SAND96-2019
Unlimited Release
Printed August 1996

Distribution
Category UC-600

# Environmental Measurement-While-Drilling-Gamma Ray Spectrometer (EMWD-GRS) System Technology Demonstration Plan for Use at the Savannah River Site F-Area Retention Basin

Cecelia V. Williams
Environmental Restoration Technologies

Grant J. Lockwood
Materials Radiation Science

Randy A. Normann
Geothermal Research

Sandia National Laboratories
Albuquerque, New Mexico 87185-5800

Ralph D. Gruebel
Tech Reps, Inc.
Albuquerque, New Mexico 87110

## ABSTRACT

The Environmental Measurement-While-Drilling-Gamma Ray Spectrometer (EMWD-GRS) system represents an innovative blend of new and existing technology that provides the capability of producing real-time environmental and drillbit data during drilling operations. This demonstration plan presents information on the EMWD-GRS technology, demonstration design, Cs-137 contamination at the Savannah River Site F-Area Retention Basin, responsibilities of demonstration participants, and the policies and procedures for the demonstration to be conducted at the Savannah River Site F-Area Retention Basin.

The EMWD-GRS technology demonstration will consist of continuously monitoring for gamma-radiation contamination while drilling two horizontal boreholes below the backfilled retention basin. These boreholes will pass near previously sampled vertical borehole locations where concentrations of contaminant levels are known. Contaminant levels continuously recorded by the EMWD-GRS system during drilling will be compared to contaminant levels previously determined through quantitative laboratory analysis of soil samples.

## Acknowledgment

This Environmental Measurement-While-Drilling-Gamma Ray Spectrometer (EMWD-GRS) system technology demonstration was funded by the Office of Science and Technology (OST) under U.S. Department of Energy (U.S. DOE) contract number DE-AC04-94AL85000.

The authors wish to acknowledge the contributions made by the following individuals in support of this demonstration:

Scott McMullen (DOE/Savannah River Site) for his confidence in the EMWD project and his vision in facilitating its demonstration at the Savannah River Site. This demonstration would not have taken place without his direct personal involvement.

Pete Zionkowski (Westinghouse Savannah River Company) for his administrative, logistics, and technical support.

Ahmet Suer (Westinghouse Savannah River Company) for his dedication to planning the demonstration, his technical support, and his tenacity in seeing that the demonstration occurred.

Kevin Kuelske, William Pardee, James Jordon, and Edward Leibfarth (Westinghouse Savannah River Company) for their technical review of this demonstration plan.

## DISCLAIMER

# Contents

## Appendices

## FIGURES



## TABLES

This Page Intentionally Left Blank

# EXECUTIVE SUMMARY

## Introduction

The Environmental Measurement-While-Drilling-Gamma Ray Spectrometer (EMWD-GRS) system represents an innovative blend of new and existing technology that produces the capability of providing real-time environmental and drill bit data during drilling operations. These real-time measurements provide technical data for field screening (i.e., "steering" the drill bit in or out of contaminated zones). There are also time, cost, and safety advantages to using the EMWD-GRS system's field screening approach: (1) data on the nature of contamination are available in minutes, as opposed to weeks or months for offsite confirmatory analysis; (2) substantial cost savings result by minimizing the number of samples required for off-site confirmatory analyses; and (3) worker safety is enhanced through the minimization of waste generated during drilling and by quickly alerting field personnel to potentially hazardous conditions; and (4) the amount of investigation derived waste (IDW) is reduced.

## Technology Description

The EMWD-GRS system is compatible with a directional drilling technique that uses minimal drilling fluids and generates little or no secondary waste. The down hole sensor is located behind the drill bit and is linked by a high-speed data transmission system to a computer at the surface. Windows™-based software, developed by Sandia National Laboratories, is used for data display and storage. During drilling operations, data on the nature and extent of contamination are collected. Instant access to the data provides information for on-site decisions regarding drilling and sampling strategies.

Down-hole components of the EMWD-GRS system being demonstrated consist of a gamma ray spectrometer, a multichannel analyzer, a 900V power supply, a signal conditioning and transmitter board, and a coil containing coaxial cable for transmitting data to the surface. To protect them from the drilling environment, down-hole components are contained within O-ring-sealed aluminum tubes. The up-hole system consists of a personal computer, a battery pack/coil, a pickup coil, and a receiver. During drilling, the GRS system monitors (1) gamma radiation, (2) the +12V and -12V required at the down-hole signal conditioning and transmitter board, (3) the up-hole battery voltage as measured down-hole, and (4) two temperatures associated with the detector and instrumentation. The system design incorporates data quality assurance techniques to ensure data reliability.

The EMWD system can provide real-time data on an 8 differential/single analog multiplexer and on any number of digital channels. Sampling speed from the analog channels can reach 100 kHz. For the EMWD-GRS system, three digital channels are used. Readings are taken at a rate of 20 per second. The telemetry system is programmable firmware that can easily support many different data formats and additional data channels. The currently used format (Digital FM Bi-phase, 4800 baud) provides excellent noise rejection. A Sandia National Laboratories (SNL) -designed receiver removes FM carrier noise, generates data clock, and buffers data to be used by an IBM or compatible personal computer. A 28V rechargeable battery pack can supply down-hole instrumentation power for more than 18 hours of drilling. The battery pack remains topside for easy maintenance.

## Demonstration Location

The EMWD-GRS system will be demonstrated at the Savannah River Site (SRS) F-Area Retention Basin near Aiken, South Carolina. The basin measures 200 ft (61 m) in length, 120 ft (36.5 m) in width and 6.9 ft (2 m) in depth, with a total volume capacity of approximately 6,128 cubic yards (4,685 $m^3$). This basin was constructed as an unlined, temporary container for potentially contaminated cooling water associated with the chemical separations process and storm sewer drainage from the F-Area Tank Farm. Contamination of this basin came from contaminated cooling water as well as various spills or overflows at the basin (WSRC, 1995). The basin was in active use from 1955 until 1972. In 1972, it was replaced by a lined retention basin located to the west of the site. In 1978, the F-Area Retention Basin was excavated, backfilled with soil, and covered with grass. The site was evaluated through soil sampling in early 1979. The major radionuclides present included strontium (Sr)-89/90 and cesium (Cs)-137. Sampling results indicated maximum Cs-137 concentrations of 1,410 pCi/g in the berm and 430 pCi/g in the basin floor. Maximum Sr-89/90 concentrations in the basin berm were 1,000 pCi/g (WSRC, 1994).

## EMWD-GRS System Demonstration

Phase I of the demonstration at the F-Area Retention Basin will determine Cs-137 background conditions for the site. Background conditions will be determined by drilling one horizontal borehole, approximately 50 ft (15 m) in length at a depth between 10 and 15 ft (3 and 4.5 m), at an adjacent radiologically "clean" test site. After background conditions are determined, the system will be demonstrated in the previously characterized F-Area Retention Basin.

Phase II of the EMWD-GRS system demonstration at the F-Area Retention Basin will consist of monitoring environmental conditions in real-time while drilling two boreholes daylight-to-daylight. These holes will pass near sample locations FRB-05, 06, 07, 08, and 19 where values of contaminant levels are known. Contaminant levels continuously recorded by the EMWD-GRS system during drilling will be compared to contaminant levels previously determined through quantitative laboratory analysis of soil samples collected at locations FRB-05, 06, 07, 08, and 19.

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AC | alternating current |
| bps | bits per second |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| COC | contaminants of concern |
| Co | cobalt |
| Cs | cesium |
| DC | direct current |
| DOE | U.S. Department of Energy |
| EMWD | Environmental Measurement -While-Drilling |
| EPA | U.S. Environmental Protection Agency |
| FM | frequency modulated |
| FRB | F-Area Retention Basin |
| ft | feet |
| GRS | Gamma Ray Spectrometer |
| HASP | health and safety plan |
| HSO | health and safety officer |
| IBM | International Business Machines |
| IC | integrated circuit |
| IDW | investigation derived waste |
| K | potassium |
| k | kilo |
| kHz | kilohertz |
| kPa | kilopascals |
| m | meter(s) |
| ma | milliampere(s) |
| mm | millimeter(s) |
| msl | mean sea level |
| NRZ | non-return to zero |
| OD | outside diameter |
| OST | Office of Science and Technology |

| | |
|---|---|
| PC | personal computer |
| pCi/g | picocuries per gram |
| psi | pounds per square inch |
| QA | quality assurance |
| QA/QC | quality assurance/quality control |
| QC | quality control |
| QAPP | quality assurance project plan |
| RCO | radiological control operations |
| RF | radio frequency |
| RI | remedial investigation |
| SNL | Sandia National Laboratories |
| SR | Savannah River |
| Sr | strontium |
| SRS | Savannah River Site |
| V | volt(s) |
| WSRC | Westinghouse Savannah River Company |

# 1.0 INTRODUCTION

The Environmental Measurement-While-Drilling- Gamma Ray Spectrometer (EMWD-GRS) system represents an innovative blend of new and existing technology to produce the capability of providing real-time environmental and drill bit data during drilling operations. These real-time measurements provide technical data for field screening (i.e., ability to "steer" the drill bit in or out of contaminated zones). There are also time, cost, and safety advantages to using the field screening approach of the EMWD-GRS system: (1) data on the nature of contamination is available in minutes, as opposed to weeks or months for offsite confirmatory analysis; (2) substantial cost savings result by minimizing the number of samples required for off-site confirmatory analyses; and (3) worker safety is enhanced through the minimization of waste generated during drilling and by quickly alerting field personnel to potentially hazardous conditions; and (4) reduction in investigation derived waste (IDW).

## 1.1 Technology Demonstration Purpose and Objectives

During development, the EMWD-GRS system was tested at the U.S. Department of Energy (DOE) radiation test facility in Grants, New Mexico, and at the directional boring test site owned by Charles Machine Works in Perry, Oklahoma. Demonstration at the Savannah River Site (SRS) F-Area Retention Basin will provide EMWD-GRS system performance data under field conditions at a previously characterized "hot" site. The system's real time measurements of radionuclide contaminant presence will be compared to radionuclide contaminant levels previously determined through soil sampling and laboratory analysis.

## 1.2 Predemonstration Arrangements

During October of 1995, a representative of Westinghouse Savannah River Company (WSRC) contacted Sandia National Laboratories (SNL), the EMWD-GRS system technology developer, about demonstrating the system at the SRS. During November 1995, representatives of SNL and Westinghouse Savannah River Company met and developed a draft agreement to demonstrate the system at the SRS near Aiken, South Carolina.

## 1.3 Demonstration Site

The site selected for the demonstration is the previously characterized F-Area Retention Basin located outside and south of the F-Area perimeter fence and east of building 281-8F of the SRS. The basin is approximately 200 ft (61 m) long, 120 ft (36.5 m) wide, and 6.9 feet (2 m) deep and has a total volume capacity of approximately 6,128 cubic yards (4,685 $m^3$). This basin was constructed as an unlined, temporary container for potentially contaminated cooling water from the chemical separations process and storm sewer drainage from the F-Area Tank Farm. When contamination was detected in cooling water, the water was diverted to the retention basin or F-Area seepage basins. Additional contamination of this basin came from various spills or overflows at the basin (WSRC, 1995). The basin was in active use from 1955 until 1972, when it was replaced by a lined retention basin located to the west of the site. In 1978, the F-Area Retention Basin was excavated, backfilled with soil, and covered with grass. At that time, a process sewer line which extended from the basin to a diversion box located approximately 500 feet (152 m) north of the basin was abandoned. The site was evaluated through soil sampling in early 1979. The major radionuclides present included Strontium (Sr)-89/90 and Cesium (Cs)-137. Sampling results indicated maximum Cs-137 concentrations of 1,410 pCi/g in the berm and 430 pCi/g in the basin floor. Maximum Sr-89/90 concentrations in the basin berm were 1,000 pCi/g (WSRC, 1995).

## 1.4 Demonstration Schedule

The agreement formally authorizing the demonstration was submitted to the Department of Energy-Savannah River (DOE-SR) on March 8, 1996. The demonstration is scheduled for April 22-26, 1996.

## 1.5 Demonstration Participants

Demonstration participants include DOE-SR, DOE-Albuquerque, Westinghouse Savannah River Company, and Sandia National Laboratories.

The demonstration is being conducted by SNL at the DOE-SR facility near Aiken, South Carolina. Site access and associated logistics will be performed by Westinghouse Savannah River Company. Health-and-safety officer oversight will be performed by SNL personnel.

# 2.0 DEMONSTRATION RESPONSIBILITIES AND COMMUNICATION

This section identifies the organizations involved in this demonstration and describes the primary responsibilities of each organization. The section also details the methods and frequency of communication to be used to coordinate the demonstration.

## *2.1 Demonstration Participants*

This demonstration is being conducted at the DOE-SR facility near Aiken, South Carolina. Site access and associated logistics will be performed by Westinghouse Savannah River Company. Heath-and-safety-officer oversight will be performed by SNL personnel. The organizational structure for the demonstration showing lines of communication is provided in Figure 1.

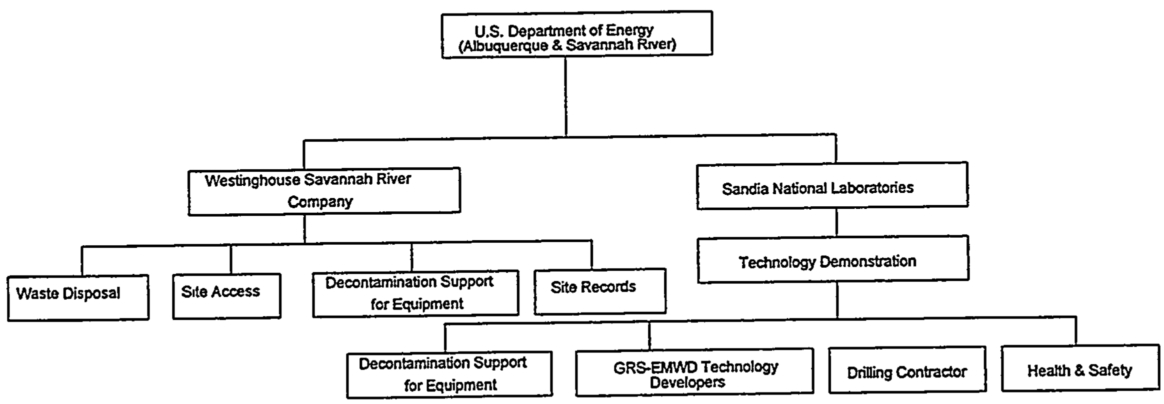



Figure 1. Demonstration organizational structure.

SNL and Westinghouse Savannah River Company personnel participating in this demonstration are listed in Table 1. The specific responsibilities of SNL and Westinghouse Savannah River Company are discussed in Section 2.2.

**Table 1. Demonstration Participant Information**

| Name | Affiliation | Responsibility | Mailing Address | Telephone Number | Fax Number | E-mail Address |
|---|---|---|---|---|---|---|
| Cecelia V. Williams | SNL | Project Leader / QA Manager/ Site Safety Officer | P.O. Box 5800 Albuquerque, NM 87185-0719 | (505) 844-5722 | (505) 844-0543 | cvwilli@sandia.gov |
| Grant J. Lockwood | SNL | Field Team Leader | P.O. Box 5800 Albuquerque, NM 87185-0719 | (505) 845-7007 | (505) 845-7244 | gjlockw@sandia.gov |
| Randy A. Norman | SNL | Technology Operator | P.O. Box 5800 Albuquerque, NM 87185-0719 | (505) 845-9675 | (505) 844-3952 | ranorma@sandia.gov |
| John Hall | Geneva Corp-Ditch-Witch™ of Georgia | Drilling Contractor | 4891 Clark Howell Hwy College Park, GA 30349 | (404) 761-0619 | (404) 761-4095 | None |
| Personnel | SNL | Decontamination Support for Equipment | N/A | N/A | N/A | N/A |
| Pete Zionkowski | WSRC | Technical Demonstrations Manager | Westinghouse Savannah River Company Savannah River Site Aiken, SC 29808 | (803) 952-6487 | (803) 952-6538 | peter.zionkowski@srs.gov at hubsmtp |
| Ahmet Suer | WSRC | Technical Contact | Westinghouse Savannah River Company Savannah River Site Aiken, SC 29808 | (808) 952-8306 | (803) 952-6538 | ahmet.suer@srs.gov at hubsmtp |
| Kevin Kuelske | WSRC | Facility Project Manager | Westinghouse Savannah River Company Savannah River Site Aiken, SC 29808 | (803) 952-6516 | (803) 952-6538 | kevin.kuelske@srs.gov at hubsmtp |
| Personnel | WSRC | Radiological Control Operations (RCO) Coverage and Support | N/A | N/A | N/A | N/A |
| Personnel | WSRC | Decontamination Support for Equipment | N/A | N/A | N/A | N/A |

## 2.2 Responsibilities

Sandia National Laboratories personnel have the following responsibilities for the demonstration:

- designing and preparing the demonstration plan;
- developing a quality assurance project plan (QAPP) (Section 7 of the demonstration plan);
- detailing procedures for using the technology;
- providing demonstration technology;
- providing drilling subcontractor for performance of the demonstration (decontamination of driller's equipment is the responsibility of the drilling contractor);
- operating and monitoring the EMWD-GRS system during the demonstration;
- documenting the experimental methodology and operation of the EMWD-GRS system during the demonstration;
- reducing and interpreting data, as required;
- providing site health & safety officer; and
- preparing a final report detailing demonstration results.

Westinghouse Savannah River Company personnel have the following responsibilities for the demonstration:

- providing site access;
- providing radiological control operations (RCO) coverage and support;
- providing a health and safety plan (HASP) (Section 9 of the demonstration plan) for the demonstration activities;
- providing health and safety information;
- providing site characterization information;
- providing site characterization confirmatory analysis data;
- providing other logistical information and support needed to coordinate access to the site for the field portion of the demonstration; and
- Providing decontamination support for equipment and disposal of investigation derived waste (IDW).

## 2.3 Communication

Both SNL and Westinghouse Savannah River Company have primary points of contact. These points of contact are:


SNL
Cecelia V. Williams — Phone: (505) 844-5722; Fax: (505) 844-0543

Westinghouse Savannah River Company
Pete Zionkowski — Phone: (803) 952-6487 or (803) 952-6538

Ahmet Suer - Technical Contact — Phone: (803) 952-8306; Fax: (803) 952-6538


## 2.4 Personnel Locations

Personnel actively participating on-site in the field portion of the EMWD-GRS technology demonstration are from SNL, Westinghouse Savannah River Company, and Geneva Corporation-Ditch-Witch™ of Georgia.

All SNL personnel are located in Albuquerque, New Mexico. All Westinghouse Savannah River Company personnel are located in Aiken, South Carolina. The drilling contractor, Geneva Corporation-Ditch-Witch™ of Georgia, is located in College Park, Georgia.

# 3.0 PREDEMONSTRATION ACTIVITIES

## *3.1 Site Selection*

The site was selected based on site availability, access, and previous site characterization that documented the presence of radionuclide-contaminated soils.

## *3.2 Predemonstration Site Characterization*

The F-Area Retention Basin site was initially characterized in 1979 by surveying 53 soil cores in the field for the presence of radionuclide species. Ten of the cores were chosen for further evaluation in the laboratory because of high levels of radioactivity (Scott et al., 1987 and WSRC, 1994a). Subsequent investigations include (WSRC 1994a):

- Phase I investigation (1993-1994)—collection and analysis of soil samples to determine potential contaminants of concern (COC) and their approximate concentrations in the soils and backfill;
- Phase 1A investigation (July 1994)—collection and analysis of background soil and groundwater samples from the groundwater aquifer in the vicinity of the basin and implementation of a video and radiological survey of the internal surfaces of the associated abandoned process line;
- Phase II Remedial Investigation (RI) (in progress)—to define the extent and magnitude of radiological substance release to environmental media surrounding the F-Area Retention Basin and associated process line (WSRC, 1994a). This investigation has documented the radionuclide contamination within the basin through soil sampling and laboratory analysis (Figure 2) (WSRC, 1995).

The two daylight-to-daylight boreholes to be drilled and monitored for radionuclides in real-time will pass near sampled locations FRB-05, 06, 07, and 08. The borehole that passes near FRB-05 and 06 will also pass near FRB-19.

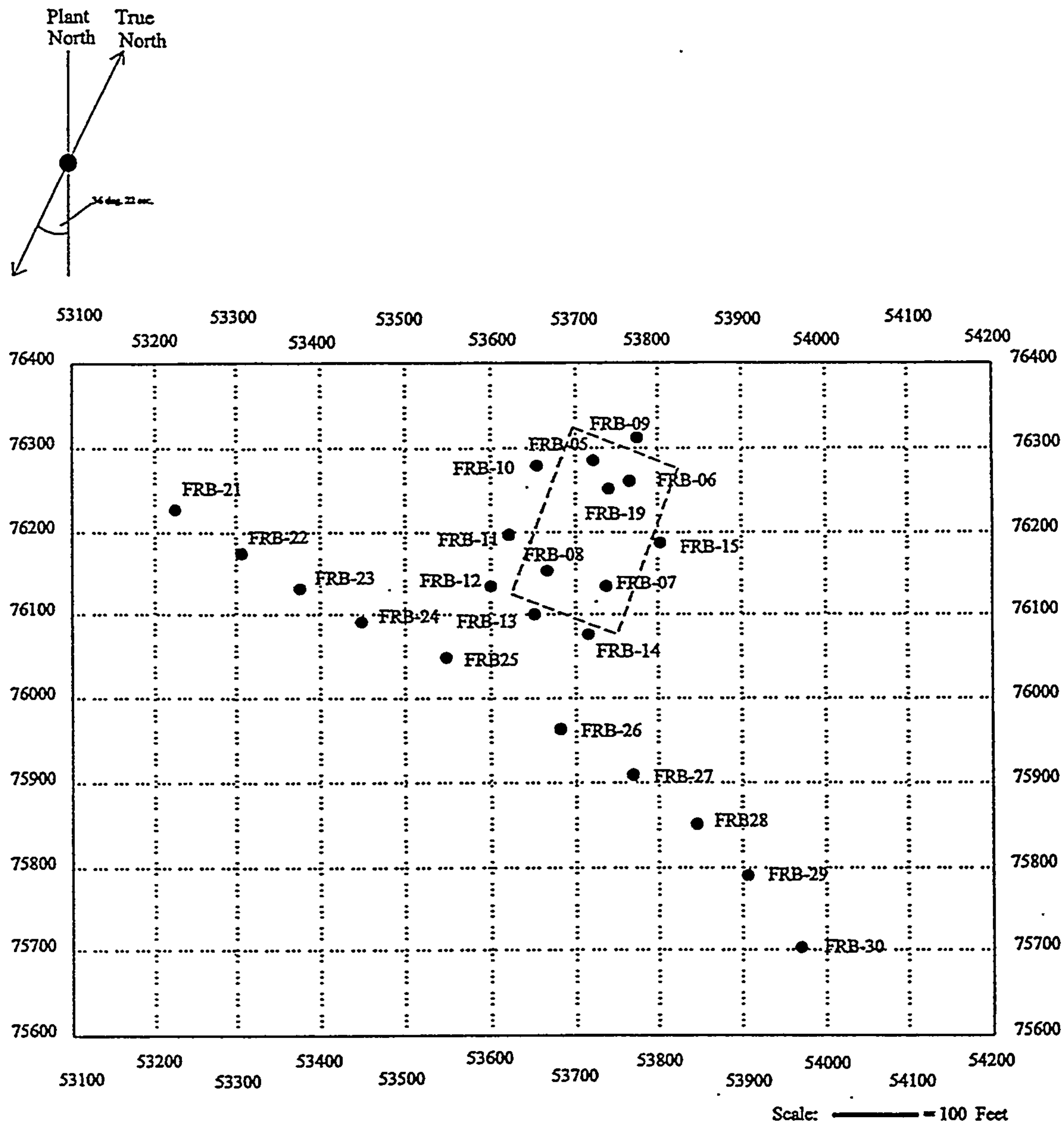



Figure 2. Soil sampling sites in and around the F-Area Retention Basin (WSRC, 1995).

# 4.0 TECHNOLOGY DESCRIPTION

Sampling during environmental drilling is essential for complete characterization of the spatial distribution and migration of near surface contaminants. However, analysis of these samples is not only expensive, but also can take weeks or months when sent to an off-site laboratory. In contrast, the environmental measurement-while-drilling (EMWD) screening capability saves money and time by quickly distinguishing between contaminated and uncontaminated areas. Real-time measurements provided by a EMWD -Gamma Ray Spectrometer (GRS) system would enable on-the-spot decisions about sampling strategies and would enhance worker safety. The system also provides the added flexibility of being able to "steer" the drill bit into or out of hazardous zones.

## *4.1 Technology Capabilities*

The EMWD-GRS system is compatible with a directional drilling technique that uses minimal drilling fluids and generates little or no secondary waste. The down-hole sensors are located behind the drill bit and are linked by a high-speed data transmission system to a computer at the surface. Sandia-developed, Windows™-based software is used for data display and storage. As drilling is conducted, data are collected on the nature and extent of contamination. Data are instantly accessible for on-the-spot decisions about drilling and sampling strategies. The system also has the capability of being able to "steer" the drill bit into or out of hazardous zones.

## *4.2 The EMWD-GRS System*

### 4.2.1 Basic System Operation

The system is comprised of four parts: a computer, magnetic pickup coil and receiver, battery pack and magnetic coil, and a down-hole electronics package. The electronics package, complete with a gamma ray spectrometer, multichannel analyzer, and coaxial coil, is located inside the drill rod next to the drill bit. The coil provides both direct current (DC) power and alternating current (AC) signal paths between the surface and the down-hole electronics package. Figure 3 shows the instrumentation mounting locations on a typical drill rig.

Figure 4 shows drilling steps. As the drill string is lengthened by adding drill rod, the coaxial cable is unspooled. The unspooled cable is attached to the battery pack and coil. The latter are mounted on the rotating drill pipe which extends behind the hydraulic head. The coil couples the AC signal between the rotating drill pipe and the stationary coil and receiver, which are mounted on the drilling platform. The receiver converts the AC signal into a serial bit stream. A computer equipped with a telemetry serial card receives the data and displays down-hole measurements in real time.

### 4.2.2 System Adaptability

The electronics package, located near the drill bit, is easily adaptable to different sensors or data formats. Adaptability is gained by using an Actel 1020B programmable logic

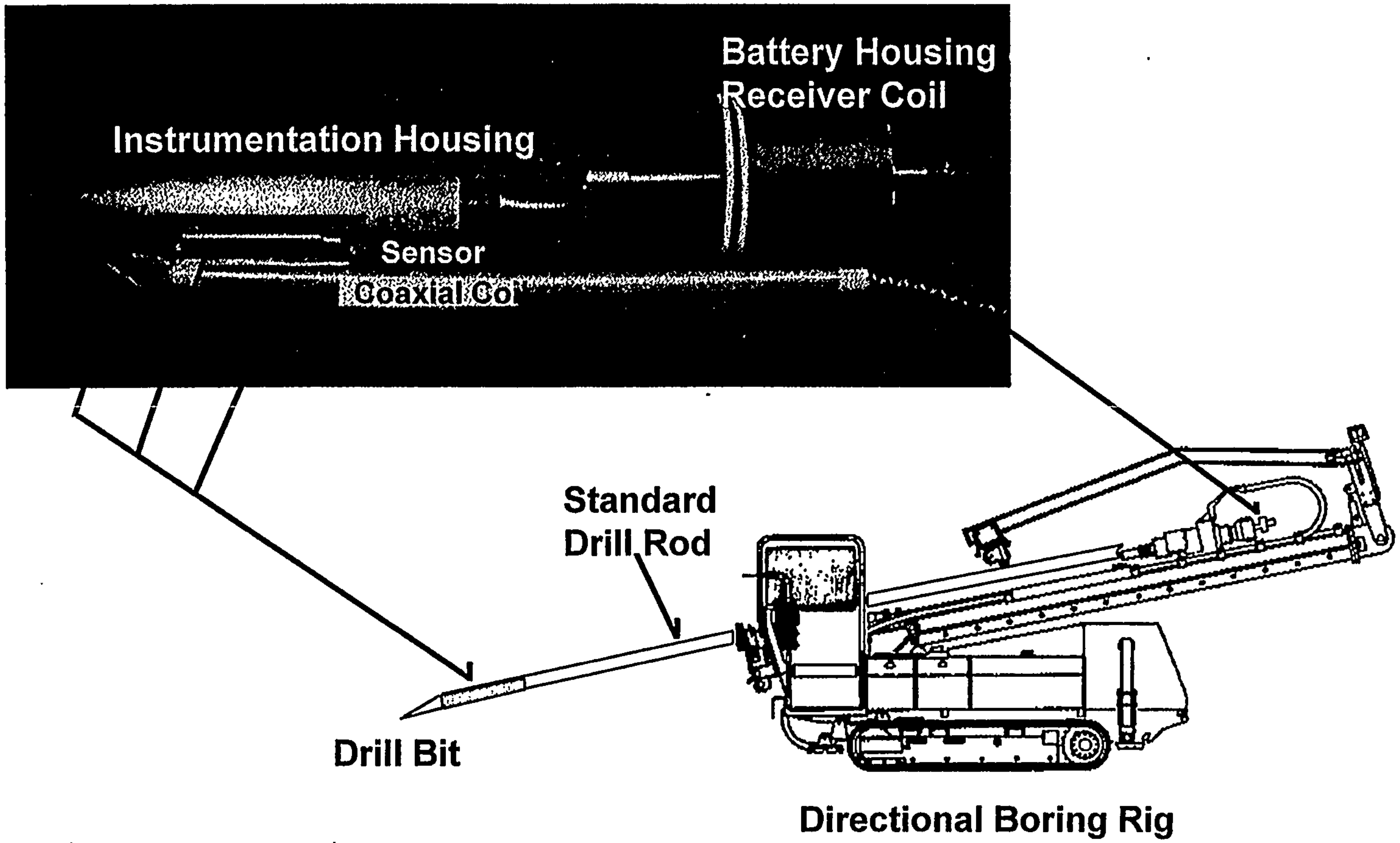



Figure 3. EMWD-GRS system component placement on typical directional boring rig.

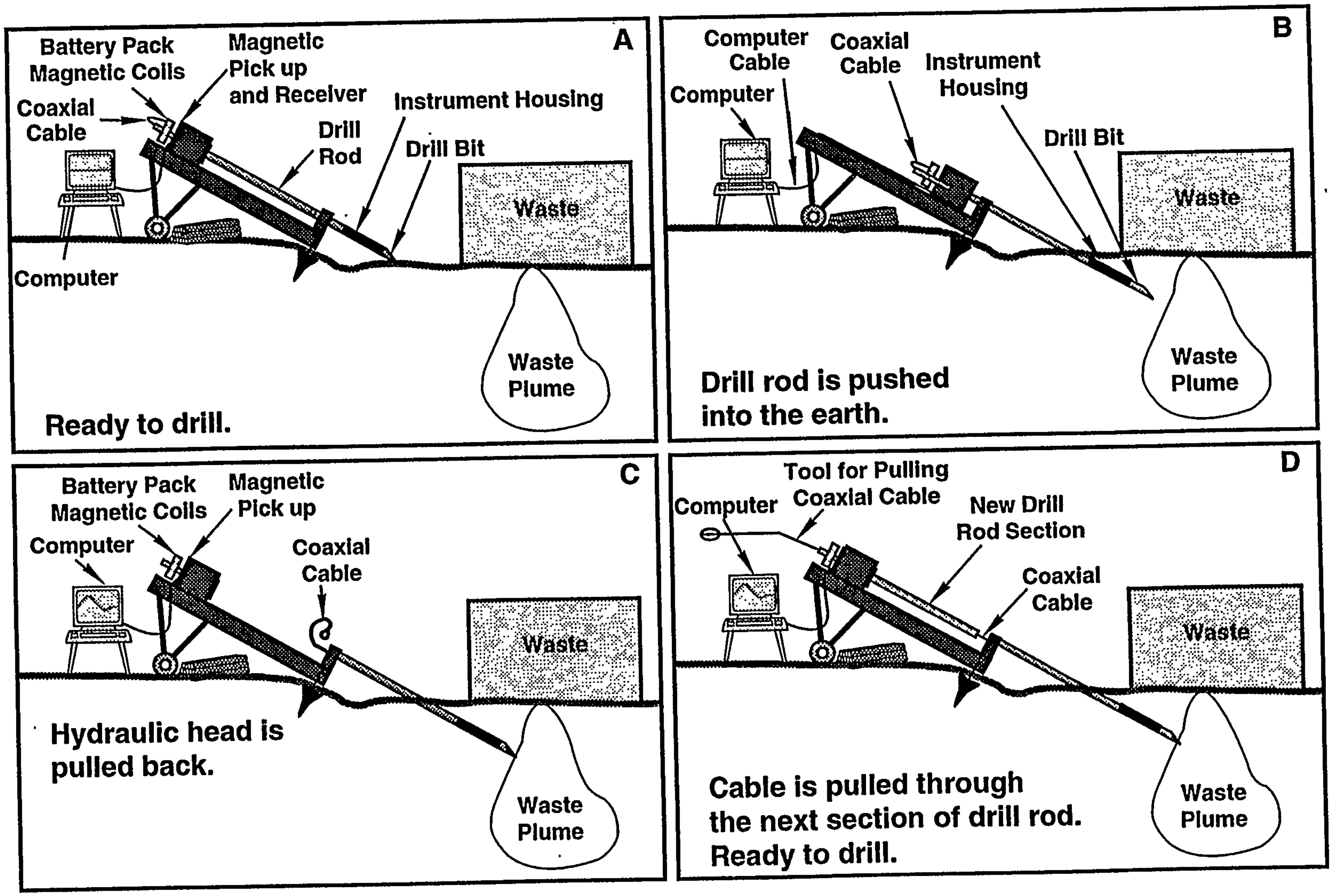



Figure 4. The Environmental Measurement-While-Drilling process using a coaxial spool.

array. This small-surface mounted integrated circuit (IC) contains some 2000 logic gates. The Actel 1020B controls the data-stream format, logic clock, and circuit interfaces. The Actel 1020B is programmed to provide the serial bit stream as bi-phase and non-return to zero (NRZ) digital. These two formats cover a wide range of communications systems including fiber optic, hardwire, and radio frequency (RF).

The system has a bit rate of 2400 bps. However, the bit rate can be increased easily. A practical limit to this FM system is ~ 30,000 bps. However, if the signal coupling at the surface continues to be strong and noise-immune, the Actel bi-phase output could drive the coaxial system directly. The bi-phase data rate could exceed 100,000 bps. Data rates that high are approaching imaged data requirements.

Another important attribute of adaptability is to provide different supply voltages for different sensors. Only battery power (30V) is supplied on the coaxial cable. Once received, this voltage is converted to four different voltages: +12V, -12V, +5V, and -5V. A DC-to-DC converter generates these different voltages. The converter increases battery life by reducing current drain from the batteries and allowing the battery voltage to range from 18V to 32V without affecting sensor electronics. A second DC-to-DC converter generates the 900V GRS bias voltage. Current requirement for the down-hole electronics is only 32 ma @ 30V.

### 4.2.3 Drilling Platform

The drilling platform for this demonstration is a J2511, a directional boring system using minimal drilling fluid and fluid mizer pipe. The boring system is supplied by Geneva Corporation-Ditch-Witch™ of Georgia. This system uses a high-frequency electromagnetic beacon with a walk-over monitor to measure drill bit location and depth.

### 4.2.4 Down-hole Components

Down-hole components of the gamma ray detection sensor system being demonstrated consist of a gamma ray spectrometer, a multichannel analyzer, a 900V power supply, a signal conditioning and transmitter board, and a coil containing coaxial cable for transmitting data to the surface. The down-hole components are contained within O-ring sealed aluminum tubes to protect them from the drilling environment.

### 4.2.5 Up-hole Components

The up-hole system consists of a battery pack/coil, pickup coil, receiver, and a personal computer. During drilling, the system monitors (1) gamma radiation by gamma ray spectrometry, (2) the +12V and -12V required at the down-hole signal conditioning and transmitter board, (3) the up-hole battery voltage as measured down-hole, and (4) two temperatures associated with the detector and instrumentation.

Since human safety is a primary consideration, reliability and high data surety are priority system requirements. To meet this requirement, the system design incorporates data quality assurance techniques to ensure data reliability. The basic format used in the EMWD-GRS system is also used in the weapons complex for very high data surety where destructive testing may cost hundreds of millions of dollars and getting "one shot" reliable data is imperative.

### 4.2.6 Cable Deployment System

The cable is contained in a spool located with the down-hole components of the system. The cable passes through the drill pipe and connects to the up-hole components. The cable is threaded through each added section of drill pipe and unspools as the drill pipe is advanced. The cable from the down-hole instrument package is pulled through each piece of drill pipe and through the drill head to the battery pack/coil mounted on a spindle at the rear of the drill head. Because the cable connection must pass through the drill pipe, which is restricted to about 5/16" (7.9 mm) at each pipe section pin, a 0.25" (6.35 mm) outside diameter (OD) Lemo coaxial connector is used. The cable is sealed as it passes through the spindle at the battery pack/coil. The spindle leads to the drill fluid handling system. Drill fluid pressure is normally in the range of 300 psi (1.435 kPa) to 500 psi (2.392 kPa), but can go as high as 1500 psi (7.177 kPa). A cord grip fitting is used to seal against the 0.07" (1.8 mm) OD coaxial cable. The sealing grommet in the cord grip fitting is slit so that it can be removed from the cable, allowing the connector to pass through the body of the cord grip fitting. This arrangement has been tested to 600 psi (2.871 kPa) air, which is approximately 3000 psi (14.354 kPa) water, without leakage. The coaxial cable is pulled through each section of drill pipe using a 16 ft (4.88 m) long, ¼" (6.35 mm) diameter rod fashioned from two pieces of aluminum rod threaded together. A tip consisting of steel wire bent backward acts as a flexible guide as the rod is inserted through the drill head and pipe from the spindle to the instrument housing. This guide tip is replaced with a tip containing the mating Lemo connector. Thus, the cable is unspooled and is pulled through the drill pipe and head as the rod is withdrawn. The time required to add a new section of pipe, deploy the cable, and prepare to acquire data is an important parameter for evaluating the system's total performance.

### 4.2.7 Data Collection System

The data collection system is comprised of four parts: a computer, magnetic pick-up coil and receiver, battery pack and magnetic coil, and the down-hole electronics package. The coil couples the AC signal between the rotating drill pipe and the stationary coil and receiver, which are mounted on the drilling platform. The receiver converts the AC signal into a serial bit stream. A computer equipped with a telemetry serial card receives the data and displays down-hole measurements in real time.

The EMWD system provides real-time data on an 8 differential/single analog multiplexer and any number of digital channels. Sampling speed from analog channels can reach 100 kHz. For the EMWD-GRS system, three digital channels are used. Readings are taken at a rate of 20 per second. The telemetry system is programmable firmware that can easily support many different data formats and additional data channels. The current format (Digital FM Bi-phase, 4800 baud) provides excellent noise rejection. A SNL-designed receiver removes FM carrier noise, generates data clock, and buffers data for use by an IBM or compatible personal computer. A 28V rechargeable battery pack can supply down-hole instrumentation power for more than 18 hours of drilling. A DC to DC converter increases battery life by reducing battery current drain and allowing the battery voltage to range from 18 to 32V without affecting sensor electronics and data quality. The battery pack remains topside for easy maintenance.

**This Page Intentionally Left Blank**

# 5.0 DEMONSTRATION SITE DESCRIPTION

## 5.1 Site Name and Location

The selected demonstration site is the previously characterized SRS F-Area Retention Basin. It is located outside and south of the F-Area perimeter fence and east of building 281-8F and the Effluent Treatment Cooling Water Basin of the Savannah River Site near Aiken, South Carolina (Figure 5).

## 5.2 Site History

The F-Area Retention Basin was constructed as an unlined, temporary container for potentially contaminated cooling water from the chemical separations process and storm sewer drainage from the F-Area Tank Farm. The basin is approximately 200 ft (61 m) long, 120 ft (35.6 m) wide, and 6.9 feet (2 m) deep and has a total volume capacity of approximately 6,128 cubic yards (4,685 $m^3$). When contamination was detected in the cooling water, the water was diverted to the retention basin or F-Area seepage basins. Contamination of this basin came from contaminated cooling water as well as from various spills or overflows at the basin (WSRC, 1995). The basin was in active use from 1955 until 1972, when it was replaced by a lined retention basin located to the west of the site. In 1978, the F-Area Retention Basin was excavated, backfilled with soil and covered with grass. A process sewer line which extended from the basin to a diversion box located approximately 500 ft north of the basin was abandoned. The site was evaluated through soil sampling in early 1979. The major radionuclides present included strontium (Sr)-89/90 and cesium (Cs)-137. Sampling results indicated maximum Cs-137 concentrations of 1,410 pCi/g in the berm and 430 pCi/g in the basin floor. Maximum Sr-89/90 concentrations in the basin berm were 1,000 pCi/g (WSRC, 1995).

## 5.3 Site Characteristics

The F-Area Retention Basin was backfilled and covered with grass during 1978. Backfill in the basin extends to a depth of approximately 10 ft (3 m). The site is at an elevation of approximately 269 ft (82 m) in an area of level to slightly sloping topography. Surface drainage from the surrounding area flows toward Four Mile Branch, located approximately 3,937 ft (1200 m) to the south (Figure 6). The slope toward Four Mile Branch is very gentle in the area of the basin, but becomes steeper near Four Mile Branch (Scott et al., 1987).

### 5.3.1 General Savannah River Site Geology

As described by GeoTrans, Inc. (1992), the SRS is situated in the Upper Atlantic Coastal Plain Province on what is known locally as the Aiken Plateau. The elevation of this plateau varies from 270 to 400 ft (82 to 122 m) above mean sea level (msl). Numerous streams have dissected the plateau into broad interstream uplands with narrow, steep-sided valleys. The geologic units range from Cretaceous to Recent in age and consist primarily of unconsolidated, interbedded gravels, sands, silts, and clays that were deposited upon a sloping crystalline basement and/or Triassic bedrock. This wedge of sediments exhibits a gentle dip and a general increase in thickness to the southeast. Individual units display variable thickness and limited aerial extent. Figure 7 presents the stratigraphic units underlying the SRS.

