INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0412

Compact Subsurface Soil Investigation System

Deactivation and Decommissioning Focus Area

Prepared for

U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

December 1998

INNOVATIVE TECHNOLOGY
Summary Report

Compact Subsurface Soil Investigation System

OST/TMS ID 2153

Deactivation and Decommissioning Focus Area

Demonstrated at
Hanford Site
Richland, Washington

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Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under "Publications."

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SECTION 1

SUMMARY

The compact subsurface soil investigation system is a mobile soil sampler used to obtain soil samples, including from below concrete floors, such as under fuel storage basins. If soils under buildings can be sampled and analyzed to document that the soil is not contaminated and thus can remain in place, the concrete structure over it may also be left in place or only partially removed. Taking soil samples through a concrete floor, often in inaccessible or congested locations, required rugged, portable equipment, such as the improved technology tested, the Geoprobe Model 540M soil sampler that is mounted on a hand cart. The traditional (baseline) technology used a comparable probe mounted on a full-size, 1-ton capacity, diesel-powered truck. The truck was not easily able to access all areas, because of its greater size and weight. In two sample holes from below the fuel storage basin at C-Reactor, the Geoprobe Model 540M was able to penetrate to the full sampling target depth of 3.3 m (10 ft). In the other three locations the sampler was stopped at lesser depths because of large stones. The Geoprobe 540M reduced schedule time and reduced costs by approximately 50% versus the baseline technology. For sampling at a congested fuel storage basin at five locations, the improved technology cost $7,300, whereas the baseline technology would have cost $13,000. As an extension of this demonstration, cost savings and schedule acceleration can be expected to increase commensurate with structure complexity/ congestion and the number of samples required.

■ Technology Summary

The Hanford Site C Reactor Technology Demonstration Group evaluated a compact subsurface soil investigation system developed by Geoprobe Systems of Salina, Kansas, for retrieving soil samples from below the C Reactor fuel storage basin concrete floor. This improved technology was demonstrated for the U.S. Department of Energy (DOE) C Reactor Interim Safe Storage (ISS) project as part of the Large Scale Demonstration and Deployment Project (LSDDP) at DOE's Hanford Site in Richland, Washington.

D&D Workers operating Geoprobe Model 540M in the Fuel Storage Basin

The fuel storage basin held large quantities of contaminated water for many years. Consequently, the possibility existed that the soils beneath the concrete floor were contaminated by water leaks. While it was agreed with the regulatory agencies that the parts of the concrete basin more than 4.6 m (15 ft) below ground level could remain in place, the soils below the basin presented an unknown risk because it could not be proven that the basin did not leak. A mobile yet rugged soil probe delivery system was required that could access the inside of the basin and take soil samples (through holes predrilled through the floor) from multiple depths under the floor. The improved technology demonstrated was a Geoprobe Model 540M, which is a compact direct-push soil sampler mounted on a two-wheeled cart.

The Geoprobe Model 540M is a hydraulically operated sampler with a remote power pack. The unit hydraulically pushes and hammers a metal sampling tube into the soil from which a sample can be withdrawn to the surface. The sampling tubes incorporate inner plastic sample holders that have a 3- to 5-cm (1.25- or 2-in.) inside diameter. Samples up to 0.7 m (2 ft) long may be obtained at multiple depths with the compact Geoprobe unit.

Problem Addressed

DOE's nuclear facilities require characterization prior to release for a D&D project. The characterization effort for the C Reactor Fuel Storage Basin was utilized to determine the extent of D&D work necessary (i.e., what portion of the basin would be removed and disposed of). Sample and computer code analyses are utilized to determine if the entire basin and substantial soils beneath the floor must be removed or if only minimal amounts of soils will be removed. Sample/analyses results will also determine the fate of the overlying structure.

Features and Configuration

- Compact size, measures 79 cm x 190 cm x 74 cm (31 in. x 21.5 in. x 28.5 in.) high when folded
- Weighs less than 330 kg (725 lb)
- May be operated in congested places that standard soil sampling equipment could not fit into
- Equipped with two wheels and can be moved like a cart
- Two workers can move and set up the sampler within a half-hour.

Potential Markets/Applicability

The compact, mobile Geoprobe soil sampler is useful at DOE, U.S. Environmental Protection Agency (EPA) or U.S. Nuclear Regulatory Commission (NRC) sites that require soil sampling at relatively inaccessible or congested locations, depending on the geologic conditions.

Advantages of the Improved Technology

The following table summarizes the evaluation of the new technology compared to the traditional (baseline) technology, which is a comparable sampler, except mounted on a truck instead of on a cart. With the truck, the sampler access would be via a temporary truck ramp and fill installed after removal of portions of the fuel basin building roof and outer transite walls. The improved technology is less costly than the baseline and reduced the project schedule time.

Category	Comments
Cost	Implementing the Geoprobe 540M technology for soil characterization costs about 50% less than the baseline. For sampling at a congested fuel storage basin at five locations, the improved technology cost $7,300, whereas the baseline technology would have cost $13,000.
Performance	The Geoprobe 540M met the performance objective and obtained soil samples per the requirement. However, 3-m (10-ft) depth was achieved at only 2 of 5 locations probed.
Implementation	Easy to implement, no special site services were required.
Secondary Waste Generation	Geoprobe Model 540M generates less secondary waste than the truck-mounted system, because no ramp or bridging would have to be removed.
ALARA and Safety	The compact unit does not improve ALARA practice over the baseline. Safety is improved over the baseline because less structural modifications and supports are required to allow the Geoprobe Model 540M access.

Operator Concerns

No operator concerns were noted during the demonstration.

Skills/Training

The training required to run Geoprobe 540M is less than one day, provided that the trainees are proficient with soil sampling in general.

■ Demonstration Summary

This report covers March 1998, when the Geoprobe 540M and truck-mounted soil sampling systems were assessed.

Geoprobe Model 540M dry run

Demonstration Site Description

At its former weapons production sites, the U. S. Department of Energy (DOE) is conducting an evaluation of improved technologies that might prove valuable for facility D&D. As part of the Hanford Site LSDDP at the C Reactor ISS Project, at least 20 technologies are being tested and assessed against baseline technologies currently in use. DOE's Office of Science & Technology/Deactivation and Decommissioning Focus Area, in collaboration with the Environmental Restoration Program, is undertaking a major effort of demonstrating improved technologies at its sites nationwide, and if successfully demonstrated at the Hanford Site, these improved technologies could be implemented at other DOE sites and similar government or commercial facilities. The site at C Reactor was the floor of the fuel storage basin, which was dry and had a number of high concrete parallel curbs that had limited clearance between them.

The goal of the sampling effort was to obtain samples at two depths (1.5 m [5 ft] and 3 m [10 ft]) from up to five different core holes. (Additional samples were taken within 0.3 m [1 ft] of the floor slab with a hand auger.) Before deploying the Geoprobe's Model 540M, five randomly selected 20-cm (8-in.) diameter holes were drilled in the fuel basin's floor slab to permit sampling probe access to the soil below.

Key Demonstration Results

By using Geoprobe Model 540M, the user can obtain soil samples quickly and efficiently at locations that do not have direct truck access, for supporting soil characterization that is required for D&D activities. The demonstration indicated these results with the unit:

- The improved technology allows soil sampling in limited access areas that were only 86 cm (34 in.) wide
- Using the improved technology costs $7,300, about 50% less than the baseline cost of $13,000
- In two sample holes, the sampling machine was able to penetrate to the full sampling depth of 3.3 m (10 ft). In the remaining sample locations the sampler was stopped at lesser depths because of large stones (even though the unit is rated at 80 kN [18,000 lb] of push force).

Regulatory Issues

- There are no regulatory issues with the use of the Geoprobe Model 540M.

Technology Availability

This technology is available through Geoprobe Systems. Renting may be an option.

Technology Limitations/Needs for Future Development

The only drawback is the inability of the sampler to perform in excessively rocky soils.

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Others
All published Innovative Technology Summary Reports are available at http://em-50.em.doe.gov. The Technology Management System, also available through the EM50 Internet web site, provides information about Office of Science and Technology (OST) programs, technologies, and problems. The OST Reference Number for Compact Subsurface Soil Investigation System is 2153.

