE treatment system because of the following: 1) the vendor could not guarantee the delivery date; 2) there was a equipment cost increase from the original estimate; 3) there was a cost increase due to provisions that IT would be required to use a supplemental carbon adsorption unit during the first weeks of operation to handle the high contaminant load; and 4) the vendor took exception to IT's performance specifications for the concentrator/condenser and photolytic oxidation unit. No technology other than excavation and SVE with vapor-phase carbon adsorption has a demonstrated track record on sites with heavily contaminated chlorinated solvents in soils.

Option 5, the No Action alternative, does not reduce contaminant toxicity, mobility, or volume "through treatment". All existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in Table A. No actions or controls are initiated to manage this risk, and therefore this alternative affords no long-term protection of human health and the environment. Option 5 provides no increased protection and does not address the groundwater Notice of Violation, and is therefore unlikely to receive regulatory approval.

Option 6, the institutional controls alternative, also does not reduce contaminant toxicity, mobility, or volume "through treatment". All existing waste is left untreated, and the magnitude of risk posed by the site goes unchanged from what is described in Table A. Human health is protected, but does nothing for protecting the environment. Option 6 does not address the groundwater NOV, and is therefore unlikely to receive regulatory approval.

Option 7, the monitored natural attenuation alternative does reduce contaminant toxicity, mobility, and volume through naturally-occurring treatment processes. However, because those processes have not been quantified and modeled, the degree to which they are occurring or may occur is unknown. Likewise, types, quantities, and risks of any residuals created by those processes are unknown. Option 7 may address the groundwater NOV, but it is thought it would take decades to degrade the chlorinated solvent contamination in the groundwater to an acceptable level. Because it was agreed in 1986 to address the NOV with the regulators in a timely matter without incurring monetary fines, it is thought that Option 7 would unlikely receive regulatory approval.

Because of these reasons, Option 2 SVE with Vapor-Phase Carbon Adsorption was selected as the remedy for the site.

4.0 PUBLIC/COMMUNITY INVOLVEMENT

It is Department of Defense (DoD) and Army policy to involve the local community as early as possible and throughout the IR process at an installation. In accomplishing this goal, RSA is complying with the public participation requirements of CERCLA/SARA, sections 40 CFR 113(k)(2)(a) and 40 CFR 117. RSA is also implementing DoD and Army policy by holding ongoing public information meetings and have established public repositories to document the administrative record of RSA's IR Program.

The repositories are conveniently located at the Huntsville/Madison County Public Library; the Triana Public Library; AMCOM Environmental Office Library, Building 112; the Redstone Arsenal Historical Office, Sparkman Center, Room 5135; and the Redstone Arsenal Scientific Library, Building 4484.

A Public Meeting was held in the evening of 30 June 1998 at the Huntsville/Madison County Public Library to discuss the interim remedial action at RSA-14. The topics covered included the site history, investigative activities and findings, known contaminants, findings of the 1997 treatability study, proposed placement of the horizontal and vertical extraction wells, the proposed SVE treatment system design, and integration with the neighboring RSA-13 groundwater pump and treatment interim remedial action.

No questions were asked or submitted to the Army representatives at this meeting (AMCOM, 1998). Since the conclusion of the Public Meeting, no questions or comments have been received by the Public Affairs Office at RSA.

5.0 DECLARATION

The selected remedy is protective of human health and the environment, attains Federal and State requirements that are applicable or relevant and appropriate to this interim remedial action, and is cost effective. This remedy satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, and volume as principal elements to the maximum extent practicable.

Because the selected remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

6.0 COORDINATION AND APPROVAL

Option 2 SVE with Vapor-Phase Carbon Adsorption was selected as the remedy for the site.

6.1 Coordination

PREPARED BY:

DATE: 20 Apr 99

Kenneth L. Hewitt, REM #5110
Environmental Engineer, Installation Restoration Division
Directorate of Environmental Management and Planning

REVIEWED BY:

DATE: 21 Apr 99

Martin W. Walker
Chief, Installation Restoration Division
Directorate of Environmental Management and Planning

REVIEWED BY:

DATE: 26 April 99

for Jerry M. Hubbard
Director, Directorate of Environmental Management and Planning

REVIEWED BY:

DATE: 27 April 99

Amy S. Meredith
Attorney Advisor
U.S. Army Aviation and Missile Command

6.2 Approval

DATE: 29 Apr 99

Steven C. Hamilton
Colonel
Commander, RASA

Table 1. Cost Summary Comparison for RSA-14 Soil Remediation Alternatives
Redstone Arsenal, Madison County, Alabama

	SOIL REMEDIATION AT RSA-14			
	TABLES 2	TABLES 3, 4a, 4b	TABLES 5, 6a, 6b	TABLES 7, 8a, 8b
COST COMPONENT	SOIL EXCAVATION, DISPOSAL, AND CLEAN SOIL BACKFILL OPTION 1	SOIL VAPOR EXTRACTION (SVE) WITH VAPOR-PHASE CARBON ADSORPTION OPTION 2	SVE WITH VAPOR-PHASE MOVING BED ADSORPTION DESORPTION OPTION 3	SVE WITH FLUID BED CONCENTRATOR, CONDENSER AND PHOTOLYTIC OXIDATION OPTION 4
INSTALLED CAPITAL COST (A)	$4,251,900	$430,300	$924,200	$746,400
REMEDIATION TIME (YEARS)	1	3	3	3
ANNUAL OPERATION (First year)	$0	$957,800	$245,700	$258,700
& MAINTENANCE (Second year and later)	$0	$221,900	$228,400	$241,400
NET PRESENT VALUE COST (B) (a) OPERATION & MAINTENANCE	$0	$1,328,900	$662,900	$699,600
TOTAL NET PRESENT VALUE (A+B)	$4,251,900	$1,759,200	$1,587,100	$1,446,000

INFLATION	4%
INTEREST	5%

a. Net Present Values for the remediation alternatives are based on 4% inflation, and 5% interest rate.