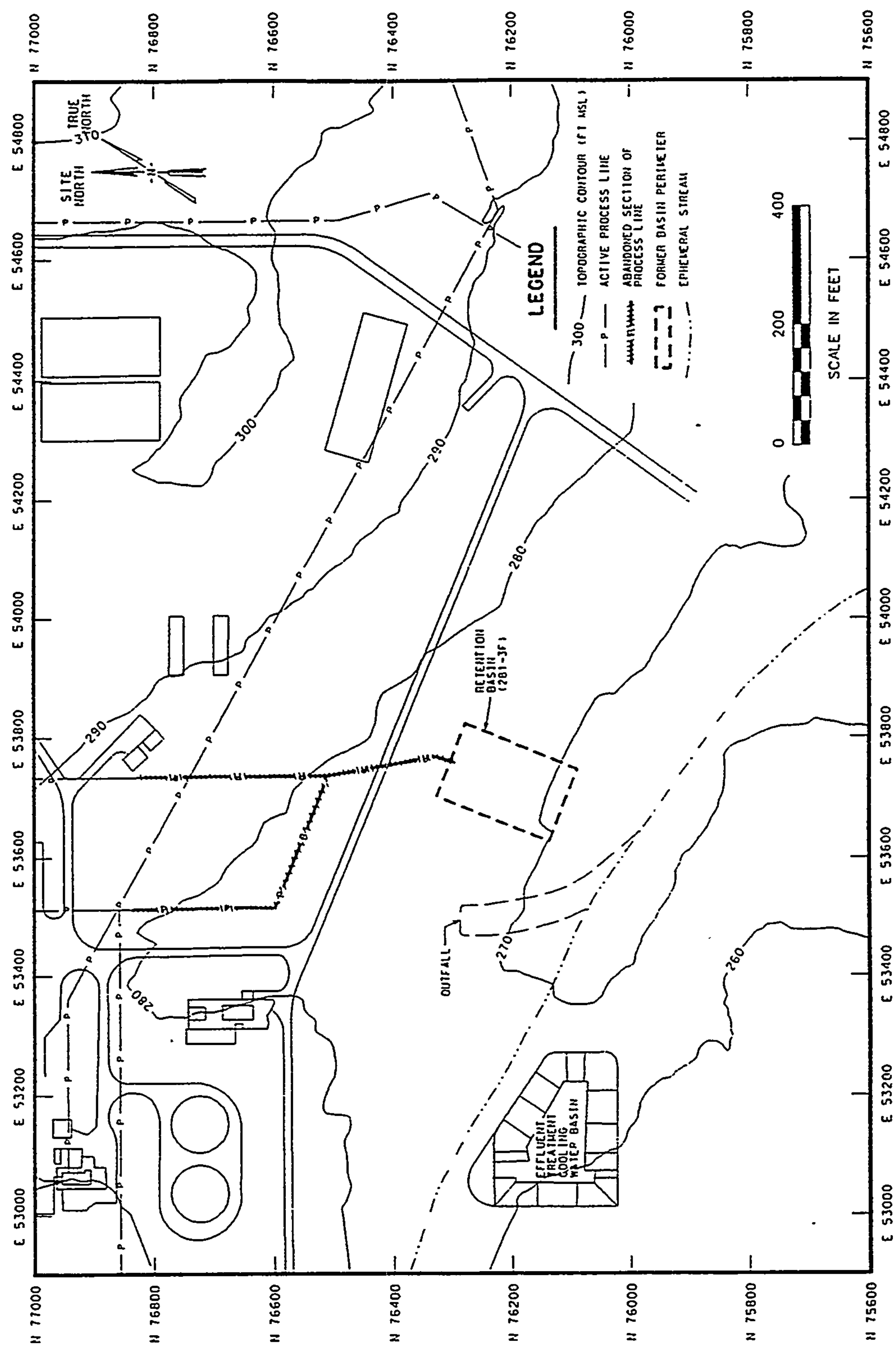



Figure 5. Location of Savannah River site F-Area Retention Basin (WSRC, 1994a).

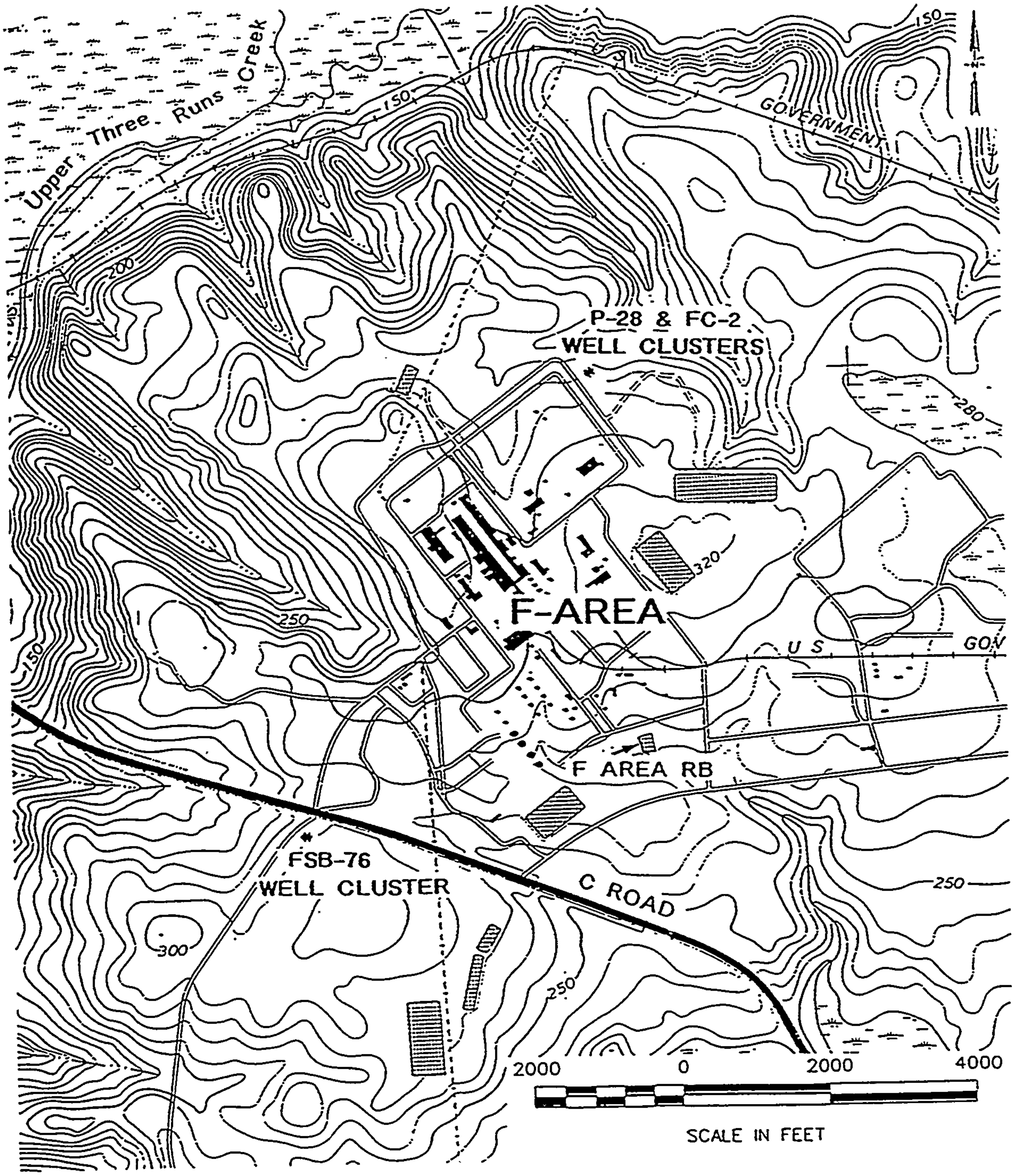



Figure 6. Topographic map of F-Area Retention Basin and surrounding area (WSRC, 1994a).

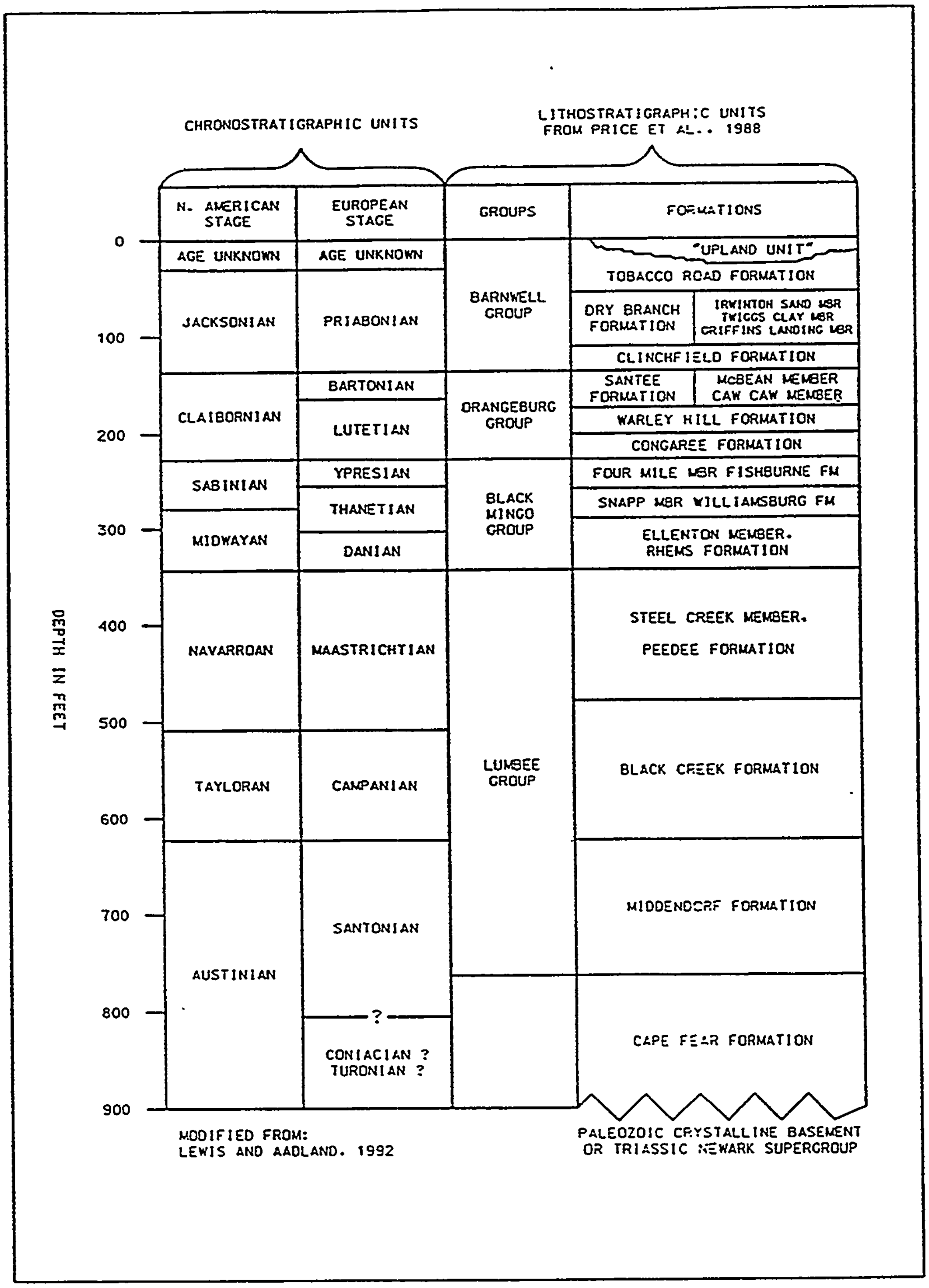



Figure 7. General stratigraphic units underlying the Savannah River Site (WSRC, 1994a).

The near surface sediments at SRS are identified as the Tobacco Road Formation and the "upland unit." The Tobacco Road Formation consists of clays, silty clays, and massive sands. The "upland unit," a mapable stratigraphic unit which caps most of the upland areas at SRS, varies in lithology from coarse gravels to silty clays (WSRC, 1994a).

### 5.3.2 F-Area Retention Basin Site Soils

Geotechnical analysis of the soils at the F-Area Retention Basin was not available during the development of this demonstration plan. As discussed in Section 5.3.1, the near surface soils range from coarse gravels to silty sands. Soils in the vicinity of the F-Area Retention Basin are expected to range from clays to sands.

### 5.3.3 Site Hydrogeology

The hydrogeologic system at the SRS is comprised of both unconfined and confined aquifers. Figure 8 presents a comparison of the hydrostratigraphic units that have been used at SRS. Discussion of hydrogeology in this section is limited to the water table aquifer since the EMWD-GRS system will be demonstrated above the water table within in the vadose zone. Depth to groundwater at the site is approximately 70-85 ft (21.3-25.9 m) based on second quarter 1990 groundwater data; however, studies conducted over the years indicate that the water table could be as shallow as 52 ft (15.8 m), depending on precipitation (WSRC, 1994a).

There are only three water table monitoring wells (FM series) at the F-Area Retention Basin, and all are positioned down gradient and to the southeast, southwest, and west of the F-Area Retention Basin (Figure 9). These wells are part of a series of ten water table wells installed in late 1961 using aluminum casing and reportedly are no longer monitored (WSRC, 1994a). The nearest routinely monitored water table wells down gradient to the basin are the FET series wells. The FET series wells surround the effluent treatment cooling water basin located approximately 400 ft (122 m) southwest.

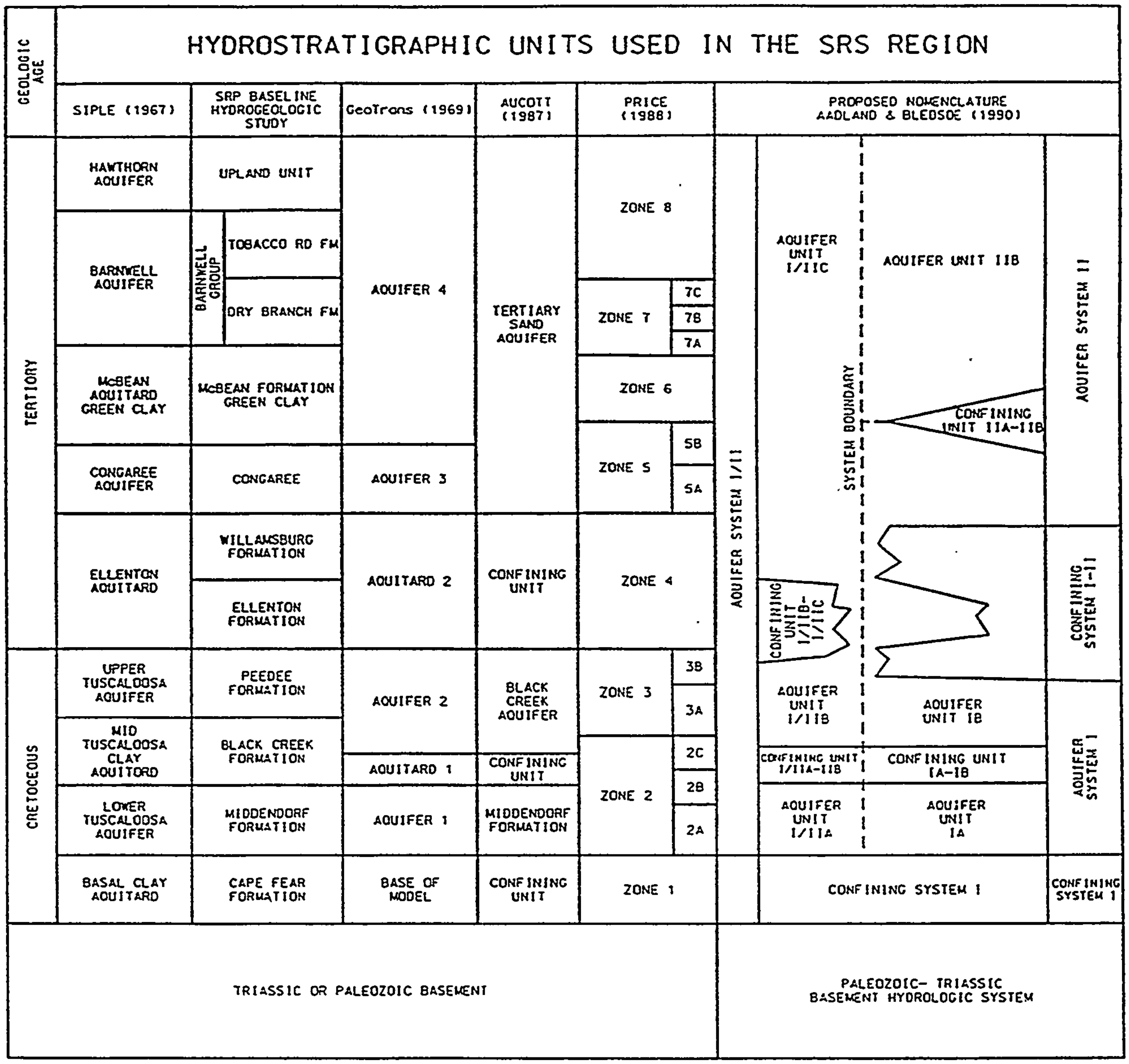
Groundwater data collected in 1993 through the SRS groundwater monitoring program indicated that the water table aquifer underlying the basin flows to the southwest (Figure 10). The hydraulic gradient of the water table is approximately 0.01 ft/ft (0.003 m/m) to the southwest based on 1993 first quarter groundwater data and as calculated from Figure 10 (WSRC, 1994a).

### 5.3.4 Site Contaminants and Distribution

All soil samples collected during the Phase I and IA investigations were analyzed for:

- Inorganics/metals
- Organics
- Radionuclide indicators and radionuclides

Analytical results for samples collected to determine background levels are found in Appendix A.




MODIFIED FROM AADLAND & BLEDSOE, 1990.

Figure 8. Hydrostratigraphic units underlying the Savannah River Site (WSRC, 1994a).

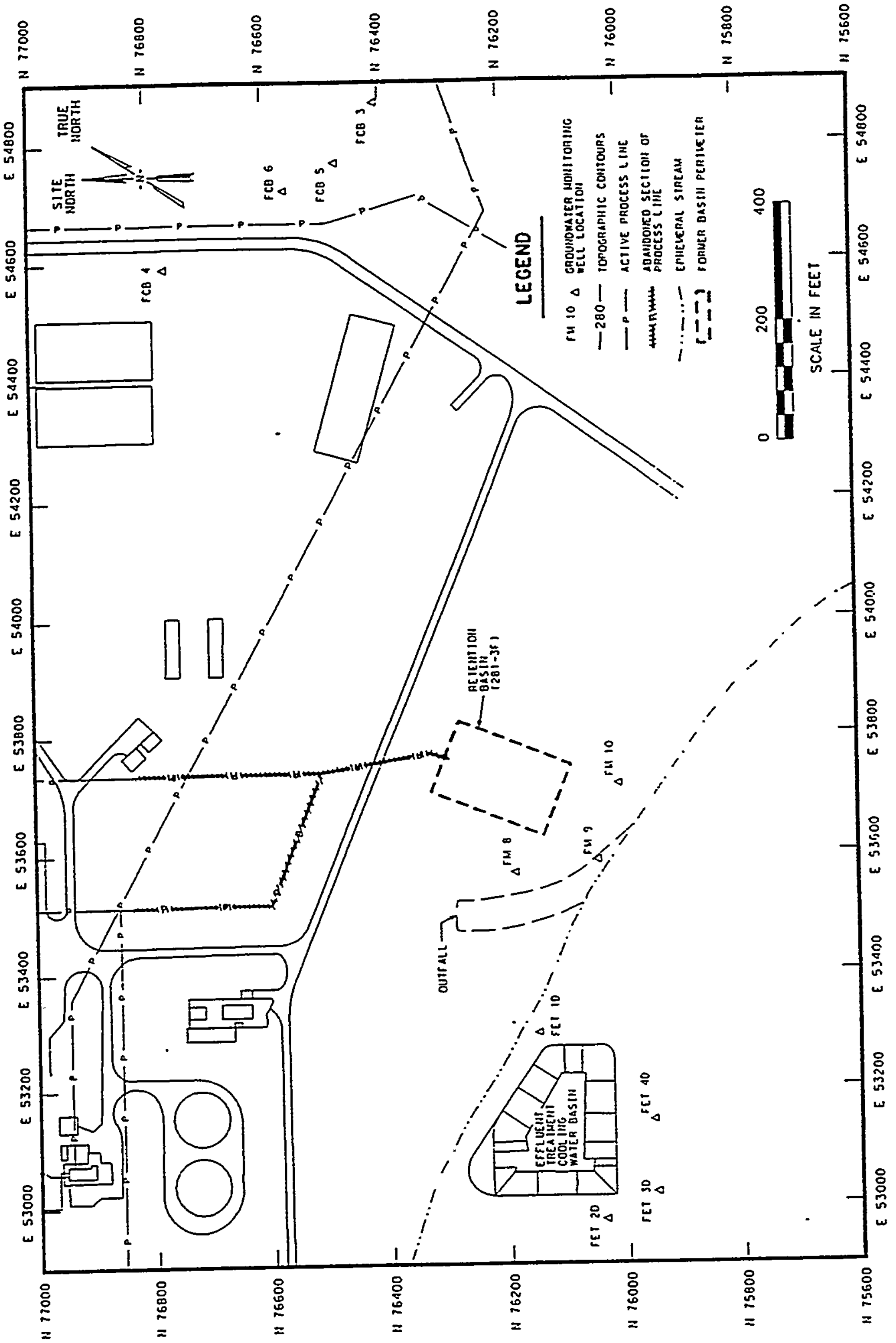
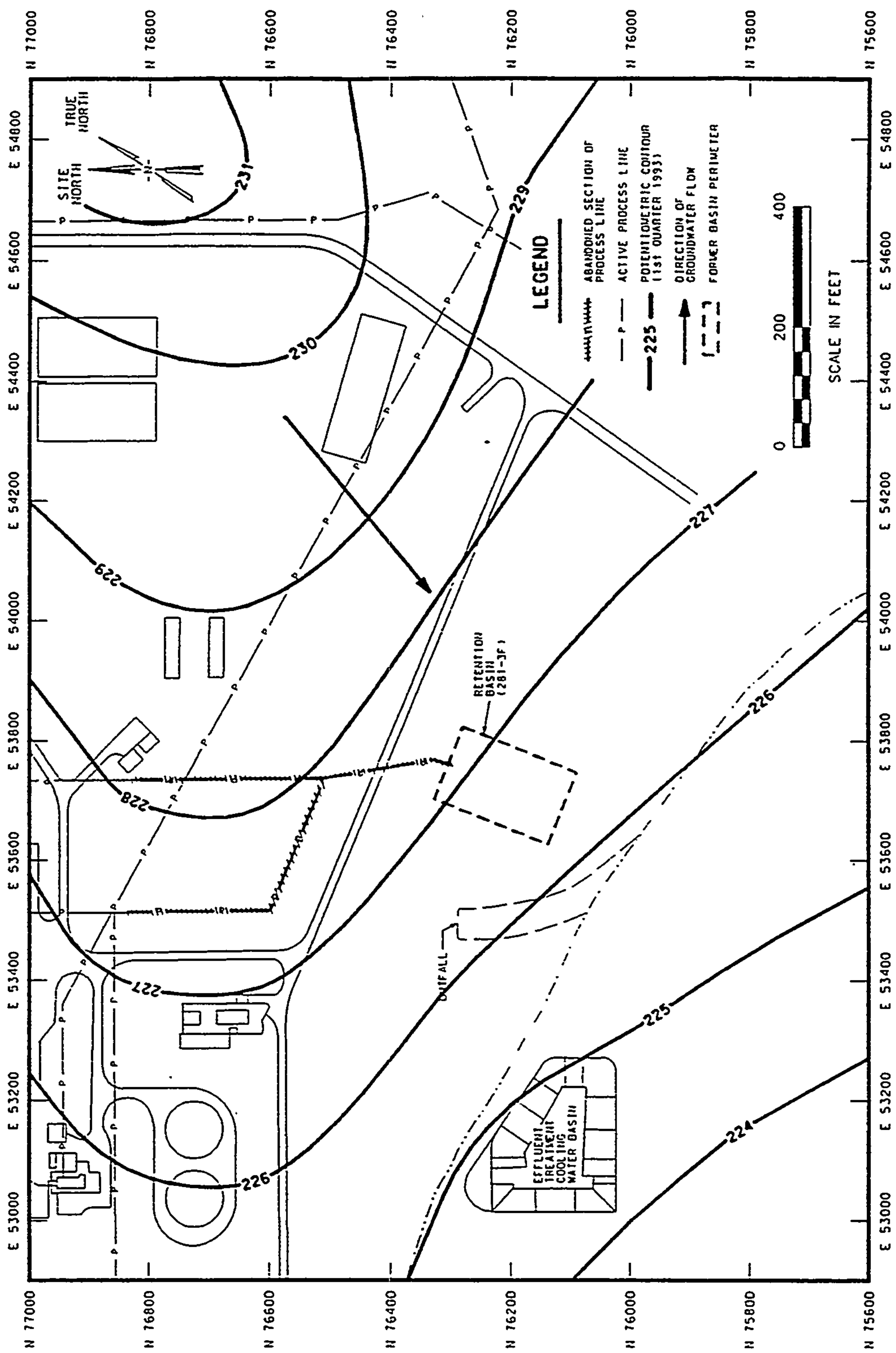



Figure 9. Location of groundwater monitoring wells in the vicinity of the F-Area Retention Basin (WSRC, 1994a).




Source: adapted from GSA Water Table Surface Open File Map, 1Q93 Data

Figure 10. Potentiometric surface of the water table (Aquifer Unit IIB) at the F-Area Retention Basin (281-3F) (WSRC, 1994a).

Results of the Phase I and Phase IA investigations were used to identify contaminants of concern (COC) in the F-Area Retention Basin (WSRC, 1994a). The identified COCs for the F-Area Retention Basin are listed in Table 2.

**Table 2. Contaminants of Concern at the SRS F-Area Retention Basin (WSRC, 1994a)**

| Radionuclides | Organics | Metals |
|---|---|---|
| Tc-99 | Carbon Disulfide | Barium |
| Cesium-137 | Di-n-Butyl Phthalate | Beryllium |
| Strontium-90 | N-nitrosodiphenylamine | Lead |
| Carbon-14 | Di-benzofuran | Nickel |
| Americium-241 | Toluene | Thallium |
| Cobalt-60 | Methylene chloride | Arsenic |
| Barium-133 | TCE | Chromium |
| Europium-154 | 2 Chloro phenol | |
| Potassuim-40 | | |
| Uranium-238 | | |
| Nickel -63 | | |
| Plutonium-239/240 | | |
| Radium-226 | | |
| Iodine-129 | | |

Radionuclide contaminant distributions for Cs-137 and Sr-90 at sample locations FRB-05, 06, 07, 08, and 19 are shown in Figures 11 and 12. As illustrated, the greatest concentrations of Cs-137 occur between the depths of 9 and 19 feet (Figure 11). The greatest concentrations of Sr-90 fall within the depth range of 9 to 28 feet (Figure 13). Analytical results for sample locations FRB-05, 06, 07, 08, and 19 are listed in Appendix B.

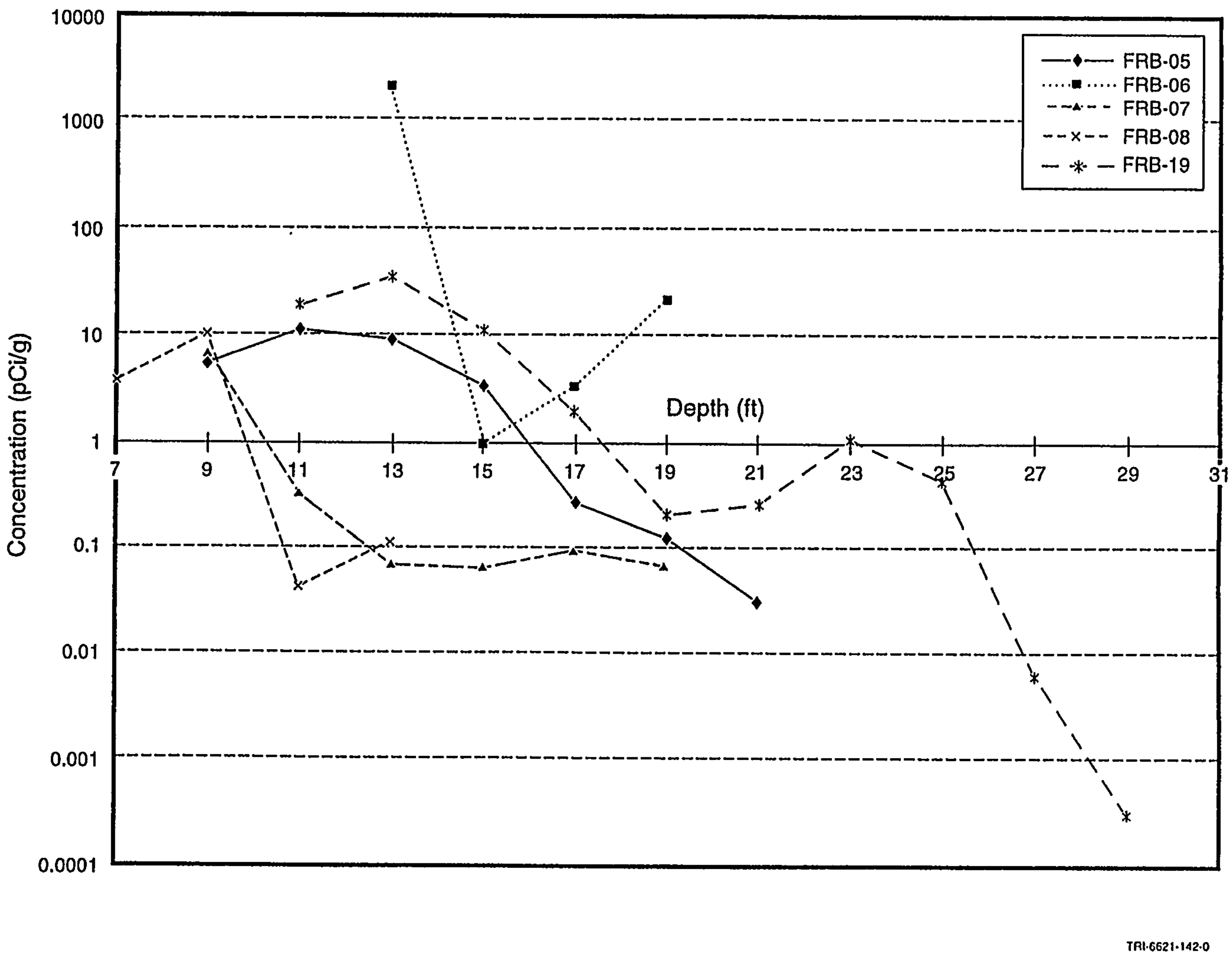



Figure 11. Concentration (pCi/g) of Cs-137 relative to depth on sampling locations FRB-05, 06, 07, 08, and 19 within the SRS F-Area Retention Basin.

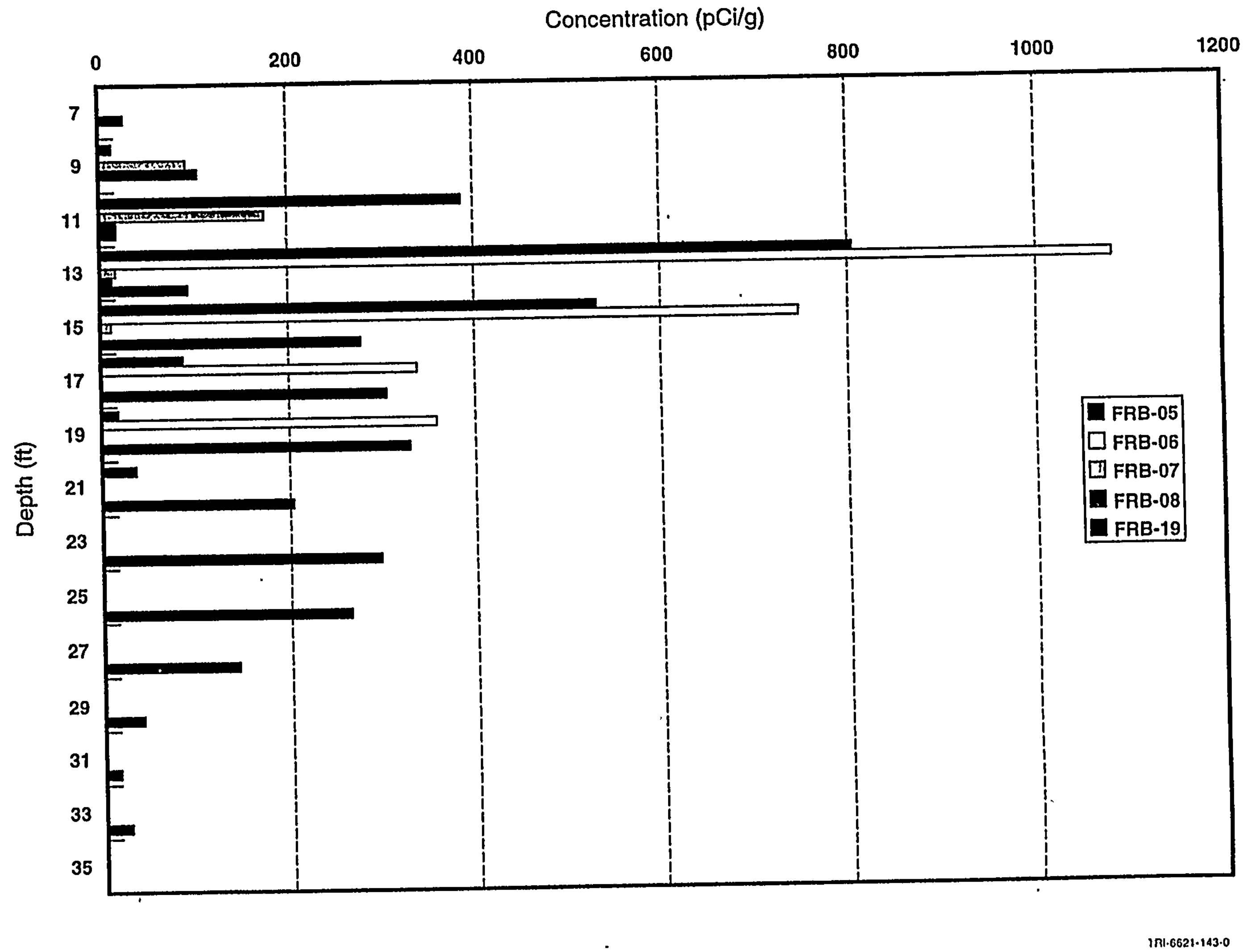



Figure 12. Concentration (pCi/g) of Sr-90 relative to depth at sampling locations FRB-05, 06, 07, 08, and 19 within the SRS F-Area Retention Basin (user defined from WSRC, 1995).

**This Page Intentionally Left Blank**

# 6.0 DRILLING AND DATA COLLECTION PLAN

## *6.1 Overview of Drilling and Evaluation Operations*

Phase I of the demonstration at the F-Area Retention Basin will determine Cs-137 background conditions. This will be accomplished by drilling one hole approximately 50 ft (15.3 m) in length at a depth ranging from 10 to 15 ft (3 to 4.5 m) at a radiological "clean" area adjacent to the F-Area Retention Basin. Investigation derived waste generated from this background determination will be considered non-contaminated and disposed of at the borehole location. After background conditions are determined, the EMWD-GRS system will be demonstrated in the previously characterized F-Area Retention Basin.

Phase II of the demonstration at the F-Area Retention Basin will consist of monitoring environmental conditions in real time while drilling two boreholes daylight-to daylight. These holes will pass near four sample locations, FRB-05 through 08, and adjacent to sample location FRB-19. Values of contaminant levels are known at all five sample locations. The contaminant levels continuously recorded by the EMWD-GRS system during drilling will be compared to contaminant levels previously determined through quantitative laboratory analysis of soil samples collected at locations FRB-05, 06, 07, 08, and 19 (WSRC, 1995). Results of the demonstration will be presented in report format.

## *6.2 Communications, Documentation, Logistics, and Equipment*

The SNL project leader for the demonstration will communicate regularly with the demonstration participants to coordinate all field activities associated with this demonstration and to resolve any logistical, technical, or quality assurance (QA) issues that may arise as the demonstration progresses. The successful implementation of the demonstration requires detailed coordination and constant communication between all demonstration participants.

All demonstration field activities will be thoroughly documented. Field documentation will include field logbooks, photographs, field data sheets, and electronic data files.

The SNL field team leader will be responsible for maintaining all field documentation. Field notes will be kept in a bound logbook. Each page will be sequentially numbered and labeled with the project name and number. Completed pages will be signed and dated by the individual responsible for the entries. Errors will have one line drawn through them, and this line will be initialed and dated.

All photographs will be logged in the field logbook. These entries will include the time, date, direction, subject of the photograph, and the identity of the photographer. Specific notes about data collected will be written in the field logbook. Any deviations from the approved final demonstration plan will be thoroughly documented in the field logbook by the SNL project leader.

The SNL demonstration team will obtain the EMWD-GRS equipment and contract drilling services for this demonstration. The drilling contractor will provide for decontamination of equipment and personnel as required by 29 CFR 1910.120-Hazardous Waste Operations and

Emergency Response. Westinghouse Savannah River Company will provide equipment/materials necessary for disposal of any radioactive/hazardous waste generated.

## 6.3 Data Collection Procedures

The data collection procedures focus on identifying the drilling locations, reading locations, and decontamination and disposal of any generated waste as discussed in the following subsections.

### 6.3.1 Drilling Locations

The drilling locations for the two daylight-to-daylight boreholes are shown in Figure 13. The boreholes will be drilled horizontally at a depth of approximately 15 ft (4.5 m), which is 5 ft (1.5 m) below the clean backfill in the retention basin. The drill rig will be positioned east of the backfilled retention basin at a location to be determined by drilling protocol. Horizontal Borehole No. 1 will be drilled near previously drilled and sampled vertical boreholes FRB-05, FRB-06, and FRB-19. Horizontal Borehole No. 2 will be drilled near previously drilled and sampled vertical boreholes FRB-07 and FRB-08.

### 6.3.2 EMWD-GRS Data Collection

The data collection procedures used with the EMWD-GRS system are the following:

1. Run decom software using default setup.
2. Start data storage by providing a file name.
3. With system mounted behind the drill bit, test rotate the drilling rig while monitoring wired connections and computer.
4. Stop rotating and place small check source (WSRC external cesium sources) near the drill bit.
5. Take reading for approximately 2 minutes.
6. After visual verification that the system is working, start the normal drilling process.
7. After completion of the drilling process, check the system once more with the field check source.
8. Close the PC file and store file to secondary backup system.

The entire procedure for data collection is located in Appendix C.

### 6.3.3 Decontamination and Disposal of Generated Waste

The F-Area Retention Basin is subject to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. The drilling contractor will provide for decontamination of equipment and personnel by 29 CFR 1910.120-Hazardous Waste Operations and Emergency Response. The drilling operations will minimize waste by using fluid mizer pipe during drilling operations. The drill bit entry pit, approximately 3 $ft^2$ ($\approx$1 $m^2$), will be lined with plastic and contain the minimal amount of drilling generated waste for appropriate disposal. Investigation derived waste generated during the technology demonstration will be handled in accordance with site procedures found

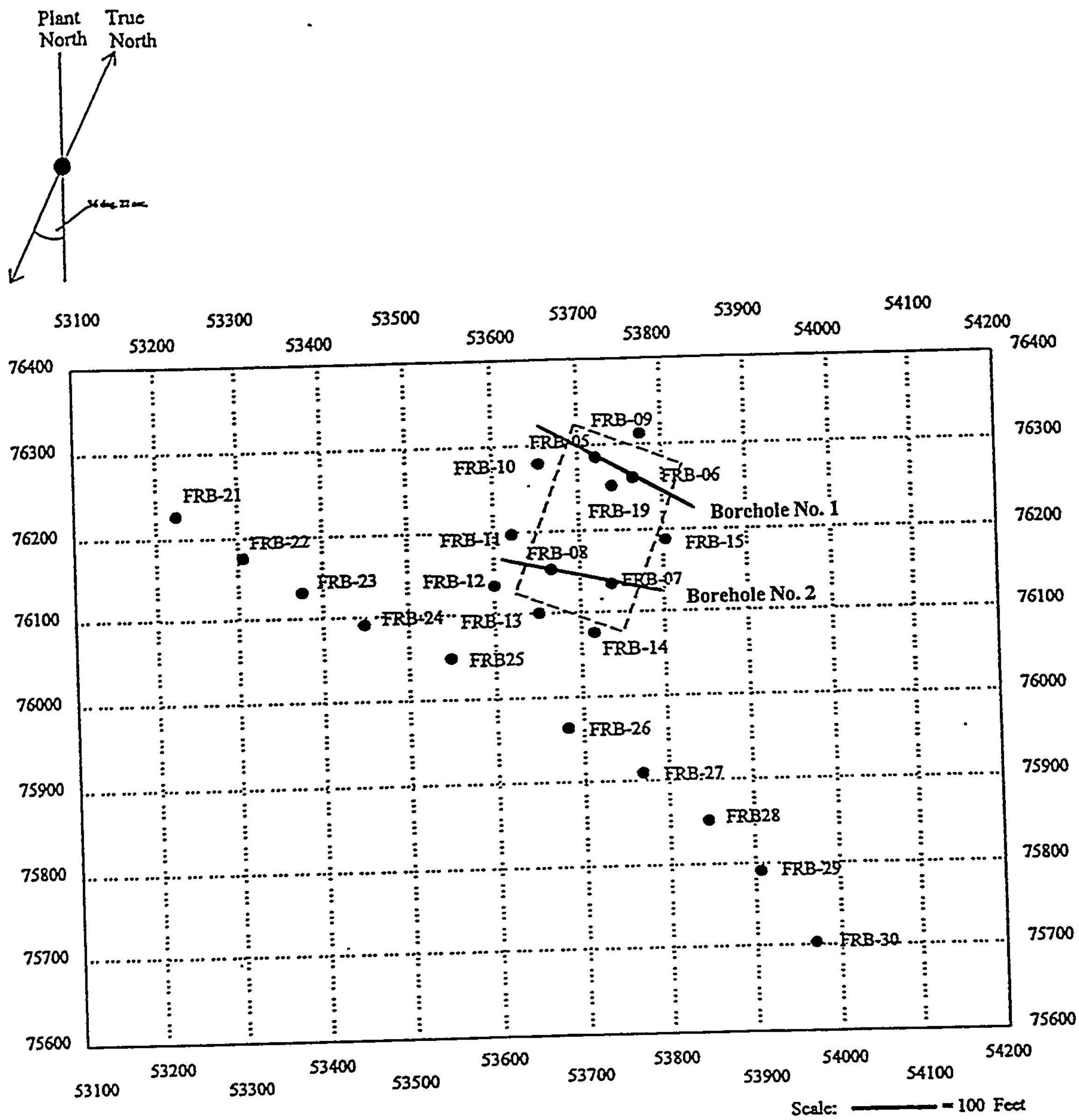



Figure 13. Locations for drilling continuously monitored daylight-to-daylight boreholes at the Savannah River Site F-Area Retention Basin (modified from WSRC, 1995).

in WSRC 1 S Manual (Procedure 3.10 and 3.15), Investigation-Derived Waste (IDW) Management Plan.

Radioactive, hazardous, and non-hazardous waste generated during the demonstration will be managed in accordance with SRS procedures and applicable regulations. Rags and material contaminated with gasoline, hydraulic fluid, diesel, etc., will be segregated, double bagged in plastic bags, and placed in controlled areas.

Radioactive and hazardous waste will be managed on site and transported for final disposition by Westinghouse Savannah River Company personnel. Westinghouse Savannah River Company is responsible for final disposition of IDW.

### 6.3.4 Schedule

The demonstration is scheduled to take place April 22-26, 1996.

Day 1

During the morning, secure badges and attend site specific training. In the afternoon, mobilize equipment at the "cold" test site adjacent to the F-Area Retention Basin and prepare for drilling horizontal borehole to determine background conditions

Day 2

Drill borehole at the "cold" test site to determine background conditions. Relocate equipment to the F-Area Retention Basin and set up for drilling horizontal Borehole No. 1. Borehole No. 1 will pass near previously sampled locations FRB-05, 06, and 19.

Day 3

Drill horizontal Borehole No. 1. Upon completing Borehole No. 1, move equipment to the horizontal Borehole No. 2 location. Borehole No. 2 will pass near previously sampled locations FRB-07, and 08.

Day 4

Drill horizontal Borehole No. 2.

Day 5

Decontaminate equipment, Demobilize, and move off location.

# 7.0 QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan (QAPP) for this demonstration specifies procedures that will be used to ensure data quality and integrity. Careful adherence to these procedures will ensure that data generated by the demonstration will meet the desired performance objectives and will provide sound analytical results.

## *7.1 Purpose and Scope*

The primary purpose of this section is to outline steps that will be taken by operators of the EMWD-GRS system to ensure that data resulting from this demonstration is of known quality and that a sufficient number of critical measurements are taken.

## *7.2 Quality Assurance Responsibilities*

The SNL project leader is responsible for coordinating the preparation of the QAPP for this demonstration. The SNL project leader will ensure that the QAPP is implemented during all demonstration activities. The SNL QA manager for the demonstration will review and approve the QAPP and will provide independent QA oversight of all demonstration activities.