SECTION 2

TECHNOLOGY DESCRIPTION

■ Overall Technology/Process Description

DOE's nuclear facilities require characterization for planning and decision-making at D&D projects. Some of the soil at D&D sites is contaminated with radionuclides, and evaluating this soil prior to excavation is an important component of the D&D program. Soils that have radioactive contamination above prescribed levels must be excavated and disposed of in a solid low-level radioactive waste (SLLRW) burial facility. However, if the soils are below a large structure that does not require removal, it becomes difficult to sample the soil and determine the need for removal.

The Geoprobe Model 540M can be used to obtain soil samples where larger, heavier units have difficulty in accessing certain sites. Thus, the Geoprobe sampler provides an attractive alternative to truck-mounted sampling equipment at locations with difficult truck access. The system consists of the following components:

Components

- Probe unit mounted on a metal box frame with rubber wheels.
- 3.8-cm (1.5-in.) hydraulic lines equipped with quick connect couplers.
- Compact (dual circuit) hydraulic power unit energized by a gasoline engine.
- Sections of pipe for holding sampling tubes and for driving sampling pipe into the soil.

Overview

The Geoprobe Model 540M was developed by Geoprobe System, Inc, of Salina, Kansas. This soil sampler is characterized by the following features, capabilities, and configuration:

- Compact size, measures 79 cm x 190 cm x 74 cm (31 in. x 21.5 in. x 28.5 in.) high when folded
- Weighs less than 330 kg (725 lbs)
- May be operated in congested places
- Equipped with two wheels and can be moved like a cart
- Two workers can move and set up the sampler within a half-hour
- Powered by an optional 18-HP Briggs and Stratton gas engine with electric start.

For the demonstration, instead of this last item, the hydraulic unit was powered by a Geoprobe truck engine.

Figure 1 shows the unit in the folded position, ready for transport. Figure 2 shows the unit in the upright position, ready for sampling.

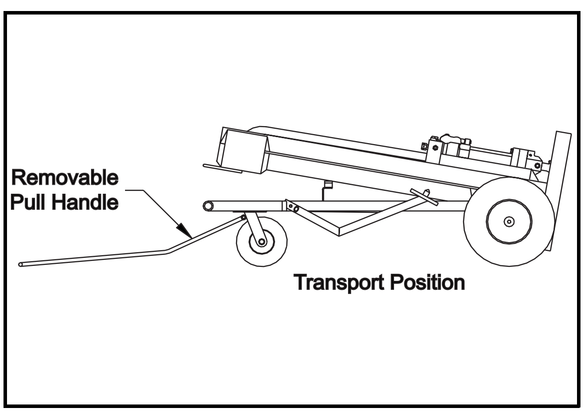

Figure 1. Unit folded.

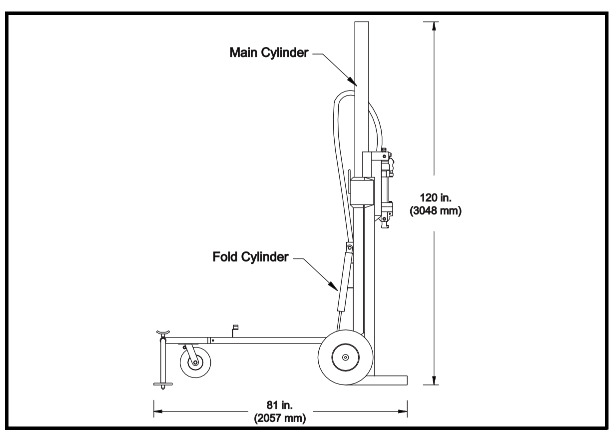

Figure 2. Unit upright.

System Operation

Setup

- If sampling beneath a floor, holes or cores must be made first at the desired sampling locations. If it is desired to use anchor bolts to control potential lateral movement of the sampler and to increase the downward probing force, install two anchors at each sampling location.
- Set the sampler at the floor level using rigging and manually wheel the sampler to the sampling location.
- Connect the hydraulic lines to the sampler and to the hydraulic power unit.
- Check that the hydraulic system is functional.

Operation

- Insert a clear plastic sampling tube in a section of pipe with screwed end fittings or threads.
- Connect the pipe section to the sampler with additional sections of drive pipe.
- Screw bolts into the floor anchors and set nuts over the sampler frame.
- Manually adjust the sampler position so that the pipe sections are approximately vertically over the desired sampling locations. For gravelly soils, add weight (e.g., sand bags, metal weights) to the sampler to help hold it down.
- Switch on hydraulic pressure and/or hammering action to advance the pipe string downward.
- Upon attaining the desired depth, the tip is removed and driving downward is resumed to collect a soil sample for a sample length of up to 61 cm (2 ft).
- Withdraw the sampling pipe, decontaminate it by rinsing, and remove the plastic sampling tube. More samples at increased depths can be taken at the same sampling location with additional plastic sampling tubes.

SECTION 3

PERFORMANCE

■ Demonstration Overview/Plan

Site Description

The demonstration was conducted at the C Reactor building complex at DOE's Hanford Site. The purpose of the LSDDP program is to demonstrate and document performance data and costs for improved technologies that can aid in placing the C Reactor into an ISS mode for up to 75 years, or until the final disposal of the reactor's core is completed. The ISS objectives include placing the reactor in a condition that will 1) not increase future decommissioning costs 2) minimize the potential for releases to the environment, and 3) reduce the frequency of inspections, thereby reducing potential risk to workers.

DOE's nuclear facilities require characterization and documentation of the results as part of planning and decision-making for D&D projects and to release areas that have been cleaned up. Some of the soil at D&D sites is contaminated with radionuclides, and sometimes with heavy metals, which if above certain levels must be excavated and disposed of in a SLLRW burial facility. However, if the soils are below a large structure that does not require removal, it becomes difficult to access the soil to take adequate characterization samples and determine the need for its removal. The site at C Reactor was the floor of the fuel storage basin, which was dry and had a number of high concrete parallel curbs that had limited clearance between them.

The C Reactor Fuel Storage Basin is a concrete structure with a floor that is 6.7 m (22 ft) below grade. If significant contamination and a resulting dose is found underneath the basin slab through soil analysis and a computer code dose calculation, the basin would be completely removed and disposed. If the sample analyses show the soil is clean, only the top 4.6 m (15 ft) of the basin will be removed and disposed.

Performance Objectives

The objective of the demonstration was to evaluate the Geoprobe Model 540M against a truck-mounted soil probe to see if the equipment performs as reliably in limited access and/or congested areas. Of five sampling locations, it was necessary to obtain samples at 3.3-m (10-ft) depth for a least one or two locations.

Demonstration Chronology

The compact soil sampling system was demonstrated during March 1998. Before deploying the Geoprobe's Model 540M, five randomly selected 20-cm (8-in.) diameter holes were drilled in the fuel basin's floor slab to permit sampling probe access to the soil below.

Baseline Technology Description

The baseline Geoprobe hydraulic probing unit is the same as for the improved technology, except that the baseline probing unit has a horizontal turntable that is attached to a truck bed. This turntable allows horizontal movement of the system for short distances without having to move the truck. The baseline probing unit, including the turntable, weighs approximately 454 kg (1000 lb) more than the probing unit used for the improved technology. The following describes the truck-mounted Geoprobe sampling unit:

- Probing unit is permanently mounted on a full-size, 1-ton capacity, diesel-powered truck
- Total weight of the unit is about 2,586 kg, (5,700 lbs) (probe weight is 771 kg [1,700 lbs], truck weight is about 1,815 kg [4,000 lbs])
- Unit dimensions (including vehicle) are approximately 22 ft long, 8 ft wide, and 8 ft high

- All tooling and supplies are stored on the truck
- Two people are needed to operate this unit efficiently.

In order to use the baseline technology, parts of the building roof and outer transite walls and part of the fuel basin above-grade concrete wall would have to be removed to allow access for the truck-mounted Geoprobe unit. The building roof and outer walls were scheduled to be removed anyway, but much later than when the soil analysis data would be most useful. Structure/load studies of the basin would be required to use the truck-mounted Geoprobe. A temporary ramp and dirt fill for truck access would be needed.