Table 2

Option 1 Preliminary Installation Cost Estimate for Soil Excavation, Disposal and Clean Soil Backfill

RSA-14, Redstone Arsenal, Madison County, Alabama

Initial Capital Costs

COST COMPONENT	DESCRIPTION	COST ($)
DIRECT CAPITAL COSTS		
1. Site Preparation	For RSA-14 area	10,000
2. Excavation (approximate)	157,500 cubic feet (5,833 cubic yard) (in place), or 8,663 tons of contaminated soil at 25 $/ton	216,600
3. Backfill with clean soil, site restoration	6,416 cubic yard of soil at 10 $/yd^3	64,200
4. Transportation and landfill disposal fee	8,663 tons of contaminated soil, at 200 $/ton	NI
5. Incineration (for wet soil)	8,663 tons of contaminated soil, at 400 $/ton Cost includes transportation	3,465,000
6. Analytical	Soil analysis, one sample every 50 cubic yard, at 200 $ per sample	23,400
7. Soil monitoring (at the end of one year) and report	Validation of the remediation	17,200
TOTAL DIRECT COSTS (TDC)		3,796,400
INDIRECT CAPITAL COSTS		
1. Engineering and related tech support	2 % TDC	75,900
2. G&A, G&A COM, and Fee	20.173 % TDC	NI
3. Insurance and Bonds	5 % TDC (included in TDC)	0
4. License, Permit, and Legal Fees	2 % TDC (included in TDC)	0
5. Start-up (sampling costs are not included)		NA
6. Contingency	10 % TDC	379,600
TOTAL INSTALLED COST (+50%, -30%)		4,251,900

NA - not applicable
NI - not included

Table 3
Option 2 Preliminary Installation Cost Estimate for Soil Vapor Extraction (SVE) and Vapor-Phase Carbon Adsorption Systems
RSA-14, Redstone Arsenal, Madison County, Alabama
Initial Capital Costs

COST COMPONENT	DESCRIPTION	COST ($)
DIRECT CAPITAL COSTS		
1. Site Preparation	For RSA-14 area	10,000
2. Groundwater Extraction Well and Pump	One horizontal well, 6" diameter, approximately 25 ft deep, 175 ft long, 150 ft screen	30,000
3. SVE Vacuum Extraction Wells	Four vertical wells, 4" diameter, stainless steel, approximately 20 ft deep	30,000
4. Demobilization of operating wells	After completion of the operation	NI
5. SVE monitoring wells (pieziometer)	Four new vacuum monitoring well sets, 20' deep 10" dia borehole, each well has 2 ft screen	16,000
6. Piping system and foundation (surface sealing is not included)	400 linear feet (2", 4" and 6" diameter) (underground construction cost is included)	16,000
7. One Vacuum Blower Skid-Mounted System (with 250 scfm blower)	Including air/water separator & instrumentation 15" Hg vacuum, 30 Hp motor	35,000
8. Air permit application	Including air modelling	10,000
9. Condensate transfer system	Condensate from the air/water separator will be discharged to WWTP	5,000
10. Vapor-phase carbon Adsorption System, rated for 500 acfm vapor flow (a)	Two skid-mounted systems, 10 feet diameter vessels, with 10,000 lbs capacity per vessel	41,000
11. Operation and Maintenance Manual	For SVE and Carbon Adsorption System	25,000
12. Process Engineering Design Manual	For SVE and Carbon Adsorption System	35,000
13. Installation	For SVE and Carbon Adsorption System	15,000
14. Electrical equipment	Including installation, wiring, and telemanager monitoring system	10,000
15. Shipping	Approximate value	5,000
TOTAL DIRECT COSTS (TDC)		283,000
INDIRECT CAPITAL COSTS		
1. Engineering and related tech support	20 % TDC	56,600
2. SVE Pilot Test (no well installation)	Completed	NI
3. G&A, G&A COM, and Fee	20.173 % TDC	NI
4. Insurance and Bonds	5 % TDC	14,200
5. License, Permit, and Legal Fees	2 % TDC	5,700
6. Start-up (sampling costs are not included)	5 % TDC	14,200
7. Contingency	20 % TDC	56,600
TOTAL INSTALLED COST (+50%, -30%)		430,300

a. Carbon cost is not included.

NI - not included

KT-Redcos3-SVECAR-12/17/97

Table 4a
Option 2 Preliminary Cost Estimate for the Operation and Maintenance of the SVE and Vapor-Phase Carbon Adsorption Systems
RSA-14, Redstone Arsenal, Madison County, Alabama
Annual Operation and Maintenance Costs
(First year)

COST COMPONENT	UNIT COST ($)	UNIT	QTY	UNITS/ PERIOD	ANNUAL COST ($)
1. Operating labor- after first month (a)	50	hour (hr)	8	hr per week	19,200
Operating labor - first month	50	hr	40	hr per week	8,000
2. Monitoring labor	50	hr	0	hr per month	0
3. Maintenance - SVE and Carbon	2,500	system/year	2	systems	5,000
Systems. - First 2 months	10,800	2 month	1	per 2 months	10,800
Third month to 12th month	4,200	10 months	1	per 10 months	4,200
4. Materials (based on TCE)					
Carbon (b) - First 2 months	1.75	pound (lbs)	268,100	lbs/first 2 months	469,200
- Third month to 12th month	1.75	lbs	72,400	lbs/10 months	126,700
5. Utilities					
. Electric Power					
1 Vacuum skid (30 Hp), pumps.	0.08	Kwhr	662	Kwhr/day	19,300
Carbon fan (10 Hp)	0.08	Kwhr	179	Kwhr/day	5,200
6. Disposal					
TCE liquid phase	400	Sample	0	drums/yr	0
7. Purchased services:					
a) Vapor samples analyses (b)	400	Sample	3	samples/month	14,400
b) Water samples analyses (System monitoring only)	350	Sample	2	samples/month	8,400
c) Soil Boring (c)	1,000	Boring	6	borings/yr	6,000
d) Soil Analyses (VOC)	400	Sample	18	samples/yr	7,200
8. Data evaluation	100	hr	40	hr/ 3 months	16,000
9. SVE quarterly report	8,000	Report	4	report / yr	32,000
10. Project management	100	hr	4	hr/ week	20,800
TOTAL OPERATING COST					772,400
1. Insurance, permits, taxes	4% operating				30,900
2. Rehabilitation costs (d)					NA
3. Periodic site review					NA
4. Contingency	20% operating				154,500
TOTAL ANNUAL OPERATING COST (+50%, -30%)					957,800