Readings will be taken and analyzed on site using the EMWD-GRS system technology. These readings will be compared to previously collected samples analyzed using U.S. Environmental Protection Agency (EPA) approved methods. The SNL project leader, field team leader and technology operator will be responsible for data readings and analysis quality assurance/quality control (QA/QC) throughout the demonstration. Primary responsibility for ensuring that the data acquisition activities comply with the requirements of the data acquisition plan will rest with the SNL field team leader. QA/QC activities for the EMWD-GRS system will include activities to assure that the demonstration will provide data of the necessary quality.

## *7.3 Data Quality Parameters*

The data obtained during the demonstration must be of sound quality for conclusions to be drawn on the performance of the EMWD-GRS system. For all measurement and monitoring activities conducted for the EPA, the Agency requires that data quality parameters be established based on the proposed end uses of the data. Data quality parameters include six indicators of data quality: representativeness, completeness, comparability, accuracy, precision, and lower-limiting the detection threshold for elimination of false-positive readings.

Data generated by EMWD-GRS system technology will be compared to data generated from previous site characterization (Appendix B).

### 7.3.1 Representativeness

Representativeness refers to the degree to which the data accurately and precisely represent the conditions or characteristics of the given parameter. In this demonstration, representativeness will be ensured by executing consistent data collection procedures, including reading locations, reading procedures, and data storage as previously outlined in Section 6.3.2.

Representativeness also will be ensured by using each method at its optimum capability to provide results that represent the most accurate and precise measurement each method is capable of achieving.

### 7.3.2 Completeness

Completeness refers to the amount of data collected from a measurement process compared to the amount that was expected to be obtained. For this demonstration, completeness refers to the proportion of valid, acceptable data generated using each method.

The completeness objective for data collection during this demonstration is to take spectral readings continuously during the drilling process. The drilling process will continue under a waste site for approximately 150 ft (45.7 m). Never before has such a complete data set been taken. Readings at selected points corresponding to soil sample locations will be compared.

There is a physical limitation to the sensitivity and resulting range of spectral gamma measurement. These limitations relate to crystal size and maximum data collection rates. Expected range of 3 to 1000 pCi/g is the ideal system limitation.

### 7.3.3 Comparability

Comparability refers to the confidence with which one data set can be compared to another. The primary objective of this demonstration is to evaluate how well the EMWD-GRS system technology performs in determining the presence or absence of Cs-137 compared to analytical data derived from previous site assessment.

Analytical methods have the unique distinction of setting the questionable EPA standard. In situ measurements as determined by the EMWD-GRS system have limiting accuracy and range of waste analyst (i.e., the gamma radiation range is expected to vary from material background to the amount of Cs-137 remaining after approximately 7 half lives). If "high" levels of gamma contamination exists at higher energies, the range may be wider than expected. Other more comparable systems can detect radiation levels within some reasonable range from natural occurring sources as uranium, thorium, and potassium. These systems have been adapted for environmental applications to add Cs-137 and cobalt (Co)-60 to the list. The process of unfolding energy peak and count rate information into gamma flux density, relating to waste concentrations within soils, has not been fully realized. Calibration procedures consistent with industry's best practices are being used while looking at new more innovative approaches. The expectation is to be consistent with off-site analysis methods.

### 7.3.4 Accuracy

Accuracy refers to the difference between the contamination readings and a reference standard. The resulting accuracy contains error variances from both the repeated contamination readings and the reference standard. The analytical reading from sampled soil will be the standard. The analytical reading is a single valued number with error bars. The EMWD-GRS system readings are a function of contamination reading versus location and sample period. Ideally, the EMWD-GRS system would be exposed to soils with uniformly distributed contamination consistent with the small sample used in laboratory analytical measurement. These ideal conditions will not exist during the demonstration.

Using the statistical nature of the gamma process and calibration information taken from controlled calibration pits at Grants, New Mexico (Leino et. al, 1994), the comparable accuracy will be established. Second calibration standards for Cs-137 will be established using previously sampled locations at a DOE facility. Calibration procedures are listed in Appendix D.

Historically, it has been understood that the standard deviation of the gamma count rate is equal to the square root of the measured count. The measured count increases has the sample period increases. For example, a deviation of 10% must have a measured count equal to 100. To increase accuracy, controls must be placed on the rate of drilling. The limiting drilling rate has not been established. The industry drilling standard for natural gamma backgrounds is 2 to 10 ft per minute.

### 7.3.5 Precision

Precision refers to the degree of mutual agreement among individual measurements and provides an estimate of random error. Precision will be established using WSRC external cesium sources for calibration and checks of the EMWD-GRS tool for response of Cs-137 in native soil. The EMWD-GRS system collects data at a sufficiently high rate so that the drilling rate does not affect data quality in moderately to highly contaminated soils. If a radiological "hot spot" is encountered, the drilling rate can be reduced to provide sufficient radiation count statistics. As discussed in the concluding paragraph of Section 7.3.4, random error is directly related to sample period, drilling rate (changing environments), and contamination levels (count rate). For greater precision at low contamination levels, the sample period must be increased and drilling rate reduced, if not stopped altogether.

### 7.3.6 Probability of False-Positive

The probability of a false-positive is the probability of a contaminated soil condition that does not exist.

The statistical nature of gamma measurements and electronic noise in any gamma measurement system does not provide a true zero reading. Given any sample period, there is a probability of measuring gamma relating to the energy levels of waste material as Cs-137 even without any laboratory-measurable quantities present. This problem requires setting the measurable threshold of waste material (such as Cs-137) below the minimum the system can measure accurately. This lower limit is an important parameter in preventing unwanted expense. The lower limit is a function of the sample period and drilling rate. The lower limit will be determined through background measurements at the radiologically "cold" site adjacent to the F-Area Retention Basin at the SRS. Approximately 100 measurements will be taken to statistically parameterize the background radiation count rates. The lower limit will be consistent with other off-site analysis methods.

## 7.4 Calibration Procedures, Quality Control Checks, and Corrective Action

This section describes the calibration procedures that apply to the EMWD-GRS technology. It also contains a discussion of the corrective action to be taken if the QC parameters fall outside of the evaluation criteria.

### 7.4.1 Calibration Procedures

Calibration will be consistent with procedures in Westinghouse Hanford WHC-SD-EN-TI-293, Rev. 0 and with Grand Junction calibration techniques for the Grants, New Mexico, calibration pits. The Westinghouse Hanford document covers the procedures for calibrating gamma-ray well logging tools using Hanford formation models. Calibration procedures for the GRS-EMWD system are located in Appendix D.

In general, a complete calibration is required every six months with an initial check before and after each drilling operation. Complete calibration every six months can be performed at calibration pits at any DOE calibration facility. The calibration to be performed has two stages. First, the linear energy peak used to channel number calibration normally uses several radioactive elements of differing gamma energy emissions. Second, the gamma flux correlation to waste concentrations requires test pits of known flux and contamination levels. These pits can be found at a number of DOE facilities, but those best-known and used most frequently are the A and B models located at Grand Junction, Colorado.

Complete calibration generates a set of coefficients correlating spectral counts rates at differing energy locations to amounts of soil contamination. Should these coefficients exceed limits or fail to produce acceptable results, the system must be recalibrated or repaired at Sandia National Laboratories, Albuquerque, New Mexico.

Initial check before and after drilling uses a simple potassium-40 (K-40) (or other common isotope) of known energy emission. This then becomes part of the data file for validation of system operation while the drilling measurements are being taken. A simple visual inspection of the initial check data is sufficient to approve the start of drilling. A failed spectrum would require replacement of failed system components. This work could be done in the field.

### 7.4.2 Soil Sample Analysis

The data to be used for evaluating the EMWD-GRS system were collected during the site assessment of the F-Area Retention Basin. Sample collection and analysis methodologies, including quality control procedures, have been fully described in WSRC, 1995.

## 7.5 Data Reduction, Validation, and Reporting

To maintain good data quality, specific procedures will be followed during data reduction, validation, and reporting. These procedures are detailed below.

### 7.5.1 Data Reduction

During the data reduction process, data will be reduced to the following formats:

- Total count rate as a function of time.
- Cs-137 count rate as a function of time.
- Spectra taken near previously sampled locations.

### 7.5.2 Data Validation

The SNL field team leader will verify the completeness of the appropriate data forms and the completeness and correctness of data acquisition and reduction. The field team leader will also review calculations to verify accuracy, completeness, and adherence to the specific technology protocols. Calibration and QC data will be examined by the SNL field team leader, SNL qa manager, and SNL project leader. Project leaders and QA managers will verify that all instrument systems are operational and that QA objectives for accuracy, completeness, and method detection limits have been met.

### 7.5.3 Data Reporting

The Final report will utilize the WSRC 1995 (ESH-EMS-950563) analysis type format for presenting a comparison between EMWD-GRS generated data and previous site characterization laboratory analysis. Interpretation of the EMWD-GRS data will be presented in an effort to draw corollaries to empirical data if direct comparison of data is not possible.

## *7.6 Data Quality Indicators*

Data transmission quality and spectral gamma quality are the two data quality indicators used with the EMWD-GRS system.

Data transmission quality indicators are built into the system. When data is collected it is sent to the computer three (3) times. The counts from each data transmission are totaled and compared to verify they are the same.

Spectral gamma quality indicators are determined by verifying the functionality and approximate calibration of the GRS using laboratory calibration sources. The functionality of the GRS is also verified while drilling by monitoring background peaks.

## *7.7 Performance and System Audits*

The following audits will be performed during this demonstration. These audits will determine if this demonstration plan is being implemented as intended.

### 7.7.1 Performance Audit

The EMWD-GRS system performance will be compared with samples collected and analyzed during previous site assessments.

### 7.7.2 On-Site System Audits

On-site system audits for field operations will be conducted upon request. These audits will be performed by the SNL project leader. After the audits, audit reports will be prepared and incorporated into the demonstration records.

## *7.8 Quality Assurance Reports to Project Manager*

QA reports provide the necessary information to monitor data quality effectively. It is anticipated that the following types of QA reports will be prepared as part of this demonstration on forms developed for this demonstration.

### 7.8.1 Status Reports

The SNL field team leader will prepare periodic reports for the project leader. These reports should discuss project progress, problems and associated corrective actions, and future scheduled activities associated with the demonstration. When problems occur, the field team leader will discuss them with the SNL project leader, estimate the type and degree of impact, and describe the corrective actions taken to mitigate the impact and to prevent a recurrence of the problems.

### 7.8.2 Audit Reports

Any QA audits or inspections that take place in the field while the demonstration is being conducted will be recorded for future use by the technology developer.

## *7.9 Corrective Action*

Whenever a performance evaluation or a technical system audit indicates that the equipment is out of calibration, the system will be evaluated to determine the source of the problem. Results of the system evaluation will be recorded in the demonstration record along with the corrective action taken. The SNL project leader will review, approve, and document all corrective actions.

# 8.0 DATA MANAGEMENT AND ANALYSIS

SNL will manage and analyze the data prior to presentation of the report to Westinghouse Savannah River Company.

The SNL project leader is responsible for obtaining, reducing, interpreting, validating, and reporting the data associated with the technology's performance. These data will be reported in hard copy and electronic format (i.e., spreadsheet). A data dictionary will be included as a text file on the same diskette containing the data.

Other items that must be included in the demonstration record are:

- field records;
- photographs, slides, and videotapes (copies);
- sample analysis from previous site assessment;
- electronic data files.

## *8.1 EMWD-GRS Reading and Location Identification*

The Reading locations will be located geographically and recorded as part of the EMWD-GRS system data collection capability. Horizontal and vertical coordinates are to be provided.

## *8.2 Data Analysis and Comparison with Previous Site-Characterization Data*

The data collected during this demonstration will be presented in a documented format (WSRC, 1995) that allows comparison with previously collected sample data. Interpretation of EMWD-GRS data will be presented in an effort to draw corollaries to empirical data (WSRC, 1995) if direct comparison of data is impossible.

**This Page Intentionally Left Blank**

# 9.0 HEALTH AND SAFETY PLAN

## *9.1 Site Specific Health and Safety Plan (HASP)*

The site specific HASP for the EMWD-GRS system demonstration of the SRS F-Area Retention Basin is listed in Appendix E.

## *9.2 Health and Safety Plan Enforcement*

The SNL project leader, field site supervisor, and site health and safety officer will be responsible for implementing and enforcing the health and safety provisions of the site-specific HASP. The SNL project leader bears ultimate responsibility for ensuring that all demonstration participants abide by the requirements of the HASP. The field site supervisor will oversee and direct field activities and is responsible for ensuring compliance with the site-specific HASP. The health and safety officer (HSO) has the ultimate responsibility during activities at the demonstration site.

This Page Intentionally Left Blank

# 10.0 DELIVERABLES

The deliverable of this demonstration is a report that details the EMWD-GRS system's overall performance and its performance in delineating the presence or absence of Cs-137 at the SRS F-Area Retention Basin. Support documentation such as copies of logbooks and calibration reports will be included as an appendices to the final report.

**This Page Intentionally Left Blank**

# 11.0 REFERENCES


GeoTrans, Inc. 1992. *Groundwater Flow Model for the General Separations Area, Savannah River Site*. GeoTrans Project No. 3017-003. Sterling, VA. GeoTrans, Inc.

Leino, R., D.C. George, B.N. Key, L. Knight, and W.D. Steele. 1994. *Field Calibration Facilities of Environmental Measurement of Radium, Thorium, and Potassium*. Doe/ID/12584-179; GJ/TMC-01 (Third Edition). Grand Junction, CO. RUST Geotech, Inc.

Westinghouse Savannah River Company. 1994a. *Phase II, Revision I Remedial Investigation Work Plan for the F-Area Retention Basin (281-3F) (U)*. WSRC-RP-94-498, Rev 1. Aiken, SC. Westinghouse Savannah River Company.

Westinghouse Savannah River Company. 1994b. *Radiological Performance Assessment for the E-Area Vaults Disposal Facility (U). WSRC-RP-94-218.* Aiken, SC. Westinghouse Savannah River Company.

Westinghouse Savannah River Company. 1995. *Quality Control Summary Report for the F-Area Retention Basin, Phase II Project.* ESH-EMS-950563. Aiken, SC. Westinghouse Savannah River Company.

Scott, S.C., T.H. Killian, N.L. Kolb, P. Corbo, and I.W. Marine. 1987. *Environmental Information Document, Separations Area Retention Basins.* DPST-85-693, E.I. du Ponte de Nemours and Company. Aiken, SC. Savannah River Laboratory.

**This Page Intentionally Left Blank**

# APPENDIX A

**Background Soil Analytical results**
**F-Area Retention Basin**
**(Table 3-2 from WSRC, 1994)**

**This Page Intentionally Left Blank**

Table 3-2
Background Soil Analytical Results
F-Area Retention Basin (281-3F)

| Sample ID<br>Facility Identifier<br>Sampling Point<br>Sample Number<br>Sampling Interval (ft.)<br>Comment | 102200<br>FRB<br>01<br>02<br>0.5 - 2.0 | 102202<br>FRB<br>01<br>03<br>5.0 - 7.0 | 102204<br>FRB<br>01<br>04<br>10.0 - 12.0 | 102205<br>FRB<br>01<br>05<br>15.0 - 17.0 | 102206<br>FRB<br>01<br>06<br>20.0 - 22.0 |
|---|---|---|---|---|---|
| *Inorganics/Metals* | *(mg/kg)* | *(mg/kg)* | *(mg/kg)* | *(mg/kg)* | *(mg/kg)* |
| Aluminum | 9450 | 15000 | 4200 | 2230 | 1440 |
| Barium | 29.9 | 27.2 | 3.22 | 1.43 | 0.954 |
| Beryllium | 0.251 | 0.236 | 0.0651 | 0.112 | 0.0727 |
| Calcium | 194 | 270 | 67.4 | 30.4 | 16.6 |
| Chromium | 13.6 | 17.8 | 11.9 | 8.32 | 2.08 |
| Cobalt | 1.7 | 1.42 | 0.306 | 0.193 | BDL |
| Copper | 2.72 | 4.86 | 1.49 | 0.659 | 0.913 |
| Iron | 11000 | 16100 | 8370 | 4380 | 2280 |
| Mercury | .0688 | .078 | .0333 | BDL | .0255 |
| Potassium | 156 | 195 | 36.2 | BDL | BDL |
| Magnesium | 148 | 247 | 38.4 | 18.5 | 7.98 |
| Manganese | 150 | 37.7 | 6.82 | 2.89 | 4.29 |
| Sodium | 16.6 | 24.6 | 15.1 | BDL | BDL |
| Nickel | 3.12 | 4.24 | 0.953 | 0.62 | BDL |
| Lead | 7.39 | 6.37 | 4.04 | 4.73 | 4.12 |
| Vanadium | 29.7 | 35.6 | 23.9 | 13.1 | 6.75 |
| Zinc | 5.15 | 7.69 | 2.3 | 0.813 | 1.12 |
| Selenium | BDL | 3.89 | BDL | BDL | BDL |
| *Organics* | *(μg/kg)* | *(μg/kg)* | *(μg/kg)* | *(μg/kg)* | *(μg/kg)* |
| Acetone | 21.8 | 5.89 | 6.75 | 6.1 | 4.72 |
| Bis-(2-ethylhexyl)-phthalate | 12.5 | 22 | 35.6 | 38.4 | 19.8 |
| Butylbenzyl phthalate | BDL | BDL | BDL | 5.97 | BDL |
| Methylene Chloride | 0.473 | 0.708 | 0.67 | 1.09 | 0.924 |
| Chloroform | 0.29 | 0.449 | 0.429 | 0.477 | 0.402 |
| Di-n-butyl Phthalate | 25.7 | 48.6 | 47.2 | 45.9 | 30.2 |
| Methylethyl Ketone | BDL | 0.326 | 0.286 | 0.318 | 0.25 |
| Toluene | 0.14 | 0.191 | 0.176 | 0.182 | 0.13 |
| 1,1-DCE | 2.12 | BDL | BDL | BDL | BDL |
| Xylenes | BDL | BDL | BDL | 0.0795 | BDL |

**Table 3-2 (continued)**
**Background Soil Analytical Results**
**F-Area Retention Basin (281-3F)**

| Sample ID<br>Facility Identifier<br>Sampling Point<br>Sample Number<br>Sampling Interval (ft.)<br>Comment | 102200<br>FRB<br>01<br>02<br>0.5 - 2.0 | 102202<br>FRB<br>01<br>03<br>5.0 - 7.0 | 102204<br>FRB<br>01<br>04<br>10.0 - 12.0 | 102205<br>FRB<br>01<br>05<br>15.0 - 17.0 | 102206<br>FRB<br>01<br>06<br>20.0 - 22.0 |
|---|---|---|---|---|---|
| *Radionuclide Indicators and Radionuclides* | *(pCi/g)* | *(pCi/g)* | *(pCi/g)* | *(pCi/g)* | *(pCi/g)* |
| Actinium-228 | 1.36 | 1.58 | 1.16 | 0.758 | 1.14 |
| Gross Alpha | 8.18 | 20.7 | 15.2 | 2.44 | 8.86 |
| Americium-241 | BDL | 0.252 | BDL | BDL | BDL |
| Nonvolatile Beta | 8.69 | 12.1 | 6.79 | BDL | 7.18 |
| Carbon-14 | 0.166 | BDL | BDL | 0.113 | 0.157 |
| Cesium-137 | 0.0793 | 0.0425 | 0.0116 | BDL | 0.00622 |
| Europium-155 | 0.103 | 0.0863 | 0.0611 | 0.0405 | 0.0859 |
| Potassium-40 | 1.16 | 1.33 | 0.634 | 0.704 | 1.04 |
| Manganese-54 | 0.0189 | 0.0282 | 0.0186 | 0.0176 | 0.0183 |
| Nickel-63 | 0.918 | 1.82 | 1.97 | 1.18 | 1.5 |
| Lead-212 | 1.37 | 1.55 | 1.2 | 0.798 | 1.17 |
| Promethium-147 | BDL | BDL | BDL | BDL | 0.0754 |
| Plutonium-238 | BDL | BDL | BDL | 0.037 | BDL |
| Plutonium-239/240 | 0.284 | 0.107 | 0.12 | 0.178 | 0.321 |
| Radium-226 | 0.445 | 0.557 | 0.442 | 0.264 | 0.224 |
| Radium-228 | 0.633 | 0.842 | 0.831 | 0.55 | 0.359 |
| Strontium-90 | 0.19 | 0.26 | BDL | BDL | BDL |
| Thorium-228 | 1.49 | 1.59 | 1.19 | 0.774 | 1.84 |
| Thorium-230 | 0.891 | 1.06 | 0.521 | 0.502 | 1.14 |
| Thorium-234 | 1.19 | 1.58 | 0.807 | 0.74 | 1.14 |
| Total Radium | 8.7 | 7.8 | 4.7 | 3 | 5.3 |
| Uranium-235 | 0.0347 | BDL | 0.0422 | BDL | BDL |
| Uranium-238 | 0.641 | 0.954 | 0.697 | 0.316 | 0.535 |
| Uranium-233/234 | 0.802 | 0.98 | 0.751 | 0.366 | 0.651 |
| Thorium-232 | 1.39 | 1.58 | 1.09 | 0.656 | 1.49 |
| Neptunium-237 | BDL | 0.0647 | 0.222 | 0.0459 | BDL |
| Neptunium-239 | 0.093 | 0.078 | 0.0553 | 0.0366 | 0.0776 |
| Technicium-99 | 1.7 | 1.4 | 1.36 | 0.484 | 0.411 |
| Yttrium-88 | BDL | BDL | BDL | BDL | 0.00541 |
| Promethium-144 | BDL | BDL | BDL | BDL | 0.00499 |
| Promethium-146 | BDL | 0.0185 | 0.00654 | BDL | 0.0754 |
| Zirconium-95 | 0.032 | 0.0331 | 0.0177 | 0.0245 | 0.0415 |

BDL = Not detected above method detection limits

# APPENDIX B

**Quantitative Laboratory Analysis of Soil Samples collected from Sampling Locations FRB-05, 06, 07, 08, and 19 at the SRS F-Area Retention Basin (from Appendix E of WSRC, 1995)**

**This Page Intentionally Left Blank**

SAMPLE NAME: FRB-0501
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102271
Interval Depths: 0.00 to 1.00
Percent Solids: 90.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.85 | mg/kg | 5.85 | EPA6010 |
| Barium, total recoverable | | | | 15.40 | mg/kg | 2.92 | EPA6010 |
| Beryllium, total recoverable | | | | 0.181 | mg/kg | 2.92 | EPA6010 |
| Chromium, total recoverable | | | | 8.34 | mg/kg | 2.92 | EPA6010 |
| Nickel, total recoverable | | | | 1.26 | mg/kg | 2.92 | EPA6010 |
| Lead, total recoverable | | | | 5.91 | mg/kg | 5.85 | EPA6010 |
| Thallium, total recoverable | U | | | 5.85 | mg/kg | 5.85 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 5.59±2.18 | pCi/g | 1.97 | EPIA-001B |
| Americium-241 | UI | | | -0.01±0.0101 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0013±0.0038 | pCi/g | 0.0058 | EPIA-013B |
| Nonvolatile beta | | | | 5.07±2.22 | pCi/g | 3.99 | EPIA-001B |
| Carbon-14 | UI | | | -0.0118±0.0863 | pCi/g | 0.166 | EPIA-003B |
| Cobalt-60 | UI | | | -0.0011±0.0025 | pCi/g | 0.0041 | EPIA-013B |
| Cesium-137 | | | | 0.101±0.0063 | pCi/g | 0.005 | EPIA-013B |
| Europium-154 | UI | | | -0.0039±0.0207 | pCi/g | 0.0213 | EPIA-013B |
| Iodine-129 | UI | | | 0.0233±0.075 | pCi/g | 0.0983 | EPIA-006B |
| Potassium-40 | UI | V | | 1.69±0.0761 | pCi/g | 0.0379 | EPIA-013B |
| Nickel-63 | | | | 1.09±0.40 | pCi/g | 0.767 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0408±0.0322 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | J | C | | 0.767±0.0642 | pCi/g | 0.0455 | EPIA-013B |
| Strontium-90 | | | | 2.61±0.284 | pCi/g | 0.309 | EPIA-004 |
| Technetium-99 | UI | | | 0.0791±0.112 | pCi/g | 0.299 | EPIA-005B |
| Uranium-238 | | | | 0.729±0.143 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.90 | µg/kg | 36.90 | EPA8270 |
| Di-n-butyl phthalate | U | | | 36.90 | µg/kg | 36.90 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.90 | µg/kg | 36.90 | EPA8270 |
| 2-Chlorophenol | U | | | 36.90 | µg/kg | 36.90 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | UJ | QO | H | 0.556 | µg/kg | 0.556 | EPA8260 |
| Carbon disulfide | UJ | QO | H | 1.11 | µg/kg | 1.11 | EPA8260 |
| Toluene | UJ | VQO | H | 0.189 | µg/kg | 0.556 | EPA8260 |
| Trichloroethylene | UJ | QO | H | 0.0556 | µg/kg | 0.0556 | EPA8260 |

SAMPLE NAME: FRB-0502
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102272
Interval Depths: 2.00 to 4.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | | | 23.10 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.238 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 12.70 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | | | | 3.13 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 4.40 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 4.57±2.11 | pCi/g | 2.61 | EPIA-001B |
| Americium-241 | UI | | | 0.0237±0.0242 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.012±0.0039 | pCi/g | 0.006 | EPIA-013B |
| Nonvolatile beta | | | | 6.20±2.41 | pCi/g | 4.22 | EPIA-001B |
| Carbon-14 | UI | | | -0.0028±0.0864 | pCi/g | 0.167 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0005±0.0026 | pCi/g | 0.0045 | EPIA-013B |
| Cesium-137 | | | | 0.0903±0.0062 | pCi/g | 0.005 | EPIA-013B |
| Europium-154 | UI | | | -0.0009±0.0214 | pCi/g | 0.023 | EPIA-013B |
| Iodine-129 | UI | | | 0.0079±0.046 | pCi/g | 0.0931 | EPIA-006B |
| Potassium-40 | UI | V | | 0.936±0.0687 | pCi/g | 0.0391 | EPIA-013B |
| Nickel-63 | UI | | | 0.712±0.369 | pCi/g | 0.736 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0008±0.0332 | pCi/g | 0.0754 | EPIA-012B |
| Radium-226 | J | C | | 0.887±0.0994 | pCi/g | 0.0687 | EPIA-013B |
| Strontium-90 | UI | | | 0.0713±0.168 | pCi/g | 0.26 | EPIA-004 |
| Technetium-99 | UI | | | 0.0212±0.109 | pCi/g | 0.294 | EPIA-005B |
| Uranium-238 | | | | 0.72±0.156 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | | | | 6.34 | µg/kg | 37.30 | EPA8270 |
| Di-n-butyl phthalate | | | | 18.30 | µg/kg | 37.30 | EPA8270 |
| N-Nitrosodiphenylamine | | | | 7.09 | µg/kg | 37.30 | EPA8270 |
| 2-Chlorophenol | | | | 7.84 | µg/kg | 37.30 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | UJ | Q | | 0.562 | µg/kg | 0.562 | EPA8260 |
| Carbon disulfide | UJ | Q | | 1.12 | µg/kg | 1.12 | EPA8260 |
| Toluene | UJ | VQ | | 0.169 | µg/kg | 0.562 | EPA8260 |
| Trichloroethylene | UJ | Q | | 0.0562 | µg/kg | 0.0562 | EPA8260 |

SAMPLE NAME: FRB-0503
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102273
Interval Depths: 8.00 to 10.00
Percent Solids: 78.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| **Metal Parameters** | | | | | | | |
| Arsenic, total recoverable | U | | | 6.75 | mg/kg | 6.75 | EPA6010 |
| Barium, total recoverable | | | | 67.90 | mg/kg | 3.37 | EPA6010 |
| Beryllium, total recoverable | | | | 0.645 | mg/kg | 3.37 | EPA6010 |
| Chromium, total recoverable | | | | 9.99 | mg/kg | 3.37 | EPA6010 |
| Nickel, total recoverable | | | | 4.90 | mg/kg | 3.37 | EPA6010 |
| Lead, total recoverable | | | | 4.31 | mg/kg | 6.75 | EPA6010 |
| Thallium, total recoverable | U | | | 6.75 | mg/kg | 6.75 | EPA6010 |
| **Radiological Parameters** | | | | | | | |
| Gross alpha | | | | 15.50±3.72 | pCi/g | 2.19 | EPIA-001B |
| Americium-241 | UI | | | 0.0153±0.0225 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.003±0.0069 | pCi/g | 0.0102 | EPIA-013B |
| Nonvolatile beta | | | | 17.40±3.34 | pCi/g | 4.56 | EPIA-001B |
| Carbon-14 | UI | | | 0.059±0.0881 | pCi/g | 0.192 | EPIA-003B |
| Cobalt-60 | UI | | | -0.0013±0.003 | pCi/g | 0.0049 | EPIA-013B |
| Cesium-137 | | | | 5.48±0.0341 | pCi/g | 0.0075 | EPIA-013B |
| Europium-154 | UI | | | -0.0348±0.0177 | pCi/g | 0.0247 | EPIA-013B |
| Iodine-129 | UI | | | 0.0064±0.059 | pCi/g | 0.122 | EPIA-006B |
| Potassium-40 | UI | V | | 2.49±0.101 | pCi/g | 0.0404 | EPIA-013B |
| Nickel-63 | UI | | | 0.669±0.338 | pCi/g | 0.672 | EPIA-022 |
| Plutonium-239/240 | | | | 0.0752±0.0459 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | J | C | | 0.967±0.0891 | pCi/g | 0.0645 | EPIA-013B |
| Strontium-90 | | | | 9.99±0.49 | pCi/g | 0.418 | EPIA-004 |
| Technetium-99 | UI | | | -0.091±0.117 | pCi/g | 0.368 | EPIA-005B |
| Uranium-238 | | | | 0.974±0.184 | pCi/g | 0.06 | EPIA-011B |
| **Semivolatile Parameters** | | | | | | | |
| Dibenzofuran | | | | 8.09 | µg/kg | 42.60 | EPA8270 |
| Di-n-butyl phthalate | U | | | 42.60 | µg/kg | 42.60 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 42.60 | µg/kg | 42.60 | EPA8270 |
| 2-Chlorophenol | U | | | 42.60 | µg/kg | 42.60 | EPA8270 |
| **Volatile Parameters** | | | | | | | |
| Dichloromethane (Methylene chloride) | J | OB | | 0.436 | µg/kg | 0.641 | EPA8260 |
| Carbon disulfide | UJ | O | | 1.28 | µg/kg | 1.28 | EPA8260 |
| Toluene | UJ | VO | | 0.282 | µg/kg | 0.641 | EPA8260 |
| Trichloroethylene | UJ | O | | 0.0641 | µg/kg | 0.0641 | EPA8260 |

SAMPLE NAME: FRB-0504
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102274
Interval Depths: 10.00 to 12.00
Percent Solids: 86.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.12 | mg/kg | 6.12 | EPA6010 |
| Barium, total recoverable | | | | 30.60 | mg/kg | 3.06 | EPA6010 |
| Beryllium, total recoverable | | | | 0.31 | mg/kg | 3.06 | EPA6010 |
| Chromium, total recoverable | | | | 11.80 | mg/kg | 3.06 | EPA6010 |
| Nickel, total recoverable | | | | 2.69 | mg/kg | 3.06 | EPA6010 |
| Lead, total recoverable | | | | 4.75 | mg/kg | 6.12 | EPA6010 |
| Thallium, total recoverable | | | | 3.46 | mg/kg | 6.12 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 14.60±3.67 | pCi/g | 2.19 | EPIA-001B |
| Americium-241 | UI | | | 0.0156±0.0243 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.00±0.0104 | pCi/g | 0.0147 | EPIA-013B |
| Nonvolatile beta | | | | 229.00±10.10 | pCi/g | 4.04 | EPIA-001B |
| Carbon-14 | UI | | | 0.0438±0.0882 | pCi/g | 0.174 | EPIA-003B |
| Cobalt-60 | | | | 0.0318±0.0063 | pCi/g | 0.0055 | EPIA-013B |
| Cesium-137 | | | | 11.20±0.0474 | pCi/g | 0.0093 | EPIA-013B |
| Europium-154 | UI | | | -0.0104±0.0211 | pCi/g | 0.0303 | EPIA-013B |
| Iodine-129 | UI | | | 0.0581±0.10 | pCi/g | 0.187 | EPIA-006B |
| Potassium-40 | UI | V | | 1.91±0.0979 | pCi/g | 0.0484 | EPIA-013B |
| Nickel-63 | | | | 2.06±0.433 | pCi/g | 0.75 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0091±0.03 | pCi/g | 0.0663 | EPIA-012B |
| Radium-226 | J | C | | 0.809±0.0774 | pCi/g | 0.0578 | EPIA-013B |
| Strontium-90 | | | | 385.00±9.59 | pCi/g | 2.09 | EPIA-004 |
| Technetium-99 | UI | | | 0.243±0.11 | pCi/g | 0.301 | EPIA-005B |
| Uranium-238 | | | | 0.841±0.153 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| Di-n-butyl phthalate | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| 2-Chlorophenol | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | | | | 0.36 | µg/kg | 0.581 | EPA8260 |
| Carbon disulfide | U | | | 1.16 | µg/kg | 1.16 | EPA8260 |
| Toluene | U | V | | 0.36 | µg/kg | 0.581 | EPA8260 |
| Trichloroethylene | U | | | 0.0581 | µg/kg | 0.0581 | EPA8260 |

SAMPLE NAME: FRB-0505
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102275
Interval Depths: 12.00 to 14.00
Percent Solids: 85.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| **Metal Parameters** | | | | | | | |
| Arsenic, total recoverable | U | | | 6.19 | mg/kg | 6.19 | EPA6010 |
| Barium, total recoverable | | | | 17.10 | mg/kg | 3.10 | EPA6010 |
| Beryllium, total recoverable | | | | 0.189 | mg/kg | 3.10 | EPA6010 |
| Chromium, total recoverable | | | | 14.20 | mg/kg | 3.10 | EPA6010 |
| Nickel, total recoverable | | | | 2.85 | mg/kg | 3.10 | EPA6010 |
| Lead, total recoverable | | | | 5.31 | mg/kg | 6.19 | EPA6010 |
| Thallium, total recoverable | U | | | 6.19 | mg/kg | 6.19 | EPA6010 |
| **Radiological Parameters** | | | | | | | |
| Gross alpha | | | | 17.80±4.15 | pCi/g | 2.11 | EPIA-001B |
| Americium-241 | UI | | | -0.0023±0.0118 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.145±0.101 | pCi/g | 0.0174 | EPIA-013B |
| Nonvolatile beta | | | | 302.00±11.70 | pCi/g | 3.98 | EPIA-001B |
| Carbon-14 | UI | | | -0.0186±0.0863 | pCi/g | 0.176 | EPIA-003B |
| Cobalt-60 | | | | 0.0314±0.0081 | pCi/g | 0.0063 | EPIA-013B |
| Cesium-137 | | | | 9.31±1.36 | pCi/g | 0.0124 | EPIA-013B |
| Europium-154 | UI | | | 0.0055±0.0259 | pCi/g | 0.0384 | EPIA-013B |
| Iodine-129 | UI | | | 0.0388±0.162 | pCi/g | 0.30 | EPIA-006B |
| Potassium-40 | UI | V | | 1.23±0.16 | pCi/g | 0.0574 | EPIA-013B |
| Nickel-63 | | | | 1.99±0.458 | pCi/g | 0.811 | EPIA-022 |
| Plutonium-239/240 | UI | | | -0.0066±0.0329 | pCi/g | 0.0821 | EPIA-012B |
| Radium-226 | J | C | | 0.821±0.102 | pCi/g | 0.0678 | EPIA-013B |
| Strontium-90 | | | | 804.00±9.06 | pCi/g | 0.786 | EPIA-004 |
| Technetium-99 | UI | | | 0.161±0.192 | pCi/g | 0.541 | EPIA-005B |
| Uranium-238 | | | | 1.02±0.207 | pCi/g | 0.0739 | EPIA-011B |
| **Semivolatile Parameters** | | | | | | | |
| Dibenzofuran | U | | | 39.10 | μg/kg | 39.10 | EPA8270 |
| Di-n-butyl phthalate | U | | | 39.10 | μg/kg | 39.10 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 39.10 | μg/kg | 39.10 | EPA8270 |
| 2-Chlorophenol | U | | | 39.10 | μg/kg | 39.10 | EPA8270 |
| **Volatile Parameters** | | | | | | | |
| Dichloromethane (Methylene chloride) | U | O | H | 0.588 | μg/kg | 0.588 | EPA8260 |
| Carbon disulfide | U | O | H | 1.18 | μg/kg | 1.18 | EPA8260 |
| Toluene | U | VO | H | 0.165 | μg/kg | 0.588 | EPA8260 |
| Trichloroethylene | U | O | H | 0.0588 | μg/kg | 0.0588 | EPA8260 |

SAMPLE NAME: FRB-0506
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102276
Interval Depths: 14.00 to 16.00
Percent Solids: 83.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.34 | mg/kg | 6.34 | EPA6010 |
| Barium, total recoverable | | | | 9.46 | mg/kg | 3.17 | EPA6010 |
| Beryllium, total recoverable | | | | 0.139 | mg/kg | 3.17 | EPA6010 |
| Chromium, total recoverable | | | | 14.00 | mg/kg | 3.17 | EPA6010 |
| Nickel, total recoverable | | | | 2.26 | mg/kg | 3.17 | EPA6010 |
| Lead, total recoverable | | | | 6.58 | mg/kg | 6.34 | EPA6010 |
| Thallium, total recoverable | U | | | 6.34 | mg/kg | 6.34 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 14.60±4.36 | pCi/g | 3.68 | EPIA-001B |
| Americium-241 | UI | | | 0.0133±0.0247 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0014±0.0075 | pCi/g | 0.0114 | EPIA-013B |
| Nonvolatile beta | | | | 235.00±10.30 | pCi/g | 4.14 | EPIA-001B |
| Carbon-14 | UI | | | 0.0263±0.0873 | pCi/g | 0.18 | EPIA-003B |
| Cobalt-60 | | | | 0.01±0.0056 | pCi/g | 0.0053 | EPIA-013B |
| Cesium-137 | | | | 3.40±0.0265 | pCi/g | 0.0082 | EPIA-013B |
| Europium-154 | UI | | | 0.0003±0.0302 | pCi/g | 0.0314 | EPIA-013B |
| Iodine-129 | UI | | | 0.0361±0.194 | pCi/g | 0.368 | EPIA-006B |
| Potassium-40 | UI | V | | 1.14±0.0839 | pCi/g | 0.0493 | EPIA-013B |
| Nickel-63 | | | | 1.19±0.41 | pCi/g | 0.778 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0352±0.0353 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | J | C | | 0.919±0.208 | pCi/g | 0.10 | EPIA-013B |
| Strontium-90 | | | | 528.00±11.50 | pCi/g | 1.79 | EPIA-004 |
| Technetium-99 | UI | | | -0.0358±0.0928 | pCi/g | 0.272 | EPIA-005B |
| Uranium-238 | | | | 1.03±0.241 | pCi/g | 0.0915 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 39.70 | µg/kg | 39.70 | EPA8270 |
| Di-n-butyl phthalate | U | | | 39.70 | µg/kg | 39.70 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 39.70 | µg/kg | 39.70 | EPA8270 |
| 2-Chlorophenol | U | | | 39.70 | µg/kg | 39.70 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.602 | µg/kg | 0.602 | EPA8260 |
| Carbon disulfide | U | | | 1.20 | µg/kg | 1.20 | EPA8260 |
| Toluene | U | V | | 0.145 | µg/kg | 0.602 | EPA8260 |
| Trichloroethylene | U | | | 0.0602 | µg/kg | 0.0602 | EPA8260 |

SAMPLE NAME: FRB-0507
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102278
Interval Depths: 16.00 to 18.00
Percent Solids: 80.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.58 | mg/kg | 6.58 | EPA6010 |
| Barium, total recoverable | | | | 8.18 | mg/kg | 3.29 | EPA6010 |
| Beryllium, total recoverable | | | | 0.15 | mg/kg | 3.29 | EPA6010 |
| Chromium, total recoverable | | | | 15.40 | mg/kg | 3.29 | EPA6010 |
| Nickel, total recoverable | | | | 2.35 | mg/kg | 3.29 | EPA6010 |
| Lead, total recoverable | | | | 5.66 | mg/kg | 6.58 | EPA6010 |
| Thallium, total recoverable | U | | | 6.58 | mg/kg | 6.58 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 17.80±4.71 | pCi/g | 2.85 | EPIA-001B |
| Americium-241 | UI | | | 0.0131±0.0152 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.0276±0.0058 | pCi/g | 0.0088 | EPIA-013B |
| Nonvolatile beta | | | | 125.00±7.75 | pCi/g | 4.36 | EPIA-001B |
| Carbon-14 | UI | | | -0.0581±0.0843 | pCi/g | 0.185 | EPIA-003B |
| Cobalt-60 | UI | | | -0.0003±0.0037 | pCi/g | 0.0063 | EPIA-013B |
| Cesium-137 | | | | 0.261±0.0097 | pCi/g | 0.0076 | EPIA-013B |
| Europium-154 | | | | 0.0403±0.0253 | pCi/g | 0.0352 | EPIA-013B |
| Iodine-129 | UI | | | 0.0875±0.07 | pCi/g | 0.153 | EPIA-006B |
| Potassium-40 | UI | V | | 1.16±0.0972 | pCi/g | 0.0552 | EPIA-013B |
| Nickel-63 | | | | 1.15±0.398 | pCi/g | 0.756 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0002±0.0124 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | J | C | | 0.899±0.0842 | pCi/g | 0.0532 | EPIA-013B |
| Strontium-90 | | | | 81.50±1.19 | pCi/g | 0.25 | EPIA-004 |
| Technetium-99 | UI | | | 0.0179±0.113 | pCi/g | 0.343 | EPIA-005B |
| Uranium-238 | | | | 0.873±0.176 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 41.30 | μg/kg | 41.30 | EPA8270 |
| Di-n-butyl phthalate | U | | | 41.30 | μg/kg | 41.30 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 41.30 | μg/kg | 41.30 | EPA8270 |
| 2-Chlorophenol | U | | | 41.30 | μg/kg | 41.30 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | | | | 0.488 | μg/kg | 0.625 | EPA8260 |
| Carbon disulfide | U | | | 1.25 | μg/kg | 1.25 | EPA8260 |
| Toluene | U | V | | 0.225 | μg/kg | 0.625 | EPA8260 |
| Trichloroethylene | | | | 0.075 | μg/kg | 0.0625 | EPA8260 |