Comparison of Improved and Baseline Technologies

The compactness of the Geoprobe Model 540M permitted the sampling machine to be deployed directly on the basin floor between concrete curbs with only an 86-cm (34-in.) -wide clearance between pairs of curbs. No additional structural support was required.

■ Technology Demonstration Results

Key Demonstration Results

By using Geoprobe 540M, the user can obtain soil samples quickly and efficiently from underneath buildings to support soil characterization required for D&D activities.

The Geoprobe model 540M successfully:

- Allows soil sampling in limited access areas only 79 cm (31 in.) wide
- Reduces costs; the improved technology costs about 50% less than the baseline in the application at C-Reactor.

Comparison of Improved Technology to Baseline

Table 1 summarizes the performance and operation of the improved technology compared to the baseline technology. Note that the baseline information is based on prior experience with the baseline system; the baseline technology was not demonstrated at C Reactor.

Table 1. Summary of performance and operation - baseline versus improved technology demonstration (Table 1 presented in two parts)

Activity or Feature	Baseline Technology	Improved Technology
Cost	More than improved technology	Implementing the Geoprobe 540M technology for soil characterization costs about 50% less than the baseline.
Field time	More than improved technology	Less than baseline technology
Setup	Longer time; maneuvering a large truck in congested areas is difficult and may require additional structural support	One half-hour

Table 1. Summary of performance and operation - baseline versus improved technology demonstration (Table 1 presented in two parts)

Activity or Feature	Baseline Technology	Improved Technology
Performance	Would delay the D&D project schedule	The Geoprobe 540M met the performance objective and obtained soil samples per the requirement. However, 3-m (10-ft) depth was achieved at only 2 of 5 locations probed.
Flexibility	Use is limited to areas accessible to large trucks	More flexible than baseline, can be used in both open and congested areas
Safety	Somewhat more dangerous using a heavy, large truck	Safer than baseline technology (no truck support to be installed)
Waste generation	Would have to remove temporary ramp and bridging used for truck access	Less secondary waste
Utility requirements	Runs off truck's power system	Minimal (110 VAC electric outlet)
Ease of Use/Training	Harder to use in congested areas. Training equivalent to improved technology	Easier to use in congested areas

DOE facilities present a wide range of D&D working conditions. The working conditions for an individual job directly affect the manner in which D&D work is performed. Evaluations of the improved and baseline technology presented in this report are based upon a specific set of conditions or work practices found at the Hanford Site, and are presented in Table 2. This table is intended to help the technology users identify work item differences between the technologies as used at the Hanford C Reactor and the conditions at the users' site.

Table 2. Summary of conditions

Variable	Site Conditions for Baseline and Improved Technologies
Scope of Work	
Quantity and type of material surveyed in test areas	Soil samples from five random locations beneath the fuel storage basin C Reactor
Location of test area	Inside the Hanford Site C Reactor fuel storage basin
Nature of work	Obtain samples of soil
Work Environment	
Level of contamination in the test areas	The demonstration site is a radiation area
Condition of floor in test areas	Curbs present at 86 cm (34 in.) intervals
Work Performance	

Table 2. Summary of conditions

Variable	Site Conditions for Baseline and Improved Technologies
Compliance requirements	EPA, 1987, *Methods for Evaluating the Attainment of Cleanup Standards*, Volume 1: "Soils and Solid Media" EPA 230/02-89-041, U.S. Environmental Protection Agency, Washington, D.C.
Work Process Steps	
Soil Sampling	Samples taken from multiple depths

Skills/Training

Training to use the equipment takes less than a day, equivalent to the truck-mounted system.

Operational Concerns

No operator concerns were noted. However, if the cart-mounted unit demonstrated is securely bolted to a floor, it is more difficult for the operator to judge the downward progress of the probe when sampling rocky soils.

Successes

The improved technology needed to fit in areas with only an 86-cm (34-in.) clearance. The Geoprobe Model 540M soil sampling equipment is only 79 cm (31 in.) wide, which met the criteria and permitted cost-effective sampling in a congested area.

Shortfalls

The compact Geoprobe Model 540M is unable to perform in excessively rocky soils.

Meeting Performance Objectives

The sampling system met the performance objective listed in the Demonstration Overview.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

■ Technology Applicability

This technology is especially useful for sampling and characterizing fine-grain to medium-grain sands and small gravels where limited space or truck access is a problem.

■ Competing Technologies

There are other compact sampling units and methods on the market, and each has its niche. The primary drivers that must be considered in the selection process are depth, formation to be sampled, and purpose or intended use for the sample.

Some examples of the various available sampling tools are:

- Hand augers utilized for fine-grain soil and shallow depths.
- Jack-hammer-adapted tools such as those manufactured by Mavrik Co. (Coeur d'Alene, Idaho), which can be utilized for sampling fine-grain to medium-coarse-grain soil at depths up to 20 feet.
- Hydraulic push with pneumatic assist or jack hammer assist such as that manufactured by Concord Environmental Co. (Hawley, Minnesota). This unit has a relatively wide range of operating ranges and uses.
- For those instances where a drilled core is necessary and/or remote operation is mandatory, Christensen Products (Salt Lake city, Utah) manufactures a wide variety of equipment.

■ Patents/Commercialization/Sponsor

The sampling system demonstrated is readily available through Geoprobe Systems of Salina, Kansas.

The demonstration at C Reactor was sponsored by DOE's Office of Science & Technology/Deactivation and Decommissioning Focus Area, in collaboration with the Environmental Restoration Program.

SECTION 5

COST

Introduction/Methodology

This cost analysis compares the Geoprobe Model 540M compact soil sampler improved technology to a baseline technology consisting of a Geoprobe Model 5400 truck-mounted soil sampler. Both technologies are used to collect soil samples at various depths by hydraulically driving (pushing) or hammering sample collection tubes into the ground. Since sample collection methodology is the same for both the improved and baseline technologies, the improved feature being compared is the compactness and portability of the Model 540M device.

The previous Hanford Site method for collecting soil samples beneath concrete floor slabs was to use a hand-powered soil auger to drill to the desired sampling depth. This methodology, however, has already proven to be ineffective in heavily cobbled or gravelly soils such as those present at the C-Reactor. Even in less restrictive soils, hand-powered auguring is only effective to approximately one meter below ground level. More powerful engine-driven augers are available in sampling configurations, but they are usually truck mounted. Another variation of the auger sampler that is more commonly used where high levels of soil contamination exist is the rotary drill or "core barrel" sampler. This device utilizes a cutting head surrounding an inner sampling tube to facilitate simultaneously cutting through the ground while extracting a sample. The cutting head is itself surrounded by an outer tube to contain the contaminated cuttings. Core barrel-type samplers also need to be mounted to a truck because of the drilling forces required. Finally, other types of hydraulically operated samplers are also available, but these are also truck mounted, in some fashion, to resist the push and extraction forces required for taking samples. The Model 540M technology allows Hanford Site technicians to take power-driven and power-extracted soil samples in tight areas without first having to demolish surrounding structures in order to gain truck access.

Activities included for cost comparison are as follows:

Improved Technology

- Move equipment to the job site
- Layout, connect, and wrap the hydraulic hoses
- Lower the compact soil sampler into the fuel basin
- Don & doff personal protective equipment (PPE) and respirators
- Set up the compact soil sampler
- Take soil samples at each of up to five locations below the fuel basin slab
- Recover the sample and decontaminate the sample probe
- Decontaminate and demobilize equipment and exit the fuel basin

Baseline Technology

- Provide additional demolition measures to ensure truck access to the fuel basin
- Move equipment to the job site
- Don & doff personal protective equipment (PPE) and respirators
- Dig out fill at the sample location and bolt down a temporary receptor chair (explained in Appendix B)
- Set up the truck-mounted soil sampler
- Take soil samples at each of up to five locations below the fuel basin slab
- Recover the sample and decontaminate the sample probe
- Decontaminate and demobilize equipment and exit the fuel basin

Cost Analysis

The Geoprobe Model 540M portable soil sampler is available for purchase from the manufacturer and rental by an equipment supplier as shown in Table 3. The detailed cost analysis is based on the purchase option for the improved sampler (and for the baseline system as well). The Hanford Site has purchased both units, and the baseline unit is used where there is ready access.