a. Operator is required to check system once per week (at 8 hours/trip).
b. Cost includes transportation and services to remove/replace/disposal of spent carbon.
c. Six borings with split spoon sampling (18 total samples).
d. Replacement of mechanical components every 10 years.
NA - not applicable, NI - not included.

Table 4b
Option 2 Preliminary Cost Estimate for the Operation and Maintenance of the SVE and Vapor-Phase Carbon Adsorption Systems
RSA-14, Redstone Arsenal, Madison County, Alabama
Annual Operation and Maintenance Costs
(Second and third year)

COST COMPONENT	UNIT COST ($)	UNIT	QTY	UNITS/ PERIOD	ANNUAL COST ($)
1. Operating labor (a)	50	hour (hr)	8	hr per week	20,800
2. Monitoring labor	50	hr	0	hr per month	0
3. Maintenance - SVE and Carbon	2,500	system/year	2	systems	5,000
Carbon change	2,500	per year	1	per year	2,500
4. Materials (based on TCE)					
Carbon (b)	1.75	pound (lbs)	12,160	lbs/year (yr)	21,300
5. Utilities					
. Electric Power					
1 Vacuum skid (30 Hp), pumps.	0.08	Kwhr	662	Kwhr/day	19,300
Carbon fan (10 Hp)	0.08	Kwhr	179	Kwhr/day	5,200
6. Disposal					
TCE liquid phase (55gal drum)	400	Sample	0	drums/yr	0
7. Purchased services:					
a) Vapor samples analyses (b)	400	Sample	3	samples/month	14,400
b) Water samples analyses (System monitoring only)	350	Sample	2	samples/month	8,400
c) Soil Boring (c)	1,000	Boring	6	borings/yr	6,000
d) Soil Analyses (VOC)	400	Sample	18	samples/yr	7,200
8. Data evaluation	100	hr	40	hr/ 3 months	16,000
9. SVE quarterly report	8,000	Report	4	report / yr	32,000
10. Project management	100	hr	4	hr/ week	20,800
TOTAL OPERATING COST					178,900
1. Insurance, permits, taxes	4% operating				7,200
2. Rehabilitation costs (d)					NA
3. Periodic site review					NA
4. Contingency	20% operating				35,800
TOTAL ANNUAL OPERATING COST (+50%, -30%)					221,900

a. Operator is required to check system once per week (at 8 hours/trip).
b. Cost includes transportation and services to remove/replace/disposal of spent carbon.
c. Six borings with split spoon sampling (18 total samples).
d. Replacement of mechanical components every 10 years.
NA - not applicable, NI - not included.

Table 5
Option 3 Preliminary Installation Cost Estimate for Soil Vapor Extraction (SVE) and Vapor-Phase Moving Bed Adsorption/Desorption Systems
RSA-14, Redstone Arsenal, Madison County, Alabama
Initial Capital Costs

COST COMPONENT	DESCRIPTION	COST ($)
DIRECT CAPITAL COSTS		
1. Site Preparation	For RSA-14 area	10,000
2. Groundwater Extraction Well and Pump	One horizontal well, 6" diameter, approximately 25 ft deep, 175 ft long, 150 ft screen	30,000
3. SVE Vacuum Extraction Wells	Four vertical wells, 4" diameter, stainless steel, approximately 20 ft deep	30,000
4. Demobilization of operating wells	After completion of the operation	NI
5. SVE monitoring wells (pieziometer)	Four new vacuum monitoring well sets, 20' deep 10" dia borehole, each well has 2 ft screen	16,000
6. Piping system and foundation (surface sealing is not included)	400 linear feet (2", 4" and 6" diameter) (underground construction cost is included)	16,000
7. One Vacuum Blower Skid-Mounted System (with 250 scfm blower)	Including air/water separator & instrumentation 15" Hg vacuum, 30 Hp motor	35,000
8. Air permit application	Including air modelling	10,000
9. Condensate transfer system	Condensate from the air/water separator will be discharged to WWTP	5,000
10. One Moving Bed Adsorption/Desorption (MBEAD) System	Skid mounted system, rated for 500 acfm	367,000
11. Operation and Maintenance Manual	For SVE and MBEAD System	25,000
12. Process Engineering Design Manual	For SVE and MBEAD System	35,000
13. Installation	For SVE and MBEAD System	15,000
14. Electrical equipment	Including installation, wiring, and telemanager monitoring system	10,000
15. Shipping	Approximate value	4,000
TOTAL DIRECT COSTS (TDC)		608,000
INDIRECT CAPITAL COSTS		
1. Engineering and related tech support	20 % TDC	121,600
2. SVE Pilot Test (no well installation)	Completed	NI
3. G&A, G&A COM, and Fee	20.173 % TDC	NI
4. Insurance and Bonds	5 % TDC	30,400
5. License, Permit, and Legal Fees	2 % TDC	12,200
6. Start-up (sampling costs are not included)	5 % TDC	30,400
7. Contingency	20 % TDC	121,600
TOTAL INSTALLED COST (+50%, -30%)		924,200