SAMPLE NAME: FRB-0508
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102279
Interval Depths: 18.00 to 20.00
Percent Solids: 80.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.58 | mg/kg | 6.58 | EPA6010 |
| Barium, total recoverable | | | | 6.27 | mg/kg | 3.29 | EPA6010 |
| Beryllium, total recoverable | | | | 0.136 | mg/kg | 3.29 | EPA6010 |
| Chromium, total recoverable | | | | 18.60 | mg/kg | 3.29 | EPA6010 |
| Nickel, total recoverable | | | | 1.83 | mg/kg | 3.29 | EPA6010 |
| Lead, total recoverable | | | | 7.40 | mg/kg | 6.58 | EPA6010 |
| Thallium, total recoverable | U | | | 6.58 | mg/kg | 6.58 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 15.80±4.39 | pCi/g | 2.94 | EPIA-001B |
| Americium-241 | UI | | | 0.0206±0.0211 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.0105±0.005 | pCi/g | 0.0079 | EPIA-013B |
| Nonvolatile beta | | | | 21.60±3.58 | pCi/g | 4.27 | EPIA-001B |
| Carbon-14 | UI | | | -0.0719±0.0857 | pCi/g | 0.189 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0008±0.0032 | pCi/g | 0.0056 | EPIA-013B |
| Cesium-137 | | | | 0.123±0.0078 | pCi/g | 0.0069 | EPIA-013B |
| Europium-154 | UI | | | -0.0093±0.0208 | pCi/g | 0.0305 | EPIA-013B |
| Iodine-129 | UI | | | -0.0313±0.066 | pCi/g | 0.146 | EPIA-006B |
| Potassium-40 | UI | V | | 1.05±0.0894 | pCi/g | 0.0508 | EPIA-013B |
| Nickel-63 | | | | 1.29±0.452 | pCi/g | 0.859 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0172±0.0454 | pCi/g | 0.0886 | EPIA-012B |
| Radium-226 | J | C | | 0.954±0.113 | pCi/g | 0.0718 | EPIA-013B |
| Strontium-90 | | | | 13.00±0.574 | pCi/g | 0.311 | EPIA-004 |
| Technetium-99 | UI | | | 0.0849±0.105 | pCi/g | 0.316 | EPIA-005B |
| Uranium-238 | | | | 0.979±0.193 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 41.40 | μg/kg | 41.40 | EPA8270 |
| Di-n-butyl phthalate | U | | | 41.40 | μg/kg | 41.40 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 41.40 | μg/kg | 41.40 | EPA8270 |
| 2-Chlorophenol | | | | 4.14 | μg/kg | 41.40 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | | | | 0.40 | μg/kg | 0.625 | EPA8260 |
| Carbon disulfide | U | | | 1.25 | μg/kg | 1.25 | EPA8260 |
| Toluene | U | V | | 0.175 | μg/kg | 0.625 | EPA8260 |
| Trichloroethylene | U | | | 0.0625 | μg/kg | 0.0625 | EPA8260 |

SAMPLE NAME: FRB-0509
Location (SRS Coordinates): 53723 E 76383 N
Sample Matrix: Soil

Sample ID: 102280
Interval Depths: 20.00 to 22.00
Percent Solids: 79.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | UJ | IX | P | 6.66 | mg/kg | 6.66 | EPA6010 |
| Barium, total recoverable | J | VIXC | P | 5.04 | mg/kg | 3.33 | EPA6010 |
| Beryllium, total recoverable | J | IX | P | 0.113 | mg/kg | 3.33 | EPA6010 |
| Chromium, total recoverable | J | IX | P | 18.80 | mg/kg | 3.33 | EPA6010 |
| Nickel, total recoverable | J | IX | P | 1.50 | mg/kg | 3.33 | EPA6010 |
| Lead, total recoverable | J | IX | P | 10.40 | mg/kg | 6.66 | EPA6010 |
| Thallium, total recoverable | UJ | IX | P | 6.66 | mg/kg | 6.66 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 29.60±9.81 | pCi/g | 6.74 | EPIA-001B |
| Americium-241 | UI | | | 0.0195±0.0231 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.0037±0.0054 | pCi/g | 0.0078 | EPIA-013B |
| Nonvolatile beta | | X | | 26.20±5.96 | pCi/g | 7.24 | EPIA-001B |
| Carbon-14 | UI | | | -0.0451±0.0856 | pCi/g | 0.189 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0023±0.0033 | pCi/g | 0.0058 | EPIA-013B |
| Cesium-137 | | | | 0.0302±0.0085 | pCi/g | 0.0068 | EPIA-013B |
| Europium-154 | UI | | | 0.0256±0.0298 | pCi/g | 0.0308 | EPIA-013B |
| Iodine-129 | UI | | | 0.0987±0.063 | pCi/g | 0.147 | EPIA-006B |
| Potassium-40 | UI | V | | 1.11±0.156 | pCi/g | 0.0545 | EPIA-013B |
| Nickel-63 | | | | 1.10±0.473 | pCi/g | 0.924 | EPIA-022 |
| Plutonium-239/240 | UI | X | | 0.0002±0.011 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.912±0.0842 | pCi/g | 0.0576 | EPIA-013B |
| Strontium-90 | | X | | 32.70±1.81 | pCi/g | 1.18 | EPIA-004 |
| Technetium-99 | UI | VX | | 0.922±0.13 | pCi/g | 0.368 | EPIA-005B |
| Uranium-238 | | | | 1.44±0.242 | pCi/g | 0.0696 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 41.90 | μg/kg | 41.90 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 18.00 | μg/kg | 41.90 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 41.90 | μg/kg | 41.90 | EPA8270 |
| 2-Chlorophenol | U | | | 41.90 | μg/kg | 41.90 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.633 | μg/kg | 0.633 | EPA8260 |
| Carbon disulfide | U | | | 1.27 | μg/kg | 1.27 | EPA8260 |
| Toluene | U | V | | 0.177 | μg/kg | 0.633 | EPA8260 |
| Trichloroethylene | U | | | 0.0633 | μg/kg | 0.0633 | EPA8260 |

**This Page Intentionally Left Blank**

SAMPLE NAME: FRB-0601
Location (SRS Coordinates): 53775 E 76260 N
Sample Matrix: Soil

Sample ID: 102249
Interval Depths: 0.00 to 1.00
Percent Solids: 92.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.72 | mg/kg | 5.72 | EPA6010 |
| Barium, total recoverable | | | | 23.20 | mg/kg | 2.86 | EPA6010 |
| Beryllium, total recoverable | | | | 0.235 | mg/kg | 2.86 | EPA6010 |
| Chromium, total recoverable | | | | 8.72 | mg/kg | 2.86 | EPA6010 |
| Nickel, total recoverable | | | | 1.79 | mg/kg | 2.86 | EPA6010 |
| Lead, total recoverable | | | | 6.47 | mg/kg | 5.72 | EPA6010 |
| Thallium, total recoverable | U | | | 5.72 | mg/kg | 5.72 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 6.88±2.51 | pCi/g | 2.29 | EPIA-001B |
| Americium-241 | UI | | | 0.0144±0.0225 | pCi/g | 0.0432 | EPIA-011B |
| Barium-133 | UI | | | -0.0021±0.0048 | pCi/g | 0.0068 | EPIA-013B |
| Nonvolatile beta | | X | | 10.10±2.66 | pCi/g | 3.85 | EPIA-001B |
| Carbon-14 | UI | | | -0.553±0.102 | pCi/g | 0.213 | EPIA-003B |
| Cobalt-60 | UIJ | X | | -0.0019±0.003 | pCi/g | 0.005 | EPIA-013B |
| Cesium-137 | | | | 0.246±0.0084 | pCi/g | 0.0058 | EPIA-013B |
| Europium-154 | UI | | | -0.0079±0.0183 | pCi/g | 0.0263 | EPIA-013B |
| Iodine-129 | UI | | | 0.0141±0.049 | pCi/g | 0.097 | EPIA-006B |
| Potassium-40 | UI | V | | 1.64±0.0946 | pCi/g | 0.0483 | EPIA-013B |
| Nickel-63 | J | X | | 1.14±0.408 | pCi/g | 0.779 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0009±0.0345 | pCi/g | 0.0783 | EPIA-012B |
| Radium-226 | J | C | | 0.805±0.0983 | pCi/g | 0.0643 | EPIA-013B |
| Strontium-90 | J | X | | 0.346±0.23 | pCi/g | 0.331 | EPIA-004 |
| Technetium-99 | UIJ | X | | -0.0076±0.163 | pCi/g | 0.428 | EPIA-005B |
| Uranium-238 | | | | 0.598±0.16 | pCi/g | 0.0691 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.10 | µg/kg | 36.10 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 26.30 | µg/kg | 36.10 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.10 | µg/kg | 36.10 | EPA8270 |
| 2-Chlorophenol | U | | | 36.10 | µg/kg | 36.10 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | J | QO | H | 0.935 | µg/kg | 0.543 | EPA8260 |
| Carbon disulfide | UJ | QO | H | 1.09 | µg/kg | 1.09 | EPA8260 |
| Toluene | UJ | VQO | H | 0.228 | µg/kg | 0.543 | EPA8260 |
| Trichloroethylene | UJ | QO | H | 0.0543 | µg/kg | 0.0543 | EPA8260 |

SAMPLE NAME: FRB-0602
Location (SRS Coordinates): 53775 E 76260 N
Sample Matrix: Soil

Sample ID: 102250
Interval Depths: 10.00 to 12.00
Percent Solids: 87.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.05 | mg/kg | 6.05 | EPA6010 |
| Barium, total recoverable | | | | 26.20 | mg/kg | 3.02 | EPA6010 |
| Beryllium, total recoverable | | | | 0.238 | mg/kg | 3.02 | EPA6010 |
| Chromium, total recoverable | | | | 10.20 | mg/kg | 3.02 | EPA6010 |
| Nickel, total recoverable | | | | 1.66 | mg/kg | 3.02 | EPA6010 |
| Lead, total recoverable | | | | 7.22 | mg/kg | 6.05 | EPA6010 |
| Thallium, total recoverable | U | | | 6.05 | mg/kg | 6.05 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 5.67±2.25 | pCi/g | 2.07 | EPIA-001B |
| Americium-241 | UI | | | -0.0096±0.0203 | pCi/g | 0.0558 | EPIA-011B |
| Barium-133 | UI | | | 0.0032±0.0044 | pCi/g | 0.0064 | EPIA-013B |
| Nonvolatile beta | | | | 5.05±2.39 | pCi/g | 4.44 | EPIA-001B |
| Carbon-14 | UI | | | -0.629±0.101 | pCi/g | 0.225 | EPIA-003B |
| Cobalt-60 | UI | | | -0.0003±0.0026 | pCi/g | 0.0044 | EPIA-013B |
| Cesium-137 | | | | 0.455±0.0102 | pCi/g | 0.0053 | EPIA-013B |
| Europium-154 | UI | | | 0.0031±0.0211 | pCi/g | 0.0229 | EPIA-013B |
| Iodine-129 | UI | | | -0.046±0.041 | pCi/g | 0.0808 | EPIA-006B |
| Potassium-40 | UI | V | | 1.13±0.0731 | pCi/g | 0.0401 | EPIA-013B |
| Nickel-63 | | | | 0.919±0.393 | pCi/g | 0.768 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0557±0.0472 | pCi/g | 0.0665 | EPIA-012B |
| Radium-226 | J | C | | 0.718±0.0611 | pCi/g | 0.0431 | EPIA-013B |
| Strontium-90 | | | | 0.571±0.275 | pCi/g | 0.313 | EPIA-004 |
| Technetium-99 | UI | | | 0.0343±0.103 | pCi/g | 0.286 | EPIA-005B |
| Uranium-238 | | | | 0.688±0.176 | pCi/g | 0.0541 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 20.60 | µg/kg | 38.20 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| 2-Chlorophenol | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | VO | H | 0.345 | µg/kg | 0.575 | EPA8260 |
| Carbon disulfide | U | O | H | 1.15 | µg/kg | 1.15 | EPA8260 |
| Toluene | J | VO | H | 0.862 | µg/kg | 0.575 | EPA8260 |
| Trichloroethylene | J | O | H | 0.0575 | µg/kg | 0.0575 | EPA8260 |

SAMPLE NAME: FRB-0603
Location (SRS Coordinates): 53775 E 76260 N
Sample Matrix: Soil

Sample ID: 102252
Interval Depths: 12.00 to 14.00
Percent Solids: 77.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | | | | 4.55 | mg/kg | 6.84 | EPA6010 |
| Barium, total recoverable | | | | 20.10 | mg/kg | 3.42 | EPA6010 |
| Beryllium, total recoverable | | | | 0.481 | mg/kg | 3.42 | EPA6010 |
| Chromium, total recoverable | | | | 35.40 | mg/kg | 3.42 | EPA6010 |
| Nickel, total recoverable | | | | 7.52 | mg/kg | 3.42 | EPA6010 |
| Lead, total recoverable | | | | 14.00 | mg/kg | 6.84 | EPA6010 |
| Thallium, total recoverable | U | | | 6.84 | mg/kg | 6.84 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 60.70±10.50 | pCi/g | 2.42 | EPIA-001B |
| Americium-241 | | | | 5.34±0.535 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.029±0.102 | pCi/g | 0.165 | EPIA-013B |
| Nonvolatile beta | | | | 2460.00±33.50 | pCi/g | 4.52 | EPIA-001B |
| Carbon-14 | UI | | | -0.638±0.102 | pCi/g | 0.253 | EPIA-003B |
| Cobalt-60 | | | | 0.184±0.0129 | pCi/g | 0.0101 | EPIA-013B |
| Cesium-137 | | | | 2070.00±0.66 | pCi/g | 0.114 | EPIA-013B |
| Europium-154 | | | | 0.983±0.193 | pCi/g | 0.224 | EPIA-013B |
| Iodine-129 | | | | 11.20±1.23 | pCi/g | 0.821 | EPIA-006B |
| Potassium-40 | UI | V | | 1.80±0.133 | pCi/g | 0.0813 | EPIA-013B |
| Nickel-63 | | | | 11.60±0.749 | pCi/g | 0.80 | EPIA-022 |
| Plutonium-239/240 | | | | 14.60±1.21 | pCi/g | 0.0116 | EPIA-012B |
| Radium-226 | J | C | | 1.31±0.698 | pCi/g | 0.939 | EPIA-013B |
| Strontium-90 | | | | 1080.00±4.18 | pCi/g | 0.367 | EPIA-004 |
| Technetium-99 | | | | 0.545±0.125 | pCi/g | 0.373 | EPIA-005B |
| Uranium-238 | | | | 17.30±1.93 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 42.60 | µg/kg | 42.60 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 49.90 | µg/kg | 42.60 | EPA8270 |
| N-Nitrosodiphenylamine | | | | 16.60 | µg/kg | 42.60 | EPA8270 |
| 2-Chlorophenol | U | | | 42.60 | µg/kg | 42.60 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | VO | H | 0.39 | µg/kg | 0.649 | EPA8260 |
| Carbon disulfide | J | O | H | 0.325 | µg/kg | 1.30 | EPA8260 |
| Toluene | U | VO | H | 0.403 | µg/kg | 0.649 | EPA8260 |
| Trichloroethylene | U | O | H | 0.0649 | µg/kg | 0.0649 | EPA8260 |

SAMPLE NAME: FRB-0604
Location (SRS Coordinates): 53775 E 76260 N
Sample Matrix: Soil

Sample ID: 102254
Interval Depths: 14.00 to 16.00
Percent Solids: 76.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.93 | mg/kg | 6.93 | EPA6010 |
| Barium, total recoverable | | | | 6.40 | mg/kg | 3.46 | EPA6010 |
| Beryllium, total recoverable | | | | 0.09 | mg/kg | 3.46 | EPA6010 |
| Chromium, total recoverable | | | | 19.40 | mg/kg | 3.46 | EPA6010 |
| Nickel, total recoverable | | | | 1.69 | mg/kg | 3.46 | EPA6010 |
| Lead, total recoverable | | | | 11.20 | mg/kg | 6.93 | EPA6010 |
| Thallium, total recoverable | U | | | 6.93 | mg/kg | 6.93 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 51.80±10.40 | pCi/g | 3.04 | EPIA-001B |
| Americium-241 | UI | | | 0.0017±0.023 | pCi/g | 0.054 | EPIA-011B |
| Barium-133 | UI | | | -0.0038±0.0107 | pCi/g | 0.0152 | EPIA-013B |
| Nonvolatile beta | | | | 1270.00±24.10 | pCi/g | 4.50 | EPIA-001B |
| Carbon-14 | UI | | | -0.655±0.101 | pCi/g | 0.255 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0005±0.0043 | pCi/g | 0.0073 | EPIA-013B |
| Cesium-137 | | | | 0.966±0.0164 | pCi/g | 0.0104 | EPIA-013B |
| Europium-154 | UI | | | 0.0144±0.0428 | pCi/g | 0.0453 | EPIA-013B |
| Iodine-129 | UI | | | -0.0342±0.133 | pCi/g | 0.303 | EPIA-006B |
| Potassium-40 | UI | V | | 1.85±0.123 | pCi/g | 0.0622 | EPIA-013B |
| Nickel-63 | | | | 0.961±0.381 | pCi/g | 0.738 | EPIA-022 |
| Plutonium-239/240 | | | | 0.186±0.0557 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | J | C | | 1.07±0.12 | pCi/g | 0.093 | EPIA-013B |
| Strontium-90 | | | | 747.00±3.63 | pCi/g | 0.384 | EPIA-004 |
| Technetium-99 | UI | | | 0.0326±0.0994 | pCi/g | 0.316 | EPIA-005B |
| Uranium-238 | | | | 1.11±0.151 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 43.70 | µg/kg | 43.70 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 25.80 | µg/kg | 43.70 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 43.70 | µg/kg | 43.70 | EPA8270 |
| 2-Chlorophenol | U | | | 43.70 | µg/kg | 43.70 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | V | | 0.434 | µg/kg | 0.658 | EPA8260 |
| Carbon disulfide | U | | | 1.32 | µg/kg | 1.32 | EPA8260 |
| Toluene | U | V | | 0.579 | µg/kg | 0.658 | EPA8260 |
| Trichloroethylene | U | | | 0.0658 | µg/kg | 0.0658 | EPA8260 |

SAMPLE NAME: FRB-0605
Location (SRS Coordinates): 53775 E 76260 N
Sample Matrix: Soil

Sample ID: 102255
Interval Depths: 16.00 to 18.00
Percent Solids: 77.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.84 | mg/kg | 6.84 | EPA6010 |
| Barium, total recoverable | | | | 6.49 | mg/kg | 3.42 | EPA6010 |
| Beryllium, total recoverable | | | | 0.159 | mg/kg | 3.42 | EPA6010 |
| Chromium, total recoverable | | | | 39.10 | mg/kg | 3.42 | EPA6010 |
| Nickel, total recoverable | | | | 1.35 | mg/kg | 3.42 | EPA6010 |
| Lead, total recoverable | | | | 15.10 | mg/kg | 6.84 | EPA6010 |
| Thallium, total recoverable | U | | | 6.84 | mg/kg | 6.84 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 19.50±5.37 | pCi/g | 2.96 | EPIA-001B |
| Americium-241 | UI | | | 0.002±0.026 | pCi/g | 0.0612 | EPIA-011B |
| Barium-133 | UI | | | 0.0064±0.0105 | pCi/g | 0.0136 | EPIA-013B |
| Nonvolatile beta | | | | 404.00±13.90 | pCi/g | 4.56 | EPIA-001B |
| Carbon-14 | UI | | | -0.686±0.101 | pCi/g | 0.253 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0026±0.004 | pCi/g | 0.0067 | EPIA-013B |
| Cesium-137 | | | | 3.37±0.0285 | pCi/g | 0.0102 | EPIA-013B |
| Europium-154 | UI | | | -0.0761±0.0275 | pCi/g | 0.0381 | EPIA-013B |
| Iodine-129 | UI | | | 0.0143±0.102 | pCi/g | 0.209 | EPIA-006B |
| Potassium-40 | UI | V | | 2.16±0.116 | pCi/g | 0.0557 | EPIA-013B |
| Nickel-63 | UI | | | 0.634±0.377 | pCi/g | 0.762 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0055±0.0255 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | J | C | | 1.04±0.0899 | pCi/g | 0.062 | EPIA-013B |
| Strontium-90 | | | | 339.00±2.40 | pCi/g | 0.337 | EPIA-004 |
| Technetium-99 | UI | | | 0.0679±0.0995 | pCi/g | 0.31 | EPIA-005B |
| Uranium-238 | | | | 0.965±0.201 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 43.00 | µg/kg | 43.00 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 24.10 | µg/kg | 43.00 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 43.00 | µg/kg | 43.00 | EPA8270 |
| 2-Chlorophenol | U | | | 43.00 | µg/kg | 43.00 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | V | | 0.597 | µg/kg | 0.649 | EPA8260 |
| Carbon disulfide | U | | | 1.30 | µg/kg | 1.30 | EPA8260 |
| Toluene | J | V | | 0.987 | µg/kg | 0.649 | EPA8260 |
| Trichloroethylene | | | | 0.0779 | µg/kg | 0.0649 | EPA8260 |

SAMPLE NAME: FRB-0606
Location (SRS Coordinates): 53775 E 76260 N
Sample Matrix: Soil

Sample ID: 102256
Interval Depths: 18.00 to 20.00
Percent Solids: 83.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.34 | mg/kg | 6.34 | EPA6010 |
| Barium, total recoverable | | | | 4.22 | mg/kg | 3.17 | EPA6010 |
| Beryllium, total recoverable | | | | 0.0913 | mg/kg | 3.17 | EPA6010 |
| Chromium, total recoverable | | | | 26.60 | mg/kg | 3.17 | EPA6010 |
| Nickel, total recoverable | | | | 0.635 | mg/kg | 3.17 | EPA6010 |
| Lead, total recoverable | | | | 8.86 | mg/kg | 6.34 | EPA6010 |
| Thallium, total recoverable | U | | | 6.34 | mg/kg | 6.34 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 5.39±2.67 | pCi/g | 2.27 | EPIA-001B |
| Americium-241 | UI | | | 0.0273±0.0249 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.147±0.103 | pCi/g | 0.0224 | EPIA-013B |
| Nonvolatile beta | | | | 212.00±9.92 | pCi/g | 4.32 | EPIA-001B |
| Carbon-14 | UI | | | -0.598±0.103 | pCi/g | 0.237 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0038±0.0041 | pCi/g | 0.0072 | EPIA-013B |
| Cesium-137 | | | | 22.00±3.20 | pCi/g | 0.0186 | EPIA-013B |
| Europium-154 | UI | | | -0.0019±0.0271 | pCi/g | 0.0399 | EPIA-013B |
| Iodine-129 | UI | | | 0.0325±0.097 | pCi/g | 0.187 | EPIA-006B |
| Potassium-40 | UI | V | | 1.90±0.223 | pCi/g | 0.0678 | EPIA-013B |
| Nickel-63 | | | | 1.10±0.435 | pCi/g | 0.841 | EPIA-022 |
| Plutonium-239/240 | | | | 0.147±0.0511 | pCi/g | 0.0126 | EPIA-012B |
| Radium-226 | J | C | | 0.977±0.0985 | pCi/g | 0.0759 | EPIA-013B |
| Strontium-90 | | | | 360.00±2.24 | pCi/g | 0.235 | EPIA-004 |
| Technetium-99 | UI | | | 0.118±0.102 | pCi/g | 0.293 | EPIA-005B |
| Uranium-238 | | | | 1.34±0.264 | pCi/g | 0.062 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 39.40 | μg/kg | 39.40 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 18.50 | μg/kg | 39.40 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 39.40 | μg/kg | 39.40 | EPA8270 |
| 2-Chlorophenol | U | | | 39.40 | μg/kg | 39.40 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | V | | 0.373 | μg/kg | 0.602 | EPA8260 |
| Carbon disulfide | U | | | 1.20 | μg/kg | 1.20 | EPA8260 |
| Toluene | U | V | | 0.446 | μg/kg | 0.602 | EPA8260 |
| Trichloroethylene | U | | | 0.0602 | μg/kg | 0.0602 | EPA8260 |

SAMPLE NAME: FRB-0701
Location (SRS Coordinates): 53732 E 76132 N
Sample Matrix: Soil

Sample ID: 102289
Interval Depths: 0.00 to 1.00
Percent Solids: 90.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.85 | mg/kg | 5.85 | EPA6010 |
| Barium, total recoverable | | V | | 20.10 | mg/kg | 2.92 | EPA6010 |
| Beryllium, total recoverable | | | | 0.185 | mg/kg | 2.92 | EPA6010 |
| Chromium, total recoverable | | | | 7.17 | mg/kg | 2.92 | EPA6010 |
| Nickel, total recoverable | | | | 2.01 | mg/kg | 2.92 | EPA6010 |
| Lead, total recoverable | | | | 5.15 | mg/kg | 5.85 | EPA6010 |
| Thallium, total recoverable | U | | | 5.85 | mg/kg | 5.85 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 4.39±2.24 | pCi/g | 2.56 | EPIA-001B |
| Americium-241 | UI | X | | 0.007±0.0183 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | 0.0004±0.0071 | pCi/g | 0.0106 | EPIA-013B |
| Nonvolatile beta | UI | X | | 3.77±3.18 | pCi/g | 6.56 | EPIA-001B |
| Carbon-14 | UI | X | | 0.0157±0.0855 | pCi/g | 0.163 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.0012±0.0053 | pCi/g | 0.0079 | EPIA-013B |
| Cesium-137 | | X | | 0.166±0.0143 | pCi/g | 0.0099 | EPIA-013B |
| Europium-154 | UI | X | | -0.0094±0.0531 | pCi/g | 0.0764 | EPIA-013B |
| Iodine-129 | UIJ | CX | | -0.0433±0.047 | pCi/g | 0.09 | EPIA-006B |
| Potassium-40 | | VX | | 1.74±0.155 | pCi/g | 0.0807 | EPIA-013B |
| Nickel-63 | UI | V | | 0.849±0.34 | pCi/g | 0.659 | EPIA-022 |
| Plutonium-239/240 | UI | X | | 0.0033±0.0136 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.931±0.0712 | pCi/g | 0.0414 | EPIA-013B |
| Strontium-90 | UI | V | | 1.75±0.443 | pCi/g | 0.434 | EPIA-004 |
| Technetium-99 | UI | X | | 0.0952±0.108 | pCi/g | 0.288 | EPIA-005B |
| Uranium-238 | | X | | 0.919±0.153 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | IY | P | 36.00 | μg/kg | 36.00 | EPA8270 |
| Di-n-butyl phthalate | UJ | IY | P | 36.00 | μg/kg | 36.00 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | IY | P | 36.00 | μg/kg | 36.00 | EPA8270 |
| 2-Chlorophenol | UJ | I | P | 36.00 | μg/kg | 36.00 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | UJ | 8IYO | P | 0.556 | μg/kg | 0.556 | EPA8260 |
| Carbon disulfide | UJ | IYO | P | 1.11 | μg/kg | 1.11 | EPA8260 |
| Toluene | UJ | V8I* | P | 0.111 | μg/kg | 0.556 | EPA8260 |
| Trichloroethylene | UJ | IYO | P | 0.0556 | μg/kg | 0.0556 | EPA8260 |

* = OB

SAMPLE NAME: FRB-0702
Location (SRS Coordinates): 53732 E 76132 N
Sample Matrix: Soil

Sample ID: 102291
Interval Depths: 2.00 to 4.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | V | | 24.10 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.256 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 10.10 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | | | | 2.06 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 8.27 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 20.40±5.30 | pCi/g | 6.29 | EPIA-001B |
| Americium-241 | UI | X | | 0.0043±0.0207 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | 0.0037±0.0073 | pCi/g | 0.0115 | EPIA-013B |
| Nonvolatile beta | | X | | 7.21±3.57 | pCi/g | 6.71 | EPIA-001B |
| Carbon-14 | UI | X | | -0.0722±0.0819 | pCi/g | 0.163 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.0014±0.0045 | pCi/g | 0.0078 | EPIA-013B |
| Cesium-137 | | X | | 0.0884±0.0125 | pCi/g | 0.0096 | EPIA-013B |
| Europium-154 | UI | X | | -0.0188±0.0478 | pCi/g | 0.0714 | EPIA-013B |
| Iodine-129 | UIJ | CX | | 0.0011±0.044 | pCi/g | 0.0888 | EPIA-006B |
| Potassium-40 | | VX | | 1.19±0.134 | pCi/g | 0.0763 | EPIA-013B |
| Nickel-63 | UI | V | | 1.04±0.388 | pCi/g | 0.746 | EPIA-022 |
| Plutonium-239/240 | UI | X | | 0.0118±0.0142 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.93±0.0546 | pCi/g | 0.0394 | EPIA-013B |
| Strontium-90 | UI | V | | 1.43±0.342 | pCi/g | 0.332 | EPIA-004 |
| Technetium-99 | UI | X | | 0.0635±0.123 | pCi/g | 0.331 | EPIA-005B |
| Uranium-238 | | X | | 0.869±0.147 | pCi/g | 0.0663 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | IY | P | 36.80 | µg/kg | 36.80 | EPA8270 |
| Di-n-butyl phthalate | UJ | VIYB | P | 14.70 | µg/kg | 36.80 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | IY | P | 36.80 | µg/kg | 36.80 | EPA8270 |
| 2-Chlorophenol | UJ | I | P | 36.80 | µg/kg | 36.80 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | UJ | 8IYO | P | 0.562 | µg/kg | 0.562 | EPA8260 |
| Carbon disulfide | UJ | IYO | P | 1.12 | µg/kg | 1.12 | EPA8260 |
| Toluene | UJ | V8I* | P | 0.27 | µg/kg | 0.562 | EPA8260 |
| Trichloroethylene | UJ | IYO | P | 0.0562 | µg/kg | 0.0562 | EPA8260 |

* = OBY

SAMPLE NAME: FRB-0703
Location (SRS Coordinates): 53732 E 76132 N
Sample Matrix: Soil

Sample ID: 102292
Interval Depths: 8.00 to 10.00
Percent Solids: 88.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.98 | mg/kg | 5.98 | EPA6010 |
| Barium, total recoverable | | V | | 14.90 | mg/kg | 2.99 | EPA6010 |
| Beryllium, total recoverable | | | | 0.149 | mg/kg | 2.99 | EPA6010 |
| Chromium, total recoverable | | | | 13.50 | mg/kg | 2.99 | EPA6010 |
| Nickel, total recoverable | | | | 2.16 | mg/kg | 2.99 | EPA6010 |
| Lead, total recoverable | | | | 7.99 | mg/kg | 5.98 | EPA6010 |
| Thallium, total recoverable | U | | | 5.98 | mg/kg | 5.98 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 34.00±6.96 | pCi/g | 3.83 | EPIA-001B |
| Americium-241 | UI | X | | -0.0139±0.0184 | pCi/g | 0.0644 | EPIA-011B |
| Barium-133 | UI | X | | 0.0117±0.0173 | pCi/g | 0.0217 | EPIA-013B |
| Nonvolatile beta | | X | | 247.00±12.90 | pCi/g | 8.03 | EPIA-001B |
| Carbon-14 | UI | X | | -0.0867±0.0815 | pCi/g | 0.165 | EPIA-003B |
| Cobalt-60 | | X | | 0.0221±0.0103 | pCi/g | 0.0096 | EPIA-013B |
| Cesium-137 | | X | | 6.60±0.071 | pCi/g | 0.0155 | EPIA-013B |
| Europium-154 | UI | X | | -0.233±0.0617 | pCi/g | 0.0821 | EPIA-013B |
| Iodine-129 | J | CX | | 0.659±0.328 | pCi/g | 0.282 | EPIA-006B |
| Potassium-40 | | VX | | 1.42±0.16 | pCi/g | 0.0823 | EPIA-013B |
| Nickel-63 | UI | V | | 1.66±0.422 | pCi/g | 0.761 | EPIA-022 |
| Plutonium-239/240 | UI | X | | 0.0495±0.0251 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.941±0.066 | pCi/g | 0.0538 | EPIA-013B |
| Strontium-90 | | V | | 91.30±1.19 | pCi/g | 0.265 | EPIA-004 |
| Technetium-99 | UI | X | | 0.223±0.115 | pCi/g | 0.308 | EPIA-005B |
| Uranium-238 | | X | | 10.50±1.04 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | IY | P | 37.50 | µg/kg | 37.50 | EPA8270 |
| Di-n-butyl phthalate | UJ | VIYB | P | 20.30 | µg/kg | 37.50 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | IY | P | 37.50 | µg/kg | 37.50 | EPA8270 |
| 2-Chlorophenol | UJ | IV | P | 37.50 | µg/kg | 37.50 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | UJ | 8IY | P | 0.568 | µg/kg | 0.568 | EPA8260 |
| Carbon disulfide | UJ | IY | P | 1.14 | µg/kg | 1.14 | EPA8260 |
| Toluene | UJ | V8IB | P | 0.125 | µg/kg | 0.568 | EPA8260 |
| Trichloroethylene | UJ | IY | P | 0.0568 | µg/kg | 0.0568 | EPA8260 |

SAMPLE NAME: FRB-0704
Location (SRS Coordinates): 53732 E 76132 N
Sample Matrix: Soil

Sample ID: 102294
Interval Depths: 10.00 to 12.00
Percent Solids: 87.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | | | | 3.26 | mg/kg | 6.05 | EPA6010 |
| Barium, total recoverable | | V | | 8.38 | mg/kg | 3.02 | EPA6010 |
| Beryllium, total recoverable | | | | 0.148 | mg/kg | 3.02 | EPA6010 |
| Chromium, total recoverable | | | | 12.70 | mg/kg | 3.02 | EPA6010 |
| Nickel, total recoverable | | | | 2.43 | mg/kg | 3.02 | EPA6010 |
| Lead, total recoverable | | | | 6.32 | mg/kg | 6.05 | EPA6010 |
| Thallium, total recoverable | U | | | 6.05 | mg/kg | 6.05 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 16.90±5.00 | pCi/g | 4.16 | EPIA-001B |
| Americium-241 | UI | X | | 0.0024±0.0206 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | 0.0028±0.0103 | pCi/g | 0.015 | EPIA-013B |
| Nonvolatile beta | | X | | 238.00±12.50 | pCi/g | 7.81 | EPIA-001B |
| Carbon-14 | UI | X | | -0.0275±0.0844 | pCi/g | 0.169 | EPIA-003B |
| Cobalt-60 | UI | X | | 0.0017±0.0051 | pCi/g | 0.0092 | EPIA-013B |
| Cesium-137 | | X | | 0.327±0.0215 | pCi/g | 0.0133 | EPIA-013B |
| Europium-154 | UI | X | | -0.0269±0.0576 | pCi/g | 0.0857 | EPIA-013B |
| Iodine-129 | UIJ | CX | | 0.0345±0.218 | pCi/g | 0.414 | EPIA-006B |
| Potassium-40 | | VX | | 0.878±0.137 | pCi/g | 0.0885 | EPIA-013B |
| Nickel-63 | UI | V | | 1.51±0.419 | pCi/g | 0.767 | EPIA-022 |
| Plutonium-239/240 | UI | X | | -0.0065±0.0129 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.813±0.0584 | pCi/g | 0.0451 | EPIA-013B |
| Strontium-90 | | V | | 174.00±2.06 | pCi/g | 0.423 | EPIA-004 |
| Technetium-99 | UI | X | | 0.0133±0.103 | pCi/g | 0.287 | EPIA-005B |
| Uranium-238 | | X | | 1.57±0.217 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | IY | P | 38.20 | µg/kg | 38.20 | EPA8270 |
| Di-n-butyl phthalate | UJ | VIYB | P | 15.30 | µg/kg | 38.20 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | IY | P | 38.20 | µg/kg | 38.20 | EPA8270 |
| 2-Chlorophenol | UJ | I | P | 38.20 | µg/kg | 38.20 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | J | 8IYB | P | 0.379 | µg/kg | 0.575 | EPA8260 |
| Carbon disulfide | UJ | IY | P | 1.15 | µg/kg | 1.15 | EPA8260 |
| Toluene | UJ | V8I* | P | 0.126 | µg/kg | 0.575 | EPA8260 |
| Trichloroethylene | UJ | IY | P | 0.0575 | µg/kg | 0.0575 | EPA8260 |

* = BY

SAMPLE NAME: FRB-0705
Location (SRS Coordinates): 53732 E 76132 N
Sample Matrix: Soil

Sample ID: 102295
Interval Depths: 12.00 to 14.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | V | | 6.81 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.118 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 11.60 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | | | | 1.40 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 11.00 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 14.00±4.14 | pCi/g | 3.92 | EPIA-001B |
| Americium-241 | UI | X | | -0.008±0.0204 | pCi/g | 0.0615 | EPIA-011B |
| Barium-133 | UI | X | | 0.0005±0.0077 | pCi/g | 0.0114 | EPIA-013B |
| Nonvolatile beta | | X | | 27.60±4.88 | pCi/g | 6.54 | EPIA-001B |
| Carbon-14 | UI | X | | -0.0254±0.0834 | pCi/g | 0.163 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.0033±0.0044 | pCi/g | 0.0075 | EPIA-013B |
| Cesium-137 | | X | | 0.071±0.0119 | pCi/g | 0.0109 | EPIA-013B |
| Europium-154 | UI | X | | -0.0201±0.0432 | pCi/g | 0.0706 | EPIA-013B |
| Iodine-129 | UIJ | CX | | 0.0011±0.116 | pCi/g | 0.246 | EPIA-006B |
| Potassium-40 | | VX | | 0.714±0.121 | pCi/g | 0.0766 | EPIA-013B |
| Nickel-63 | UI | V | | 1.53±0.524 | pCi/g | 0.995 | EPIA-022 |
| Plutonium-239/240 | UI | X | | -0.0191±0.0238 | pCi/g | 0.0662 | EPIA-012B |
| Radium-226 | | X | | 0.632±0.0691 | pCi/g | 0.0519 | EPIA-013B |
| Strontium-90 | | V | | 13.40±0.622 | pCi/g | 0.369 | EPIA-004 |
| Technetium-99 | UI | X | | 0.0719±0.0995 | pCi/g | 0.269 | EPIA-005B |
| Uranium-238 | | X | | 1.05±0.167 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | IY | P | 37.30 | µg/kg | 37.30 | EPA8270 |
| Di-n-butyl phthalate | UJ | VIYB | P | 20.10 | µg/kg | 37.30 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | IY | P | 37.30 | µg/kg | 37.30 | EPA8270 |
| 2-Chlorophenol | UJ | I | P | 37.30 | µg/kg | 37.30 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | UJ | 8IY | P | 0.562 | µg/kg | 0.562 | EPA8260 |
| Carbon disulfide | UJ | IY | P | 1.12 | µg/kg | 1.12 | EPA8260 |
| Toluene | UJ | V8I* | P | 0.124 | µg/kg | 0.562 | EPA8260 |
| Trichloroethylene | UJ | IY | P | 0.0562 | µg/kg | 0.0562 | EPA8260 |

* = BY

SAMPLE NAME: FRB-0706
Location (SRS Coordinates): 53732 E 76132 N
Sample Matrix: Soil

Sample ID: 102296
Interval Depths: 14.00 to 16.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | V | | 6.50 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.118 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 12.40 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | | | | 1.25 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 5.84 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 21.60±5.32 | pCi/g | 5.30 | EPIA-001B |
| Americium-241 | UI | X | | 0.0137±0.0226 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | 0.0059±0.0113 | pCi/g | 0.0118 | EPIA-013B |
| Nonvolatile beta | | X | | 25.80±4.86 | pCi/g | 6.76 | EPIA-001B |
| Carbon-14 | UI | X | | -0.0171±0.0853 | pCi/g | 0.166 | EPIA-003B |
| Cobalt-60 | UI | X | | 0.0028±0.0052 | pCi/g | 0.0095 | EPIA-013B |
| Cesium-137 | | X | | 0.0659±0.0143 | pCi/g | 0.012 | EPIA-013B |
| Europium-154 | UI | X | | -0.0151±0.0484 | pCi/g | 0.0798 | EPIA-013B |
| Iodine-129 | UIJ | CX | | 0.0023±0.135 | pCi/g | 0.26 | EPIA-006B |
| Potassium-40 | | VX | | 0.74±0.118 | pCi/g | 0.0845 | EPIA-013B |
| Nickel-63 | UI | V | | 0.99±0.368 | pCi/g | 0.707 | EPIA-022 |
| Plutonium-239/240 | UI | X | | 0.0136±0.0199 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.858±0.0666 | pCi/g | 0.0438 | EPIA-013B |
| Strontium-90 | | V | | 8.70±0.607 | pCi/g | 0.437 | EPIA-004 |
| Technetium-99 | UI | X | | 0.0039±0.0989 | pCi/g | 0.27 | EPIA-005B |
| Uranium-238 | | X | | 0.89±0.15 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | IY | P | 37.40 | µg/kg | 37.40 | EPA8270 |
| Di-n-butyl phthalate | UJ | VIYB | P | 20.20 | µg/kg | 37.40 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | IY | P | 37.40 | µg/kg | 37.40 | EPA8270 |
| 2-Chlorophenol | UJ | I | P | 37.40 | µg/kg | 37.40 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | J | 8IYB | P | 0.371 | µg/kg | 0.562 | EPA8260 |
| Carbon disulfide | UJ | IY | P | 1.12 | µg/kg | 1.12 | EPA8260 |
| Toluene | UJ | V8IB | P | 0.124 | µg/kg | 0.562 | EPA8260 |
| Trichloroethylene | UJ | IY | P | 0.0562 | µg/kg | 0.0562 | EPA8260 |

SAMPLE NAME: FRB-0707
Location (SRS Coordinates): 53732 E 76132 N
Sample Matrix: Soil

Sample ID: 102298
Interval Depths: 16.00 to 18.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | V | | 3.33 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.052 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 9.49 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | U | | | 2.96 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 5.16 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 10.70±3.55 | pCi/g | 3.54 | EPIA-001B |
| Americium-241 | UI | X | | 0.0044±0.0088 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | 0.0058±0.0109 | pCi/g | 0.0125 | EPIA-013B |
| Nonvolatile beta | | X | | 8.20±3.51 | pCi/g | 6.50 | EPIA-001B |
| Carbon-14 | UI | X | | -0.0245±0.0844 | pCi/g | 0.165 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.0006±0.0053 | pCi/g | 0.009 | EPIA-013B |
| Cesium-137 | | X | | 0.0963±0.0144 | pCi/g | 0.0116 | EPIA-013B |
| Europium-154 | UI | X | | 0.026±0.0526 | pCi/g | 0.0835 | EPIA-013B |
| Iodine-129 | UIJ | CX | | -0.0393±0.108 | pCi/g | 0.222 | EPIA-006B |
| Potassium-40 | | VX | | 0.797±0.151 | pCi/g | 0.075 | EPIA-013B |
| Nickel-63 | UI | V | | 1.01±0.374 | pCi/g | 0.717 | EPIA-022 |
| Plutonium-239/240 | UI | X | | 0.0002±0.0119 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.914±0.0618 | pCi/g | 0.0453 | EPIA-013B |
| Strontium-90 | UI | V | | 1.62±0.341 | pCi/g | 0.326 | EPIA-004 |
| Technetium-99 | UI | X | | 0.153±0.109 | pCi/g | 0.292 | EPIA-005B |
| Uranium-238 | | X | | 0.946±0.16 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | IY | P | 36.70 | µg/kg | 36.70 | EPA8270 |
| Di-n-butyl phthalate | UJ | VIYB | P | 17.20 | µg/kg | 36.70 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | IY | P | 36.70 | µg/kg | 36.70 | EPA8270 |
| 2-Chlorophenol | UJ | I | P | 36.70 | µg/kg | 36.70 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | J | 8IYB | P | 0.36 | µg/kg | 0.562 | EPA8260 |
| Carbon disulfide | UJ | IY | P | 1.12 | µg/kg | 1.12 | EPA8260 |
| Toluene | UJ | V8IB | P | 0.101 | µg/kg | 0.562 | EPA8260 |
| Trichloroethylene | UJ | IY | P | 0.0562 | µg/kg | 0.0562 | EPA8260 |

**This Page Intentionally Left Blank**

SAMPLE NAME: FRB-0801
Location (SRS Coordinates): 53670 E 76156 N
Sample Matrix: Soil