Table 3. Costs for improved technology acquisition and rental options

ACQUISITION OPTION	ITEM	COST(1)		
Equipment Purchase(1)	**Model 540M Portable Soil Sampler:**			
	• Geoprobe Model 540M Probe Unit			$14,420
	• 50' #12 Hose w/Couplers			$385
	• Truck Connection Kit (optional)			$100
	• Stanley Gas Power Unit			$6,850
	• Accessory Tool Package			$5,800
	• Large-Bore Soil Sampling Kit			$1,563
	• Screen-Point Water Sampler			$1,582
	• Post-Run Tubing System			$497
	• Macro Core Soil Sampling System			$1669
	• Delivery and Training			$1250
	Total:			**$34,116**
Equipment Rental(2)	**Model 540M Portable Soil Sampler:**	**Daily**	**Weekly**	**Monthly**
	• Geoprobe Model 540M Probe Unit	$400	$725	$1,875
	• 50' #12 Hose w/Couplers	$16	$40	$100
	• Stanley Gas Power Unit	$180	$300	$775
	• Accessory Tool Package(3)	N/A	N/A	$144
	• Large-Bore Soil Sampling Kit	N/A	$15	$40
	• Screen-Point Water Sampler	N/A	$36	$95
	• Macro Core Soil Sampling System	N/A	$20	$53

(1) Purchase costs are based on 1997 pricing data made available from Geoprobe Systems, Salina, Kansas
(2) Rental costs are based on data made available from Riverrock Environmental, Bainbridge Is, Washington.
(3) Not all items standard with the accessories tool package are available for rent. Several of these are disposable components or are commonly available hand tools. See the cost backup data to this report for a complete breakdown of accessory tool items, their costs, and availability for rental or purchase.
N/A = not available

The baseline technology, also from Geoprobe, is available for purchase and rental as follows:

Table 4. Costs for baseline technology acquisition and rental options

ACQUISITION OPTION	ITEM	COST		
Equipment Purchase[1]	**Model 5400 Soil Probe w/F250 Pickup:**			
	• Geoprobe Model 5400 Probe Unit	$24,000		
	• Hydraulic Conversion Package	$3,800		
	• Vacuum/Volume System	$700		
	• Truck Cap	$3,485		
	• Ford F-250 Truck[1]	$28,250		
	• Accessory Tool Package	$5,800		
	• Large-Bore Soil Sampling Kit	$1,563		
	• Screen-Point Water Sampler	$1,582		
	• Post-run Tubing System	$497		
	• Macro Core Soil Sampling System	$1,669		
	• Delivery & Training	$1,250		
	Total:	**$72,596**		
Equipment Rental[2]	**Model 5400 Soil Probe w/F250 Pickup:**	**Daily**	**Weekly**	**Monthly**
	• Geoprobe Model 5400 Probe Unit	$600	$1,800	$5,000
	• Accessory Tool Package[3]	N/A	N/A	$144
	• Large-Bore Soil Sampling Kit	N/A	$15	$40
	• Screen-Point Water Sampler	N/A	$36	$95
	• Macro Core Soil Sampling System	N/A	$20	$53

(1) All costs are based on 1997 pricing data made available from Geoprobe Systems, Salina, Kansas, except for the truck, for which the price is estimated.
(2) Rental costs are based on data made available from Riverrock Environmental, Bainbridge Is, Washington.
(3) Not all items standard with the accessories tool package are available for rent. Several of these are disposable components or are commonly available hand tools. See the cost backup data to this report for a complete breakdown of accessory tool items, their costs, and availability for rental or purchase.

Observed production rates and unit costs for principal components of the demonstration are presented in Table 5. The unit costs account only for sampler setup, taking samples to depths ranging from 1.5 to 3 m (5 to 10 ft), and recovery /decontamination of sample tubes. Mobilization, providing access, safety meetings, and demobilization are excluded here.

Table 5. Summary of production rates and unit costs

IMPROVED TECHNOLOGY - Geoprobe, Model 540M Portable Soil Sampler		
Cost Element	**Production Rate[2]**	**Unit Cost[1]**
Setup, Sampling, and Recovery	27 min/sample	$131/sample
BASELINE TECHNOLOGY - Geoprobe, Model 5400 Soil Probe w/F-250 Pickup Truck		
Cost Element	**Production Rate[2]**	**Unit Cost[1]**
Setup, Sampling, and Recovery	27 min/sample	$140/sample

(1) Unit costs and production rates shown do not include mobilization, other losses associated with non-productive portions of the work (such as suit-up, breaks, etc.), RCT support, or waste disposal. The intention of this table is to show unit costs at their elemental level, free of site-specific factors such as may be presented by the site work culture or work environment influences. These tables can be used to compute site-specific costs by inserting quantities and adjusting the units for conditions unique to an individual D&D job.
(2) Production rates include setting up the device components necessary for taking the sample, hydraulically driving or hammering and extracting, disassembling, and decontaminating the sample tube The production rate experienced in demonstrating the improved technology is applied to the baseline technology, since the baseline technology was not demonstrated, and since the sampling technology for both the improved and baseline technologies is essentially the same.

■ Costs Conclusions

Figure 3 is a chart displaying a comparison of costs between the improved and baseline technologies for

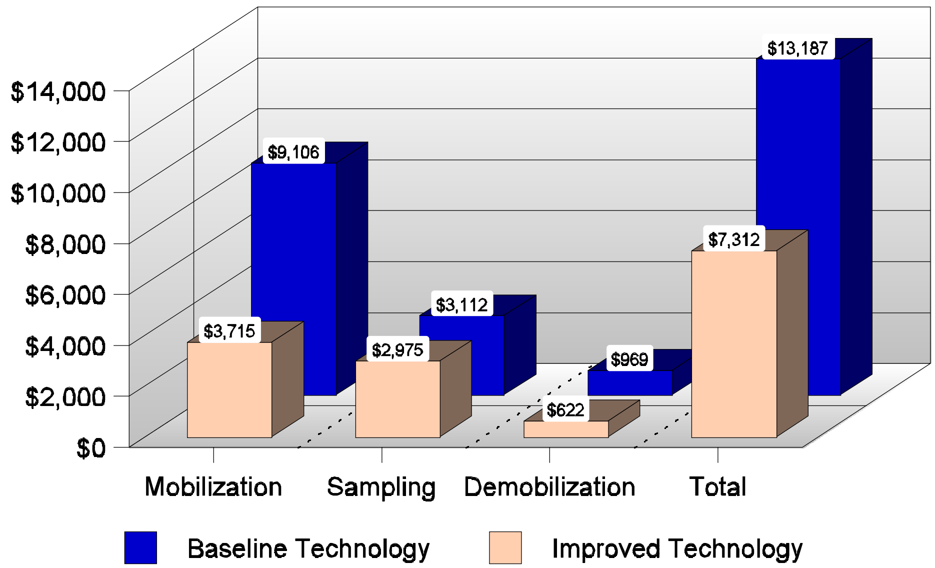

Figure 3. Costs.

taking soil samples at 5 randomly selected locations under the fuel basin floor slab.

Costs for the improved technology are based on actual times recorded for sampling beneath the floor slab of the C-Reactor fuel basin. Sampling was performed by sampling technicians at 5 randomly selected test hole locations and took, roughly, over one week to accomplish. Other costs included for the improved technology are mobilizing equipment and lowering the compact sampler into the fuel basin, setting up and wrapping hydraulic lines, setting anchor bolt locations at the test holes, providing RCT support and monitoring for radiological contamination, breaking down and demobilizing equipment at the completion of the work, and marking and recording the samples collected for later lab analysis.