NI - not included

KT-Redcos3-SVEADE-12/17/97

Table 6a

Option 3 Preliminary Cost Estimate for the Operation and Maintenance of the SVE and Moving Bed Adsorption/Desorption Systems RSA-14, Redstone Arsenal, Madison County, Alabama Annual Operation and Maintenance Costs (First year)

COST COMPONENT	UNIT COST ($)	UNIT	QTY	UNITS/ PERIOD	ANNUAL COST ($)
1. Operating labor-after first month (SVE and MBEAD Systems)(a)	50	hour (hr)	8	hr per week	19,200
Operating labor - first month	50	hr	40	hr per week	8,000
2. Monitoring labor	50	hr	0	hr per month	0
3. Maintenance - SVE + MBEAD	2,500	system/year	2	systems	5,000
- Extraction wells	1,200	well/yr	4	wells	NI
4. Materials					NA
5. Utilities					
. Electric Power					
1 Vacuum skid (30 Hp), pumps	0.08	Kwhr	662	Kwhr/day	19,300
. MBEAD Blower and other items	0.08	Kwhr	840	Kwhr/day	24,500
6. Disposal					
TCE liquid phase (2,800 gallons) first year	3	gallon	2,800	gallons/yr	8,400
7. Purchased services:					
a) Vapor samples analyses (b)	400	Sample	4	samples/month	19,200
b) Water samples analyses (System monitoring only)	350	Sample	3	samples/month	12,600
c) Soil Boring (c)	1,000	Boring	6	borings/yr	6,000
d) Soil Analyses (VOC)	400	Sample	18	samples/yr	7,200
8. Data evaluation	100	hr	40	hr/ 3 months	16,000
9. SVE quarterly report	8,000	Report	4	report / yr	32,000
10. Project management	100	hr	4	hr/ week	20,800
TOTAL OPERATING COST					198,200
1. Insurance, permits, taxes	4% operating				7,900
2. Rehabilitation costs (d)					NA
3. Periodic site review					NA
4. Contingency	20% operating				39,600
TOTAL ANNUAL OPERATING COST (+50%, -30%)					245,700

a. Operator is required to check system once per week (at 8 hours/trip).
b. Start-up sampling costs are not included.
c. Six borings with split spoon sampling (18 total samples).
d. Replacement of mechanical components every 10 years.
NA - not applicable, NI - not included.

Table 6b
Option 3 Preliminary Cost Estimate for the Operation and Maintenance of the SVE and Moving Bed Adsorption/Desorption Systems
RSA-14, Redstone Arsenal, Madison County, Alabama
Annual Operation and Maintenance Costs
(Second and third year)

COST COMPONENT	UNIT COST ($)	UNIT	QTY	UNITS/ PERIOD	ANNUAL COST ($)
1. Operating labor (a) (SVE and MBEAD Systems)	50	hour (hr)	8	hr per week	20,800
Operating labor - first month	50	hr	0	hr per week	0
2. Monitoring labor	50	hr	0	hr per month	0
3. Maintenance - SVE + MBEAD	2,500	system/year	2	systems	5,000
- Extraction wells	1,200	well/yr	4	wells	NI
4. Materials					NA
5. Utilities					
. Electric Power					
1 Vacuum skid (30 Hp), pumps	0.08	Kwhr	662	Kwhr/day	19,300
. MBEAD blower and pumps	0.08	Kwhr	840	Kwhr/day	24,500
6. Disposal					NA
TCE liquid phase (in 55 gallon drums)	400	drum	2	drums/yr	800
7. Purchased services:					
a) Vapor samples analyses (b)	400	Sample	4	samples/month	19,200
b) Water samples analyses (System monitoring only)	350	Sample	3	samples/month	12,600
c) Soil Boring (c)	1,000	Boring	6	borings/yr	6,000
d) Soil Analyses (VOC)	400	Sample	18	samples/yr	7,200
8. Data evaluation	100	hr	40	hr/ 3 months	16,000
9. SVE quarterly report	8,000	Report	4	report / yr	32,000
10. Project management	100	hr	4	hr/ week	20,800
TOTAL OPERATING COST					184,200
1. Insurance, permits, taxes	4% operating				7,400
2. Rehabilitation costs (d)					NA
3. Periodic site review					NA
4. Contingency	20% operating				36,800
TOTAL ANNUAL OPERATING COST (+50%, -30%)					228,400

a. Operator is required to check system once per week (at 8 hours/trip).
b. Start-up sampling costs are not included.
c. Six borings with split spoon sampling (18 total samples).
d. Replacement of mechanical components every 10 years.
NA - not applicable, NI - not included.

Table 7

Option 4 Preliminary Installation Cost Estimate for Soil Vapor Extraction (SVE) and Vapor-Phase Fluid-Bed Concentrator/Photolytic Oxidation Systems RSA-14, Redstone Arsenal, Madison County, Alabama Initial Capital Costs