Sample ID: 102282
Interval Depths: 0.00 to 1.00
Percent Solids: 91.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Barium, total recoverable | J | VX | | 30.40 | mg/kg | 2.89 | EPA6010 |
| Beryllium, total recoverable | | | | 0.20 | mg/kg | 2.89 | EPA6010 |
| Chromium, total recoverable | | | | 7.71 | mg/kg | 2.89 | EPA6010 |
| Nickel, total recoverable | | | | 1.40 | mg/kg | 2.89 | EPA6010 |
| Lead, total recoverable | | | | 5.20 | mg/kg | 5.78 | EPA6010 |
| Thallium, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 13.70±3.65 | pCi/g | 2.97 | EPIA-001B |
| Americium-241 | UI | | | 0.0125±0.0232 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | -0.005±0.0084 | pCi/g | 0.0126 | EPIA-013B |
| Nonvolatile beta | | X | | 5.69±2.45 | pCi/g | 4.45 | EPIA-001B |
| Carbon-14 | UI | | | -0.0175±0.0861 | pCi/g | 0.164 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.0002±0.0056 | pCi/g | 0.01 | EPIA-013B |
| Cesium-137 | | X | | 0.0916±0.0126 | pCi/g | 0.0112 | EPIA-013B |
| Europium-154 | UI | X | | -0.0176±0.0337 | pCi/g | 0.0482 | EPIA-013B |
| Iodine-129 | UI | | | 0.0121±0.064 | pCi/g | 0.102 | EPIA-006B |
| Potassium-40 | | X | | 0.966±0.149 | pCi/g | 0.10 | EPIA-013B |
| Nickel-63 | UI | V | | 1.12±0.516 | pCi/g | 1.02 | EPIA-022 |
| Plutonium-239/240 | UI | X | | 0.0139±0.0245 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.734±0.0642 | pCi/g | 0.0404 | EPIA-013B |
| Strontium-90 | | X | | 2.24±0.419 | pCi/g | 0.394 | EPIA-004 |
| Technetium-99 | UI | VX | | 0.727±0.131 | pCi/g | 0.325 | EPIA-005B |
| Uranium-238 | | | | 0.467±0.105 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.50 | µg/kg | 36.50 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 13.90 | µg/kg | 36.50 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.50 | µg/kg | 36.50 | EPA8270 |
| 2-Chlorophenol | U | | | 36.50 | µg/kg | 36.50 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.549 | µg/kg | 0.549 | EPA8260 |
| Carbon disulfide | U | | | 1.10 | µg/kg | 1.10 | EPA8260 |
| Toluene | U | V | | 0.187 | µg/kg | 0.549 | EPA8260 |
| Trichloroethylene | U | | | 0.0549 | µg/kg | 0.0549 | EPA8260 |

SAMPLE NAME: FRB-0802
Location (SRS Coordinates): 53670 E 76156 N
Sample Matrix: Soil

Sample ID: 102283
Interval Depths: 2.00 to 4.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | V | | 20.00 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.185 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 9.41 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | | | | 2.15 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 6.98 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 11.60±3.27 | pCi/g | 2.54 | EPIA-001B |
| Americium-241 | UI | X | | 0.0118±0.0294 | pCi/g | 0.0622 | EPIA-011B |
| Barium-133 | UI | X | | 0.0017±0.008 | pCi/g | 0.0119 | EPIA-013B |
| Nonvolatile beta | | X | | 6.19±2.41 | pCi/g | 4.20 | EPIA-001B |
| Carbon-14 | UI | X | | -0.618±0.097 | pCi/g | 0.211 | EPIA-003B |
| Cobalt-60 | UI | X | | 0.0019±0.005 | pCi/g | 0.0092 | EPIA-013B |
| Cesium-137 | | X | | 0.0686±0.0128 | pCi/g | 0.0123 | EPIA-013B |
| Europium-154 | UI | X | | 0.00±0.00 | pCi/g | 0.0441 | EPIA-013B |
| Iodine-129 | UI | X | | 0.0472±0.049 | pCi/g | 0.102 | EPIA-006B |
| Potassium-40 | | X | | 1.39±0.165 | pCi/g | 0.0787 | EPIA-013B |
| Nickel-63 | UI | V | | 2.02±0.973 | pCi/g | 1.93 | EPIA-022 |
| Plutonium-239/240 | | X | | 0.0937±0.0443 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.778±0.065 | pCi/g | 0.0385 | EPIA-013B |
| Strontium-90 | | X | | 5.25±0.469 | pCi/g | 0.37 | EPIA-004 |
| Technetium-99 | UI | VX | | 0.845±0.133 | pCi/g | 0.337 | EPIA-005B |
| Uranium-238 | | X | | 0.654±0.107 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.70 | μg/kg | 36.70 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 14.30 | μg/kg | 36.70 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.70 | μg/kg | 36.70 | EPA8270 |
| 2-Chlorophenol | U | | | 36.70 | μg/kg | 36.70 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 22.50 | μg/kg | 22.50 | EPA8260 |
| Carbon disulfide | U | | | 44.90 | μg/kg | 44.90 | EPA8260 |
| Toluene | | V | | 4.04 | μg/kg | 22.50 | EPA8260 |
| Trichloroethylene | U | | | 2.25 | μg/kg | 2.25 | EPA8260 |

SAMPLE NAME: FRB-0803
Location (SRS Coordinates): 53670 E 76156 N
Sample Matrix: Soil

Sample ID: 102284
Interval Depths: 6.00 to 8.00
Percent Solids: 82.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.42 | mg/kg | 6.42 | EPA6010 |
| Barium, total recoverable | | V | | 51.00 | mg/kg | 3.21 | EPA6010 |
| Beryllium, total recoverable | | | | 0.467 | mg/kg | 3.21 | EPA6010 |
| Chromium, total recoverable | | | | 10.60 | mg/kg | 3.21 | EPA6010 |
| Nickel, total recoverable | | | | 3.48 | mg/kg | 3.21 | EPA6010 |
| Lead, total recoverable | | | | 6.21 | mg/kg | 6.42 | EPA6010 |
| Thallium, total recoverable | U | | | 6.42 | mg/kg | 6.42 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 13.20±3.80 | pCi/g | 3.32 | EPIA-001B |
| Americium-241 | UI | X | | 0.0384±0.0299 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | -0.04±0.0123 | pCi/g | 0.0186 | EPIA-013B |
| Nonvolatile beta | | X | | 58.80±5.31 | pCi/g | 4.02 | EPIA-001B |
| Carbon-14 | UI | X | | -0.717±0.0968 | pCi/g | 0.232 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.0031±0.0066 | pCi/g | 0.0108 | EPIA-013B |
| Cesium-137 | | X | | 3.74±0.0556 | pCi/g | 0.0155 | EPIA-013B |
| Europium-154 | UI | X | | -0.0156±0.032 | pCi/g | 0.0543 | EPIA-013B |
| Iodine-129 | UI | X | | -0.0049±0.072 | pCi/g | 0.139 | EPIA-006B |
| Potassium-40 | | X | | 4.22±0.242 | pCi/g | 0.0903 | EPIA-013B |
| Nickel-63 | UI | V | | 0.933±0.372 | pCi/g | 0.721 | EPIA-022 |
| Plutonium-239/240 | | X | | 0.0854±0.0346 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.997±0.0769 | pCi/g | 0.0494 | EPIA-013B |
| Strontium-90 | | X | | 23.20±1.79 | pCi/g | 1.34 | EPIA-004 |
| Technetium-99 | UI | VX | | 0.92±0.144 | pCi/g | 0.395 | EPIA-005B |
| Uranium-238 | | X | | 1.05±0.195 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | | | | 9.49 | µg/kg | 39.50 | EPA8270 |
| Di-n-butyl phthalate | UJ | VB | | 23.30 | µg/kg | 39.50 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 39.50 | µg/kg | 39.50 | EPA8270 |
| 2-Chlorophenol | U | | | 39.50 | µg/kg | 39.50 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | J | O | | 0.951 | µg/kg | 0.61 | EPA8260 |
| Carbon disulfide | UJ | O | | 1.22 | µg/kg | 1.22 | EPA8260 |
| Toluene | UJ | VO | | 0.317 | µg/kg | 0.61 | EPA8260 |
| Trichloroethylene | J | O | | 0.134 | µg/kg | 0.061 | EPA8260 |

SAMPLE NAME: FRB-0804
Location (SRS Coordinates): 53670 E 76156 N
Sample Matrix: Soil

Sample ID: 102285
Interval Depths: 8.00 to 10.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | V | | 11.70 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.147 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 13.70 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | | | | 1.92 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 5.87 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 36.30±6.25 | pCi/g | 2.74 | EPIA-001B |
| Americium-241 | UI | X | | 0.0335±0.0306 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | 0.0024±0.0184 | pCi/g | 0.028 | EPIA-013B |
| Nonvolatile beta | | X | | 274.00±11.50 | pCi/g | 5.04 | EPIA-001B |
| Carbon-14 | UI | X | | -0.612±0.0977 | pCi/g | 0.212 | EPIA-003B |
| Cobalt-60 | | X | | 0.019±0.0106 | pCi/g | 0.0091 | EPIA-013B |
| Cesium-137 | | X | | 10.30±0.098 | pCi/g | 0.0171 | EPIA-013B |
| Europium-154 | UI | X | | 0.0104±0.0359 | pCi/g | 0.0544 | EPIA-013B |
| Iodine-129 | UI | X | | -0.0393±0.084 | pCi/g | 0.146 | EPIA-006B |
| Potassium-40 | | X | | 1.25±0.16 | pCi/g | 0.0685 | EPIA-013B |
| Nickel-63 | UIJ | VO | L | 2.78±0.973 | pCi/g | 1.85 | EPIA-022 |
| Plutonium-239/240 | | X | | 0.139±0.0457 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.806±0.071 | pCi/g | 0.0534 | EPIA-013B |
| Strontium-90 | | X | | 102.00±1.48 | pCi/g | 0.367 | EPIA-004 |
| Technetium-99 | UI | VX | | 0.722±0.133 | pCi/g | 0.338 | EPIA-005B |
| Uranium-238 | | X | | 7.81±0.936 | pCi/g | 0.0617 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | | | | 4.09 | µg/kg | 37.20 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 18.20 | µg/kg | 37.20 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 37.20 | µg/kg | 37.20 | EPA8270 |
| 2-Chlorophenol | U | | | 37.20 | µg/kg | 37.20 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | J | O | H | 0.416 | µg/kg | 0.562 | EPA8260 |
| Carbon disulfide | U | O | H | 1.12 | µg/kg | 1.12 | EPA8260 |
| Toluene | U | VO | H | 0.18 | µg/kg | 0.562 | EPA8260 |
| Trichloroethylene | J | O | H | 0.101 | µg/kg | 0.0562 | EPA8260 |

SAMPLE NAME: FRB-0805
Location (SRS Coordinates): 53670 E 76156 N
Sample Matrix: Soil

Sample ID: 102286
Interval Depths: 10.00 to 12.00
Percent Solids: 87.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | | | | 2.14 | mg/kg | 6.05 | EPA6010 |
| Barium, total recoverable | | V | | 5.35 | mg/kg | 3.02 | EPA6010 |
| Beryllium, total recoverable | | | | 0.119 | mg/kg | 3.02 | EPA6010 |
| Chromium, total recoverable | | | | 17.50 | mg/kg | 3.02 | EPA6010 |
| Nickel, total recoverable | | | | 1.44 | mg/kg | 3.02 | EPA6010 |
| Lead, total recoverable | | | | 6.69 | mg/kg | 6.05 | EPA6010 |
| Thallium, total recoverable | U | | | 6.05 | mg/kg | 6.05 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 12.50±3.41 | pCi/g | 2.90 | EPIA-001B |
| Americium-241 | UI | X | | 0.0385±0.0357 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | -0.0205±0.009 | pCi/g | 0.0138 | EPIA-013B |
| Nonvolatile beta | | X | | 19.50±3.47 | pCi/g | 4.49 | EPIA-001B |
| Carbon-14 | UI | X | | -0.682±0.0964 | pCi/g | 0.217 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.002±0.0053 | pCi/g | 0.0093 | EPIA-013B |
| Cesium-137 | | X | | 0.0422±0.011 | pCi/g | 0.0118 | EPIA-013B |
| Europium-154 | UI | X | | 0.0039±0.0361 | pCi/g | 0.055 | EPIA-013B |
| Iodine-129 | UI | X | | -0.105±0.173 | pCi/g | 0.223 | EPIA-006B |
| Potassium-40 | | X | | 0.926±0.156 | pCi/g | 0.0942 | EPIA-013B |
| Nickel-63 | UI | V | | 2.64±0.988 | pCi/g | 1.90 | EPIA-022 |
| Plutonium-239/240 | | X | | 0.0811±0.0392 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.785±0.104 | pCi/g | 0.0652 | EPIA-013B |
| Strontium-90 | | X | | 13.80±0.573 | pCi/g | 0.319 | EPIA-004 |
| Technetium-99 | UI | VX | | 0.799±0.14 | pCi/g | 0.364 | EPIA-005B |
| Uranium-238 | | X | | 1.65±0.367 | pCi/g | 0.117 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 37.70 | μg/kg | 37.70 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 13.60 | μg/kg | 37.70 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 37.70 | μg/kg | 37.70 | EPA8270 |
| 2-Chlorophenol | U | | | 37.70 | μg/kg | 37.70 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.575 | μg/kg | 0.575 | EPA8260 |
| Carbon disulfide | U | | | 1.15 | μg/kg | 1.15 | EPA8260 |
| Toluene | U | V | | 0.115 | μg/kg | 0.575 | EPA8260 |
| Trichloroethylene | U | | | 0.0575 | μg/kg | 0.0575 | EPA8260 |

SAMPLE NAME: FRB-0806
Location (SRS Coordinates): 53670 E 76156 N
Sample Matrix: Soil

Sample ID: 102287
Interval Depths: 12.00 to 14.00
Percent Solids: 86.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | | | | 7.13 | mg/kg | 6.12 | EPA6010 |
| Barium, total recoverable | | V | | 4.44 | mg/kg | 3.06 | EPA6010 |
| Beryllium, total recoverable | | | | 0.0949 | mg/kg | 3.06 | EPA6010 |
| Chromium, total recoverable | | | | 23.30 | mg/kg | 3.06 | EPA6010 |
| Nickel, total recoverable | | | | 1.12 | mg/kg | 3.06 | EPA6010 |
| Lead, total recoverable | | | | 7.56 | mg/kg | 6.12 | EPA6010 |
| Thallium, total recoverable | U | | | 6.12 | mg/kg | 6.12 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | X | | 15.20±3.80 | pCi/g | 2.92 | EPIA-001B |
| Americium-241 | UI | X | | 0.0318±0.0358 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | X | | 0.0056±0.0089 | pCi/g | 0.0139 | EPIA-013B |
| Nonvolatile beta | | X | | 14.20±3.14 | pCi/g | 4.50 | EPIA-001B |
| Carbon-14 | UI | X | | -0.53±0.10 | pCi/g | 0.221 | EPIA-003B |
| Cobalt-60 | UI | X | | -0.0016±0.0053 | pCi/g | 0.0091 | EPIA-013B |
| Cesium-137 | | X | | 0.115±0.0182 | pCi/g | 0.0126 | EPIA-013B |
| Europium-154 | UI | X | | 0.0072±0.0346 | pCi/g | 0.0517 | EPIA-013B |
| Iodine-129 | UI | X | | 0.0535±0.07 | pCi/g | 0.116 | EPIA-006B |
| Potassium-40 | | X | | 1.01±0.14 | pCi/g | 0.0825 | EPIA-013B |
| Nickel-63 | UI | V | | 1.74±0.559 | pCi/g | 1.05 | EPIA-022 |
| Plutonium-239/240 | | X | | 0.0622±0.0371 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | X | | 0.731±0.111 | pCi/g | 0.0673 | EPIA-013B |
| Strontium-90 | | X | | 8.35±0.569 | pCi/g | 0.406 | EPIA-004 |
| Technetium-99 | UI | VX | | 0.957±0.143 | pCi/g | 0.374 | EPIA-005B |
| Uranium-238 | | X | | 1.20±0.229 | pCi/g | 0.0713 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 14.90 | µg/kg | 38.20 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| 2-Chlorophenol | U | | | 38.20 | µg/kg | 38.20 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.581 | µg/kg | 0.581 | EPA8260 |
| Carbon disulfide | U | | | 1.16 | µg/kg | 1.16 | EPA8260 |
| Toluene | U | V | | 0.14 | µg/kg | 0.581 | EPA8260 |
| Trichloroethylene | U | | | 0.0581 | µg/kg | 0.0581 | EPA8260 |

SAMPLE NAME: FRB-1901
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102257
Interval Depths: 0.00 to 1.00
Percent Solids: 86.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.12 | mg/kg | 6.12 | EPA6010 |
| Barium, total recoverable | | | | 29.40 | mg/kg | 3.06 | EPA6010 |
| Beryllium, total recoverable | | | | 0.315 | mg/kg | 3.06 | EPA6010 |
| Chromium, total recoverable | | | | 13.60 | mg/kg | 3.06 | EPA6010 |
| Nickel, total recoverable | | | | 3.93 | mg/kg | 3.06 | EPA6010 |
| Lead, total recoverable | | | | 6.89 | mg/kg | 6.12 | EPA6010 |
| Thallium, total recoverable | U | | | 6.12 | mg/kg | 6.12 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 22.60±5.02 | pCi/g | 2.77 | EPIA-001B |
| Americium-241 | UI | | | 0.0309±0.0277 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.0314±0.0048 | pCi/g | 0.007 | EPIA-013B |
| Nonvolatile beta | | | | 8.35±2.72 | pCi/g | 4.50 | EPIA-001B |
| Carbon-14 | UI | | | -0.002±0.0871 | pCi/g | 0.174 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0016±0.0031 | pCi/g | 0.0054 | EPIA-013B |
| Cesium-137 | | | | 0.118±0.0073 | pCi/g | 0.0064 | EPIA-013B |
| Europium-154 | UI | | | -0.003±0.0192 | pCi/g | 0.028 | EPIA-013B |
| Iodine-129 | UI | | | 0.057±0.075 | pCi/g | 0.118 | EPIA-006B |
| Potassium-40 | UI | V | | 1.24±0.0892 | pCi/g | 0.0519 | EPIA-013B |
| Nickel-63 | J | C | | 1.69±0.529 | pCi/g | 0.99 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0044±0.0205 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | V | | 0.791±0.0632 | pCi/g | 0.0405 | EPIA-013B |
| Strontium-90 | UIJ | C | | -0.27±0.247 | pCi/g | 0.283 | EPIA-004 |
| Technetium-99 | UI | | | 0.215±0.107 | pCi/g | 0.294 | EPIA-005B |
| Uranium-238 | J | C | | 0.936±0.146 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 37.90 | μg/kg | 37.90 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 28.10 | μg/kg | 37.90 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 37.90 | μg/kg | 37.90 | EPA8270 |
| 2-Chlorophenol | U | | | 37.90 | μg/kg | 37.90 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | VO | H | 0.837 | μg/kg | 0.581 | EPA8260 |
| Carbon disulfide | U | O | H | 1.16 | μg/kg | 1.16 | EPA8260 |
| Toluene | UJ | V8BOH | | 0.314 | μg/kg | 0.581 | EPA8260 |
| Trichloroethylene | | O | H | 0.453 | μg/kg | 0.0581 | EPA8260 |

SAMPLE NAME: FRB-1902
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102258
Interval Depths: 10.00 to 12.00
Percent Solids: 87.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.05 | mg/kg | 6.05 | EPA6010 |
| Barium, total recoverable | | | | 15.80 | mg/kg | 3.02 | EPA6010 |
| Beryllium, total recoverable | | | | 0.16 | mg/kg | 3.02 | EPA6010 |
| Chromium, total recoverable | | | | 13.10 | mg/kg | 3.02 | EPA6010 |
| Nickel, total recoverable | | | | 2.57 | mg/kg | 3.02 | EPA6010 |
| Lead, total recoverable | | | | 4.70 | mg/kg | 6.05 | EPA6010 |
| Thallium, total recoverable | U | | | 6.05 | mg/kg | 6.05 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 22.90±4.96 | pCi/g | 3.45 | EPIA-001B |
| Americium-241 | | | | 0.458±0.0838 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0076±0.0151 | pCi/g | 0.0152 | EPIA-013B |
| Nonvolatile beta | | | | 60.10±5.46 | pCi/g | 4.46 | EPIA-001B |
| Carbon-14 | UI | | | 0.0829±0.0896 | pCi/g | 0.174 | EPIA-003B |
| Cobalt-60 | | | | 0.0072±0.0048 | pCi/g | 0.0044 | EPIA-013B |
| Cesium-137 | | | | 19.50±0.0593 | pCi/g | 0.0086 | EPIA-013B |
| Europium-154 | UI | | | -0.0024±0.0161 | pCi/g | 0.028 | EPIA-013B |
| Iodine-129 | | | | 2.21±0.351 | pCi/g | 0.186 | EPIA-006B |
| Potassium-40 | UI | V | | 1.24±0.0734 | pCi/g | 0.0403 | EPIA-013B |
| Nickel-63 | J | C | | 0.959±0.383 | pCi/g | 0.742 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0264±0.0274 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | V | | 0.77±0.0958 | pCi/g | 0.0751 | EPIA-013B |
| Strontium-90 | J | C | | 12.30±0.613 | pCi/g | 0.378 | EPIA-004 |
| Technetium-99 | UI | | | 0.156±0.11 | pCi/g | 0.299 | EPIA-005B |
| Uranium-238 | J | C | | 1.03±0.196 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 37.40 | μg/kg | 37.40 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 34.40 | μg/kg | 37.40 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 37.40 | μg/kg | 37.40 | EPA8270 |
| 2-Chlorophenol | U | | | 37.40 | μg/kg | 37.40 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | VO | H | 0.621 | μg/kg | 0.575 | EPA8260 |
| Carbon disulfide | U | O | H | 1.15 | μg/kg | 1.15 | EPA8260 |
| Toluene | UJ | V8* | H | 0.172 | μg/kg | 0.575 | EPA8260 |
| Trichloroethylene | U | O | H | 0.0575 | μg/kg | 0.0575 | EPA8260 |

* = OB

SAMPLE NAME: FRB-1903
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102259
Interval Depths: 12.00 to 14.00
Percent Solids: 88.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.98 | mg/kg | 5.98 | EPA6010 |
| Barium, total recoverable | | | | 11.30 | mg/kg | 2.99 | EPA6010 |
| Beryllium, total recoverable | | | | 0.164 | mg/kg | 2.99 | EPA6010 |
| Chromium, total recoverable | | | | 12.40 | mg/kg | 2.99 | EPA6010 |
| Nickel, total recoverable | | | | 2.17 | mg/kg | 2.99 | EPA6010 |
| Lead, total recoverable | | | | 6.86 | mg/kg | 5.98 | EPA6010 |
| Thallium, total recoverable | U | | | 5.98 | mg/kg | 5.98 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | UI | | | -0.574±1.43 | pCi/g | 4.36 | EPIA-001B |
| Americium-241 | UI | | | 0.0073±0.0261 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.009±0.0136 | pCi/g | 0.022 | EPIA-013B |
| Nonvolatile beta | UI | | | 0.682±1.73 | pCi/g | 3.99 | EPIA-001B |
| Carbon-14 | UI | | | 0.061±0.0867 | pCi/g | 0.167 | EPIA-003B |
| Cobalt-60 | | | | 0.0257±0.0054 | pCi/g | 0.0048 | EPIA-013B |
| Cesium-137 | | | | 35.50±0.088 | pCi/g | 0.0121 | EPIA-013B |
| Europium-154 | UI | | | -0.144±0.0189 | pCi/g | 0.0265 | EPIA-013B |
| Iodine-129 | UI | | | 0.00±0.00 | pCi/g | 0.234 | EPIA-006B |
| Potassium-40 | UI | V | | 0.89±0.0759 | pCi/g | 0.0439 | EPIA-013B |
| Nickel-63 | J | C | | 1.11±0.341 | pCi/g | 0.637 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0319±0.0321 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | UI | V | | 0.582±0.194 | pCi/g | 0.143 | EPIA-013B |
| Strontium-90 | J | C | | 93.10±1.32 | pCi/g | 0.319 | EPIA-004 |
| Technetium-99 | UI | | | 0.108±0.0999 | pCi/g | 0.27 | EPIA-005B |
| Uranium-238 | J | C | | 0.555±0.143 | pCi/g | 0.0721 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 37.00 | µg/kg | 37.00 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 28.10 | µg/kg | 37.00 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 37.00 | µg/kg | 37.00 | EPA8270 |
| 2-Chlorophenol | U | | | 37.00 | µg/kg | 37.00 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | V | | 0.739 | µg/kg | 0.568 | EPA8260 |
| Carbon disulfide | U | | | 1.14 | µg/kg | 1.14 | EPA8260 |
| Toluene | UJ | V8 | | 0.227 | µg/kg | 0.568 | EPA8260 |
| Trichloroethylene | | | | 0.102 | µg/kg | 0.0568 | EPA8260 |

SAMPLE NAME: FRB-1904
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102260
Interval Depths: 14.00 to 16.00
Percent Solids: 85.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.19 | mg/kg | 6.19 | EPA6010 |
| Barium, total recoverable | | | | 2.03 | mg/kg | 3.10 | EPA6010 |
| Beryllium, total recoverable | | | | 0.0985 | mg/kg | 3.10 | EPA6010 |
| Chromium, total recoverable | | | | 8.73 | mg/kg | 3.10 | EPA6010 |
| Nickel, total recoverable | U | | | 3.10 | mg/kg | 3.10 | EPA6010 |
| Lead, total recoverable | | | | 4.43 | mg/kg | 6.19 | EPA6010 |
| Thallium, total recoverable | U | | | 6.19 | mg/kg | 6.19 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 16.70±5.32 | pCi/g | 4.36 | EPIA-001B |
| Americium-241 | UI | | | 0.0369±0.0325 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0061±0.0128 | pCi/g | 0.0182 | EPIA-013B |
| Nonvolatile beta | | | | 464.00±14.30 | pCi/g | 4.19 | EPIA-001B |
| Carbon-14 | UI | | | 0.109±0.0868 | pCi/g | 0.171 | EPIA-003B |
| Cobalt-60 | | | | 0.0132±0.0067 | pCi/g | 0.0067 | EPIA-013B |
| Cesium-137 | | | | 11.10±0.0519 | pCi/g | 0.0116 | EPIA-013B |
| Europium-154 | UI | | | -0.142±0.0313 | pCi/g | 0.0398 | EPIA-013B |
| Iodine-129 | UI | | | 0.0118±0.163 | pCi/g | 0.301 | EPIA-006B |
| Potassium-40 | UI | V | | 3.04±0.121 | pCi/g | 0.0673 | EPIA-013B |
| Nickel-63 | J | C | | 1.22±0.408 | pCi/g | 0.772 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0244±0.0416 | pCi/g | 0.075 | EPIA-012B |
| Radium-226 | | V | | 0.934±0.18 | pCi/g | 0.117 | EPIA-013B |
| Strontium-90 | J | C | | 275.00±2.12 | pCi/g | 0.289 | EPIA-004 |
| Technetium-99 | UI | | | 0.0775±0.101 | pCi/g | 0.285 | EPIA-005B |
| Uranium-238 | J | C | | 0.608±0.173 | pCi/g | 0.0644 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 38.60 | µg/kg | 38.60 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 25.10 | µg/kg | 38.60 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 38.60 | µg/kg | 38.60 | EPA8270 |
| 2-Chlorophenol | U | | | 38.60 | µg/kg | 38.60 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | V | | 0.812 | µg/kg | 0.588 | EPA8260 |
| Carbon disulfide | U | | | 1.18 | µg/kg | 1.18 | EPA8260 |
| Toluene | UJ | V8 | | 0.153 | µg/kg | 0.588 | EPA8260 |
| Trichloroethylene | | | | 0.0941 | µg/kg | 0.0588 | EPA8260 |

SAMPLE NAME: FRB-1905
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102261
Interval Depths: 16.00 to 18.00
Percent Solids: 84.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.27 | mg/kg | 6.27 | EPA6010 |
| Barium, total recoverable | | | | 3.61 | mg/kg | 3.13 | EPA6010 |
| Beryllium, total recoverable | | | | 0.152 | mg/kg | 3.13 | EPA6010 |
| Chromium, total recoverable | | | | 3.40 | mg/kg | 3.13 | EPA6010 |
| Nickel, total recoverable | | | | 0.779 | mg/kg | 3.13 | EPA6010 |
| Lead, total recoverable | | | | 6.63 | mg/kg | 6.27 | EPA6010 |
| Thallium, total recoverable | | | | 3.47 | mg/kg | 6.27 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 17.60±4.82 | pCi/g | 3.17 | EPIA-001B |
| Americium-241 | UI | | | 0.0087±0.0194 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.0308±0.0092 | pCi/g | 0.0144 | EPIA-013B |
| Nonvolatile beta | | | | 571.00±16.20 | pCi/g | 4.06 | EPIA-001B |
| Carbon-14 | UI | | | 0.0825±0.0864 | pCi/g | 0.173 | EPIA-003B |
| Cobalt-60 | | | | 0.0112±0.0057 | pCi/g | 0.0066 | EPIA-013B |
| Cesium-137 | | | | 1.93±0.0233 | pCi/g | 0.0108 | EPIA-013B |
| Europium-154 | UI | | | -0.0259±0.0285 | pCi/g | 0.0412 | EPIA-013B |
| Iodine-129 | UI | | | -0.0857±0.137 | pCi/g | 0.28 | EPIA-006B |
| Potassium-40 | UI | V | | 2.55±0.13 | pCi/g | 0.0612 | EPIA-013B |
| Nickel-63 | J | CI | L | 1.92±0.407 | pCi/g | 0.706 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.003±0.0059 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | V | | 1.05±0.10 | pCi/g | 0.0664 | EPIA-013B |
| Strontium-90 | J | C | | 305.00±2.27 | pCi/g | 0.299 | EPIA-004 |
| Technetium-99 | UI | | | 0.182±0.114 | pCi/g | 0.321 | EPIA-005B |
| Uranium-238 | J | C | | 0.427±0.12 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | UJ | Q | | 39.20 | µg/kg | 39.20 | EPA8270 |
| Di-n-butyl phthalate | UJ | Q | | 39.20 | µg/kg | 39.20 | EPA8270 |
| N-Nitrosodiphenylamine | UJ | Q | | 39.20 | µg/kg | 39.20 | EPA8270 |
| 2-Chlorophenol | J | Q | | 13.30 | µg/kg | 39.20 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | V | | 0.381 | µg/kg | 0.595 | EPA8260 |
| Carbon disulfide | U | | | 1.19 | µg/kg | 1.19 | EPA8260 |
| Toluene | UJ | V8 | | 0.107 | µg/kg | 0.595 | EPA8260 |
| Trichloroethylene | U | | | 0.0595 | µg/kg | 0.0595 | EPA8260 |

SAMPLE NAME: FRB-1906
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102262
Interval Depths: 18.00 to 20.00
Percent Solids: 83.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.34 | mg/kg | 6.34 | EPA6010 |
| Barium, total recoverable | | | | 1.68 | mg/kg | 3.17 | EPA6010 |
| Beryllium, total recoverable | | | | 0.137 | mg/kg | 3.17 | EPA6010 |
| Chromium, total recoverable | | | | 4.08 | mg/kg | 3.17 | EPA6010 |
| Nickel, total recoverable | | | | 0.912 | mg/kg | 3.17 | EPA6010 |
| Lead, total recoverable | | | | 5.46 | mg/kg | 6.34 | EPA6010 |
| Thallium, total recoverable | U | | | 6.34 | mg/kg | 6.34 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 10.60±3.90 | pCi/g | 0.623 | EPIA-001B |
| Americium-241 | UI | | | 0.0093±0.0256 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.0013±0.0078 | pCi/g | 0.0114 | EPIA-013B |
| Nonvolatile beta | | | | 712.00±18.20 | pCi/g | 4.07 | EPIA-001B |
| Carbon-14 | UI | | | 0.102±0.0895 | pCi/g | 0.181 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0031±0.0036 | pCi/g | 0.0063 | EPIA-013B |
| Cesium-137 | | | | 0.202±0.0115 | pCi/g | 0.0087 | EPIA-013B |
| Europium-154 | UI | | | 0.0245±0.022 | pCi/g | 0.0353 | EPIA-013B |
| Iodine-129 | UI | | | -0.0867±0.131 | pCi/g | 0.271 | EPIA-006B |
| Potassium-40 | UI | V | | 1.39±0.104 | pCi/g | 0.0552 | EPIA-013B |
| Nickel-63 | J | C | | 1.45±0.453 | pCi/g | 0.848 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0265±0.0195 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | V | | 0.952±0.112 | pCi/g | 0.0793 | EPIA-013B |
| Strontium-90 | J | C | | 327.00±2.43 | pCi/g | 0.319 | EPIA-004 |
| Technetium-99 | UI | | | 0.0429±0.0987 | pCi/g | 0.287 | EPIA-005B |
| Uranium-238 | J | C | | 0.387±0.115 | pCi/g | 0.0631 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 39.70 | µg/kg | 39.70 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 27.40 | µg/kg | 39.70 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 39.70 | µg/kg | 39.70 | EPA8270 |
| 2-Chlorophenol | U | | | 39.70 | µg/kg | 39.70 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.602 | µg/kg | 0.602 | EPA8260 |
| Carbon disulfide | U | | | 1.20 | µg/kg | 1.20 | EPA8260 |
| Toluene | UJ | V8 | | 0.0964 | µg/kg | 0.602 | EPA8260 |
| Trichloroethylene | U | | | 0.0602 | µg/kg | 0.0602 | EPA8260 |

SAMPLE NAME: FRB-1907
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102263
Interval Depths: 20.00 to 22.00
Percent Solids: 89.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Barium, total recoverable | | | | 2.56 | mg/kg | 2.96 | EPA6010 |
| Beryllium, total recoverable | | | | 0.157 | mg/kg | 2.96 | EPA6010 |
| Chromium, total recoverable | | | | 4.52 | mg/kg | 2.96 | EPA6010 |
| Nickel, total recoverable | | | | 0.676 | mg/kg | 2.96 | EPA6010 |
| Lead, total recoverable | | | | 6.30 | mg/kg | 5.91 | EPA6010 |
| Thallium, total recoverable | U | | | 5.91 | mg/kg | 5.91 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 12.00±3.63 | pCi/g | 1.71 | EPIA-001B |
| Americium-241 | UI | | | 0.0196±0.0336 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0011±0.005 | pCi/g | 0.0076 | EPIA-013B |
| Nonvolatile beta | | | | 394.00±13.80 | pCi/g | 3.98 | EPIA-001B |
| Carbon-14 | UI | | | 0.0224±0.0842 | pCi/g | 0.162 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0026±0.0025 | pCi/g | 0.0045 | EPIA-013B |
| Cesium-137 | | | | 0.249±0.0081 | pCi/g | 0.0055 | EPIA-013B |
| Europium-154 | UI | | | -0.0845±0.0164 | pCi/g | 0.0241 | EPIA-013B |
| Iodine-129 | UI | | | -0.0191±0.09 | pCi/g | 0.176 | EPIA-006B |
| Potassium-40 | UI | V | | 0.903±0.0747 | pCi/g | 0.038 | EPIA-013B |
| Nickel-63 | J | C | | 0.923±0.361 | pCi/g | 0.698 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0002±0.0101 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | V | | 0.769±0.101 | pCi/g | 0.0749 | EPIA-013B |
| Strontium-90 | J | C | | 202.00±2.19 | pCi/g | 0.416 | EPIA-004 |
| Technetium-99 | UI | | | 0.0937±0.111 | pCi/g | 0.298 | EPIA-005B |
| Uranium-238 | J | C | | 0.394±0.112 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 37.30 | µg/kg | 37.30 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 27.20 | µg/kg | 37.30 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 37.30 | µg/kg | 37.30 | EPA8270 |
| 2-Chlorophenol | U | | | 37.30 | µg/kg | 37.30 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.562 | µg/kg | 0.562 | EPA8260 |
| Carbon disulfide | U | | | 1.12 | µg/kg | 1.12 | EPA8260 |
| Toluene | UJ | V8 | | 0.0787 | µg/kg | 0.562 | EPA8260 |
| Trichloroethylene | U | | | 0.0562 | µg/kg | 0.0562 | EPA8260 |

SAMPLE NAME: FRB-1908
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102264
Interval Depths: 22.00 to 24.00
Percent Solids: 84.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 6.27 | mg/kg | 6.27 | EPA6010 |
| Barium, total recoverable | | | | 2.44 | mg/kg | 3.13 | EPA6010 |
| Beryllium, total recoverable | | | | 0.252 | mg/kg | 3.13 | EPA6010 |
| Chromium, total recoverable | | | | 5.52 | mg/kg | 3.13 | EPA6010 |
| Nickel, total recoverable | | | | 0.962 | mg/kg | 3.13 | EPA6010 |
| Lead, total recoverable | | | | 3.76 | mg/kg | 6.27 | EPA6010 |
| Thallium, total recoverable | U | | | 6.27 | mg/kg | 6.27 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 29.50±6.60 | pCi/g | 3.60 | EPIA-001B |
| Americium-241 | UI | | | -0.0055±0.0256 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.0041±0.0074 | pCi/g | 0.0121 | EPIA-013B |
| Nonvolatile beta | | | | 861.00±19.90 | pCi/g | 4.36 | EPIA-001B |
| Carbon-14 | UI | | | 0.0889±0.0874 | pCi/g | 0.175 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0002±0.004 | pCi/g | 0.0057 | EPIA-013B |
| Cesium-137 | | | | 0.975±0.0154 | pCi/g | 0.008 | EPIA-013B |
| Europium-154 | UI | | | -0.0096±0.0231 | pCi/g | 0.034 | EPIA-013B |
| Iodine-129 | UI | | | -0.05±0.088 | pCi/g | 0.179 | EPIA-006B |
| Potassium-40 | UI | V | | 1.83±0.103 | pCi/g | 0.0505 | EPIA-013B |
| Nickel-63 | J | C | | 2.11±0.527 | pCi/g | 0.947 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0002±0.0101 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | V | | 0.733±0.132 | pCi/g | 0.0919 | EPIA-013B |
| Strontium-90 | J | C | | 298.00±2.27 | pCi/g | 0.305 | EPIA-004 |
| Technetium-99 | UI | | | 0.0876±0.112 | pCi/g | 0.321 | EPIA-005B |
| Uranium-238 | J | C | | 0.571±0.13 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 39.10 | µg/kg | 39.10 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 18.80 | µg/kg | 39.10 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 39.10 | µg/kg | 39.10 | EPA8270 |
| 2-Chlorophenol | U | | | 39.10 | µg/kg | 39.10 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.595 | µg/kg | 0.595 | EPA8260 |
| Carbon disulfide | U | | | 1.19 | µg/kg | 1.19 | EPA8260 |
| Toluene | UJ | V8 | | 0.0833 | µg/kg | 0.595 | EPA8260 |
| Trichloroethylene | U | | | 0.0595 | µg/kg | 0.0595 | EPA8260 |

SAMPLE NAME: FRB-1909
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102265
Interval Depths: 24.00 to 26.00
Percent Solids: 88.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| **Metal Parameters** | | | | | | | |
| Arsenic, total recoverable | U | | | 5.98 | mg/kg | 5.98 | EPA6010 |
| Barium, total recoverable | | | | 1.25 | mg/kg | 2.99 | EPA6010 |
| Beryllium, total recoverable | | | | 0.30 | mg/kg | 2.99 | EPA6010 |
| Chromium, total recoverable | | | | 3.76 | mg/kg | 2.99 | EPA6010 |
| Nickel, total recoverable | | | | 0.579 | mg/kg | 2.99 | EPA6010 |
| Lead, total recoverable | | | | 5.49 | mg/kg | 5.98 | EPA6010 |
| Thallium, total recoverable | | | | 4.08 | mg/kg | 5.98 | EPA6010 |
| **Radiological Parameters** | | | | | | | |
| Gross alpha | | | | 23.80±3.90 | pCi/g | 2.03 | EPIA-001B |
| Americium-241 | | | | 3.77±0.425 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0051±0.007 | pCi/g | 0.0102 | EPIA-013B |
| Nonvolatile beta | | | | 827.00±13.60 | pCi/g | 2.76 | EPIA-001B |
| Carbon-14 | UI | | | 0.0672±0.0882 | pCi/g | 0.169 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0012±0.0028 | pCi/g | 0.005 | EPIA-013B |
| Cesium-137 | | | | 0.416±0.0108 | pCi/g | 0.0067 | EPIA-013B |
| Europium-154 | UI | | | -0.00±0.0272 | pCi/g | 0.0293 | EPIA-013B |
| Iodine-129 | UI | | | -0.0568±0.088 | pCi/g | 0.173 | EPIA-006B |
| Potassium-40 | UI | V | | 1.04±0.0736 | pCi/g | 0.0424 | EPIA-013B |
| Nickel-63 | J | C | | 1.12±0.412 | pCi/g | 0.79 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0146±0.0482 | pCi/g | 0.106 | EPIA-012B |
| Radium-226 | UI | V | | 0.621±0.105 | pCi/g | 0.0748 | EPIA-013B |
| Strontium-90 | J | C | | 264.00±2.11 | pCi/g | 0.298 | EPIA-004 |
| Technetium-99 | UI | | | 0.104±0.112 | pCi/g | 0.305 | EPIA-005B |
| Uranium-238 | J | C | | 0.437±0.128 | pCi/g | 0.06 | EPIA-011B |
| **Semivolatile Parameters** | | | | | | | |
| Dibenzofuran | U | | | 37.30 | µg/kg | 37.30 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 54.10 | µg/kg | 37.30 | EPA8270 |
| N-Nitrosodiphenylamine | | | | 16.10 | µg/kg | 37.30 | EPA8270 |
| 2-Chlorophenol | U | | | 37.30 | µg/kg | 37.30 | EPA8270 |
| **Volatile Parameters** | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.568 | µg/kg | 0.568 | EPA8260 |
| Carbon disulfide | U | | | 1.14 | µg/kg | 1.14 | EPA8260 |
| Toluene | UJ | V8 | | 0.0682 | µg/kg | 0.568 | EPA8260 |
| Trichloroethylene | U | | | 0.0568 | µg/kg | 0.0568 | EPA8260 |

SAMPLE NAME: FRB-1910
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102266
Interval Depths: 26.00 to 28.00
Percent Solids: 90.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.85 | mg/kg | 5.85 | EPA6010 |
| Barium, total recoverable | | | | 0.532 | mg/kg | 2.92 | EPA6010 |
| Beryllium, total recoverable | | | | 0.113 | mg/kg | 2.92 | EPA6010 |
| Chromium, total recoverable | | | | 0.808 | mg/kg | 2.92 | EPA6010 |
| Nickel, total recoverable | | | | 0.608 | mg/kg | 2.92 | EPA6010 |
| Lead, total recoverable | | | | 3.91 | mg/kg | 5.85 | EPA6010 |
| Thallium, total recoverable | U | | | 5.85 | mg/kg | 5.85 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 6.10±1.88 | pCi/g | 0.292 | EPIA-001B |
| Americium-241 | UI | | | 0.0148±0.0316 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.003±0.0055 | pCi/g | 0.0082 | EPIA-013B |
| Nonvolatile beta | | | | 275.00±8.12 | pCi/g | 2.84 | EPIA-001B |
| Carbon-14 | UI | | | 0.0262±0.0869 | pCi/g | 0.166 | EPIA-003B |
| Cobalt-60 | UI | | | -0.0004±0.0028 | pCi/g | 0.0048 | EPIA-013B |
| Cesium-137 | | | | 0.0062±0.0056 | pCi/g | 0.006 | EPIA-013B |
| Europium-154 | UI | | | 0.0029±0.0188 | pCi/g | 0.0278 | EPIA-013B |
| Iodine-129 | UI | | | -0.0033±0.076 | pCi/g | 0.148 | EPIA-006B |
| Potassium-40 | UI | V | | 0.888±0.0743 | pCi/g | 0.045 | EPIA-013B |
| Nickel-63 | J | C | | 0.99±0.389 | pCi/g | 0.752 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0192±0.0281 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | UI | V | | 0.499±0.127 | pCi/g | 0.0819 | EPIA-013B |
| Strontium-90 | J | C | | 143.00±2.27 | pCi/g | 0.607 | EPIA-004 |
| Technetium-99 | UI | | | 0.214±0.122 | pCi/g | 0.319 | EPIA-005B |
| Uranium-238 | J | C | | 0.599±0.151 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.40 | μg/kg | 36.40 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 28.00 | μg/kg | 36.40 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.40 | μg/kg | 36.40 | EPA8270 |
| 2-Chlorophenol | U | | | 36.40 | μg/kg | 36.40 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.556 | μg/kg | 0.556 | EPA8260 |
| Carbon disulfide | U | | | 1.11 | μg/kg | 1.11 | EPA8260 |
| Toluene | UJ | V8 | | 0.0556 | μg/kg | 0.556 | EPA8260 |
| Trichloroethylene | U | | | 0.0556 | μg/kg | 0.0556 | EPA8260 |