The baseline technology estimatedcosts are predicated on similar sampling activities and sampling production rates used for the improved technology, but with difference of utilizing the truck-mounted hydraulic sampler. Several measures must be undertaken in order to gain truck access to the bottom of the fuel basin. First, the wall and roof structure providing enclosure over the top of the fuel basin must be demolished and the below-grade retaining walls and center divider wall of the fuel basin taken down from approximately 6 m 22.8 cm (20 ft 9 in.) above the floor of the fuel basin to approximately 1.5 m 22.8 cm (5 ft 9 in.) above the floor of the fuel basin (or 4.6 m [15 ft] of below-grade wall demolished). Next, approximately 160 internal columns that previously supported wood planking over the top of the fuel basin must be cut off at the top of the concrete divider walls (0.8 m [2 ft 6 in.] above the floor slab). Finally, a ramp made of clean fill material must be built to the top of the divider walls to enable vehicle access to most of the basin and leveled off to the top of the divider walls with clean fill material to facilitate driving access to the five randomly selected sample locations.

All of these measures will ultimately be accomplished in the actual demolition of the C-Reactor, thus, their costs will not be added to other costs for the baseline technology, with one main exception. That exception is a more refined level of demolition that must be exercised in anticipation of sampling with the truck. For example, the internal columns must be cut such that no jagged edges stick up above the top of the divider walls, rebar exposed during concrete wall demolition must be trimmed flush, and large pieces of concrete rubble must be removed from the anticipated driving areas.

It must also be noted that additional costs will be incurred if contamination above the release level is found in the soil beneath the fuel basin. If this were to happen, all of the clean fill brought in to facilitate truck access must be removed so the fuel basin concrete floor slab and contaminated soil can be removed. Costs covering this possibility are not included in the calculation of the baseline costs.

Appendix B of this report contains Cost Summary Tables used to calculate costs for both the improved and baseline technologies (Tables B-2 and B-4, respectively). Verbal descriptions and explanations of each cost item and the elements that comprise them are also included.

Cost Summary

Figure 3 shows that the baseline technology is nearly double in cost versus the improved technology. This difference is primarily due to the costs associated with getting the Truck-Mounted Soil Sampler to the bottom of the fuel basin (mobilization/rigging). The Geoprobe Model 5400 Truck-Mounted Sampler was chosen as the baseline technology because it is currently a common method used at the Hanford Site for sampling soils. Although other technologies could suffice as the baseline, they too, to be effective in gravelly soils, must operate from a truck platform.

The outcome of this cost analysis is that the improved technology, when compared to the chosen baseline, provides a superior way of taking soil samples beneath the floor slab of the fuel basin. This is particularly true in terms of timing. The improved technology can be used before any demolition takes place versus the extensive demolition that must occur before the baseline technology can be used. By obtaining analyses from the soil samples earlier, the extent of ultimate fuel basin demolition required was appropriately scheduled. The compact soil sampler also has obvious advantages when being used in congested, building structure areas with irregular geometry and changes of elevation. The features that give it this advantage, however, also yield some disadvantages. Because it is light and portable and the soil beneath the fuel basin is heavily cobbled, the compact soil sampler failed several times to reach the desired depth when large underground stones were encountered. This is discussed in more detail in the technical portion of this report.

Overall, the Geoprobe, Model 540M compact soil sampler yielded adequate sampling results at less cost than the chosen baseline without first having to demolish structures to gain access to sample locations.

SECTION 6

REGULATORY/POLICY ISSUES

■ Regulatory Considerations

- There are no special regulatory permits required for the operation and use of the Geoprobe Model 540M.

- The technology can be used in daily operation under the requirements of 10 CFR, Parts 20, 835, and proposed 834 for protection of workers and the environment from radiological contaminants; and 29 CFR, OSHA worker requirements.

- Although the demonstration took place at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site, no CERCLA requirements apply.

■ Safety, Risk, Benefits, and Community Reaction

Worker Safety

- Radiation protection worker safety instructions already in use at the facility apply.

- Normal worker safety precautions and practices prescribed by OSHA for equipment operation must be followed.

Community Safety

- It is not anticipated that using the Geoprobe sampling technology would present any adverse impacts to community safety.

■ Environmental Impacts

- It is not anticipated that implementation of the compact Geoprobe Model 540M would present any adverse impacts to the environment.

■ Socioeconomic Impacts

- No socioeconomic impacts are expected in association with use of this technology.

SECTION 7

LESSONS LEARNED

■ Implementation Considerations

- The Geoprobe Model 540M sampler is useful for sampling in congested areas or areas that are inaccessible to large and/or heavy vehicles.

■ Technology Limitations/Needs for Future Development

- This equipment has difficulty in probing heavy-cobble gravel and strongly cemented formations.

■ Technology Selection Considerations

- Successful deployment of this sample would depend on the type of geologic formation present. The technology may be suitable for DOE nuclear D&D sites or similar sites that must be characterized prior to closure, transfer, or release. A proper evaluation of the geologic formation, and possibly a pretest, may be required prior to final selection.

APPENDIX A

REFERENCES

10 CFR Part 20, "Standards for Protection Against Radiation" *Code of Federal Regulations,* as amended.

10 CFR Part 834, "Environmental Radiation Protection," *Code of Federal Regulations,* as proposed.

10 CFR Part 835, "Occupational Radiation Protection," *Code of Federal Regulations,* as amended.

29 CFR Part 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations,* as amended.

29 CFR Part 1926, "Safety and Health Regulations for Construction," *Code of Federal Regulations,* as amended.

EPA, 1987, *Methods for Evaluating the Attainment of Cleanup Standards*, Volume 1: "Soils and Solid Media" EPA 230/02-89-041, U.S. Environmental Protection Agency, Washington, D.C.

Geoprobe Systems, 1998, *1998-99 Tools and Equipment Catalog,* Salina, Kansas

Means Construction Equipment Cost Data, 1997, R.S. Means Co., Kingston, Massachusetts

USACE, 1996, *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary*. Headquarters, U.S. Army Corps of Engineers, 20 Massachusetts Avenue, NW, Washington, D.C., 20314-1000.

USAEC, 1974, *Termination of Operating Licenses for Nuclear Reactors,* Regulatory Guide 1.86, U.S. Atomic Energy Commission, Washington D.C.

USOMB, Office of Management and Budget Circular No. A-94 for Cost Effectiveness Analysis, U.S. Office of Management and Budget, Washington D.C.

APPENDIX B

COST SUMMARY

The selected basic activities being analyzed come from the Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS) (USACE 1996). The HTRW RA WBS, developed by an interagency group, is used in this analysis to provide consistency with the established national standards.

Some costs are omitted from this analysis, for ease of understanding and facilitating comparison with costs for the individual site. The overhead and general and administrative (G&A) mark up costs for the site contractor managing the demonstration are omitted from this analysis. Overhead and G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the Hanford Site.

The following assumptions were used as the basis of the cost analysis:

- Oversight engineering, quality assurance, and administrative costs for the demonstration are not included. These are normally covered by another cost element, generally as an undistributed cost
- The procurement cost of 7.5% was applied to applied to all equipment costs to account for costs of administering the purchase (this cost is included in the hourly rate)
- The equipment hourly rates represent the Government's ownership, and are based on general guidance contained in Office of Management and Budget (OMB) Circular No. A-94 for Cost Effectiveness Analysis
- The standard labor rates established by the Hanford Site for estimating D&D work are used in this analysis for the portions of the work performed by local crafts
- The analysis uses an eight-hour work day
- An anticipated life of 5 years is used in the calculation for both the improved and baseline technologies.

Improved Technology - Geoprobe Systems, Model 540M Compact Soil Sampler

MOBILIZATION (WBS 331.01)

Move Equipment to the Job Site: This activity includes time for moving the Compact Soil Sampler and its associated equipment to the fuel storage basin. The activity is measured as one-each (lump sum) for the demonstration.

Lower the Compact Soil Sampler into the Fuel Storage Basin: Two riggers are used for this activity to lower the Compact Soil Sampler approximately 15 feet into the fuel storage basin. A mobile jib crane is used to perform the activity. Since the work takes place in a high-radiation area, the riggers are required to be suited in double PPE. The activity is measured as one each (lump sum) for the demonstration.