COST COMPONENT	DESCRIPTION	COST ($)
DIRECT CAPITAL COSTS		
1. Site Preparation	For RSA-14 area	10,000
2. Groundwater Extraction Well and Pump	One horizontal well, 6" diameter, approximately 25 ft deep, 175 ft long, 150 ft screen	30,000
3. SVE Vacuum Extraction Wells	Four vertical wells, 4" diameter, stainless steel, approximately 20 ft deep	30,000
4. Demobilization of operating wells	After completion of the operation	NI
5. SVE monitoring wells (pieziometer)	Four new vacuum monitoring well sets, 20' deep 10" dia borehole, each well has 2 ft screen	16,000
6. Piping system and foundation (surface sealing is not included)	400 linear feet (2", 4" and 6" diameter) (underground construction cost is included)	16,000
7. One Vacuum Blower Skid-Mounted System (with 250 scfm blower)	Including air/water separator & instrumentation 15" Hg vacuum, 30 Hp motor	35,000
8. Air permit application	Including air modelling	10,000
9. Condensate transfer system	Condensate from the air/water separator will be discharged to WWTP	5,000
10. One Fluid Bed Concentrator/Condenser Photolytic Oxidation (FBCUV) System	Skid mounted system, rated for 500 acfm	250,000
11. Operation and Maintenance Manual	For SVE and FBCUV System	25,000
12. Process Engineering Design Manual	For SVE and FBCUV System	35,000
13. Installation	For SVE and FBCUV System	15,000
14. Electrical equipment	Including installation, wiring, and telemanager monitoring system	10,000
15. Shipping	Approximate value	4,000
TOTAL DIRECT COSTS (TDC)		491,000
INDIRECT CAPITAL COSTS		
1. Engineering and related tech support	20 % TDC	98,200
2. SVE Pilot Test (no well installation)	Completed	NI
3. G&A, G&A COM, and Fee	20.173 % TDC	NI
4. Insurance and Bonds	5 % TDC	24,600
5. License, Permit, and Legal Fees	2 % TDC	9,800
6. Start-up (sampling costs are not included)	5 % TDC	24,600
7. Contingency	20 % TDC	98,200
TOTAL INSTALLED COST (+50%, -30%)		746,400

NI - not included

Table 8a

Option 4 Preliminary Cost Estimate for the Operation and Maintenance of (SVE) and Vapor-Phase Fluid-Bed Concentrator/Photolytic Oxidation Systems
RSA-14, Redstone Arsenal, Madison County, Alabama
Annual Operation and Maintenance Costs
(First year)

COST COMPONENT	UNIT COST ($)	UNIT	QTY	UNITS/ PERIOD	ANNUAL COST ($)
1. Operating labor-after first month (SVE and FBCUV Systems)(a)	50	hour (hr)	8	hr per week	19,200
Operating labor - first month	50	hr	40	hr per week	8,000
2. Monitoring labor	50	hr	0	hr per month	0
3. Maintenance - SVE + FBCUV	2,500	system/year	2	systems	5,000
- Extraction wells	1,200	well/yr	4	wells	NI
4. Materials					NA
5. Utilities					
. Electric Power					
1 Vacuum skid (30 Hp), pumps	0.08	Kwhr	662	Kwhr/day	19,300
. FBCUV Blower and other items	0.08	Kwhr	1,200	Kwhr/day	35,000
6. Disposal					
TCE liquid phase (2,800 gallons) first year	3	gallon	2,800	gallons/yr	8,400
7. Purchased services:					
a) Vapor samples analyses (b)	400	Sample	4	samples/month	19,200
b) Water samples analyses (System monitoring only)	350	Sample	3	samples/month	12,600
c) Soil Boring (c)	1,000	Boring	6	borings/yr	6,000
d) Soil Analyses (VOC)	400	Sample	18	samples/yr	7,200
8. Data evaluation	100	hr	40	hr/ 3 months	16,000
9. SVE quarterly report	8,000	Report	4	report / yr	32,000
10. Project management	100	hr	4	hr/ week	20,800
TOTAL OPERATING COST					208,700
1. Insurance, permits, taxes	4% operating				8,300
2. Rehabilitation costs (d)					NA
3. Periodic site review					NA
4. Contingency	20% operating				41,700
TOTAL ANNUAL OPERATING COST (+50%, -30%)					258,700

a. Operator is required to check system once per week (at 8 hours/trip).
b. Start-up sampling costs are not included.
c. Six borings with split spoon sampling (18 total samples).
d. Replacement of mechanical components every 10 years.
NA - not applicable, NI - not included.

Table 8b

Option 4 Preliminary Cost Estimate for the Operation and Maintenance of the SVE and Moving Bed Adsorption/Desorption Systems

RSA-14, Redstone Arsenal, Madison County, Alabama

Annual Operation and Maintenance Costs

(Second and third year)