SAMPLE NAME: FRB-1911
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102267
Interval Depths: 28.00 to 30.00
Percent Solids: 91.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Barium, total recoverable | | | | 0.423 | mg/kg | 2.89 | EPA6010 |
| Beryllium, total recoverable | | | | 0.0746 | mg/kg | 2.89 | EPA6010 |
| Chromium, total recoverable | | | | 1.23 | mg/kg | 2.89 | EPA6010 |
| Nickel, total recoverable | U | | | 2.89 | mg/kg | 2.89 | EPA6010 |
| Lead, total recoverable | | | | 3.80 | mg/kg | 5.78 | EPA6010 |
| Thallium, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 6.34±1.53 | pCi/g | 0.884 | EPIA-001B |
| Americium-241 | | | | 0.0977±0.0459 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0036±0.0034 | pCi/g | 0.0053 | EPIA-013B |
| Nonvolatile beta | | | | 22.90±2.46 | pCi/g | 2.47 | EPIA-001B |
| Carbon-14 | UI | | | 0.0263±0.0849 | pCi/g | 0.159 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0012±0.0024 | pCi/g | 0.0036 | EPIA-013B |
| Cesium-137 | UI | | | 0.0003±0.003 | pCi/g | 0.0044 | EPIA-013B |
| Europium-154 | UI | | | -0.003±0.0135 | pCi/g | 0.0195 | EPIA-013B |
| Iodine-129 | UI | | | -0.0297±0.043 | pCi/g | 0.0813 | EPIA-006B |
| Potassium-40 | UI | V | | 0.777±0.062 | pCi/g | 0.0343 | EPIA-013B |
| Nickel-63 | J | C | | 1.37±0.416 | pCi/g | 0.775 | EPIA-022 |
| Plutonium-239/240 | UI | | | 0.0061±0.0187 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | UI | V | | 0.491±0.0951 | pCi/g | 0.0664 | EPIA-013B |
| Strontium-90 | J | C | | 38.70±1.35 | pCi/g | 0.677 | EPIA-004 |
| Technetium-99 | UI | | | 0.127±0.119 | pCi/g | 0.311 | EPIA-005B |
| Uranium-238 | J | C | | 0.542±0.142 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.60 | µg/kg | 36.60 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 28.50 | µg/kg | 36.60 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.60 | µg/kg | 36.60 | EPA8270 |
| 2-Chlorophenol | U | | | 36.60 | µg/kg | 36.60 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.549 | µg/kg | 0.549 | EPA8260 |
| Carbon disulfide | U | | | 1.10 | µg/kg | 1.10 | EPA8260 |
| Toluene | UJ | V8 | | 0.143 | µg/kg | 0.549 | EPA8260 |
| Trichloroethylene | U | | | 0.0549 | µg/kg | 0.0549 | EPA8260 |

SAMPLE NAME: FRB-1912
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102268
Interval Depths: 30.00 to 32.00
Percent Solids: 91.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Barium, total recoverable | | | | 0.585 | mg/kg | 2.89 | EPA6010 |
| Beryllium, total recoverable | | | | 0.0856 | mg/kg | 2.89 | EPA6010 |
| Chromium, total recoverable | | | | 1.12 | mg/kg | 2.89 | EPA6010 |
| Nickel, total recoverable | U | | | 2.89 | mg/kg | 2.89 | EPA6010 |
| Lead, total recoverable | | | | 2.52 | mg/kg | 5.78 | EPA6010 |
| Thallium, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 10.40±2.31 | pCi/g | 2.01 | EPIA-001B |
| Americium-241 | UI | | | 0.014±0.0241 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | -0.002±0.0049 | pCi/g | 0.007 | EPIA-013B |
| Nonvolatile beta | | | | 53.80±3.67 | pCi/g | 2.90 | EPIA-001B |
| Carbon-14 | UI | | | 0.0322±0.0864 | pCi/g | 0.162 | EPIA-003B |
| Cobalt-60 | UI | | | 0.0007±0.0028 | pCi/g | 0.005 | EPIA-013B |
| Cesium-137 | UI | | | -0.0013±0.0039 | pCi/g | 0.0057 | EPIA-013B |
| Europium-154 | UI | | | 0.0138±0.019 | pCi/g | 0.0266 | EPIA-013B |
| Iodine-129 | UI | | | 0.0011±0.034 | pCi/g | 0.067 | EPIA-006B |
| Potassium-40 | UI | V | | 1.02±0.0734 | pCi/g | 0.0435 | EPIA-013B |
| Nickel-63 | J | C | | 0.741±0.365 | pCi/g | 0.724 | EPIA-022 |
| Plutonium-239/240 | UI | | | -0.008±0.0092 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | | V | | 0.773±0.0962 | pCi/g | 0.0696 | EPIA-013B |
| Strontium-90 | J | C | | 13.30±0.634 | pCi/g | 0.381 | EPIA-004 |
| Technetium-99 | UI | | | 0.013±0.105 | pCi/g | 0.279 | EPIA-005B |
| Uranium-238 | J | C | | 0.863±0.208 | pCi/g | 0.0629 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.10 | μg/kg | 36.10 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 18.40 | μg/kg | 36.10 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.10 | μg/kg | 36.10 | EPA8270 |
| 2-Chlorophenol | U | | | 36.10 | μg/kg | 36.10 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.549 | μg/kg | 0.549 | EPA8260 |
| Carbon disulfide | U | | | 1.10 | μg/kg | 1.10 | EPA8260 |
| Toluene | UJ | V8 | | 0.0549 | μg/kg | 0.549 | EPA8260 |
| Trichloroethylene | U | | | 0.0549 | μg/kg | 0.0549 | EPA8260 |

SAMPLE NAME: FRB-1913
Location (SRS Coordinates): 53742 E 76253 N
Sample Matrix: Soil

Sample ID: 102269
Interval Depths: 32.00 to 34.00
Percent Solids: 91.00

| Constituent | RQ | AQ | B | Result | Unit | D.Limit | Method |
|---|---|---|---|---|---|---|---|
| Metal Parameters | | | | | | | |
| Arsenic, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Barium, total recoverable | | | | 0.743 | mg/kg | 2.89 | EPA6010 |
| Beryllium, total recoverable | | | | 0.0908 | mg/kg | 2.89 | EPA6010 |
| Chromium, total recoverable | | | | 0.721 | mg/kg | 2.89 | EPA6010 |
| Nickel, total recoverable | U | | | 2.89 | mg/kg | 2.89 | EPA6010 |
| Lead, total recoverable | | | | 4.67 | mg/kg | 5.78 | EPA6010 |
| Thallium, total recoverable | U | | | 5.78 | mg/kg | 5.78 | EPA6010 |
| Radiological Parameters | | | | | | | |
| Gross alpha | | | | 11.30±3.22 | pCi/g | 2.14 | EPIA-001B |
| Americium-241 | | | | 0.465±0.103 | pCi/g | 0.06 | EPIA-011B |
| Barium-133 | UI | | | 0.0042±0.0041 | pCi/g | 0.0061 | EPIA-013B |
| Nonvolatile beta | | | | 66.50±5.73 | pCi/g | 4.11 | EPIA-001B |
| Carbon-14 | UI | | | 0.0549±0.0876 | pCi/g | 0.163 | EPIA-003B |
| Cobalt-60 | UIJ | X | | -0.0004±0.0026 | pCi/g | 0.0043 | EPIA-013B |
| Cesium-137 | | | | 0.0088±0.0044 | pCi/g | 0.0053 | EPIA-013B |
| Europium-154 | UIJ | X | | 0.0086±0.0133 | pCi/g | 0.0226 | EPIA-013B |
| Iodine-129 | UIJ | X | | 0.022±0.046 | pCi/g | 0.092 | EPIA-006B |
| Potassium-40 | UI | V | | 0.898±0.0792 | pCi/g | 0.0385 | EPIA-013B |
| Nickel-63 | J | C | | 0.911±0.39 | pCi/g | 0.763 | EPIA-022 |
| Plutonium-239/240 | UIJ | IX | L | 0.0028±0.0115 | pCi/g | 0.06 | EPIA-012B |
| Radium-226 | UI | V | | 0.584±0.105 | pCi/g | 0.067 | EPIA-013B |
| Strontium-90 | J | CI | L | 24.90±0.83 | pCi/g | 0.402 | EPIA-004 |
| Technetium-99 | UI | | | 0.0747±0.128 | pCi/g | 0.337 | EPIA-005B |
| Uranium-238 | J | C | | 0.363±0.11 | pCi/g | 0.06 | EPIA-011B |
| Semivolatile Parameters | | | | | | | |
| Dibenzofuran | U | | | 36.40 | µg/kg | 36.40 | EPA8270 |
| Di-n-butyl phthalate | U | V | | 19.70 | µg/kg | 36.40 | EPA8270 |
| N-Nitrosodiphenylamine | U | | | 36.40 | µg/kg | 36.40 | EPA8270 |
| 2-Chlorophenol | U | | | 36.40 | µg/kg | 36.40 | EPA8270 |
| Volatile Parameters | | | | | | | |
| Dichloromethane (Methylene chloride) | U | | | 0.549 | µg/kg | 0.549 | EPA8260 |
| Carbon disulfide | U | | | 1.10 | µg/kg | 1.10 | EPA8260 |
| Toluene | UJ | V8 | | 0.0549 | µg/kg | 0.549 | EPA8260 |
| Trichloroethylene | U | | | 0.0549 | µg/kg | 0.0549 | EPA8260 |

**This Page Intentionally Left Blank**

# APPENDIX C

## Environmental Measurement-While-Drilling-Gamma Ray Spectrometer Data Collection Procedure

**This Page Intentionally Left Blank**

# EMWD-GRS Data Collection Procedures

## 1.0 Check System Operation on Site

Check for full operation of tool and computer interface prior to attachment of downhole tool to drill string or mounting uphole components on drill rig.

## 2.0 Mount System and Verify System Functionality

A. Downhole battery voltage >22V.
B. Temperature measurement.
C. Collect normal background spectrum at drill site.
D. System lock reading - 0eb90Hex.

## 3.0 Start Recording Data to Disk and Commence Drilling

A. Continuous recording of data while drilling as follows:
   1. After each 3 drill rod segments, stop recording, close data file and name (i.e., RB_F01.PCM, RB_F04.PCM, etc.)
   2. Restart recording under a new data file name, start drilling the next three rod segments.
   3. Repeat steps 1 and 2 until drilling is completed.

B. At or near sampling location, stop drilling and record spectrum for a predetermined amount of time.

This Page Intentionally Left Blank

# APPENDIX D

## Environmental Measurement-While-Drilling-Gamma Ray Spectrometer Spectral Gamma Calibration Procedures

The draft procedures for calibrating the EMWD-GRS systems gamma ray spectrometer are outlined in this Appendix. Please note:

1. Laboratory calibration procedures are outlined in the draft procedures.

2. Field calibration procedures: Currently, there are no field calibration procedures for the environmental data collection. The calibration for this demonstration will be a function of the WSRC extended Cs-137 source model.

**This Page Intentionally Left Blank**

# EMWD Spectral Gamma Calibration and Field Measurement

**Introduction**

There are two main elements for converting spectral gamma energy readings into a indication of soil contamination levels. First is the linear correlation of gamma energy Vs channel location. In general this correlation can be determined in the lab using known source material emitting gamma particles at differing energy levels. Second is the calibration of gamma flux density Vs contamination levels. This second process is not directly determined by laboratory standards. In fact this second step is under investagation at many DOE waste sites.

In this report a calibration process is looked at for the spectral gamma NaI detector used in the environmental measurement while drilling system (EMWD). A quick look at linear channel calibration is given, using actual EMWD laboratory data. To better understand the unfolding process for calculating radionuclides, a short explaination for unfolding naturally occuring radionclides for uranium exploration is given. This process is also used to gage the preformance of newly developed spectral systems for environmental work. Following the unfolding process for natural radiation will be a look at actual spectral logging data from a waste site and an unfolding method for cesium and cobalt.

The final goal of this work is to justify and document reasoning for taking a simplier approach concentrating on cesium detection.

**Gamma Energy Vs Channel Location**

This function very closely matches a straight line with a zero intercept, measured gamma energy = a * (Channel Number) + b. The NaI crystal sensor is exposed to differing radio nuclide emitting gamma particles of differing energy levels. Exposure is continued until peaks appear in the spectrum at count levels assuring accurate peak channel measurement, normally >100 counts or X10 background. Below are the laboratory measured values for the given sources.

**Table 1: Linear Calibration Results**

| Source Element | Peak Energy (MeV) | Peak Channel Number | % Difference From Calc. |
|---|---|---|---|
| Cs 137 | 0.662 | 92 | 1.1 |
| Co 60 | 1.173, 1.332 | 163, 186 | 0.7, 0 |
| Mn 54 | 0.835 | 115 | 1.7 |
| Na 22 | 0.511, 1.275 | 74, 178 | 2.9, 0 |



DRAFT

The resulting linear regression for energy Vs channel number is: Y MeV = 7.18 X$10^{-3}$ MeV * (Channel Number) - 4.90X$10^{-3}$ MeV @ room temperature. Working backwards using the given channel number and the known energy gamma the percent deference was calculated. The correlation coefficient of Table 1 values is 0.9996. The linear response of a NaI detector is very good. However, a number of factors can cause the slope 'a' to change while drilling, primarily temperature, high voltage drift, and photon-multiplier tube aging. Controlling these parameters is critical to proper measurement.

**Flux Density Vs Contamination Levels**

Gamma counts rate is a relative measure of gamma flux, dependent on many factors as detector size, housings, ect. This flux is proportional to the amount of radioactive material in the soil. Thus, the measured flux is converted to pCi/g by calibration coefficients derived from calibration models. These models have known amounts of source material distributed in a large enough volume to appear infinitely large to traveling gamma rays, about a two to four foot radius about the sensor.

However, soil conditions infinitely vary for moister content and physical make up. Moister and soil types influence the measured gamma flux. Limitations in calibration for flux density Vs contamination levels in soil result in an assumption that all soil conditions are consistent with the calibration models.

The most commonly used calibration models are maintained for DOE's Grand Junction Projects Office in Grand Junction Co. by contract with Rust Geotech Inc[i]. These models were built to calibrate instrumentation used for uranium exploration. As such these models contain three naturally occurring elements, K-40, Ra-226, and Th-232, (KUT). Because these models are well characterized and documented they are used to set a baseline accuracy for all subterranean gamma instrumentation. Stromswold (1981) uses gamma count windows centered about energy peaks of the three naturals which unfold from highest energy to lowest. Table 2 shows his suggested windows.

## Table 2 Spectral Energy Windows for Unfolding KUT

| Element | Unique Gamma Ray (MeV) | Energy Window (MeV) |
|---|---|---|
| Potassium (K-40) | 1.46 | 1.320-1.575 |
| Uranium (Ra-226) | 1.76 & 2.20 | 1.650-2.390 |
| Thorium (Th-232) | 2.61 | 2.475-2.765 |

In working with subterranean gamma there is a problem of higher energy gamma rays being counted in lower channels, down scattering. By choosing the Thorium window about the 2.61MeV gamma, Thorium can be solved for because potassium and uranium don't have any gamma rays higher than 2.39MeV. Once thorium is known then the solution for uranium can be found because potassium is below the 1.65MeV window used for uranium. This process is called unfolding. The Grand Junction B models are well suited for this unfolding process. The B model concentrations listed in Table 3 below.

## Table 3. Grand Junction B-Model Concentrations

| Model | Concentration Th (pCi/g) | Concentration Ra (pCi/g) | Concentration K (pCi/g) |
|---|---|---|---|
| BT Upper | 58.78 ± 1.53 | 10.46 ± 0.51 | 10.13 ± 1.34 |
| BU Upper | 0.65 ± 0.06 | 194.59 ± 5.94 | 10.63 ± 1.00 |
| BK Lower | 0.10 ± 0.02 | 1.03 ± 1.67 | 54.00 ± 1.67 |

By placing the spectrometer into each of the three models, subtracting electrical noise, and counting gamma for each of the three windows in Table 2, a rate matrix R is produced. Matrix R is guaranteed to be nonsingular because of the window selection process assures an upper triangular form. Using the concentrations of Table 3 a set of coefficients relating window count rates to concentrations (pCi/g) can be solved for using Eq1. An important note on counting periods; The statistical nature of gamma counting requires long enough counting periods to gain a meaning full count rate. The standard deviation of the gamma count is equal to its square root, i.e. 100counts has a 10count sdv.

$$A = C R^{-1} \quad \text{Eq1.}$$

*A is a 3X3 Matrix of Calibration Coefficients*
*R is a 3X3 Matrix of Count Rate reading for each of the three windows*
*C is a 3X3 Matrix of Known model concentrations from Table 3*

Once A is known then the system is tested against a forth model (BM) which is a mix of all three elements. A properly calibrated spectrometer then solves for concentration levels for KUT using equation Eq2.

$$C = AR \quad \text{Eq2.}$$

Equation 2 is used to convert gamma flux rates to density measurements in pCi/g as the system is drilling or logging. There are a number of additional considerations to the process which should be addressed. First, the linear calibration relating gamma energy peaks to channel numbers in the spectrum is used for setting the KUT windows of Table 2. Anything which alters this calibration effects the calculated concentration levels. The measure of the gamma rate is dependent on concentration levels but also the MCA conversion rate. Low power MCAs normally employ slow conversion methods increasing dead time (DT). Where DT and R are both in units of seconds, Eq3 below is used compensate for a slow MCA.

$$R' = R * 1\text{sec} / (1\text{sec} - DT) \quad \text{Eq3.}$$

*DT is a function of MCA total counts and conversion time*
*R' is a new MCA compensated rate matrix*

In the general solution of converting gamma count rates to KUT soil concentrations, a basic assumption was made; Only naturally occuring gamma sources are found in the soil. The man-made rad waste creates a new set of gamma emmitters in contaminated soils.

In the case of Cesium (Cs-137), its' gamma ray is at 0.66MeV. Using this unfolding process Cesium would be unfolded after potassium. Too follow this logic, every radioactive element distributed within the soil must be accounted for in the unfolding process. The dominate waste radionuclides generally found in the soils at Hanford and Savannah River are Cesium-137, Europium-154, Europium-152, and Cobalt-60. In a Westinghouse Savannah River 1994 report on H-Area retention basin list maximum concentrations as shown in Table 4. Table 4 is by no means a complete list of man-made waste, rad or otherwise.

## Table 4. Example of found Radionuclides at a Waste Site

| Radionuclides | Max. Concentration, pCi/g |
|---|---|
| Cesium-137 | 33000 |
| Europium-152 | 47 |
| Europium-154 | 33 |
| Cobalt-60 | 1.8 |

Figure 1 is log data taken with a HPGe detector used at Hanford, (C.J. Koizumi, 1993). There are two important attributes demonstrated by this data. First, the total count is a good indicator of waste radionuclides in the soil. Second, cesium waste maybe independent of other radionuclides.

A complete gamma spectrum is shown in Figure 2. This spectrum was taken at 16.8m depth in the log run shown in Figure 1. Here the spectrum is scaled out to 2.8MeV. By scaling out so high the thorium peak at 2.61MeV can be monitored for changing backgrounds. The measured concentrations for this spectrum at as follows: 3 pCi/g of Co-60, 29 pCi/g of Eu-154 and 8 pCi/g of K-40. The vast majority of spectral activity is below the K-40 peak at 1.46MeV.

Looking again at Figure 2, the down scattering of higher energy gamma into the 0.66MeV energy channel is a concern. Because of the low energy Cs-137 gamma virtually all background and other man-made rad waste interferes with the cesium measurement.

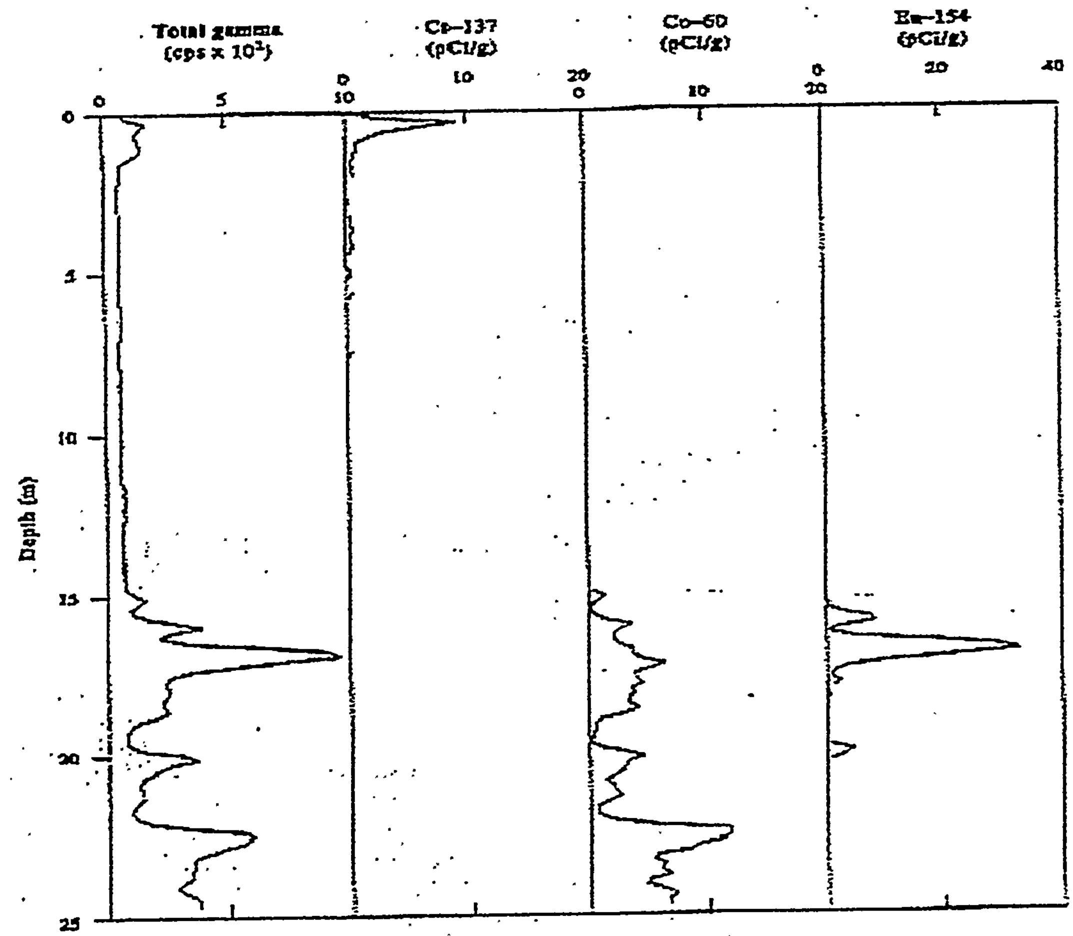



Figure 1. Spectral log near Hanford waste tank, (C.J. Koizumi, 1993)

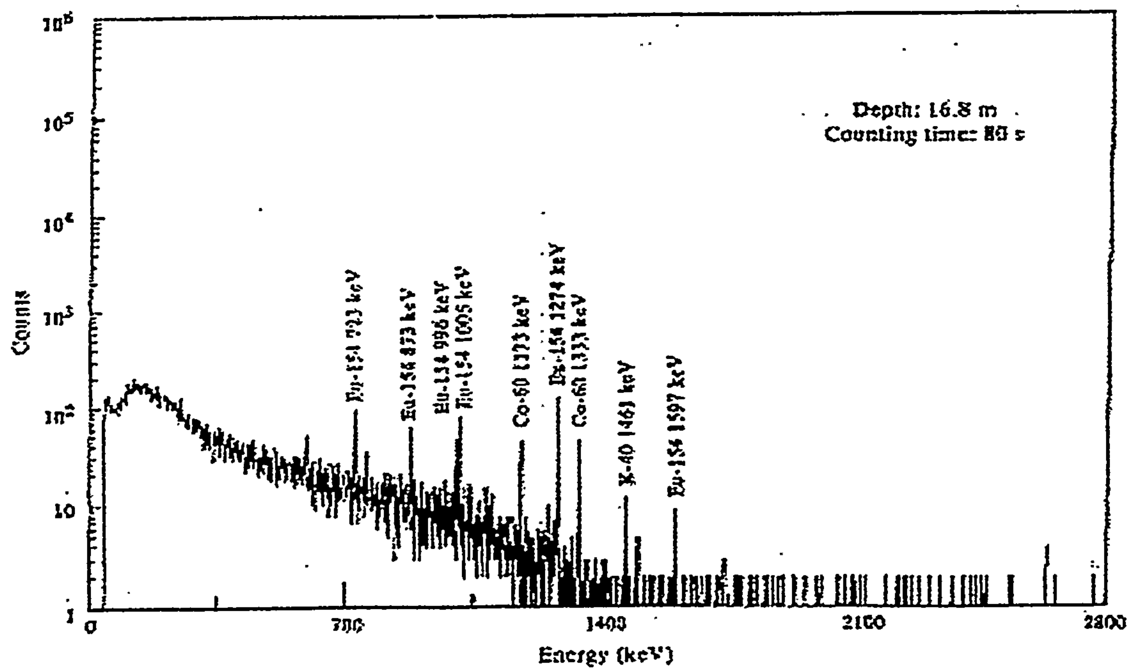



Figure 2. An example of a complete gamma spectrum taken for the log in Figure 1. (C.J. Koizumi, 1993)

**Unfolding Co and Cs From Background, An Example**

Unfolding the three naturals along with cesium and cobalt (Randall and Stromswold, 1995) used windows 1.105 to 1.420MeV for cobalt and 0.590 to 0.715MeV for cesium. Lumping the background Th and U counts as a single constant term, the Cs and Co unfolding formulas are shown below.

$$C_{Co} = aR_{Co} - bR_{K} - cR_{Cs} - BKG_{Co} \quad \text{Eq4.}$$

$$C_{Cs} = dR_{Cs} - eR_{Cs}^{2} - fR_{Co} - BKG_{Cs} \quad \text{Eq5.}$$

*Terms 'a'-'f' are unique coefficients.*

*BKG is the constant background subtraction of each element.*

*In all cases $BKG_{Cs} > BKG_{Co}$.*

Both equations 4 and 5 use the K40 rates directly. This is done because the cobalt upper gamma is very near that of potassium. The NaI detector resolution will overlap gamma counts. In Eq5 has a cobalt count rate term for calculation of cesium. Often cesium and cobalt are found together and the down scattering of the higher energy cobalt is a significant. Eq5 incorporates a squared term for pile up correction at very high count rates.

**Suggested Approaches For EMWD**

The EMWD MCA is a 256 channel multi-channel analyzer. The NaI crystal is (at present) a four by one inch cylinder. Complete spectrums are transmitted to the surface every 30 seconds. Spectrums are not being taken while data is being transmitted. The actual sample period is ~20 seconds. Spectrums can be summed at the surface to longer sample periods.

The main focus of the EMWD system is to detect and measure cesium contamination levels while drilling. There are no cesium waste models for calibration of spectral gamma logging systems. Even if such a model existed there are too many types of mixed radionuclides at each DOE site for any NaI system to accurately unfold. Two methods are suggested for calibrating a system to unfold Cs-137 from natural background spectrums. In both cases, total gamma counts will be used to detect increased levels of man-made waste. The total count might also help detect when count rates are increased by man-made waste other than Cs-137 by the simple relationship in Eq6.

$$TC - aR_{Cs} - bR_{K} - BKG_{TC} \stackrel{?}{=} 0 \quad \text{Eq6}$$

*TC = total counts*

*$BKG_{TC}$ taken from reading is a clean area.*

*a & b coefficients derived from field testing.*



**DRAFT**

Calibration Method 1
This method would treat the spectrum readings in the same fashion as calibrating any spectral gamma logging system as addressed earlier in this report.

Set the linear range to 2.80MeV, full scale. Choose windows for all three naturals plus Cs-137. Eq1 is now composed of 4X4 matrixes. B-models can be used where the model concentration of Cs-137 is assumed zero. To solve for matrix A a forth model of known concentration of Cs-137 must be used. This Cs-137 model may actually be a characterized well as logged in Figure 1 at a waste site. This approach is heavily dependent on the quality of the Cs-137 model. The matrix inversion simultaneous solution of linear equations produces a least squares fit to given data. The solution maybe sensitive to slight changes in concentration levels, non-robust. This problem is compounded by the lack of a properly configured mixed model to help test the solution.

Calibration Method 2
The energy range will be low, upper end limited at 1.6MeV. This is done to utilize system sensitivity about the range of interest, see Figure 2. Gamma rays above this threshold are counted as a total and stored in channel 255. By monitoring this channel normal thorium and uranium background levels can be monitored. These background levels will be characterized at the site by drilling a short bore outside of the contaminated area. Along with channel 255, the potassium and cesium windows will also be characterized for background down scattering. Using the B-model, the cesium window can be characterized for potassium down scattering.

$$C_{Cs} = aR_{Cs} - bR_K - BKG_{Cs} \quad \text{Eq7}$$

Several cesium dominated wells of differing levels will be required to curve fit system response to cesium. If background reading remain constant and Cs-137 dominates all other types of man-made waste then the linear relationship should be well bounded.

**Conclusion**
The EMWD spectrometer is capable of linear calibration of gamma energy peaks at room temperature. The logging industry in cooperation with DOE has developed spectral gamma calibration methods and facilities. These method and facilities are not sufficient to fully calibrate spectral gamma systems for subterranean measurement of man-made mixed waste.

Actual logging data taken of rad waste by a HPGe system points to the complexity of the problem. For the EMWD system using a NaI detector there is no recognized solution for calibration or unfolding spectrums in man-made rad waste sites with unknown radionuclide.

Two methods were looked for calibration and unfolding. One method expands the accepted method used for spectral gamma logging tool calibration used in uranium exploration wells. The second method assumes a fixed background and attempts to equate a linear relationship between gamma count rates in cesium directly. Both methods or some combination of approaches needs to be tested before release for site characterization.

---

[i] R. Leino, D.C. George, B.N. Key, L. Knight, and W.D. Steele, June 1994, Third Edition, Field Calibration Facilities for Environmental Measruement of Radium, Thorium, and Potassium, technical Measurements Center Grand Junction Projects Office

# APPENDIX E

**Site Specific Health and Safety Plan for the Environmental Measurement-While-Drilling-Gamma Ray Spectrometer System Demonstration at the SRS F-Area Retention Basin**

**This Page Intentionally Left Blank**

11/22/94
Document Preparer
Shelia L. McFalls 11/22/94
Document Reviewer

# SITE SPECIFIC HEALTH

# AND SAFETY PLAN

**FOR THE**

## F-AREA RETENTION BASIN (281-3F)

## PHASE II RI INVESTIGATION

WORKING COPY
VERIFIED TO BE THE LATEST REVISION
BY: _______ DATE: 11-29-94
KJK 5/16/95
MUST BE VERIFIED PRIOR TO EACH USE

## Q-SHP-F-00003

## REVISION 01

## NOVEMBER 1994

(This page intentionally left blank.)

# SITE SPECIFIC HEALTH AND SAFETY PLAN

# FOR THE

# F-AREA RETENTION BASIN (281-3F)

# PHASE II RI INVESTIGATION

| | |
|---|---|
| [signature] PREPARED BY: Kevin J. Kuelske | 11/22/94 DATE |
| [signature] WASTE SITE CUSTODIAN: Kevin J. Kuelske | 11/22/94 DATE |
| [signature] ER CUSTODIAN'S LEVEL 4 MANAGER: Wayne F. Johnson | 11/28/94 DATE |
| RW Reese for C. Lark<br>RADIOLOGICAL CONTROL and HEALTH PHYSICS MANAGER | 11-28-94 DATE |
| [signature] for L.K. [signature]<br>INDUSTRIAL HYGIENE and RESPIRATORY PROTECTION MANAGER | 11/23/94 DATE |
| Mark T. Hubbard<br>OCCUPATIONAL SAFETY PROGRAMS and ASSESSMENTS | 11/22/94 DATE |
| Davida Matthews<br>EMERGENCY SERVICES DEPARTMENT MANAGER | 11/28/94 DATE |
| [signature] FOR: C.E. Hughey<br>ER QUALITY ASSURANCE MANAGER | 11/29/94 DATE |
| [signature]<br>HEALTH AND SAFETY OFFICER | 11/29/94 DATE |

(This page intentionally left blank.)

## LIST OF REVISIONS

| Revision Number | Revision Date | Pages Affected |
|---|---|---|
| 0 | June 1994 | All |
| 1 | November 1994 | x, 1-10, 12,13,18,19,24 |

(This page intentionally left blank.)

## TABLE OF CONTENTS

(This page intentionally left blank.)

## List of Figures



## List of Tables

(This page intentionally left blank.)

## List of Acronyms

| | |
|---|---|
| ADS | Analytical Development Section |
| ALARA | As Low As Reasonably Achievable |
| ANSI | American National Standards Institute |
| CB | Citizen's Band |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CPR | Cardiopulmonary Resuscitation |
| DOE | Department of Energy |
| EP | Excavation Permit |
| EPA | Environmental Protection Agency |
| ERD | Environmental Restoration Department |
| FARB | F-Area Retention Basin |
| GPR | Ground Penetrating Radar |
| H&S | Health and Safety |
| HAZWOPER | Hazardous Waste Operations and Emergency Response |
| HEPA | High Efficiency Particulate Air |
| HP | Health Protection |
| HSO | Health and Safety Officer |
| IH | Industrial Hygiene |
| MCL | Maximum Containment Level |
| MSL | Mean Sea Level |
| OJT | On-the-Job Training |
| OSHA | Occupational Safety and Health Administration |
| OVA | Organic Vapor Analyzer |
| PM | Project Manager |
| PPE | Personal Protective Equipment |
| QA | Quality Assurance |
| RBA | Radiological Buffer Area |
| RCO | Radiological Control Operations |
| RCRA | Resource Conservation and Recovery Act |
| RESRAD | Residual radioactive dose calculation computer code |
| RFI | RCRA Facility Investigation |
| RI | Remedial Investigation |
| RWP | Radiation Work Permit |
| SAFER | Streamlined Approach for Environmental Restoration |
| SCBA | Self Contained Breathing Apparatus |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| SIRIM | Site Item Reportability and Issue Management |
| SRO | SIRIM Reporting Official |
| SRS | Savannah River Site |
| SRSOC | SRS Operations Center |
| SSHASP | Site Specific Health and Safety Plan |
| STR | Subcontract Technical Representative |
| TO | Technical Oversight |
| TSD | Treatment, Storage, or Disposal Facility |
| VOC | Volatile Organic Compound |
| WCP | Work Clearance Permit |
| WSRC | Westinghouse Savannah River Company |

(This page intentionally left blank.)

## 1.0 INTRODUCTION

This document describes the safety, health, and emergency response requirements for investigation activities at the existing F-Area Retention Basin, 281-3F (FARB). The Site Specific Health and Safety Plan (SSHASP) contains information concerning personnel responsibilities, waste unit characterization, environmental monitoring, personal protective equipment, and required safety and health procedures. In addition to the requirements outlined in this SSHASP, all work will be performed in accordance with WSRC 4Q (Industrial Hygiene Manual), WSRC 8Q (Employee Safety Manual), WSRC 5Q (Radiological Control), WSRC 20Q (Health and Safety Manual for Hazardous Waste Operations), WSRC 3Q5 (Hydrogeologic Data Collection), and the WSRC RFI/RI Program Plan (latest revision). **In addition to the requirements of this SSHASP, subcontractors and WSRC employees involved with subcontractor activities are subject to the safety requirements of the subcontractor or WSRC, depending upon which requirements are more stringent.**

## 2.0 SITE HISTORY AND PROJECT DESCRIPTION

### 2.1 Unit Description

The F-Area Retention Basin (281-3F) was used from 1955 to 1973. This open, unlined basin provided temporary emergency storage for potentially contaminated cooling water from the chemical separations process. When radioactivity was encountered in the cooling water, immediate action was taken to diver the water from surface drainage streams to the retention basin. The cooling water could potentially be contaminated if chemical processing materials leaked into it. During the holding period, some quantity of water seeped into the ground. If the radioactivity was above stream release limits, the waste water was processed by deionization to reduce contamination and permit release. The exact quantities of water disposed in the retention basin is unknown. The volume and curie content of the water in the intermittent discharge varied. only trace quantities of chemicals are believed to have been discharged to the basin.

The unlined retention basin stopped receiving effluent in 1973 when it was replaced by a new, lined retention basin (281-3F). After a characterization study, 0.6 m of sediment was removed from the floor of the F-Area Retention Basin in 1978-79. The basin was backfilled with dirt and covered with grass.

### 2.2 Project Description

**The Phase II RI Investigation activities at the F-Area Retention Basin (FARB) will involve collection of stream surface water and sediment as well as soil samples from within and surrounding the basin and associated process sewer line. The activities to be performed are outlined in the Phase I, Rev 1 RI Work Plan for the F-Area Retention Basin (281-3F). Four distinct areas will be sampled. First, sediment and surface water sampling at the small, unnamed stream adjacent to the unit will be taken to assess the basin's imapt on the surrounding wetlands. This activity will be performed in a radiologically clean area and will not require a radiological buffer area (RBA). Second, soil samples will be collected from four location with the former basin to a depth not to exceed the ground water table. Third, soil samples will be collected from eight location along the basin perimeter to assess the lateral migration of contaminants. Finally, 11 samples will be collected from along the process pipeline to access the potential leakage from this pipeline. All sampling, except along the stream, will be performed in a temporary RBA and will require continuous RCO Coverage.**

**Drilling activities will be required for collection of all soil samples especially inside the basin and along its perimeter. Along the process sewer line, which is mostly inside F-Area, hand augers will be used down to 10 feet to ensure no underground utilities are encountered. All samples collected will be screen by either RCO (if "blue tagged") or by ADS prior to shipment off site for analysis. Proposed sampling location can be seen in Figures 1 and 2.**

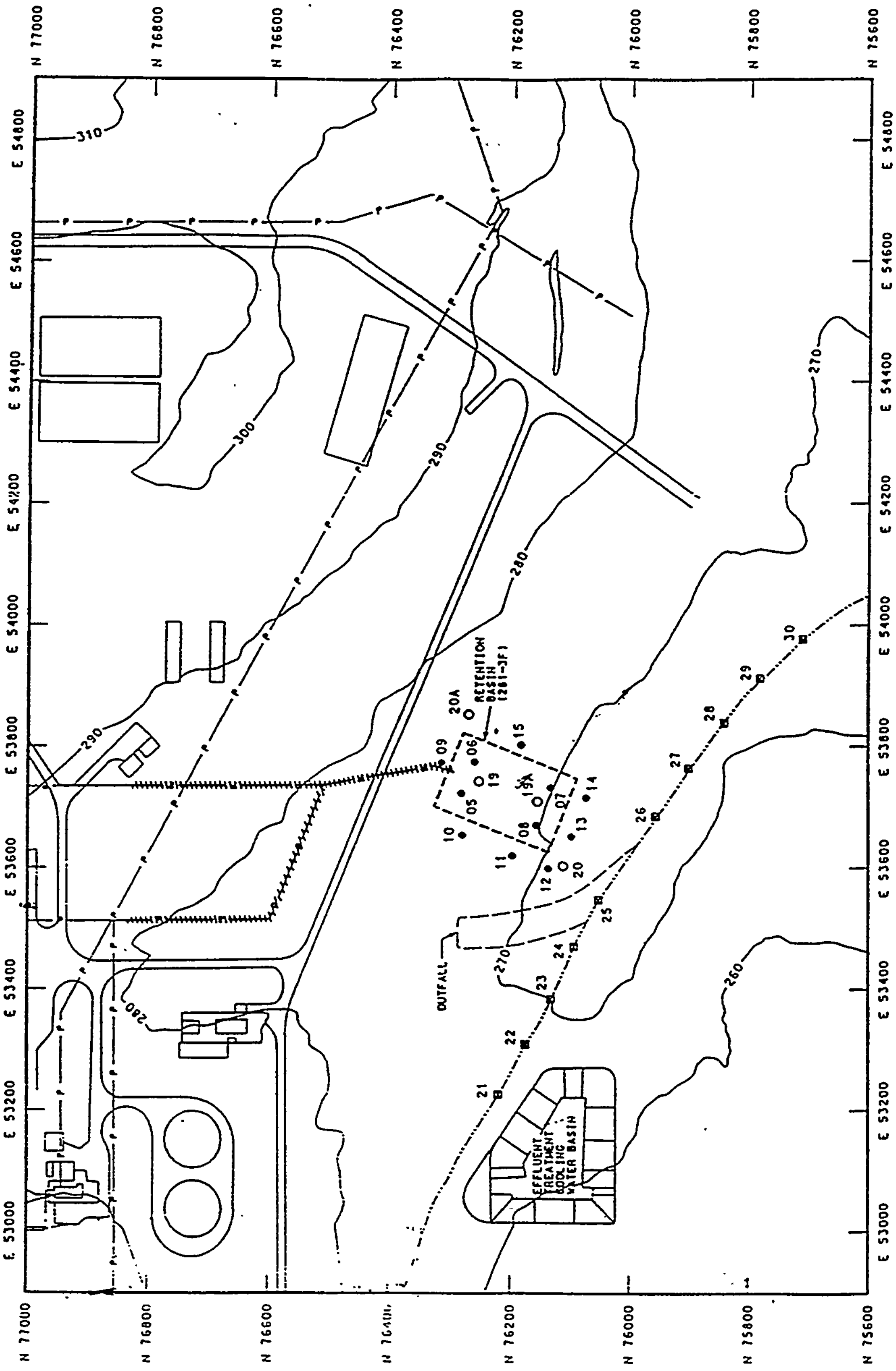



**Figure 1.** Soil, Surface Water/Sediment, and Geotechnical Sampling Locations

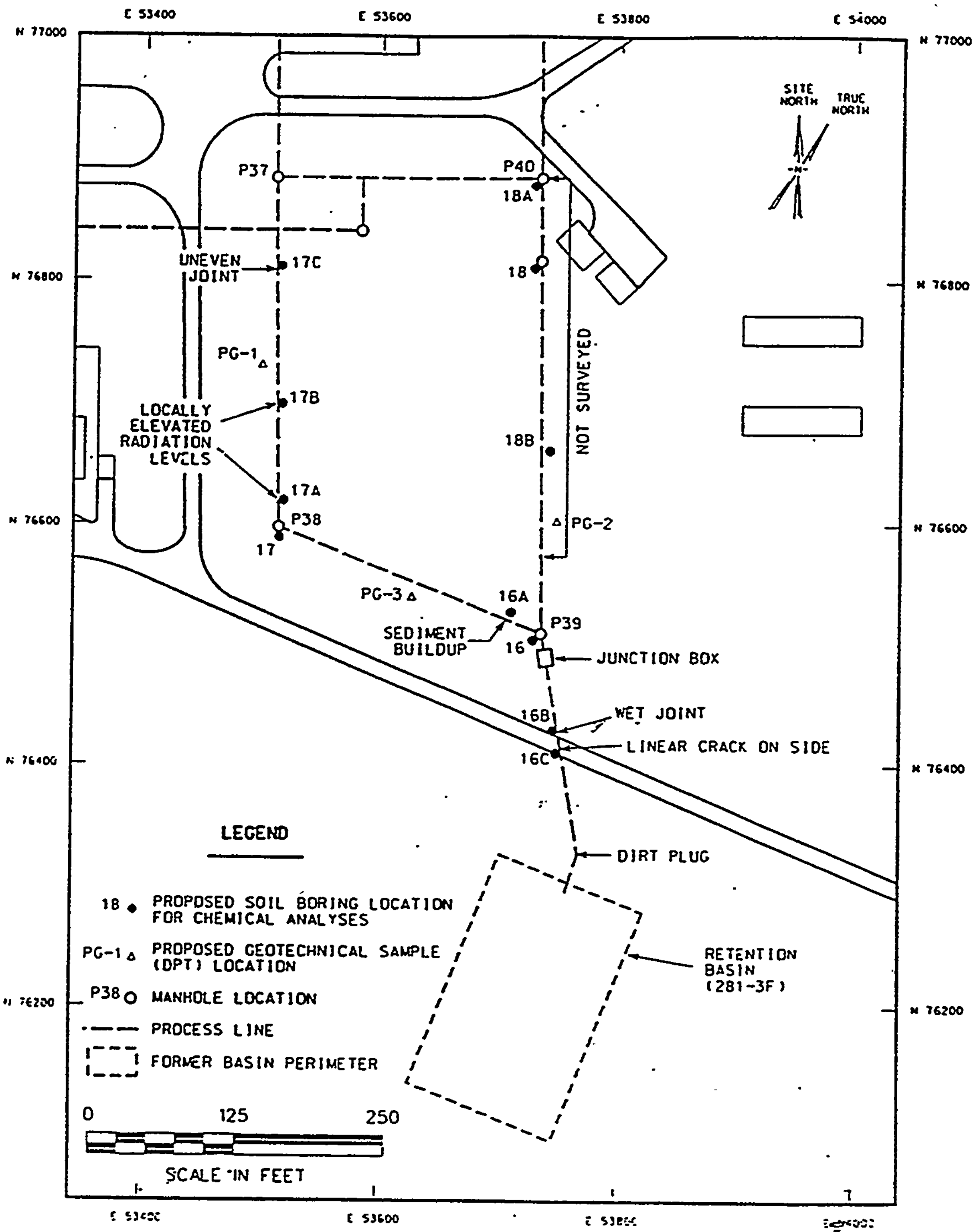



Figure 2. Soil and Geotechnical Sampling Lacations Along the Process Line

## 3.0 SITE ORGANIZATION AND RESPONSIBILITIES

### 3.1 General

Westinghouse Savannah River Company (WSRC) is the prime Management and Operations Contractor for the Savannah River Site (SRS) with ultimate authority and primary responsibility for unit/site operations that include unit/site health and safety. The SRS RI Project Manager (PM) is responsible for overall project coordination and reports to the RCRA/CERCLA Program Coordinator. The Health and Safety Officer (HSO) (whose duties are described below) may be the same person as the Technical Oversight (TO). The TO is responsible for monitoring drilling and/or sampling activities to ensure that these activities match the requirements of the RI Work Plan.