Don Personal Protective Equipment: During the demonstration of the improved technology, two sample technicians, one RCT and one D&D worker are required to suit up in double PPE for entry into the fuel storage basin. Since suiting up is required for every day of demolition work inside the contamination area, donning PPE is measured as a daily activity. Material costs for daily PPE for work in the fuel basin are shown in the table below:

Equipment	Cost Each Time Used ($)	No. Used Per Day	Cost Per Day ($)
Air Purifying Respirator (PAPR)	71.06	1 ea	71.06
Face Shield	1.28	1 ea	1.28
Double Booties	0.62	4 pr	2.48
Double Coverall	5.00	4 ea	20.00
Double Hood	2.00	4 ea	8.00
Gloves (inner)	0.14	2 pr	.28
Gloves (outer)	1.30	2 pr	2.60
Gloves (liner)	0.29	2 pr	.58
Rubber Overshoe	1.38	2 pr	2.76
Total			**109.04**

The PAPR cost is based on a price of $603/each, assumes 50 uses, requires four cartridges per day at a cost of $14/each, and maintenance and inspection costs of $150 over the life of the PAPR (50 uses). The face shield cost is based on a price of $64 each and assumes 50 uses. This assumes one worker remains outside the zone and does not suit up. The time spent changing PPE each day is based on observed times.

Set Anchor Bolts @ 5 Sample Locations: This activity precedes actual sampling and is, therefore, considered a mobilization step. It involves setting expansion anchors into the existing concrete slab at each test hole location. The anchor bolts are required to hold the compact soil sampler in place during the hydraulic push or hammer phase of sample collection. It is measured as a one-each activity.

SAMPLING (WBS 331.17)

Daily Rad Safety Meeting: This activity is required standard Hanford Site procedure when working in a high-radiation area. It involves the full working crew and takes place before entering the contamination zone for the day. Therefore, it is measured as a daily activity.

Sample with the Hand-Held Auger @ 4 Holes: As part of the characterization of soils under the concrete floor slab at the fuel storage basin, it is necessary to take samples from the first 6 in. just below the slab. This is more efficiently done with a hand auger since it requires very little force to drill in and extract the sample at this shallow depth. Although the auger sampling has no bearing on comparison of costs between the improved and baseline technologies (the same type of sampling will be conducted for the baseline technology), it is nevertheless included to accurately represent the total cost of the complete sampling effort. The activity was performed prior to sampling with the compact soil sampler at 4 of the 5 sample hole locations. It is measured as a one-each (lump-sum) activity.

Set Up the Compact Soil Sampler: This activity involves moving the portable sampler unit into position at the sample hole, bolting the unit to the in-place concrete anchors, attaching the hydraulic lines, and assembling the sampling components including the outer tube, tube liner, cutting shoe, and end cap. It also includes adding weight (ballast in the form of sand bags) when necessary to keep the unit stable during hydraulic push or hammer-type insertions that are deep or that encounter significant resistance due to rocks and cobbles present in the soil. The activity requires two double-suited sampling technicians accompanied by one double-suited RCT and one double-suited D&D worker all present in the fuel building basin. In addition, one RCT (non-suited) and one D&D worker (non-suited) assist this crew from outside the fuel basin by supplying material needs and monitoring the personnel and waste exiting the fuel basin. The cost element is measured as one lump-sum activity that is the total of all setup activities taking place over several days (approximately a two-week total time frame). Table B-1 lists the days, individual times and total times for the setup activity.

Take Sample with the Compact Soil Sampler: This activity also involves two double-suited sampling technicians accompanied by one double-suited RCT and one double-suited D&D worker as well as one RCT (non-suited) and one D&D worker (non-suited) assisting from outside the fuel basin. During performance of this activity, the two samplers start the gasoline-powered hydraulic pump unit and then operate controls mounted to the compact soil sampler to hydraulically push-drive or hammer-drive 1-inch diameter by 2-foot long sample tubes encased in 2-in. diameter steel pipe sections to various discreet depths at 5 randomly selected sample locations. The cost element is measured as one lump-sum activity that is the total of all sampling taking place over several days (approximately a two-week time frame). Table B-1 lists the days, individual times and total times for sampling activity.

Recover Sample & Decon.: This activity involves the same crew listed for the previous two activities and is the sample extraction part of the process. The compact soil sampler performs the extraction hydraulically. Once removed, the outer tube is wiped clean of soil residue and checked for radiological contamination by the RCT. After decontamination (if required), the outer pipe section is then disassembled to allow removal of the plastic tube liner containing the sample. Samples are then labeled and removed from the work area for later transportation to a lab. This cost element is measured as one lump-sum activity. Table B-1 lists the days, individual times and total times for the sample recovery and decontamination activity.

Table B-1. Sampling activities and times with the compact soil probe

Sampling Location	Date Sampled	Depth of Drive for Sample	Activity (time in min.)				Total (time in min.)
			Prepare for Sampling	Sample	Extract & Decon. Sample	Notes	
Hole No. 1							
• 1st sample	3/3/98	from 0 ft to 5 ft	NA	50	NA	sampling attempt failed due to an obstruction	50
Hole No. 2							
• 1st sample	3/5/98	from 0 ft to 2 ft	4	4	23	-	31
• 2nd sample	3/5/98	from 2 ft to 4 ft	13	2	16	-	31
• 3rd sample	3/9/98	from 4 ft to 6.5 ft	10	20	(included in sample time)	-	30
Hole No. 3							
• 1st sample	3/10/98	from 1.5 ft to 3.5 ft	6	17	3	-	26
• 2nd sample	3/10/98	from 3.5 ft to 6.5 ft	4	6	5	no sample recovered	15
Hole No. 4							
• 1st sample	3/11/98	from 6.5 ft to 8.5 ft	6	15	13	-	34
• 2nd sample	3/11/98	from 0 ft to 2 ft	1	4	1	-	6
• 3rd sample	3/11/98	from 4 ft to 5.5 ft	6	4	5	-	15
• 4th sample	3/11/98	from 5.5 ft to 6.5 ft	10	7	2	-	19
Hole No. 5							
• 1st sample	3/12/98	from 0 ft to 2 ft	21	7	16	-	44
• 2nd sample	3/12/98	from 2 ft to 4.5 ft	5	3	9	-	17
• 3rd sample	3/12/98	from 4.5 ft to 6.5 ft	10	4	12	-	26
• 4th sample	3/12/98	from 6.5 ft to 8.5 ft	5	6	NA	sampler liner jammed	11
• 5th sample	3/12/98	from 8.5 ft to 10.5 ft	19	7	27	sampler liner jammed	53
		TOTALS:	**120 min**	**156 min**	**132 min**		**408 min**
						Average for one hole	82 min (1.4 hr)

DEMOBILIZATION (WBS 331.21)

Disassemble Equipment & Hydraulic Hoses & Decontaminate Equipment: This activity includes unwrapping, disassembling and decontaminating the outside of hydraulic hoses as well as decontaminating the compact soil sampler and its associated components. The activity is performed by D&D workers with RCTs present and is done once at the end of all the sampling work. This activity is measured as one lump sum.

Lift the Compact Soil Sampler from the Fuel Basin: This activity is also performed once at the end of all sampling activity. It requires the presence of the D&D workers and the RCTs and also includes two riggers to lift the compact soil sampler out of the fuel basin with a mobile jib crane. The activity is also measured as one lump sum.

Exit the Fuel Basin: This cost item includes exiting the contamination area (fuel basin), doffing PPE and disposing of them and disposing of used or waste material generated by the sampling process. It is done at the end of every day of work in the fuel basin and is, therefore, measured as a daily activity.