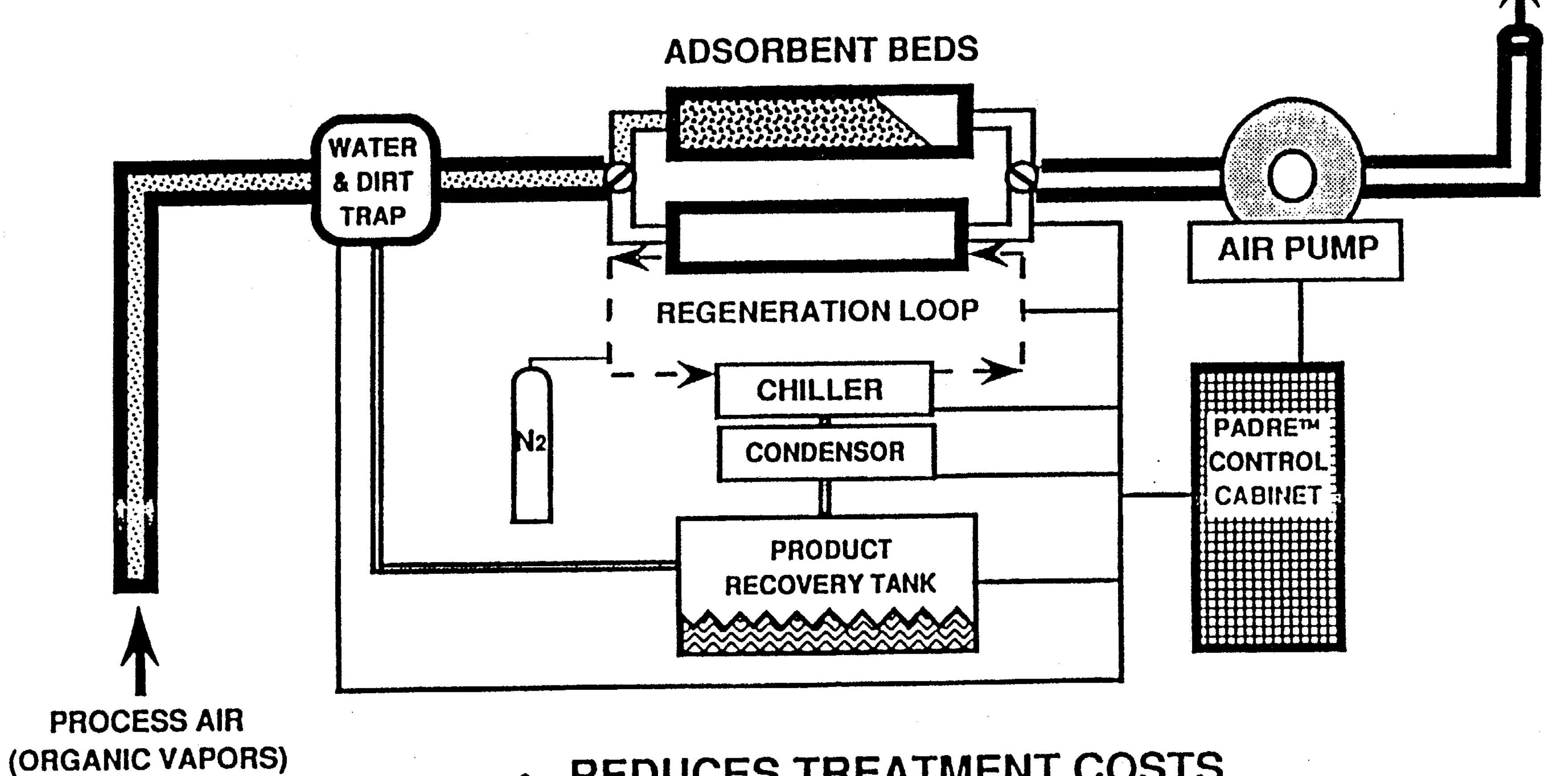
COST COMPONENT	UNIT COST ($)	UNIT	QTY	UNITS/ PERIOD	ANNUAL COST ($)
1. Operating labor	50	hour (hr)	8	hr per week	20,800
(SVE and FBCUV Systems)(a)					
Operating labor - first month	50	hr	0	hr per week	0
2. Monitoring labor	50	hr	0	hr per month	0
3. Maintenance - SVE + FBCUV	2,500	system/year	2	systems	5,000
- Extraction wells	1,200	well/yr	4	wells	NI
4. Materials					NA
5. Utilities					
. Electric Power					
1 Vacuum skid (30 Hp), pumps	0.08	Kwhr	662	Kwhr/day	19,300
. FBCUV Blower and other items	0.08	Kwhr	1,200	Kwhr/day	35,000
6. Disposal					NA
TCE liquid phase	400	drum	2	drums/yr	800
(in 55 gallon drums)					
7. Purchased services:					
a) Vapor samples analyses (b)	400	Sample	4	samples/month	19,200
b) Water samples analyses	350	Sample	3	samples/month	12,600
(System monitoring only)					
c) Soil Boring (c)	1,000	Boring	6	borings/yr	6,000
d) Soil Analyses (VOC)	400	Sample	18	samples/yr	7,200
8. Data evaluation	100	hr	40	hr/ 3 months	16,000
9. SVE quarterly report	8,000	Report	4	report / yr	32,000
10. Project management	100	hr	4	hr/ week	20,800
TOTAL OPERATING COST					194,700
1. Insurance, permits, taxes	4% operating				7,800
2. Rehabilitation costs (d)					NA
3. Periodic site review					NA
4. Contingency	20% operating				38,900
TOTAL ANNUAL OPERATING COST (+50%, -30%)					241,400

a. Operator is required to check system once per week (at 8 hours/trip).
b. Start-up sampling costs are not included.
c. Six borings with split spoon sampling (18 total samples).
d. Replacement of mechanical components every 10 years.
NA - not applicable, NI - not included.