In the event that conditions warrant that work be performed in a **Radiologically Buffer Area**, the work will be performed under the control of the SRS Radiological Control Operations (RCO) Department. SRS RCO will be responsible for directing and monitoring all unit/site health and safety concerns associated with radiological materials, and when present, will be the field SRS Health and Safety representative. The SRS Industrial Hygiene (IH) Department is responsible for reviewing this SSHASP for compliance to IH procedures and may perform monitoring for non-radiological hazards in the field.

The SRS RI Project Manager [WSRC Environmental Restoration Department (ERD)] has developed this Site Specific Health and Safety Plan (SSHASP) in cooperation with the SRS IH, RCO, Occupational Safety Programs and Assessments, Emergency Services Department, and Quality Assurance (QA).

The SRS RI PM and the subcontractor Project Managers (PM) assure that all project personnel are medically fit for duty, are current in HAZWOPER or equivalent training, and have a current respirator fit test (if required). Each subcontractor PM will also ensure that all unit/site project personnel understand and accept the SSHASP prior to performing work on the project. The chain of command for health and safety issues for this project will be SRS PM to subcontract PM to subcontractor TO/HSO to subcontractor field management (FM) to the drillers. However, all personnel at the job site can stop work at any time for any health or safety concern.

### 3.2 Health and Safety Officer (HSO)

The HSO will monitor sampling activities for the SRS RI PM who will ensure compliance with all health and safety requirements by project personnel. The HSO will be present during all drilling, excavation, and sample collection activities at the waste unit. The SRS RI PM and the subcontractor HSO will not allow work to begin until the SSHASP, Radiation Work Permit (RWP) (where applicable), Work Clearance Permit (WCP), and Excavation Permit (EP) (where applicable) have been provided to, reviewed, and signed by all appropriate field personnel. The SSHASP, RWP (where applicable), and WCP must be visibly posted at the unit/site. Before entering the controlled area of the work site, all personnel must attend a unit/site-specific briefing session, to be conducted by the HSO, on the potential unit/site hazards and specific requirements of this SSHASP. In addition to the unit/site-specific briefing, all unit/site personnel and authorized visitors must sign a Daily Sign-In/Out Log (see Appendix C) and will be required to provide current documentation of medical clearance and HAZWOPER or equivalent training. If any documentation is not available or is out-of-date, the HSO will advise the personnel that requirements stated in 29 CFR 1910.120 apply and will not allow entrance into the controlled areas of the work site. The SRS RI PM will be informed if any subcontractor personnel or third party visitor attempts to access the work zone without proper documentation.

If there is any question whether an unplanned occurrence on the unit/site may compromise worker health and safety, the HSO has the authority to interrupt operations and to remove all personnel from the area. If practical, the SRS RI PM should be consulted before any operation is interrupted. If work is stopped due to any health and safety concern, immediate attention should be given by health and safety personnel working in cooperation with the SRS RI PM to identify and correct the cause of concern as quickly as possible. Any such incident should be fully documented by the HSO and reported to the SRS RI PM. In the event of a work stoppage, the SRS RI PM must be kept appraised of progress in resolving the incident until normal operations are resumed. In absence of the

TO/HSO, the FM of each subcontractor becomes the active HSO and has overall responsibility for monitoring and ensuring that their project personnel will comply with this SSHASP.

Specific duties of the HSO include, but are not limited to:

- Conduct a health and safety meeting (prior to the initiation of any fieldwork) in which both general health and safety concerns and those health and safety concerns specific to the RI characterization at the Waste Unit are addressed to the satisfaction of all in attendance. The HSO must document the workers in attendance by obtaining their signatures/ initials on the "Site Safety Meeting Attendance" sheet in Appendix C, and any new workers must receive a documented briefing on the health and safety concerns covered in the original meeting. *
- Collaborate with SRS RCO in a fashion that ensures compliance with appropriate procedures.*
- Identify and prevent all recognized work practices or conditions that may result in injury or exposure to toxic substances.*
- Obtain and interpret instrument readings to determine the degree of hazard present (with the exception of radiation monitoring for health protection considerations, which will be conducted by RCO).
- Monitor the use of personnel protective equipment (PPE) for SRS as determined by personal protection levels stated in this SSHASP (except for personal protection levels related to radiation).*
- Monitor decontamination procedures.
- Conduct pre-entry and periodic safety training as necessary.
- Assist in the coordination of emergency response activities for onsite personnel and with emergency support groups at SRS; ensure work site is equipped with communications capability for emergency notifications not only to the SRS Operations Center but from the SRS Operations Center.*
- Monitor personnel safety performance for SRS to ensure that required work practices are in compliance with this SSHASP during RI operations.*
- Assist with coordination of emergency response activities.
- Monitor for SRS who will ensure compliance with, and determine effectiveness of, this SSHASP.*

  * Duties to be performed by active subcontractor HSO if TO/HSO is not onsite.

In addition, an alternate HSO shall be identified if the HSO is unable to perform his duties. The alternate HSO will hold the same responsibilities and training requirements as the HSO.

### 3.3 Project Manager (PM)

The Project Manager (PM) is the individual from WSRC responsible for overall project coordination. The PM must make appropriate notifications in emergencies. The PM must not allow work to begin until this SSHASP has been provided to all field personnel. The PM must also ensure that all personnel attend a site specific briefing session conducted by the HSO.

All personnel have the responsibility and authority to order a work stoppage should unsafe conditions exist.

In addition to the requirements set forth in this SSHASP, all work performed by subcontractors will be performed in accordance with WSRC 4Q (Industrial Hygiene Procedures Manual), WSRC 8Q (Employee Safety Manual), WSRC 5Q (Radiological Control), WSRC 20Q (Health and Safety Manual for Hazardous Waste Operations), and the WSRC RFI Program Plan (latest revision). Any modifications to the SSHASP will be documented on the Health and Safety Field Modification Form (see **Appendix C**) and approved by the SRS RI PM and HSO prior to commencement of activities.

The project manager is also responsible for coordination of site surveillances. Surveillances may be conducted by ER QA or the Subcontractor Safety Group. The ER QA Department will determine that all procedures, including this SSHASP, are properly followed and implemented. The Subcontractor Safety Group will ensure that the subcontractor HSO is performing his duties in accordance with this SSHASP and the Employee Safety Manual, WSRC 8Q.

## 4.0 HAZARD AND RISK ANALYSIS

It is the responsibility of all personnel to understand and be aware of all hazardous materials that may be present during this phase of the investigation at the F-Area Retention Basin.. The materials that have been identified to exist at the F-Area Retention Basin are identified in sections 4.1.1 through 4.1.3. **During this phase of the investigation, radioactive materials are expected to be encountered.**

In the event that any hazardous materials are encountered, the principles of "As Low As Reasonably Achievable" (ALARA) shall be followed. ALARA has three main tenants; time, distance, and shielding. That is, it is the responsibility of each person to minimize the amount of time to exposure to, as well as maximize distance from, any source of hazardous material. In addition, if the hazardous material is anticipated to be significant, RCO and/or IH may require shielding or other engineering barriers to reduce exposure.

### 4.1 Hazardous Constituents

Hazardous constituents around the F-Area Retention Basin are anticipated to be identical to those identified during Phase I sampling at the F-Area Retention Basin (281-3F) conducted in January, 1994. Results of this sampling indicated that the only contamination received by the basin were radioactive isotopes, mainly Cs-137 and Sr-90. Neither soil gas screening (July 1993) nor Phase I sampling detected any metal or organic contamination at levels of concern at the 281-3F Retention Basin or process sewer line. Further details of the contamination expected at the FARB are present in the following sections.

#### 4.1.1 Radioactive Contamination

Radiological contamination is the primary concern of work activities at the FARB. Records indicated that cooling water contaminated with radioisotopes, primarily Cs-137 and Sr-90, were sent to the F-Area Retention Basin from the Tank Farm and Canyon building on several occasions during the operating span from 1955 to 1973. Generally the F-Area Retention Basin revived cooling water which was too highly contaminated to be sent to the seepage basins.

Phase I Sampling at the retention basin confirmed the expectations of the nature of contamination at the F-Area Retention Basin. Radioactive Cs-137 and Sr-90 were detected in significant quantities in the soil (60 - 100 pCi/g) as well as during RCO field screening. All non-basin soil samples were determined to be <u>non</u> contaminated by field screen and laboratory analysis. It is anticipated that, given the deep water table at the basin, the radioactive contaminants have not yet reached the ground water. **Since samples will be collected from inside the FARB, this sampling will be conducted inside an RBA.**

#### 4.1.2 Volatile Organic Compounds (VOCs)

One soil gas survey has been conducted at the F-Area Retention Basin (281-3F) waste unit. The soil gas survey was conducted in July 1993 at the perimeter of the basin as indicated by radiological and "orange ball" markers. No organic contamination was detected during this unit screening.

Phase I sampling at the F-Aire Retention Basin (281-3F) was conducted in January 1994. During the investigation four soil samples were taken from the basin area and analyzed for organic contaminants including, volatiles, semi-volatiles, and tentatively identified compounds. No organic compounds were detected above regulatory action levels. However, some semi-volatile contaminants were discovered at one location at the basin where burning was apparently conducted during remediation prior to placement of backfill material over the basin. Since these contaminants were not introduced as part of the normal operating procedure of the retention basin they are not expected to exist inside the FARB. The list of semi-volatiles contaminants detected at the basin is given below:

| | | |
|---|---|---|
| 1,4 Dichlorobenzene | 2-Methylnaphthalene | Anthracene |
| Benzo(a)pyrene | Benzo(b)flouranthene | Benzo(g,h,i)perylene |
| Bis(2-ethylhexyl) Phthalate | Butyl Benzyl phthalate | Chrysene |
| Dibenzofuran | Diethyl Phthalate | Flouranthene |
| Fluorene | Naphthalene | Phenanthrene |
| Pyrene | Acetone | |

#### 4.1.3 Metals

Phase I sampling at the F-Area Retention Basin (281-3F) indicated the presence of small amounts of Beryllium. This metal is not believed to be part of the process at the canyon and therefor is believed not to have been introduced into the FARB. No other metal contaminants were detected at the F-Area Retention Basin in significant quantities.

Health risks associated with metals is not expected to be a major concern.

### 4.2 Exposure Routes

A summary of the exposure assessment activities covered under this SSHASP is presented in Table 1. For the work to be accomplished during the proposed activities, the main routes of exposure is the possibility of direct contact or inhalation of contaminated soils.

**Table 1.**
**Old F-Area Seepage Basin Potential Exposure Pathways**

| MEDIA | HAZARD | PATHWAY | POTENTIAL |
|---|---|---|---|
| Ground Water | Contamination | Direct Contact<br>Human Ingestion | Very Low<br>Very Low |
| Surface-Water | Contamination | Direct Contact<br>Human Ingestion<br>Offsite Migration | Very Low<br>Very Low<br>Very Low |
| Soil | Contamination | Direct Contact<br>Vapor/Dust Inhalation<br>Transport to Surface Water | Medium<br>Medium<br>Low |
| Air | Contamination | Inhalation of airborne particulates | Medium |

*Hazards due to contact with soils:*

Potential for personnel contamination due to direct contact with soil is low since no drilling will occur within the waste unit (orange ball markers). The greatest risk of contamination will be contact with drill cuttings from within and along the basin perimeter. RCO will evaluate all drill locations for radiation safety and provide **continuous coverage at locations which may encounter radioactive soil contamination.**

*Hazards due to contact with ground water:*

Potential for personnel contamination due to direct contact with ground water is very low since past sampling and current transport models indicated that no contamination has reached the ground water. The greatest risk of contamination will e contact with ground water from down gradient wells. RCO will evaluate all drill locations fro radiation safety and provide spot coverage to check for ground water contamination.

*Hazards due to Organic Vapors:*

Potential for personnel exposure to organic vapors is very low since no organic chemicals are known to have been released to the FARB. The presence of organic vapors will be monitored with an on-sit OVA or HNu by the TO/HSO at the discretion of IH and any decision to wear respirators must be made by IH in cooperation with the TO/HSO.

## 4.3 Environmental Health Considerations

### 4.3.1 Cold Stress

Low body temperatures will likely result in reduced mental alertness, reduction in rational decision-making capability, loss of consciousness, or death.

Mild to severe pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering develops when the body core temperature has fallen to 35° C (95° F). Useful physical and mental work is limited when severe shivering occurs. Because prolonged cold exposure at temperatures well above freezing can lead to hypothermia, whole body protection must be provided. If work activities are performed in temperatures below 40° F, adequate insulating clothing to maintain core temperature must be worn by all workers. Damp or wet clothing may contribute to cold stress. All workers should be aware of the effect of wind chill on exposed skin. Appendix B contains additional cold stress information.

### 4.3.2 Heat Stress

The major disorders due to heat stress are heat cramps, heat exhaustion, and heat stroke. Heat cramps are painful spasms which occur in the muscles of workers who sweat profusely in the heat and drink large quantities of water, but fail to replace the body's lost salts and electrolytes.

Heat exhaustion is characterized by extreme weakness or fatigue, dizziness, nausea, and headache. In serious cases, a worker may vomit or lose consciousness. The skin is clammy and moist, complexion pale or flushed, and the body temperature can be normal or slightly higher than normal. Treatment consists of rest in a cool place and replacement of body water and salt lost by perspiration. Mild cases may recover spontaneously with this treatment. Severe cases may require care for several days. There are no permanent effects.

Heat stroke is caused by the breakdown of the body's heat regulating mechanism. The skin is very dry and hot with a red or bluish appearance. Unconsciousness, mental confusion, or convulsions may occur. Without quick and adequate treatment, the result can be death or permanent brain damage. Medical assistance should be given quickly.

The person should be moved to a cool place. Body heat should be reduced artificially by soaking the person with water and vigorous fanning.

Wearing of protective clothing, such as Tyvek, KleenGuard, polyethylene coated Tyvek, or saran coated Tyvek suits may increase the danger of heat stress.

Workers should be aware of the symptoms, dangers, and appropriate preventive and treatment measures associated with heat stress. Appendix B contains additional heat stress information.

## 5.0 SAFETY AND HEALTH TRAINING

### 5.1 General

Training of each worker is to be verified by the HSO prior to site entry. In accordance with the general site policy and the guidelines set forth in WSRC 20Q, "Health and Safety Manual for Hazardous Waste Operations," Procedure E, the following is required:

- GET, if employee is on site for more than 10 days or needs to have unescorted access to the SRS.
- Radiation Worker II Training as required by WSRC 5Q.
- RCRA training if the site is a RCRA Treatment, Storage or Disposal facility (TSD) or there is a potential for generation of hazardous waste.
- HAZWOPER or equivalent training, outlined below, including On-the-Job Training (OJT.)

**Table 2. Training Requirements for Waste Site Workers**

| Individual | 40 Hour HAZWOPER | 24 Hour HAZWOPER | 8 Hour Supervisor | OJT |
|---|---|---|---|---|
| HSO / Alternate | Required | | Required | 3 Day Required* |
| Technical Field Oversight | Required | | | 3 Day Required |
| Laborer | Required | | | Required* |
| Onsite Management and Supervisors | Required, see exceptions 1910.120 (e)(4) | | Required | 3 Day Required |
| Low Risk Workers** | | Required | | 1 Day Required |

* Laborers without OJT must be supervised by the HSO for at least three days when they begin a HAZWOPER.

** See 29 CFR 1910.120 (e) (3) (ii-iii)

HSO training also requires First Aid/CPR and Bloodborne Pathogen.

### 5.2 Task Specific

The HSO will arrange or provide any site specific training required by field employees prior to beginning field activities. This will consist of a review of the specific hazards of concern, risks, symptoms of exposure and an overview of the SSHASP to include delineation of work zones, access, decontamination protocols, safety and emergency procedures and emergency contacts listed in section 8.5. **The SRS custodian, RCO, IH and ERD project manager are invited to this training, if conducted by a subcontractor.**

## 5.3 Training Documentation

Documentation of all applicable health and safety training will be maintained and will be provided to the SRS RI PM within a reasonable time upon request. **The project STR and/or Waste Site custodian will maintain records.**

## 5.4 Visitors

Visitors are responsible for providing training records to the ERD project manager and/or the HSO before entering the worksite. The HSO will review unit specific procedures and hazards with the visitors before access to the site is allowed.

# 6.0 PERSONAL PROTECTIVE EQUIPMENT (PPE) AND PROCEDURES

## 6.1 General

PPE will be determined by WSRC RCO and TO HSO taking into consideration the level of contamination expected and detected (reference WSRC 20Q, "Health and Safety Manual for Hazardous Waste Operations," Procedure G). Non-intrusive operations do not require any PPE other than appropriate safety gear as determined by standard SRS procedures. Workers within the exclusion zone will wear PPE as directed by WSRC RCO and/or the TO HSO and workers outside the exclusion zone and visitors will begin in Level D PPE. The following guidelines shall apply to all tasks:

- PPE shall be available at storage locations which may vary for different projects and will be described by the HSO at pre-entry briefings. The HSO will describe appropriate donning/doffing procedures.
- PPE shall be inspected by the wearer prior to use. The project manager or designee shall assure that respirators are supplied, inspected, and maintained by the WSRC respirator facility.
- Decontamination procedures are described in Chapter 10.
- PPE that cannot be decontaminated shall be stored in a satellite or staging area within the waste unit until pickup for disposal. ERD is responsible for this function.
- ERD will evaluate this PPE program using information collected from interviews with workers, medical records,. technical oversight personnel, and other pertinent sources. Recommendations and changes will be incorporated as needed. The SRS RI PM is responsible for preparing periodic reports describing results of evaluations and maintaining reports as part of the project records.

## 6.2 Respiratory Protection Program

### 6.2.1 Respirator Certification

All personnel with the potential of exposure to harmful airborne contamination must have medical respirator certification by a qualified physician, and respirator fit prior to respirator usage.

### 6.2.2 Self Contained Breathing Apparatus (SCBA) Certification/Tritium Suit Certification

Before an individual may enter an area designated for use of SCBA, the individual must have documented medical qualification for SCBA utilization; training in the proper inspection, maintenance, and use of the SCBA unit; and must receive a unit-specific safety briefing. The unit-specific briefing addresses known levels and types of hazards at the unit, the "buddy system", operations to be performed, appropriate emergency procedures, and the potential consequences of failing to maintain proper respiratory protection. Failure to meet any of these requirements prohibits an individual from the use of SCBA equipment. Individuals using tritium suits or other respiratory protection equipment not specifically mentioned in this SSHASP shall be trained to use that equipment and obtain concurrence from ERD before using that equipment, except in emergencies.

### 6.2.3 Respirator Selection

<u>Respirators for non radioactive species</u>

Respiratory protection or other controls may be required in the event that ambient concentrations of organics are detected at the work site. In the event that ambient or changing concentrations of organics are detected work will be stopped until the source of the readings is identified. If readings persist, the HSO in consultation with IH will determine if respirators are required. Respirators are issued per 4Q1.6, Procedure 501.

Respirators for airborne radioactive species

In the event that airborne radioactivity is detected, the SRS RCO will stop the job and reevaluate the appropriate protection prior to resumption of field activities. Respiratory protection requirements are detailed in WSRC 5Q Chapter 5, Part 3.

### 6.3 Non-Respiratory PPE

#### 6.3.1 Non-Intrusive Operations

For non-intrusive activities, no exposure to contaminants is anticipated. PPE and safety equipment should be selected according to WSRC 3Q5 (Hydrogeologic Data Collection) and the WSRC RFI/RI Program Plan (latest revision) and other standard procedures appropriate to the task.

#### 6.3.2 Intrusive Operations

For intrusive operations, Level D clothing is appropriate unless directed otherwise by WSRC RCO. Hard hats and safety glasses with side shields should be used during all drilling activities. If determined necessary after monitoring by the HSO, Level D (modified) clothing (Tyvek, boots and gloves) and equipment must be maintained throughout the duration of the work in the exclusion zone. The following minimum PPE (or equivalent) are available to all personnel:

- Tyvek Suits
- Suitable work gloves (Cotton, leather etc.)*
- Chemical resistant gloves (Nitrile, Tyvek, etc.)
- Ear Plugs*
- Hard Hat*
- Fire Extinguisher (ABC)* (10 pound on drill rigs, 5 pound for generic site)
- CB Radio or Two way radio or Cellular phone
- Decon Sprayers
- Drink Cooler
- Eyewash (15 Minute)
- Safety Glasses with side shields*
- Goggles (Splash Protection)
- First Aid Kit (with Bloodborne Pathogen Kit)*

* Supplied by subcontractor

## 7.0 MEDICAL SURVEILLANCE

Employees who may be exposed at or above the permissible exposure limits (PEL) or wear a respirator for 30 days or more per year must be covered by a medical surveillance program as required by 29 CFR 1910.120 and described in Procedure F of the WSRC 20Q, "Health and Safety Manual for Hazardous Waste Operations". All field personnel must present evidence of fitness for duty, signed by a physician.

The medical facility at 704-F is the closest medical facility to the FARB and should be visited in case of injury or medical emergency.

## 8.0 HEALTH AND SAFETY MONITORING

Monitoring of temperature for heat/cold stress will be performed as necessary by the HSO by calling the nearest weather station for temperature and relative humidity measurements. Should weather temperatures and humidity warrant, HSO shall take all necessary measures to minimize risk of heat stress and heat stroke (e.g., heavy work shall be performed in early and late hours of the day, HSO shall determine if adequate fluids and shade are available for workers, work will be done in work-rest cycles, etc.). **The Heat Stress telephone number is 7-0576. Guidelines for Heat Stress and Cold Exposure are described in Appendix B of this SSHASP.** Each monitoring instrument will be calibrated as required by IH and RCO as described below. Calibrations will be recorded in a logbook.

## 8.1 Ambient Air Monitoring

**Air monitoring will be used to identify and quantify airborne levels of hazardous substances in order to determine the appropriate level of employee protection needed on site. Volatile organic compounds (VOCs) are not known nor suspected to be present in the FARB. Initial airborne monitoring for radioactivity at each borehole site will be provided by RCO. To confirm levels of airborne chemical contaminants, any Immediate Dangerous to Life and Health (IDLH) and other dangerous situations, such as the presence of flammable atmospheres, oxygen-deficient environments and toxic levels of airborne contaminants monitoring at each borehole site will be provided by the subcontractor and will be conducted prior to drilling each borehole. Monitoring instruments for the initial survey will include a combustible gas indicator, oxygen detector and Organic Vapor Analyzer (OVA) or HNu, and will be used in the order presented. Monitoring for VOCs in the personnel breathing zone will be conducted every time a sample is taken with an OVA or HNu in every boring to the water table and periodically to the total depth. If concentrations of VOCs above background are detected, work will stop and personnel will leave the exclusion zone immediately. Work will not continue until the HSO has assessed the situation to accommodate the elevated VOC levels.**

**If radionuclides are detected in samples collected from the boreholes, to monitor potential airborne radioactivity, an air sampling network will be established to form a perimeter around each borehole location. Sample collection will be provided by a portable pump attached to a power source, by which the sample is continuously collected onto filter paper. The collector will be probed by HP during drilling with HP110 and Ludlum monitoring instruments at a frequency determined prior to investigation activities. In the event that unacceptable emissions are detected at the work site, all work will stop and personnel will leave the exclusion zone immediately. Work will not continue until HP personnel determine the extent of contamination and the personal protection required to safely complete the task.**

## 8.2 Personnel Monitoring

**For the proposed FARB investigation activities, the potential radiological dose to workers is estimated to be minimal. Exposure during field activities is expected to be a maximum 10 mrem per person in a two week period. In addition, personnel will be notified if any nearby facility occurrences warrant the temporary suspension of work to ensure that personnel are not exposed to unnecessary contamination and/or radiation.**

**SRS RCO will provide coverage for work by surveying for radiation and radioactive contamination. Coverage will be provided continuously for drilling and sample collection activities in the FARB perimeter fence and intermittently for the remainder of investigation activities after an initial work site survey. Contamination and radiation will be detected by portable instruments at each FARB work site. For clearance purposes, soil core and water samples will be taken to a RCO facility lab for analysis for radioactive material. RCO coverage will not be required below the following levels:**

- **No detectable radiation above naturally occurring background. (Natural background not to exceed 50 microRems/hr.)**
- **Smearable contamination less than 20 dpm alpha and less than 200 dpm beta-gamma and 10,000 dpm tritium.**

**Monitoring for radioactive contamination of soil and equipment used and exposed during drilling will be performed by RCO using portable instruments at the work site. When drilling and sampling of a borehole are completed, RCO will (if no contamination is detected during these processes) declare the work site "clean" (free of radiation and contamination). If contamination is detected during field activities, protective clothing and/or dosimetry requirements will be upgraded to protect personnel from increased levels of contamination and/or radiation, according to procedures outlined in WSRC 5Q 1.2-217V (TLD Badges - Types and Usage), WSRC 5Q 1.2-218 (Dosimeters) and WSRC 5Q. Containment of the work site will also be required for work to continue, such as a SRS windbreak, wind speed limitations and weather condition limitations.**

**Whole body counts and biological sampling may be conducted during certain work activities at work sites identified by SRS RCO. The need for and frequency of this monitoring will be established by SRS RCO, based upon the work plan. SRS RCO will provide guidance on personnel monitoring and bioassay requirements and IH for potential non-radioactive chemical exposures.**

**If a change facility is not in close proximity to a drilling work site, one will be established and a count rate meter installed if electricity is provided to the change facility; otherwise, RCO will perform the necessary personnel monitoring.**

8.3 Non-Radioactive Species (this section applies to intrusive operations only)

An OVA or HNu will be used to detect levels of organic vapor above background. Organic vapor monitoring will be performed by IH or the HSO at the start of each work day and/or new location. HNu's are calibrated in accordance with 4Q1.2 Procedure 119.

Working requirements when organic vapors have been detected will be determined by the HSO and IH. If explosive conditions are detected, work will be delayed until appropriate engineering measures can be taken.

8.4 Radioactive Species (this section applies to intrusive operations only)

SRS RCO will determine the proper monitoring equipment to be used to detect alpha, beta, and gamma emitters. At a minimum, WSRC RCO will conduct a pre-job screening to identify types and levels of contamination at the FARB. The information will be utilized in developing the RWP for the basin activities. The job specific RWP, if required, will address the types and frequency of radiation detection required at the FARB investigation activities. If work is not performed within an RBA, RCO will monitor intermittently for the presence of contamination. Some samples may be collected for counting with scalers. Field radiation monitors are calibrated using WSRC 5Q1.3 Procedure 144 and scalers are calibrate using WSRC 5Q1.3 Procedures 404 and 405.

## 9.0 SITE CONTROL

*This section applies only if conditions become such that the HSO, ERD Project Manager, RCO and/or IH personnel deem it necessary (i.e., if contamination has been detected). Work will be conducted in accordance with WSRC 20Q, "Health and Safety Manual for Hazardous Waste Operations," Procedure D.*

Organization will consist of three general zones of operation on each work site (see Figures 4 and 5) established to reduce potential migration of work site substances and the risk of personnel exposure to work site materials. These zones will be named as follows:

- Exclusion Zone;
- Contamination Reduction Zone;
- Support Zone.

Prior to any work activity, zone boundaries will be established by the HSO and RCO if necessary in accordance with Procedure 9 of the 8Q Manual. Personnel entering the work zone will be required to sign in and out on the "Work Zone Entry and Exit Log" form in Appendix C of this SSHASP.

The initial exclusion zone will be an area centered around the borehole with a minimum radius of 10 feet. Boundaries for other activities may be established by the HSO and RCO. After work begins and monitoring of the work site has been conducted, the extent of the Exclusion Zone may be revised with the approval of the HSO and RCO. Zone boundaries may require modification based on changes in weather, conditions in the Exclusion Zone, new data, modifications of the RI work plan, etc.

## 9.1 Exclusion Zone

The Exclusion Zone is that area where active operations take place. This area is considered potentially contaminated, and all personnel within the area will utilize the levels of personal protection prescribed below. A checkpoint will be established at the periphery of the Exclusion Zone to regulate the flow of personnel and equipment into and out of the area. The HOT LINE will be posted or well-defined by geographical and physical boundaries. The Exclusion Zone may be subdivided into areas based upon environmental measurements, the results of previous surveys relative to the concentrations of known or suspected substances, and expected on-site work conditions. Area delineation corresponds with the level of protection required for entry; for example, Area D of the Exclusion Zone requires D-Level personal protection. Criteria for determining area delineation are summarized as follows:

Area A is that area where the highest levels of potential contamination may exist and is designated as the area where maximum respiratory (SCBA), skin, and eye protection are required (i.e., Level A personal protection).

Area B is that area where maximum respiratory protection (SCBA) is required; however, there is a low probability of dermal toxicity (requires Level B personal protection).

Area C is the area where respiratory protection of a lesser degree than the criteria established for Areas A or B is required (full-face, negative-pressure, air-purifying respirator with appropriate cartridges) and the probability of skin contamination by toxic materials through dermal routes is unlikely (requires Level C personal protection).

Area D is that area where respiratory protection is not a requirement.

The level of personal protection to be utilized in the Exclusion Zone will be Level D unless otherwise directed by the HSO or RCO. If directed by the HSO or RCO, a person certified in SCBA operation will be present during drilling/excavation, in case of emergency.

## 9.2 Contamination Reduction Zone

The Contamination Reduction Zone is a buffer between the Exclusion and Support Zones. It is structured to prevent the migration of substances from the Exclusion Zone to areas where these substances are not present. All equipment and personnel cleansing procedures are performed within this area. The boundary between the Reduction and Support Zones is known as the Control Line and is designed to separate areas of potential contamination from clean areas. Entry from the Support Zone into the Reduction Zone will be through a controlled access point. Personnel making this entry will be wearing, at a minimum, personal protection one step below that which is prescribed for the Exclusion Zone. Exit from the Reduction Zone to the Support Zone requires the removal of any suspected or known work site substances through compliance with established cleansing procedures.

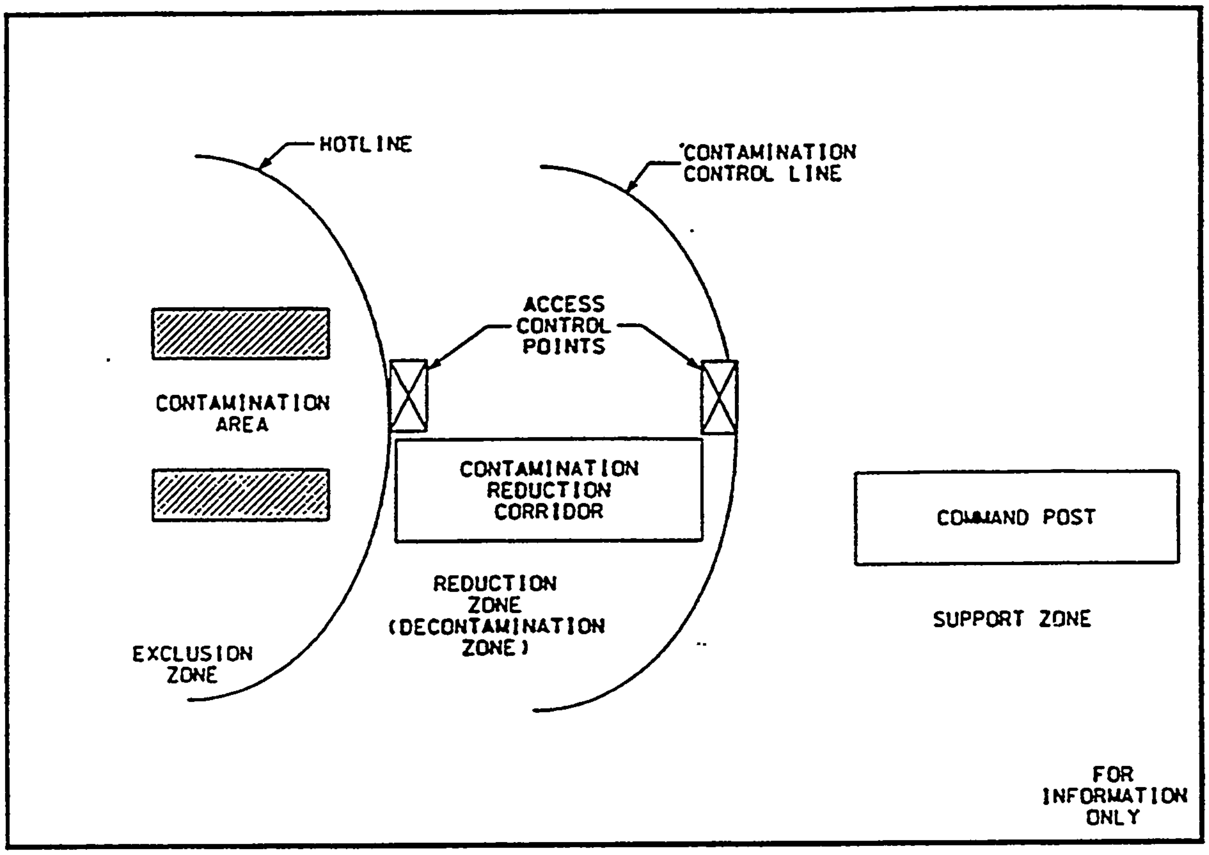



Figure 3. Schematic of Work Zones.

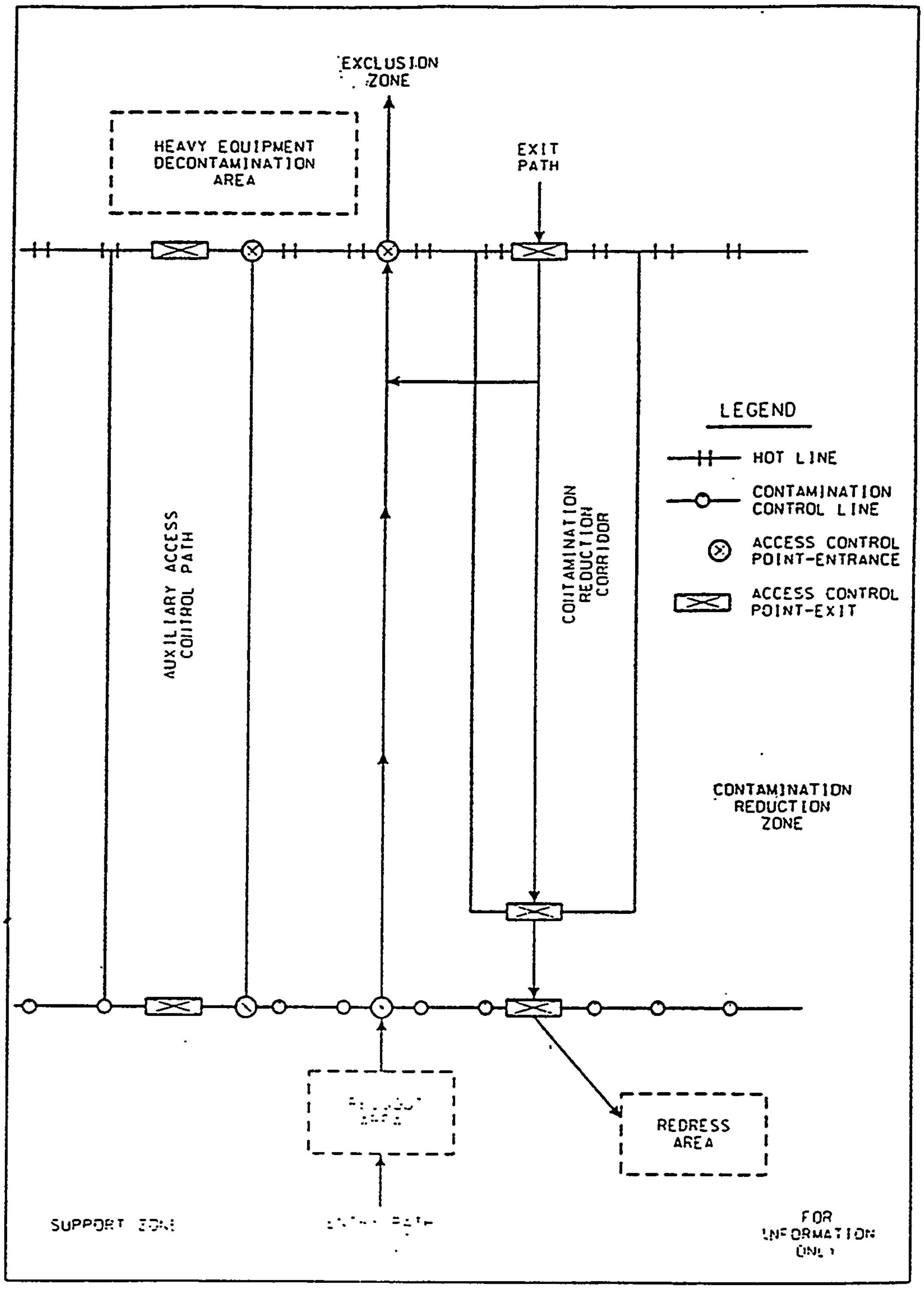



Figure 4. Schematic for Personnel / Equipment Control.

### 9.3 Support Zone

The Support Zone is considered clean, and generally is the outermost of the designated areas. The command post for field operations, first aid station, communications, and other elements necessary to support site operations are contained within this area, and normal street clothes (Level D) are generally worn. Command post location within the Support Zone will be based upon a number of factors, including wind direction and accessibility.

### 9.4 Emergency and Support Equipment

This section applies only to the extent directed by the HSO, ERD Project Manager, RCO and/or IH personnel.

Adequate emergency equipment will be available to protect all work site personnel from known or anticipated health and safety hazards. Before entry to any work area, all personnel and visitors will be advised of the necessity for and utilization of emergency equipment. As a minimum, emergency equipment to be made available on-site will include the following during all activities:

- First aid kits (16 unit as specified in National Safety Council Data Sheet No. 202 or equivalent);
- Portable eyewash station meeting ANSI Z35801, 1986;
- Decontamination sprayers, water, and soap;
- Respirators (including a minimum of two SCBA, if applicable; see Section 6.2) (ANSI Z88.2-1980);
- Fire extinguisher, minimum 10 pound ABC on drill rig, 5 pound for general site use;
- Appropriate monitoring equipment (see Chapter 8.0);
- Communication equipment (two-way emergency radios or cellular telephones approved for use at SRS).

SUPPORT EQUIPMENT

- Drink cooler with water.
- PPE listed in Chapter 6.0.

### 9.5 General Health and Safety Measures

The following general operating procedures will be followed by all field personnel. These precautionary measures are designed to reduce the risks of inadvertent or accidental radiological and chemical exposure or injury during field operations. Instructing respective employees in safe work practices and emergency procedures is the responsibility of the HSO.

#### 9.5.1 Personal Precautions

Eating, drinking, chewing gum or tobacco, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in any RBA, Exclusion or Contamination Reduction Zones. However cold water and disposable cups may be located in the decontamination area such that employees will have access to water with only removal of gloves, hat, and respirator where used except when in an RBA. Smoking is not allowed at any time in the waste site.

Contact lenses shall not be worn in Exclusion and Contamination Reduction Zones.

Hands and face must be thoroughly washed upon leaving the work area; however, if in an RBA washing might not be needed. Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garment is removed.

Avoid contact with contaminated or suspected contaminated surfaces. Whenever possible, avoid walking through puddles, pools, mud, etc, Avoid kneeling or sitting on the ground, equipment or drums.

Personal articles shall be prohibited in Exclusion and Contamination Reduction Zones.

Medicine and alcohol can exacerbate the effects from exposure to toxic chemicals. Alcoholic beverage intake is prohibited at SRS and should be minimized or avoided on off-work hours during field operations. Prescribed drugs should not be taken by personnel during field operations where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified physician. Do not work when ill.

### 9.6 Drilling Safety

**Drilling safety is the responsibility of each member of the drilling crew. Standard operating safety procedures shall comply with the Westinghouse Savannah River Company Manual WSRC-3Q5, "Hydrogeologic Data Collection," Chapter 2 and DOE Order 5480.4.**

### 9.7 General Operating Procedures

- Safety protocols for oral and hand signals will be established.
- All unfamiliar operations will be rehearsed prior to implementation.
- Personnel involved in active operations will work in pairs, "buddies."
- A minimum of "buddies" plus a third party equipped at the same level of personal protection as the field team personnel (for emergency response), will be required if conditions require SCBA and/or fully encapsulated suits. Communications between all work site personnel will be maintained at all times.
- A wind indicator will be provided to determine upwind escape routes during intrusive operations.
- Only necessary equipment will be allowed in contaminated areas.
- Appropriate areas for support, contamination reduction, and exclusion will be established and will be described at the initial operation specific (i.e., drilling, excavation, etc.) health and safety meeting.
- The HSO will conduct, at a minimum, weekly health and safety meetings.
- Job sites will be maintained in a clean, safe, and orderly manner. Daily cleanup activities shall be performed, including the following:

All stored material that will be used in work activity will be stored square to the site. An unobstructed walkway at least three feet wide will be provided for access to materials.

All loose material will be picked up and stored away from the work activity in a neat, orderly manner.

All work areas, walkways, and material storage areas shall be kept free of trash and debris.

Common sense of the worker should prevail in preventing cold stress. This may include ingestion of warm beverages and/or removal of wet clothing.