Table B-2. Improved technology cost summary - Geoprobe, Model 540M Compact Soil Probe

Work Breakdown Structure (WBS)	Unit	Unit Cost $	Quantity	Total Cost $	Computation of Unit Cost: Prod Rate	Duration (hr)	Labor & Equipment Rates: Labor Items	$/hr	Equip. Items	$/hr	Other Costs / and Comments
MOBILIZATION (WBS 331.01)			**Subtotal**	$ 3,714.96							
Move Equipment to the Job Site	ls	$ 80.82	1	$ 80.82		1.00	2 DD	$ 63.94	GSS+ SHP+CA	$ 16.88	
Layout & Connect Hydraulic Hoses	ls	$ 59.34	1	$ 59.34		0.33	2 DD + 2 RCT	$ 162.94	GSS+ SHP+CA	$ 16.88	
Wrap Hydraulic Hoses	ls	$ 83.21	1	$ 83.21		0.50	2 DD + 2 RCT	$ 162.94	SHP	$ 3.48	
Lower the Compact Soil Sampler into the Fuel Basin	ls	$ 203.02	1	$ 203.02		1.00	2 RG + 2 RCT	$ 186.14	GSS+ SHP+CA	$ 16.88	
Don Personal Protective Equipment (PPE)	day	$ 569.97	5	$ 2,849.83		0.50	1 DD + 1 RCT+ 2 ST	$ 267.61	_	_	includes 4 sets of PPE per day @ $109.04 / set
Set Anchor Bolts at 5 Sample Locations	ls	$ 438.74	1	$ 438.74		1.00	2 DD + 2 RCT + 2 RG	$ 250.08	RD		includes 2 sets of PPE for one day for the riggers
MONITORING & SAMPLING (WBS 331.02)			**Subtotal**	$ 2,975.17							
Rad Safety Meeting	day	$ 89.75	5	$ 448.77		0.33	2 DD + 2 RCT + 2 ST	$ 271.98	-	-	
Sample with the Hand-Held Auger at 4 holes	ls	$ 568.62	1	$ 568.62		2.08	2 DD + 2 RCT + 2 ST	$ 271.98	AB	$ 1.00	
Set Up the Compact Soil Probe for Sampling	ls	$ 575.72	1	$ 575.72		2.00	2 DD + 2 RCT + 2 ST	$ 271.98	GSS + SHP	$ 15.88	
Take Samples with the Compact Soil Probe	ls	$ 748.77	1	$ 748.77		2.60	2 DD + 2 RCT + 2 ST	$ 271.98	GSS + SHP	$ 15.88	
Recover Sample & Decon.	ls	$ 633.29	1	$ 633.29		2.20	2 DD + 2 RCT + 2 ST	$ 271.98	GSS + SHP	$ 15.88	
DEMOBILIZATION (WBS 331.21)			**Subtotal**	$ 622.15							
Disassemble Equip. & Air Hoses & Decontaminate	ls	$ 178.82	1	$ 178.82		1.00	2 DD + 2 RCT	$ 162.94	GSS + SHP	$ 15.88	
Lift the Compact Soil Sampler from the Fuel Basin	ls	$ 298.90	1	$ 298.90		1.00	2 DD + 2 RCT + 2 ST	$ 282.02	GSS+ SHP+CA	$ 16.88	
Exit the Fuel Basin	day	$ 144.43	1	$ 144.43		0.50	2 DD + 2 RCT + 2 ST	$ 271.98	GSS+ SHP+CA	$ 16.88	
TOTAL				**$ 7,312.27**							

Crew Item	Rate $/hr	Abbreviation	Crew Item	Rate $/hr	Abreviation	Equipment Item	Rate $/hr	Abreviation	Equipment Item	Rate $/hr	Abreviation
Field Supervisor	59.60	SU	Rigger	43.57	RG	Geoprobe, Model 540M Compact Soil Sampler	11.71	GSS	Hand-Held Auger	1.00	
D&D Worker	31.97	DD	Scientist	65.18	SC	Stanley Hydraulic Power Unit	3.48	SHP			
Teamster	36.35	TM	Sampling Technician	54.52	ST	Come-Along & Chainfall	1.00	CA			
Heavy-Equipment Operator	38.68	OP	Radiologic Control Technician	49.50	RCT	Roto-Hammer Drill	1.00	RD			

Baseline Technology - Geoprobe, Model 5400 Truck-Mounted Soil Probe Unit

MOBILIZATION (WBS 331.01)

Provide Additional Demolition Measures: Getting the truck-mounted soil probe unit down to the bottom of the fuel basin will require several demolition measures as well as bringing in clean fill material in order to build an access ramp and level off the top of the divider walls. As previously noted, these steps will not be included as part of the cost for the baseline technology since they are already part of scheduled demolition at the C Reactor. However, additional (or more refined) demolition to facilitate truck access will have to occur that wouldn't have otherwise occurred under a straight demolition scenario. Anticipated activities required to facilitate truck access, their estimated hours, and the trades needed to perform them are detailed in Table B-3. Although these anticipated costs are itemized, they are added together as a lump sum for inclusion in Table B-4.

Table B-3. Detail of additional demolition measures required for the baseline technology

Anticipated Activity	Labor		Equipment		Est. Hours	Total Cost
	Crew[(2)]	Crew Rate/hr	Description[(2)]	Rate/hr		
1. Cut 160 existing support columns flush with top of 2'-6" high divider walls[(1)]	2 W + 1 RCT	$136.64	ATW	$4.05	24	$3,376.56
2. Cut rebar exposed due to concrete wall demolition	2 W + 1 RCT	$136.64	ATW	$4.05	8	$1,125.52
3. Remove large rubble from driving area	1 OP + 2 DD + 1 RCT	$152.12	SBT + DT	$35.48	8	$1,500.80
4. Smooth & compact driving area	1 OP + 2 DD + 1 RCT	$152.12	CT	$49.47	8	$1,612.72
					Total:	**$7,615.60**

Notes:
(1) The hours estimated for this activity include only the extra hours required to cut the columns neatly flush with the top of the divider walls since the columns have to be cut for the C-Reactor demolition anyway.
(2) See Table B-4 for definitions of abbreviations for labor categories and equipment types and labor and equipment rates.

Move Equipment to the Job Site: This activity includes time for moving the Truck-Mounted Soil Sampler and its associated equipment to the fuel storage basin. The activity is measured as one-each (lump sum) for the sampling job.

Don Personal Protective Equipment: Workers conducting sampling in the fuel basin after its partial demolition need only suit up in single PPE since the fuel basin will no longer be a high-radiation area. Additionally, only those workers actually doing the sampling are required to be suited up. The RCT present at the sampling locations is not required to be in PPE. Therefore, only the two sample technicians and one D&D worker are required to suit up in single PPE for each day the sampling is conducted. Material costs for daily PPE for work in the fuel basin are shown in the table below:

Equipment	Cost Each Time Used ($)	No. Used Per Day	Cost Per Day ($)
Air Purifying Respirator (PAPR)	71.06	1 ea	71.06
Face Shield	1.28	1 ea	1.28
Booties	0.62	2 pr	1.24
Coverall	5.00	2 ea	10.00
Double Coverall (5% of the			0.56
time)	2.00	2 ea	4.00
Hood	0.14	2 pr	.28
Gloves (inner)	1.30	2 pr	2.60
Gloves (outer)	0.29	2 pr	.58
Gloves (liner)	1.38	2 pr	2.76
Rubber Overshoe			
Total			**94.36**

The PAPR cost is based on a price of $603/each, assumes 50 uses, requires four cartridges per day at a cost of $14/each, and maintenance and inspection costs of $150 over the life of the PAPR (50 uses). The face shield cost is based on a price of $64 each and assumes 50 uses. This assumes one worker remains outside of the zone and does not suit up. The time spent changing the PPE each day is based on observed times.

Dig Out the Fill at the Sample Location and Bolt Down a Temporary Receptor Chair: Because the truck will be driven on top of the divider walls, it will be necessary to dig down to the sample location 2 feet 6 inches below the top of the divider wall. It is anticipated that this can be done with a D&D worker using a hand-held shovel. Because the foot of the hydraulic soil sampler cannot extend beyond ground level, it is also necessary to make up the distance with some kind of portable chair designed to endure the compression and tension loads necessary for hydraulically driving and extracting a sample. The chair is built using steel channel and plate and is sized to fit around an 8-in. diameter sample hole cored through the concrete floor slab. It is provided with bolt holes on both ends so it can be affixed to the slab and the foot of the sampler unit. The costs for excavating the hole, building the receptor chair and bolting it place is measured as one lump sum.