PADRE™
VAPOR TREATMENT SYSTEM

FIGURE 1

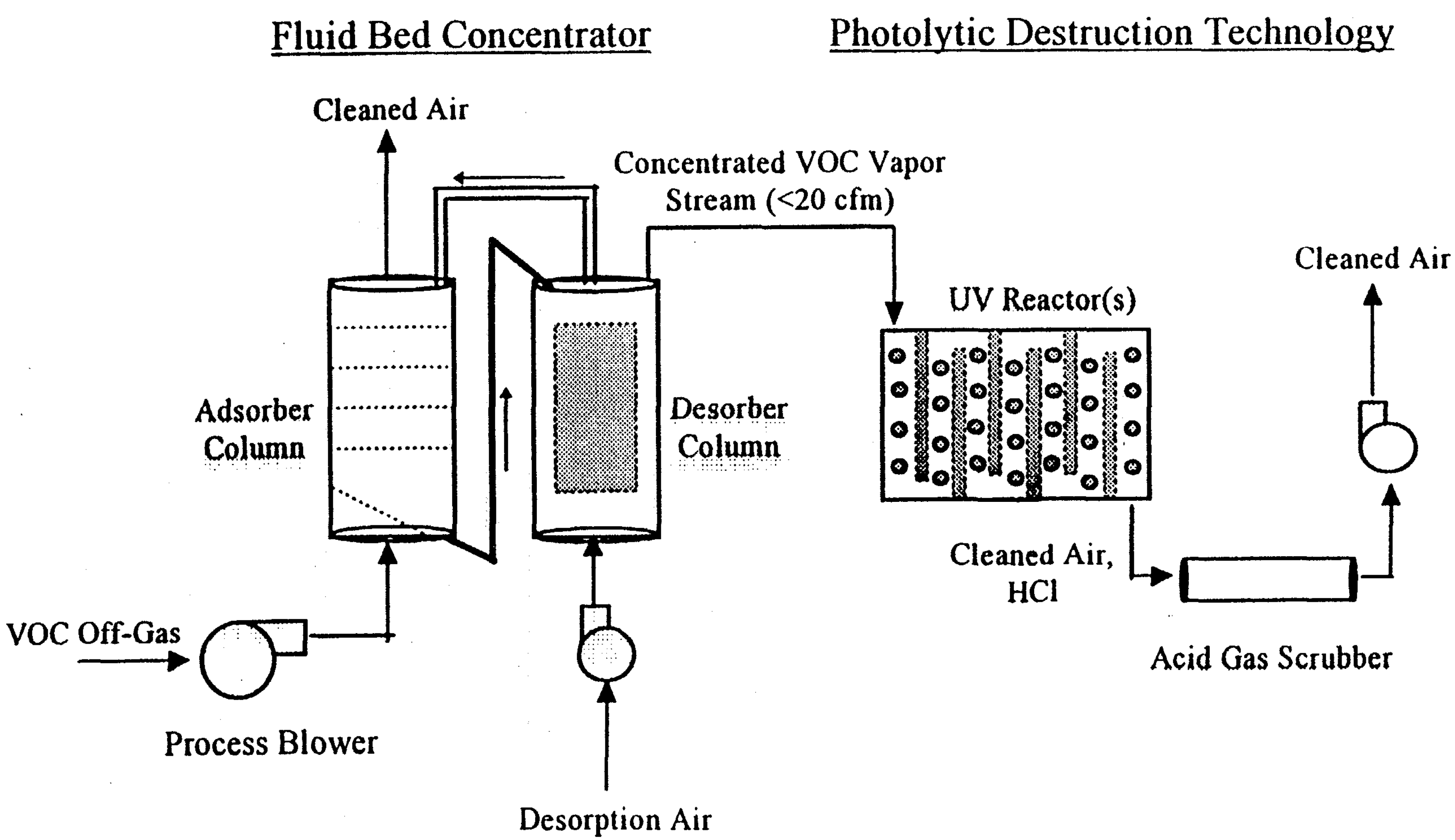
MOVING BED ADSORPTION/DESORPTION SYSTEM



- **REDUCES TREATMENT COSTS TO ONLY A FRACTION**

FIGURE 2

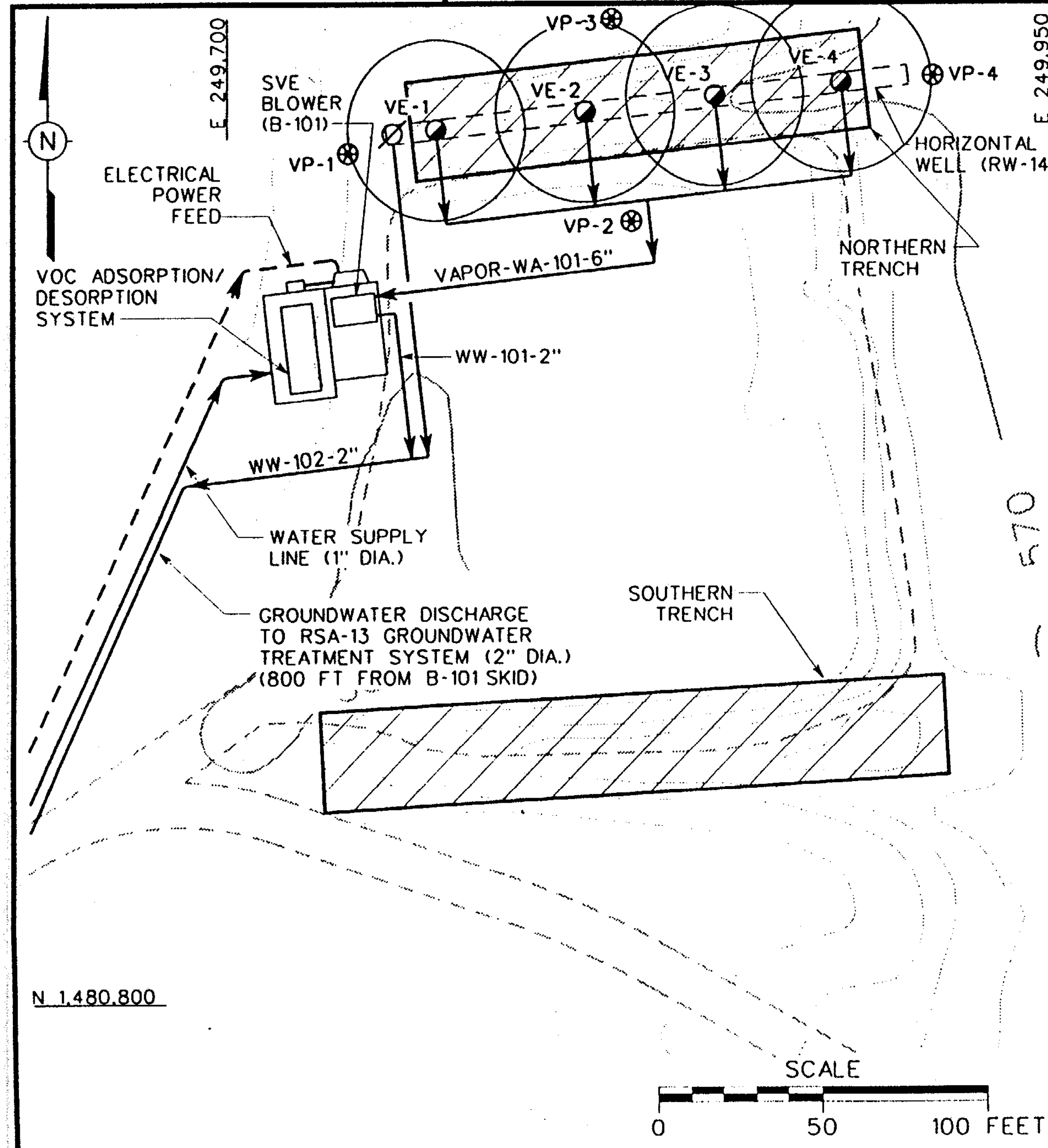
FLUID BED CONCENTRATOR/CONDENSER AND PHOTOLYTIC OXIDATION SYSTEM



Process Technologies, Inc.