SAMPLING (WBS 331.17)

Daily Rad Safety Meeting: This activity is required standard Hanford Site procedure when working in a high-radiation area. It involves the full working crew and takes place before entering the contamination zone for the day. Therefore, it is measured as a daily activity.

Sample with the Hand-Held Auger @ 4 Holes: As part of the characterization of soils under the concrete floor slabs of the fuel storage basin, it is necessary to take samples from the first 6-inches just below the slab. This is more efficiently done with a hand auger since it requires very little force to drill in and extract the sample at this shallow depth. Although the auger sampling has no bearing on comparison of costs between the improved and baseline technologies (the same type of sampling will be conducted for the improved technology), it is nevertheless included to accurately represent the total cost of the complete sampling effort. The activity is performed before using the truck-mounted sampler. It is measured as a one-each (lump-sum) activity.

Set Up the Truck-Mounted Soil Sampler: This activity involves using the portable bridging to position the truck at the sample holes, extending the unit outrigger, bolting the receptor chair to the concrete surrounding the sample hole, bolting the sampler unit foot pads to the receptor chair, and assembling the sampling components including the outer tube, tube liner, cutting shoe, and end cap. The activity requires two double-suited sampling technicians accompanied by one double-suited RCT and one double-suited D&D worker all present in the fuel basin. In addition, one RCT (non-suited) and one D&D

worker (non-suited) assist this crew from outside the fuel basin by supplying material needs and monitoring personnel and waste exiting the fuel basin. The cost element is measured as one-lump sum activity that is the total of all setup activities taking place. Table B-1 lists the days, individual times in minutes and total times for the setup activity for the improved technology and these same activities and times are used for the baseline technology since the sampling methodology and device are the same. This cost element is measured as a lump sum.

Take Sample with the Compact Soil Sampler: This activity also involves two double-suited sampling technicians accompanied by one double-suited RCT and one double-suited D&D worker as well as one RCT (non-suited) and one D&D worker (non-suited) assisting from outside the fuel basin. During performance of this activity, the two samplers start the hydraulic pump unit (powered by the truck engine) and then operate the soil probe via a set of controls mounted at the back of the truck. Soil probes 1-1/2 inches in diameter by various lengths are then push- or hammer-driven to various discreet sampling depths at the 5 randomly selected locations. Since the baseline scenario was not actually demonstrated, times for each sampling drive are based on an average established during the demonstration of the improved technology and are listed in Table B-1. The cost element is measured on per sample basis.

Recover Sample & Decon.: This activity involves the same crew listed for the previous two activities and is the sample extraction part of the process. The Truck-Mounted Soil Sampler performs the extraction hydraulically. Once removed, the outer pipe section is wiped clean of soil residue and checked for radiological contamination by the RCT. After decontamination (if required), the outer pipe section is then disassembled to allow removal of the plastic tube liner containing the sample. Samples are then labeled and removed from the work area for later transportation to a lab. Table B-1 lists the days, individual times and total times for the sample recovery and decontamination activity for the improved technology. These same activities and times are used for the baseline technology since the sampling methodology and device are the same. This cost element is measured as a lump sum.

Disassemble Equipment & Decontaminate Equipment: This activity includes decontaminating the Truck-Mounted Soil Sampler and its associated components. The activity is performed by D&D workers with RCTs present and is done once at the end of all the sampling work. This activity is measured as one lump sum.

Exit the Fuel Basin: This cost item includes exiting the contamination area (fuel basin), doffing PPE and disposing of them and disposing of used or waste material generated by the sampling process. It is done at the end of every day of work in the fuel basin and is, therefore, measured as a daily activity.

Table B-4. Baseline technology cost summary - Geoprobe, Model 5400 Truck-Mounted Soil Probe

Work Breakdown Structure (WBS)	Unit	Unit Cost $	Quantity	Total Cost $	Computation of Unit Cost: Prod Rate	Duration (hr)	Labor & Equipment Rates: Labor Items	$/hr	Equip. Items	$/hr	Other Costs / and Comments
MOBILIZATION (WBS 331.01) Subtotal				$ 9,106.32							
Provide Additional Demolition Measures	ls	$ 7,615.60	1	$ 7,615.60	-	-	see Table B-3.	-	see Table B-3.	-	Cost calculation made in Table C-3.
Move Equipment to the Job Site	ls	$ 99.99	1	$ 99.99		1.00	2 DD	$ 63.94	GST + F250	$ 36.05	Task time taken from the improved technology demonstration
Don Personal Protective Equipment	day	$ 164.87	5	$ 824.33		0.50	1 DD + 1 RCT + 2 ST	$ 141.01	_	_	Includes 2 sets of PPE per day @ $94.36 per set
Dig Out the Fill at the Sample Location and Bolt Down a Temporary Receptor Chair	ea.	$ 113.28	5	$ 566.40		0.50	1 DD + 1 RCT + 2 ST	$ 190.51	GST + F250	$ 36.05	Other costs include $400 to fabricate a temporary receptor chair
MONITORING & SAMPLING (WBS 331.02) Subtotal				$ 3,112.32							
Rad Safety Meeting	day	$ 89.75	5	$ 448.77		0.33	2 DD + 2 RCT + 2 ST	$ 271.98	-	-	
Sample with the Hand-Held Auger at 4 Holes	ls	$ 568.62	1	$ 568.62		2.08	2 DD + 2 RCT + 2 ST	$ 271.98	AB	$ 1.00	
Set Up the Truck-Mounted Soil Sampler.	ls	$ 616.06	1	$ 616.06		2.00	2 DD + 2 RCT + 2 ST	$ 271.98	GST + F250	$ 36.05	Task time taken from the improved technology demonstration
Take Samples with the Truck-Mounted Soil Probe	ls	$ 801.21	1	$ 801.21		2.60	2 DD + 2 RCT + 2 ST	$ 271.98	GST + F250	$ 36.05	Task time taken from the improved technology demonstration
Recover Sample & Decon.	ls	$ 677.67	1	$ 677.67		2.20	2 DD + 2 RCT + 2 ST	$ 271.98	GST + F250	$ 36.05	Task time taken from the improved technology demonstration
DEMOBILIZATION (WBS 331.21) Subtotal				$ 969.07							
Disassemble Equip. & Decontaminate	ls	$ 198.99	1	$ 198.99		1.00	2 DD + 2 RCT	$ 162.94	GST + F250	$ 36.05	
Exit the Fuel Basin	day	$ 154.02	5	$ 770.08		0.50	2 DD + 2 RCT + 2 ST	$ 271.98	GST + F250	$ 36.05	
TOTAL				**$ 13,187.70**							

Crew Item	Rate $/hr	Abbreviation	Crew Item	Rate $/hr	Abreviation	Equipment Item	Rate $/hr	Abreviation	Equipment Item	Rate $/hr	Abreviation
Field Supervisor	59.60	SU	Rigger	43.57	RG	Geoprobe, Model 5400 Truck-Mounted Soil Sampler	21.71	GTS	Hand-Held Auger	1.00	AB
D&D Worker	31.97	DD	Welder	43.57	W	Ford F-250 Pickup Truck	14.34	F250	Dump Truck (12 cy)	11.51	DT
Teamster	36.35	TM	Sampling Technician	54.52	ST	Small Tractor w/Bucket	23.97	SBT	Acetylene Torch Welder	4.05	ATW

APPENDIX C

ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Description
ALARA	as low as reasonably achievable
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
cy	cubic yard
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DOE-RL	DOE-Richland Operations Office
EPA	U.S. Environmental Protection Agency
FETC	Federal Energy Technology Center
G&A	general and administrative costs
ISS	interim safe storage
ls	lump sum
LSDDP	Large-Scale Demonstration and Deployment Project
NRC	U. S. Nuclear Regulatory Commission
PPE	personal protective equipment
RCT	radiological control technician
SLLRW	solid low-level radioactive waste
USACE	U.S. Army Corps of Engineers
WBS	work breakdown structure

Note: Additional definitions are given in Tables B-2 and B-4 in Appendix B.