12 DEC 97 14:11:28
C:\IT\DS-CIVIL\772650ES.232 TBRADSHA

STARTING DATE: 02MAY97	DATE LAST REV.12 DEC 97	DRAFT. CHCK. BY: C.TUMLIN	INITIATOR: N.ALINO	DWG. NO.: \772650ES.232
DRAWN BY: C.TUMLIN	DRAWN BY: TBRADSHA	ENGR. CHCK. BY: K.TRUONG	PROJ. MGR.: D.BURTON	PROJ. NO.: 772650



LEGEND

- UNIMPROVED ROADS AND PARKING
- TOPOGRAPHIC CONTOURS (FT-MSL)
- TRENCHES
- SVE EXTRACTION WELL ZONE OF INFLUENCE (27 FT RADIUS)
- VACUUM PIEZOMETER (2" DIA)
- VACUUM EXTRACTION WELL (4" DIA)
- HORIZONTAL GROUNDWATER RECOVERY WELL

FIGURE 3
RSA-14 SVE SYSTEM LAYOUT

U. S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT
REDSTONE ARSENAL
MADISON COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

INTERNATIONAL TECHNOLOGY CORPORATION

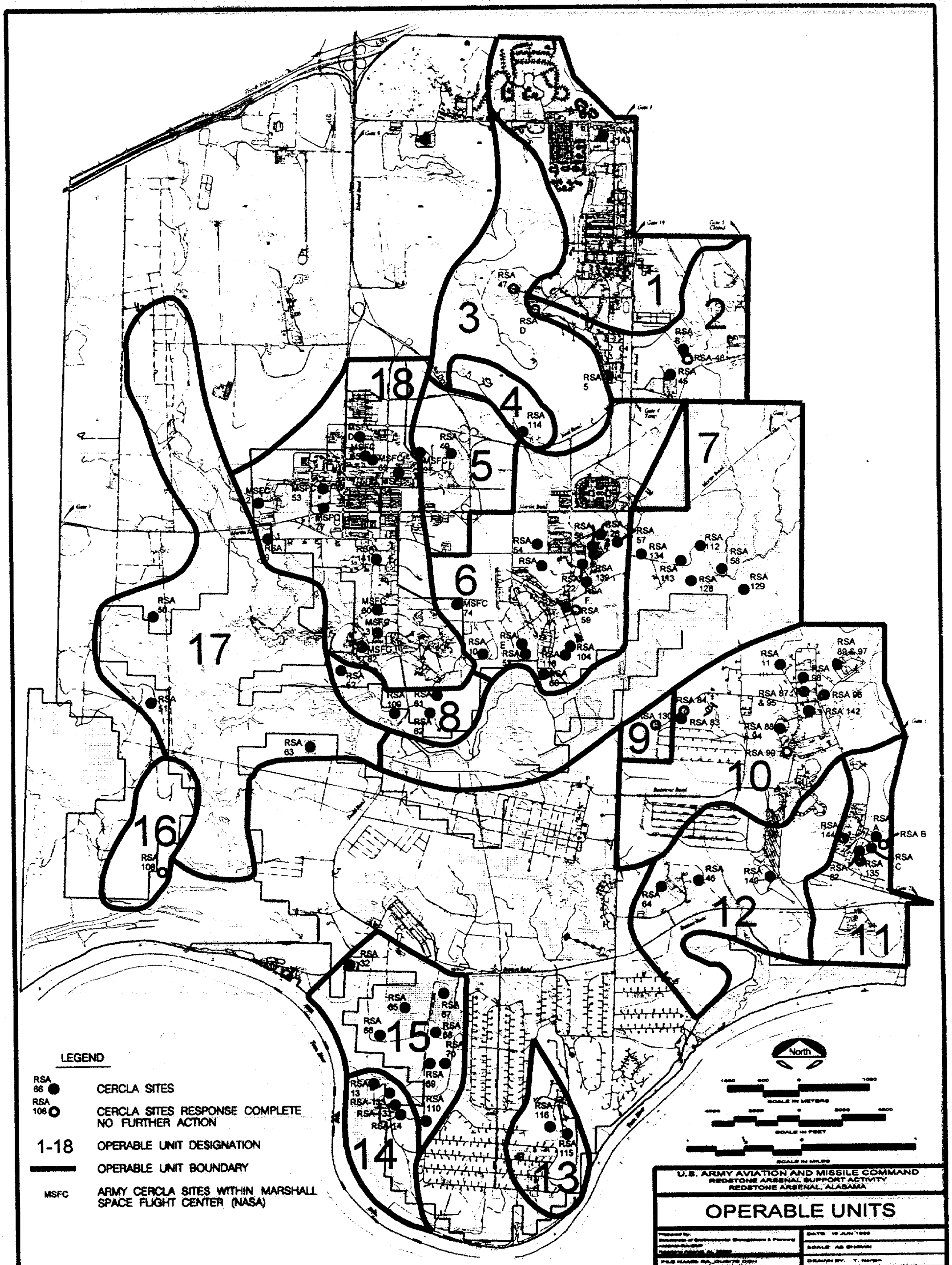
TABLE 9

COST SUMMARY COMPARISONS

Redstone Arsenal, AL

Option	Description	Capitol Cost	Annual O&M Cost	Present Worth (30 yr. @ 5 %)
5	No Action	$0	$4,000	$61,490
6	Institutional Controls	$80,223	$117,850	$1,891,872
7*	Monitored Natural Attenuation	$76,461	~$400,000	>$6,000,000

* Estimated from USAF MNA at several bases and amount was increased due to 3 aquifers at OU-14



AMSAM-RA-EMP-MP 990205 Scale: 1 in = 6000 ft