Guidelines for control of heat stress in WSRC 4Q are to be followed. Heat stress controls are required for continuous work longer than 1 hour when temperature is above 85 degrees F and humidity is above 60%. Temperature and other weather-related information can be obtained from the Weather Center Analysis Lab at 5-1182 or from the SRS Operations Center (SRSOC) at 5-2117. The following steps can be taken to reduce heat stress:

- Acclimate the body.
- Drink more liquids to replace body water lost during sweating.
- Increase salt consumption (salt tablets are not recommended).
- Wear personal cooling devices.

- **When using supplied-air respirators or suits, equip them with a vortex tube (maximum length 50 feet with a plastic suit).**
- Follow appropriate work/rest cycle.

## 9.8 Trenching and Excavations

**Excavations in excess of 4 feet deep must meet the requirements of WSRC 8Q Procedure 34 and 29 CFR 1926, Subpart P. The project manager is responsible for providing an approved Vessel or Confined Space Entry Permit per the requirements of WSRC 8Q Procedure 33.**

## 10.0 DECONTAMINATION

Personnel decontamination is highly task-specific and will be determined by the HSO, RCO (if applicable), and the ERD project manager. It will be consistent with WSRC 5Q, "Radiological Controls Manual" and WSRC 20Q, "Health and Safety Manual for Hazardous Waste Operations,", Procedure K. Decontamination procedures will be performed on tools and equipment taken from the Exclusion Zone, if monitoring indicates the presence of hazardous substances. The equipment will be decontaminated at the end of the project or between individual work operations as needed.

For all egress from the Exclusion Zone, stations for decontamination of personnel will consist of the following:

- RCO clearance point specific to needs;
- Equipment drop;
- Boot and glove disposal (if disposable items);
- Coverall drop;
- Respirator drop (wash and rinse periodically) applies to chemicalcontamination only; and
- Personnel shower, if work site conditions warrant.

If contamination is detected or suspected, cleansing procedures for Level D will include the following:

- Decontamination solutions: soap and water, and water rinse;
- Place equipment/tools on table or groundcloth;
- Remove hard hat;
- Wash outer work gloves and remove duct tape;
- Remove outer work gloves;
- Remove Tyvek suit and place in plastic bag;
- Remove Safety Glasses
- Remove inner surgical gloves and place in plastic bag;
- Thoroughly wash hands, arms, and face; rinse with clean water; and
- Pump all decontamination fluids into drums, apply appropriate labels, and place on pallets for removal from work site.

The HSO may modify the above decontamination procedure commensurate with level and variety of PPE and contamination encountered. Equipment decontamination procedures are described in Appendix A for specific intrusive tasks. Specific requirements for waste disposal WSRC-IM-90-138, "Waste Disposal Manual", WSRC 1S, "Waste Acceptance Criteria", Procedure 6.3 of WSRC 3Q, "Environmental Compliance Manual", and Chapters 3 and 4 of WSRC 5Q, "Radiological Controls Manual".

Equipment and material suspected to be contaminated with radioactivity will be handled according to standard SRS procedures.

## 11.0 EMERGENCY RESPONSE PLANS

As specified in WSRC 20Q, "Health and Safety Manual for Hazardous Waste Operations," Procedure L, a plan is required to handle anticipated emergencies. An emergency situation is considered to exist if:

a. any member of the field crew is injured in an accident, or exhibits any adverse effects or symptoms of chemical, heat, or cold exposure,
b. safety monitoring indicates unit conditions more hazardous than anticipated,
c. an immediate danger to life or health exists.

### 11.1 General Emergency Procedures

In the event that any member of the field crew experiences any adverse effects or symptoms of exposure while on the scene, the entire field crew will immediately halt work and act according to the instructions provided by the HSO. This includes heat or cold exposure as well as chemical/radiological exposure.

The discovery of any condition which would suggest the existence of a situation more hazardous than anticipated will result in the evacuation of the field team and re-evaluation of the hazard and the level of protection required. Contact shall be made to appropriate departments (Rad Con, IH, and Subcontractor Safety Group) to identify the source and assess conditions prior to restarting work.

In the event that an accident occurs, the HSO will document any information related to the accident, and the project manager will use the information to complete an accident report to include notification of the Subcontractor Safety Group at 4-5663. Follow-up action will be taken to correct the situation that caused the accident.

- In the event that any member of the field crew experiences any adverse effects or symptoms of exposure while on the scene, the entire field crew will immediately halt work, notify the HSO, and act according to the instructions provided.

- The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated will result in the evacuation of the field team and re-evaluation of the hazard and the level of protection required.

- In life-threatening situations, work shall stop and care will be instituted immediately. All personnel will leave the affected area. Respirators will be removed when clear of the affected area if breathing difficulties are evident. Protective clothing will be removed or cut away if this will not cause delays, interfere with treatment, or aggravate the problem. If contaminated

- if protective clothing cannot be removed, victim will be wrapped in clean materials, if conditions allow, to help prevent possible contamination of medical personnel and ambulances.

- In the event that an accident occurs, the HSO will fully document all pertinent information related to the accident. An Employee Injury/Exposure Incident Report form is included in Appendix C, and this form will assist the HSO in documenting important details. This report will be provided to the project manager upon request.

- Notification will be made by the SRS RI PM (or designee)to the ERD SIRIM Reporting Official and SRSOC for emergency medical services. Please refer to WSRC 9B, "Site Item Reportability and Issue Management (SIRIM)" and WSRC 9B1, "General Site Requirements for SIRIM" for information regarding emergency reporting as it relates to SIRIM.

Rehearsals of the emergency procedures shall be conducted by the HSO if warranted.

### 11.2 Personal Injury

Designated work site personnel will be trained in American Red Cross (or equivalent) first aid procedures and will administer appropriate first aid treatment, including CPR, in emergency situations. These general emergency procedures will be carried out in the event of injury:

- Notify the HSO of the incident.
- If the victim can be moved safely, remove the victim from the Exclusion Zone to the Decontamination Zone using established control points.
- Administer first aid as appropriate.
- Notify SRS Operations Center (SRSOC) @ 5-2117, 5-1911, 5-2661 or CB radio, channel 9, to request emergency medical services.

NOTE: The unit HSO and RCO personnel (if in a radiological area) shall direct the removal of injured personnel from the Exclusion Zone and shall approve any necessary deviation from established decontamination procedures. Such deviation shall be based upon the severity or life threatening nature of the injury.

### 11.3 Chemical Exposure

This procedure shall be followed for chemical exposure emergencies:

1. Move the victim from the immediate area of exposure or contamination only if absolutely necessary, taking precautions to prevent additional exposure of other individuals.
2. Notify the HSO of the exposure incident.
3. If victim can be moved safely, proceed from the Exclusion Zone to the Contamination Reduction Zone through established control points.
4. Decontaminate clothing or remove if safe to do so.
5. Administer additional first aid treatment as appropriate.

<u>For skin or eye contact</u>, thoroughly wash affected area with water (eyes should be flushed for at least 15 minutes).

<u>For inhalation exposure</u>, ensure that victim has adequate fresh air.

Call SRSOC @ 5-2117, 5-1911, 5-2661 or CB radio, channel 9, to request emergency medical services.

### 11.4 Fire or Explosion

<u>In the event of a fire or explosion</u>:
Immediately evacuate injured personnel and leave the area.
Administer first aid as appropriate.
Notify SRSOC @ 5-2117, 5-1911, 5-2661 or CB radio, channel 9

### 11.5 Emergency Contacts

A. <u>The first priority contact is the site emergency phone number 5-1911, the SRS OPERATIONS CENTER (SRSOC)</u>, which will contact ambulance and other emergency help as necessary.

SRSOC @ 5-2117, 5-1911, 5-2661 (provides emergency services)

NOTE: In the event no telephone can be reached, Channel 9 can be accessed with a Citizens' Band (CB) Radio for emergency assistance.

B. The following people are designated as Site Item Reportability and Issue Management (SIRIM) Reporting Officials (SRO) in the Waste Site Contingency Plan located in the RCRA Part A Permit. These people have the authority and resources necessary to deal with a waste site incident. An ERD SRO is to be contacted if an incident occurs.

**Table 3**

**ERD Phone Listing**

| NAME | DEPARTMENT | SITE PHONE | HOME PHONE |
|---|---|---|---|
| **Primary:**<br>Kevin J. Kuelske | ERD | (803) 644-6659 | (706) 855-0766 |
| **Secondary:**<br>Wayne F. Johnson | ERD | (803) 644-6858<br>725-PAGE (2238) | (803) 278-3689 |

Notify the ERD if unforeseen circumstances require the immediate procurement of additional personal protective or emergency equipment.

Attending emergency physicians should be given the telephone number of the subcontractor's medical director to obtain immediate access to an employee's medical records and for consultation purposes.

### 11.6 Accident Reporting

*On-the-job accidents or incidents resulting in injury or illness to personnel will be reported to the ERD project manager following any accident.* Any accidents in an RBA will be reported to RCO for their reporting requirements. Subcontractors are required to follow injury/illness reporting regulations as specified in 29 CFR 1904 as well as contacting the Subcontractor Safety Group (Reuben Raysor @ 4-5663). The HSO is responsible for providing a written report describing unsafe work practices, conditions, illness, injury or incidents for the WSRC RI PM to be used when filing a report with the ERD and the Safety Department in accordance with SIRIM. Please refer to WSRC 9B and WSRC 9B1 for information regarding accident reporting as it relates to SIRIM. The reports will contain the following information:

- person(s) injured, name, branch, social security number and title
- date and time of incident
- witnesses
- description of incident
- symptoms: type, time, activity, others affected
- specific injured part (which part, right or left, etc.)
- protective gear utilized
- related problems with protective gear
- monitoring instruments used at the time of the incident
- contaminant levels
- on-site medical treatment
- treatment facility (name, address, phone, physician), with reports attached

- accident investigation (cause, corrective action)
- summary of adequacy of the plan.
- report date, author signature, and title.

A sample Employee Injury/Exposure Incident Report is included in Appendix C.

## 12.0 CONFINED SPACE ENTRY

Site Procedures (Procedure 33 of WSRC 8Q) shall be followed, including the issuance of a Work Clearance Permit and a Confined Space Entry Permit. Refer to WSRC 8Q for more information. SRS-specific training is required for confined space entry. No confined space entries are expected to be required for the investigation activities.

## 13.0 SPILL CONTROL

A spill control kit will be located at the Waste Unit at the direction of the HSO, project manager, RCO or IH. If aid is required in containing a spill, contact SRSOC via radio (CB-9) or via telephone (5-2117, 5-1911, 5-2661).

All spills should be reported immediately to the waste site custodian/project manager, Kevin J. Kuelske (644-6659) and ERD Environmental Coordinator, Susan Dyer (644-6764). Spill reports will be made in accordance with the WSRC 9B Manual.

All drilling operations will comply with spill control measures described in WSRC 3Q5, Section 3.0, WSRC 3Q, Procedure 2.4, and WSRC 1B Manual. Any equipment remaining in one location for more than 1 work day is also subject to these requirements. A spill cleanup/control kit will be provided at the site.

## 14.0 RECORD KEEPING

All work clearance permits shall be maintained by the project manager and the HSO. Each subcontractor must maintain employee training records. A record of all significant events occurring at the waste unit including visitors and safety operations will be maintained by the HSO. The HSO will complete the health and safety field forms (Appendix C) as necessary. The information to be logged will include:

- Date
- Location
- List of employees and visitors by area and hours exposed
- PPE utilized
- Monitoring results
- Description of materials removed from subsurface
- List of equipment contaminated/decontaminated
- Description of unusual events

**Other records to be maintained by the ERD Project Engineer or ER Training include:**

- Medical surveillance files
- Training files
- Daily logs of subcontractors
- Accident reports
- Radiation survey logsheets
- SSHASP (as required by ER-AP-017, "ER Records Management" (U))
- Work plans, including job descriptions
- Safety and Pre-entry briefing record.

## 15.0 REFERENCES

### 15.1 References

1. **Industrial Hygiene Procedure Manual WSRC 4Q, "IH - Heat Stress Management".**
2. **Title 29, Code of Federal Regulations, Part 1910.120, "Hazardous Waste Operations and Emergency Response".**
3. **WSRC Procedure Manual 9B, "Site Item Reportability and Issue Management (SIRIM)"**
4. **WSRC Procedure Manual 9B1, "General Site Requirements for SIRIM"**
5. **WSRC Procedure Manual 3Q5, " Hydrogeologic Data Collection".**
6. **WSRC Procedure Manual 4Q, "Industrial Hygiene Manual".**
7. **WSRC Procedure Manual 5Q, "Radiological Controls Manual".**
8. **WSRC Procedure Manual 6Q, "Savannah River Site Emergency Plan"**
9. **WSRC Procedure Manual 8Q, "Employee Safety Manual".**
10. **WSRC Procedure Manual 20Q, "Health and Safety Manual for Hazardous Waste Operations".**
11. **WSRC Procedure Manual WSRC-C1, "Environmental Restoration Administrative Procedures Manual (U)".**
12. **Phase II Revision 1 Remedial Investigation Work Plan for the F-Area Retention Basin (182-3F) (U), October 1994, WSRC-RP-94-498.**

### 15.2 Appendices

Appendix A: Summary of Operation Specific Safety Procedures

Appendix B: Guidelines for Heat Stress and Cold Exposure

Appendix C: Subcontractor Technical Oversight/HSO Health and Safety Forms

# APPENDIX A

# SUMMARY OF OPERATION SPECIFIC SAFETY PROCEDURES

## SUMMARY of OPERATION SPECIFIC SAFETY PROCEDURES

### A1 MONITORING

A1.1 A member of RCO will coordinate and conduct monitoring of radioactive species. Periodic examination of materials removed from the surface and subsurface will be conducted by RCO to determine if respiratory protection or other PPE is required.

A1.2 Monitoring with an OVA or equivalent before and during drilling will be performed by the HSO and/or IH as necessary, to determine if respiratory protection is required as described in section 3.2.3. Any instruments may become radiologically controlled if they are contaminated during their use in the field.

### A2 PROTECTIVE CLOTHING

A2.1 Standard safety clothing (Level D) will be required unless monitoring indicates otherwise. Personnel who will be in contact with waste materials removed from the waste site will have chemical resistant coveralls, shoe covers, and gloves or appropriate radiation protective clothing as circumstances require.

A2.2 Decontamination of clothing is not anticipated to be necessary. If monitoring indicates otherwise, the HSO will provide directions. In cases where contamination is limited, disposable coveralls, gloves, and shoe covers are recommended.

A2.3 SCBA is to be used in emergency conditions only. Work should halt until monitoring indicates SCBA is no longer necessary.

### A3 OTHER CONTROLS

A3.1 At the direction of the HSO, SCBA or an equivalent portable emergency air supply should be located within 150 feet, or as close to the RCA as practical, of active drilling locations for rescue purposes. At least 1 person qualified to use SCBA should be available during drilling operations.

A3.2 At least one person normally located outside of the exclusion zone should be trained in CPR.

A3.3 Generators should be located downwind of drilling depending upon the air activity.

### A4 DECONTAMINATION

Contaminated equipment and contaminated PPE cannot leave the waste site.

Equipment

A4.1 The auger flights will be steam cleaned between each hole. HSO is to verify that the auger flights have been properly cleaned prior to beginning drilling at a new site. The HSO will ensure that the split spoons are also decontaminated after each use: Runoff will be directed onto the ground and away from holes in the waste site.

A4.2 Before the drill rig can move to a new work area, the HSO and RCO must give approval that the work area is closed as clean.

PPE

A4.3 Workers exiting the exclusion area will be monitored with the OVA or equivalent to determine if contamination is present.

If no contamination is detected, the PPE should be deposited in the support zone. Reuse is encouraged when possible. If contamination is detected, decontaminate as described in Section 10. If PPE cannot be decontaminated, it must be placed with the waste material removed from the hole. Successfully decontaminated PPE may be placed in the support zone and reused when feasible.

## A5 CONTAMINATED WASTE MATERIALS

Contaminated waste materials are not expected to be generated in large quantities at this waste unit.

A5.1 Contaminated PPE, soil, and waste from holes will be stockpiled within the waste site and covered at the end of each day with plastic or tarps. Stockpiles should be placed and covered so that runoff will not carry any of the materials from the stockpile location(s).

A5.2 Contaminated PPE will be placed to the side of the work site as directed by the ERD Project Manager.

## A6 CONTINGENCY PROCEDURES

A6.1 In the event that an atmosphere > 10% of the Lower Explosive Limit (LEL) is detected, the area is to be evacuated and equipment is to be shutdown until levels go below 10% LEL.

A6.2 Section 8 of the SSHASP describes emergency procedures. Phone numbers are listed in 8.5. Channel 9 of the Citizens' Band radio is monitored by emergency response personnel.

A6.3 If an atmosphere > 50% of the LEL and/or < 15% $O_2$ persists in a hole, then the hole will be vented by introducing a gas into the bottom of the hole via a flexible hose. Air may be used if the mixture is below the Upper Explosive Limit (UEL). An inert gas such as nitrogen or argon is preferred.

## A7 EXCAVATION

No excavation is anticipated as part of this project.

Procedure is to be developed by subcontractor performing excavation and will comply with guidelines set forth in this SSHASP and OSHA Regulations 29 CFR Part 1926, Subpart P "Excavations."

# APPENDIX B

# GUIDELINES FOR HEAT STRESS AND COLD EXPOSURE

# Heat Stress Management

Approved by

President, Westinghouse Savannah River Company

## Purpose

The Heat Stress Management procedure is intended to minimize the risk of heat related disorders. It provides information and training to recognize risk factors and the signs and symptoms of heat stress. This procedure also describes guidelines for controlling heat stress. Engineering controls are preferred, administrative controls are to be used when feasible, and personal protective equipment is to be used as a last resort. If none of these methods prove to be effective, work/rest regimens may be put in place to minimize heat stress risks.

## Scope

The responsibilities and policies defined in this procedure apply to all WSRC and affected subcontractors at the Savannah River Site (SRS).

## Terms and Definitions

**acclimatized personnel** - employees who have increased their tolerance for working in hot environments by gradually increasing their exposure to heat for at least an hour per day for 10 consecutive working days

**buddy system** - A buddy system allows two employees to observe each other for signs and symptoms of heat stress while working in a hot environment. The buddy system is especially important when there are new personnel (unacclimatized) on the job.

**ice vest** - a cooling garment to be worn under protective clothing when working in a hot environment

**required guideline** - The information contained in Attachments A and B of this procedure are guidelines for Heat Stress Management. They are based upon the ACGIH Threshold Limit Values for Heat Stress. Supervisors should consider individual job tasks, worker variability and availability of heat stress controls in the application of these guidelines. Consult Industrial Hygiene for technical support when necessary.

Procedure IH-502, Rev. 1, "Heat Stress Management," has been completely revised; no revision bars are used.

**unacclimatized personnel** - Employees who are unaccustomed to working in a hot environment. This might include new employees or employees returning from an extended vacation (two weeks).

**vortex tube** - an auxiliary cooling device that provides for conditioning of breathing air prior to its entrance into a plastic suit

**Wet Bulb-Globe Temperature Index (WBGT)** - a Heat Stress Index that takes not only air temperature into consideration, but also humidity, air velocity, radiant heat and work load. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends the use of this index to determine a work/rest regimen for work in a hot environment.

**work/rest regimen** - the amount of time allowable for work, as compared to the amount of time required for rest based on the WBGT Index

## Responsibilities

### Management

Management shall use the required guidelines outlined in the SRS Heat Stress Management Program.

### Supervisors

Supervisors are to ensure that heat stress exposures to their employees are minimized. Consequently, affected supervision must be trained in recognizing the early signs and symptoms of heat stress-related disorders (see Attachment D), predisposing health conditions (see Attachment E), and where applicable, administering aid when heat stress-related disorders occur. (See Administrative Controls for specific training requirements.) Other responsibilities include:

- Obtaining WBGT outdoor readings, when needed, from All-in-1 (Videotext) or by phoning 7-0576. This information is updated at least three times daily.
- Consulting the required guidelines set forth in each of the five Heat Stress Categories listed in Attachment A and then disseminating this information to affected employees. Contact Industrial Hygiene for professional assistance, clarification of specific guidelines or variance requests.
- Ensuring that personnel are trained in work/rest regimen guidelines. (See Administrative Controls for specific training requirements.)
- Ensuring that personnel are provided with an adequate supply of water and a cool rest area, i.e., shaded or air-conditioned, when practical
- Ensuring that body cooling devices, if appropriate for the job, are made readily available and are effectively used by personnel for increased stay time

- Providing training (see Administrative Controls for specific training requirements) for workers on recognizing the signs and symptoms of heat stress disorders and applying effective preventive measures to avoid injury. As with all occupational health training, formal documentation must be retained.
- Having knowledge of the physical health and degree of acclimatization of their employees.
- Accountability for heat stress injuries occurring among their employees.
- Notifying Area Industrial Hygienist of heat-related injuries.
- Initiating heat injury investigations (see Attachment C, OSR 4-700).

## Industrial Hygiene

Industrial Hygiene (IH) shall take environmental measurements (See 4Q1.1, Procedure 118) three times a day from May through September and post the results via ALL-IN-1 (in Videotext under Safety and Health Topics) and a recorded phone message (phone 7-0576). All other measurements will be taken as environmental conditions dictate or when requested by Operations. Other responsibilities include:

- Evaluating new body-cooling devices.
- Providing professional assistance in determining specific heat stress controls.
- Giving technical support to operations on unusually hot jobs or unusual circumstances.
- Assisting in investigations to determine the root cause of heat stress injury.
- Assisting supervisors in completing Heat Injury Questionnaires.
- Reminding supervisors in early April for the need of heat stress training for their employees.
- Conducting an annual review of this procedure.

## Health Protection Operations

Health Protection Operations (HPO) shall take environmental measurements in Radiologically Controlled Areas as requested by Operations. Also, HP may provide coverage in the event that IH coverage is limited and Operations personnel are not qualified.

## Employees

Personnel must inform their supervisors of any physical problems (see Attachment E) that may increase the potential for developing a heat stress disorder. Other responsibilities include:

- Following required guidelines listed in Attachment A by referencing the SRS Heat Stress Index Card (Attachment F) when instructed by supervision.
- Participating in the buddy system.
- Notifying supervision at the onset of heat stress disorder symptoms or when these symptoms are recognized in fellow employees.

## Procedure

### A. Heat Stress Categories/Implementation

WBGT Index ranges are classified into Categories I, II, III, IV and V (see Attachment A). Each category includes a work/rest regimen (which should be considered if engineering controls and/or the use of personal protective equipment are impractical) and an hourly water intake based on a moderate work load. Additional required guidelines are given for unacclimatized personnel. The WBGT Index may be decreased if personnel are wearing body-cooling equipment and may be increased if personnel are wearing:

(1) Cotton coveralls (one or two pair) with a respirator, or

(2) impervious type of protective clothing (e.g., Hazmat Suit or plastic suit without a vortex tube).

Additional required guidelines are given for unacclimatized personnel in Attachment A and in Attachment F.

The information in Attachment A must be used in making decisions relative to managing heat stress. However, the recommendations given in Attachment A are guidelines, not absolute requirements. Past experience with the work environment, the specific tasks to be performed, and the specific individuals involved can be very valuable when applying these guidelines to specific work situations.

### B. Environmental Measurement

The WBGT Index for outdoor work will be updated three times a day. The results shall be recorded in ALL-IN-1 (in-Videotext under Health and Safety Topics) and on a phone recording (call 7-0576). Additional measurements may be taken earlier or later in the day as needed. These services will be maintained by IH. Heat stress measurements will be available starting in May continuing through September and may run earlier or later in the year as environmental conditions dictate. Indoor facility-specific readings will continue to be taken by IH at the request of Operations. HPO may be requested to perform heat stress monitoring in RCAs and when other coverage is unavailable.

Supervisors are responsible for obtaining WBGT readings as needed from All-In-1 or from the recorded phone message. The required guidelines outlined in Attachment A of this procedure should then be implemented.

SRS Heat Stress Index Cards (OSR 4-703) are available through Stores (Caption 26, Item 9263.00). This card lists all five heat stress categories on one side and the five most common heat stress-related disorders on the other. IH recommends that both supervisors and workers reference this card when determining heat stress management responses.

When presented with extreme or unusual work conditions, supervision should contact the Area Industrial Hygiene office for technical support, environmental monitoring and implementation of appropriate heat stress controls.

## C. Administrative Controls

Cool rest areas should be established when practical. They should be shaded or air-conditioned where feasible.

Supervision should consider scheduling heavy work for the coolest part of the shift.

Employees should be able to recognize symptoms of heat stress in themselves as well as in other employees (buddy system). See Attachment D for a list of heat stress symptoms.

Water or other fluids should be readily available during hot work activities whether indoors or outdoors. NOTE: **HIGHLY SUGARED FLUIDS, I.E., SOFT DRINKS, KOOL-AID™, ETC., SHOULD BE AVOIDED.**

Employees and supervisors shall be given annual training on the potentially serious results of heat injury, the general symptoms of these conditions, and how they can be prevented. SRS Heat Stress Training consists of viewing a videotape entitled "Heat Stress: Protect Yourself." Supervision should document training on OSR 4-388 (Rev 2/93), SRS Annual Training Documentation.

Supervision should encourage personnel to drink water before beginning work and throughout the shift. Recommended water intakes based on the WBGT Index are listed in Attachment A. Special consideration should be made for work in contamination areas.

To protect against developing an electrolyte imbalance, supervision should encourage personnel to add extra salt to their food during the first few days of acclimatization (AS APPROVED BY A PHYSICIAN).

Acclimatization is necessary for personnel who are expected to do moderate to strenuous work in a hot environment. Supervision can reasonably expect that their personnel are acclimatized after gradually exposing them to a hot working environment for 10 consecutive work days. Work durations should increase at the rate of an hour per day during this period.

Personnel who are at higher risk for developing a heat stress disorder while working in a hot environment should either be closely monitored by supervisors during the job or evaluated by Medical before starting work. Conditions that increase individual susceptibility to heat are listed on Attachment E.

## D. Personal Protective Equipment

Belt-mounted vortex tubes are available (call the Respirator Equipment Facility at 2-4241) for use with plastic suits on high pressure breathing air systems. They are suitable for use whenever respiratory protection is required. Maximum cooling is achieved when the calibration on the vortex tube is current and when the manifold air pressure is 120 psig. NOTE: Manifold-mounted vortex tubes do not cool as effectively as the belt-mounted variety.

Ice vests help to minimize heat strain while working in areas of high heat and humidity. They are suitable for use under protective clothing, but should not be worn directly on the skin. The manufacturer's recommendation regarding the amount of ice to place in the garment should be followed in order to achieve the maximum service time of the ice vest. If the use of the work/rest regimen is indicated by the WBGT Index, ice vests can increase the work time up to one hour if negative pressure respirators are worn and up to two hours if they are not, provided that employees are allowed to take periodic breaks in a cool area. Contact Industrial Hygiene for information on ordering ice vests.

## E. Engineering Controls

Engineering controls should be used where practical. These controls include spot coolers, cooling fans and shielding from radiant heat. It should be noted that cooling fans are not effective for heat stress control when the ambient air temperature is 95°F or higher. An Area Industrial Hygienist should be consulted for projects involving engineering controls.

## F. Heat Injury Investigations

Supervisors are responsible for conducting an investigation any time there is an injury resulting from heat stress among their personnel (see Attachment C ). At the request of the affected supervision, Industrial Hygiene will assist in coordinating investigations/interviews to determine root causes for any heat injury incident. Information as to water intake, work/rest regimen compliance, current medical condition, respirator use, protective clothing and other pertinent factors use will be compiled for review and development of lessons learned.

## Records

1. Heat Injury Investigation (OSR 4-700). Records shall be maintained in accordance with Manual 1Q, QAP 17-1, "Quality Assurance Records Management."

## References

1. American Conference of Governmental Industrial Hygienists, TLV Booklet for 1990-1991. Work/Rest Regimen for a moderate work load was used to develop Attachment A.
2. USASC&FG Regulation No. 40-1, Prevention of Heat Casualties
3. TB MED 507, NAVMED P-5052-5, AFP 160-1: "Prevention, Treatment and Control of Heat Injury"
4. Masadi, Roger and Robert F. Kinney, "Evaluation of Five Commercial Microclimate Cooling Systems for Military Use"
5. WSRC Manual 4Q1.1, Procedure 118, "Operating Procedures for Reporting and Recording WBGT Index Reading for Sitewide Dissemination"

## Attachments

A. Table 1, Recommended SRS Heat Stress Management Guidelines (OSR 4-703)
B. Table 2, Clinical Features and First-Aid Treatment of Common Heat Stress-Related Disorders (back of OSR 4-703)
C. Heat Injury Investigation (OSR 4-700)
D. Early Signs and Symptoms of Potential Heat Illness
E. Predisposing Factors for the Development of a Heat Stress-Related Disorder
F. SRS Heat Stress Index Card (OSR 4-703, Caption 26, Item 9263.00)

Attachment A. Table 1, Recommended SRS Heat Stress Management Guidelines

## Table 1

## Recommended SRS Heat Stress Management Guidelines

| CATEGORY | *WBGT INDEX RANGE F° | RECOMMENDED WATER INTAKE QTS/HR | **ACCLIMATIZED WORK/REST REGIMEN/MINUTES | UNACCLIMATIZED ADMINISTRATIVE CONTROLS |
|---|---|---|---|---|
| I. (WHITE) | 77.0 - 81.9 | 1/2 | CONTINUOUS | EMPHASIZE NEED FOR WATER INTAKE |
| II. (GREEN) | 82.0 - 84.9 | 1/2 | 45/15 | EMPHASIZE NEED FOR WATER INTAKE; USE BUDDY SYSTEM |
| III. (YELLOW) | 85.0 - 87.9 | 1 | 30/30 | EMPHASIZE NEED FOR WATER INTAKE; USE BUDDY SYSTEM; NO STRENUOUS WORK |
| IV. (RED) | 88.0 - 89.9 | 1-1/2 | 15/45 | EMPHASIZE NEED FOR WATER INTAKE; USE BUDDY SYSTEM; LIGHT WORK ONLY |
| V. (BLACK) | 90.0 or above | CONSULT INDUSTRIAL HYGIENE FOR ESSENTIAL WORK (OR HPO ON THE OFF-SHIFT/WEEKEND). | | |

Current SRS Heat Stress Conditions may be obtained in Videotext under Safety and Health Topics or by phoning 7-0576

* USE OF A BELT-MOUNTED VORTEX TUBE DECREASES THE WBGT BY 10°F.

  USE OF AN ICE VEST W/O A NEGATIVE PRESSURE RESPIRATOR CAN INCREASE WORK UP TO 2 HOURS; WITH A NEGATIVE PRESSURE RESPIRATOR, UP TO 1 HOUR.

  USE OF COVERALLS (1 OR 2 PR) AND N.P. RESPIRATOR INCREASES THE WBGT BY 7°F.

  WHEN USING IMPERVIOUS TYPE PROTECTIVE CLOTHING (e.g., HAZMAT SUIT OR PLASTIC SUIT WITHOUT A VORTEX TUBE), INDUSTRIAL HYGIENE IS AVAILABLE FOR CONSULTATION.

** EMPLOYEES SHOULD BE ALLOWED TO REST IN COOL AREAS.

Attachment B. Table 2, Clinical Features and First Aid Treatment of Common Heat Stress-Related Disorders

## Table 2

## Clinical Features and First Aid Treatment of Common Heat Stress-Related Disorders

| DISORDER | CLINICAL FEATURES | TREATMENT |
|---|---|---|
| HEAT STROKE | HOT DRY SKIN; CAN BE RED OR BLUE. CONFUSION, COMA, CONVULSIONS. BODY TEMPERATURE OF 105°F 107°F. | MEDICAL EMERGENCY. MOVE TO A COOLER AREA AND CALL MEDICAL IMMEDIATELY. |
| HEAT SYNCOPE | FAINTING AFTER STANDING ERECT AND IMMOBILE IN HEAT. | PROMPTLY MOVE TO COOLER AREA. |
| HEAT EXHAUSTION | FATIGUE, NAUSEA, HEADACHE, GIDDINESS, CLAMMY, MOIST SKIN, PALE COMPLEXION. | PROMPTLY MOVE TO COOLER AREA. ADMINISTER FLUIDS IF VICTIM IS CONSCIOUS. |
| HEAT CRAMPS | PAINFUL SPASMS OF MUSCLES USED DURING WORK (ARMS, LEGS OR ABDOMINAL). | ADMINISTER SALTED FLUIDS. REST IN A COOL AREA. |
| HEAT RASH | MANY TINY BLISTER-LIKE LESIONS ON AFFECTED AREA. | WASH AREA; THEN THOROUGHLY DRY. WEAR LOOSE CLOTHING. |

Attachment C. Heat Injury Investigation (OSR 4-700, Rev 3/10/93)

# Heat Injury Investigation

Name ______________________ Date ______________________

Age ____________ Sex ____________ Organization ______________

Time of Injury ____________ WBGT Reading ________ Location ____________

Supervisor ______________________ Address ______________________

Activity at time of injury ______________________________________

_____________________________________________________________

Type of protective clothing worn at time of injury _________________

_____________________________________________________________

Number of consecutive days on job _____________________________

Quantity of water consumed __________________________________

Existing medical conditions __________________________________

Previous heat injury ________________________________________

_____________________________________________________________

Received occupational health training on heat stress? ______________

Date of last training ________________________________________

Diagnosis _________________________________________________

_____________________________________________________________

Additional comments _______________________________________

_____________________________________________________________

## Attachment D. Early Signs and Symptoms of Potential Heat Illness

- Thirsty
- Rapid pulse
- Headache
- Fatigue, experience an overall weakness
- Light-headed, dizzy
- High body temperature, with or without sweating
- Pale, clammy skin
- Flushed face
- Concentrated color of urine (yellow)

## Attachment E. Predisposing Factors for the Development of a Heat Stress-Related Disorder

- Acute and chronic infections including the convalescent state
- Febrile (feverish) conditions
- Reactions to immunizations
- Vascular diseases
- Conditions affecting sweat secretion
- Skin trauma, such as heat rash or acute sunburn
- Previous occurrence of heat injury
- Dehydration
- Lack of sleep, cumulative fatigue
- Recent alcohol intake
- Dieting
- Some medications

## Attachment F. The SRS Heat Stress Index Card

COMMON HEAT RELATED ILLNESSES

| DISORDER | CLINICAL FEATURES | TREATMENT |
|---|---|---|
| HEAT STROKE | HOT DRY SKIN: CAN BE RED OR BLUE. CONFUSION, COMA, CONVULSIONS. BODY TEMPERATURE OF 105°F - 107°F. | MEDICAL EMERGENCY. MOVE TO A COOLER AREA AND CALL MEDICAL IMMEDIATELY. |
| HEAT SYNCOPE | FAINTING AFTER STANDING ERECT AND IMMOBILE IN HEAT. | PROMPTLY MOVE TO COOLER AREA. |
| HEAT EXHAUSTION | FATIGUE, NAUSEA, HEADACHE, GIDDINESS, CLAMMY, MOIST SKIN, PALE COMPLEXION. | PROMPTLY MOVE TO COOLER AREA. ADMINISTER FLUIDS IF VICTIM IS CONSCIOUS. |
| HEAT CRAMPS | PAINFUL SPASMS OF MUSCLES USED DURING WORK (ARMS, LEGS OR ABDOMINAL). | ADMINISTER SALTED FLUIDS. REST IN A COOL AREA. |
| HEAT RASH | MANY TINY BLISTER-LIKE LESIONS ON AFFECTED AREA. | WASH AREA: THEN THOROUGHLY DRY. WEAR LOOSE CLOTHING. |

SRS HEAT STRESS CATEGORIES

| CATEGORY | *WBGT INDEX RANGE F° | RECOMMENDED WATER INTAKE QTS/HR | **ACCLIMATIZED WORK/REST REGIMEN/MINUTES | UNACCLIMATIZED ADMINISTRATIVE CONTROLS |
|---|---|---|---|---|
| I. | 77.0 - 81.9 | 1/2 | CONTINUOUS | ENFORCE WATER/FLUID INTAKE |
| II. | 82.0 - 84.9 | 1/2 | 45/15 | ENFORCE WATER INTAKE: USE BUDDY SYSTEM |
| III. | 85.0 - 87.9 | 1 | 30/30 | ENFORCE WATER INTAKE: USE BUDDY SYSTEM: NO STRENUOUS WORK |
| IV. | 88.0 - 89.9 | 1-1/2 | 15/45 | ENFORCE WATER INTAKE: USE BUDDY SYSTEM: LIGHT WORK ONLY |
| V. | 90.0 or above | CONSULT INDUSTRIAL HYGIENE FOR ESSENTIAL WORK (OR EPO ON THE OFF-SHIFT/WEEKEND) | | |

- USE OF A BELT-MOUNTED VORTEX TUBE DECREASES THE WBGT BY 10°F.
- USE OF AN ICE VEST W/O A NEGATIVE PRESSURE RESPIRATOR CAN INCREASE WORK UP TO 2 HOURS: WITH A NEGATIVE PRESSURE RESPIRATOR, UP TO 1 HOUR.
- USE OF COVERALLS (1 OR 2 PR) AND N.P. RESPIRATOR INCREASES THE WBGT BY 7°F.
- WHEN USING IMPERVIOUS TYPE OF PROTECTIVE CLOTHING (e.g. HAZMAT SUIT OR PLASTIC SUIT WITHOUT A VORTEX TUBE) CONSULT INDUSTRIAL HYGIENE.

*WBGT DOES NOT DIFFER SIGNIFICANTLY FROM ORDINARY TEMPERATURE (°F) AT RELATIVE HUMIDITY OF APPROXIMATELY 75% OR GREATER.

**EMPLOYEES SHOULD BE ALLOWED TO REST IN COOL AREAS.

Current SRS Heat Stress Conditions may be obtained in Videotext under Safety and Health Topics or by phoning 7-0576.

# COLD EXPOSURE PROTOCOL

Cold injury (frostbite and hypothermia) and impaired ability to work are dangers at low temperatures and when the wind-chill factor is low. To guard against them:

1. Do not allow core oral temperature to fall below 96.8°F.

2. Pain in extremities may be the first dangers to cold stress. Work must be terminated if pain and shivering becomes evident.

3. Change clothes if worker becomes wet.

4. Follow Table 1 for determining Wind Chill
   Follow Table 2 for Work/Warm-Up Schedule

5. **Clothing**

   Workers shall dress in layers protecting exposed skin. Layers should be shed as the air temperature rises.

6. Workers in protective clothing should wear cotton or other absorbent materials to absorb sweat and maintain body warmth.

7. **Buddy System**

   All workers shall use the buddy system and consistently watch for frost-bit and/or excessive shivering.

8. **Warming**

   If conditions warrant, special tents, trailers or rest rooms, etc. will be made available for workers to warm in regular intervals. (See Table 2.)

9. **Dehydration**

   Warm sweet drinks and soups will be provided to provide caloric intake and fluid volume.

10. **The Health and Safety Officer**

    The Health and Safety Officer is responsible for briefing workers for signs and symptoms of impending hypothermia and frost-bite. If conditions warrant special thermometry will be considered if the air temperatures falls below 60°F.

# APPENDIX C

## SUBCONTRACTOR TECHNICAL OVERSIGHT/HSO HEALTH AND SAFETY FIELD FORMS

# HEALTH AND SAFETY PLAN FIELD MODIFICATION FORM

PAGE NO. ______ OF ____

PROJECT: ____________________________________________

PROJECT LOCATION: ____________________________________

PROJECT NO.: _________________________________________

HEALTH AND SAFETY OFFICER: ___________________________

FIELD MODIFICATION TO SSHASP: ________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

PREPARED BY: _________________________________________
TO HSO DATE

ACCEPTED BY: _________________________________________
TO FM DATE

ACCEPTED BY: ______________________________ ____________
SRS PM DATE

APPROVED BY: ______________________________ ____________
TO HSD DATE

NOTE: Field Modifications to SSHASP must be discussed with the TO HSD with subsequent written approval. Secure approval through fax

# SITE SAFETY MEETING ATTENDANCE

PAGE ____ OF ____

PROJECT: ______________________ DATE: ______________________

PROJECT NUMBER: ______________________ TIME: ______________________

MEETING CONDUCTED BY: ______________________ ______________________

NAME SIGNATURE

SIGNATURE DISCLOSURE: Each person, by signing this form, commits to having read and understood; then accepts all requirements and procedures outlined in the Site-Specific Safety and Health Plan (SSHASP).

PERSONNEL PRESENT

| | NAME/FIRM | SIGNATURE/DATE | SOCIAL SECURITY NUMBER |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |
| 6. | | | |
| 7. | | | |
| 8. | | | |
| 9. | | | |
| 10. | | | |
| 11. | | | |
| 12. | | | |
| 13. | | | |
| 14. | | | |
| 15. | | | |
| 16. | | | |
| 17. | | | |
| 18. | | | |
| 19. | | | |
| 20. | | | |

# ATMOSPHERIC MONITORING LOG
## FIELD HEALTH AND SAFETY

Page ____ of ____
Date ___/___/___
Circle: Sun Mon Tue Wed Thu Fri Sat

Site: ______________________ Project No.: ______________
Health and Safety Officer: ______________________
Action Levels: D__ ' C__ ' B __ ' (Stop work, call in for instructions)
(check box and write in levels for upgrade)
Task/Equipment: ______________________
Weather: ______________________

| Time | OVA PPM | DUST $mg/m^3$ | RAD | NOISE dB | | Comments: Duration of Readings, Upgrades, Location, etc. |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Additional Comments: ______________________

Signature: ______________

# RECORD OF RESPIRATORY WEAR (OSHA RECORD)

Page ___ of ___
Week Ending ___/___/___
Expense Code 76
Expense Type 119
Subcontract Code 1

oyee Name: ______________ Employee No.: ______________
t/Project Site: ______________

| ate (1) | Project Number | Time in Respiratory (Hours) | Instrument Reading (2) (HNu or OVA) | Type of Respirator (3) | Office Use Only |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Totals | | | | | |

ments: ______________

s:
(1) Record on a daily basis
(2) If worn because of dusty conditions - Note "Dusty Conditions"
(3) Level C or B

______________
HSOApproval

Attach to Timesheet and Forward to Corporate Acounting on a <u>Weekly</u> Basis

## EMPLOYEE INJURY/EXPOSURE INCIDENT REPORT

(Submit to HSD within 24 hours)

Date: ______________________

Employee: ______________________ Employee No. ______________

Site Name: ______________________

Site Location: ______________________

Project No.: ______________________

Exposure (yes or no): ______________ Injury (yes or no) ______________

Date of Incident: ______________________ Time: ______________

Location: ______________________

Activity During Time of Incident: ______________________

______________________

Site Conditions at Time of Incident:

Temperature ______________ Wind Speed ______________

Humidity ______________ Other ______________

Precipitation ______________

Cause of Exposure/Injury: ______________________

______________________

______________________

Type of Exposure/Injury: ______________________

______________________

Material Exposed to and Concentration Levels: ______________________

______________________

______________________

Employee Injury/Exposure Incident Report
Page 2

Nature of Exposure/Injury (part of body, etc.): ______________________________

______________________________________________________________

______________________________________________________________

Hospital and Attending Physician: ______________________________

______________________________________________________________

______________________________________________________________

Medical Care Received (onsite and offsite): ______________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

Other Individuals Involved: ______________________________

______________________________________________________________

Witnesses: ______________________________

______________________________________________________________

Has HSD Been Notified: ______________ No ______________ Yes (Attach Documentation)

Incident Report Completed by: ______________________________

# DAILY SIGN-IN/OUT LOG

PROJECT:____________________
PROJECT LOCATION:____________________
PROJECT NO.:____________________
HSO:____________________
DATE:____________________
PAGE NO.:____________________

| TIME | | NAME/FIRM | SIGNATURE | PURPOSE ONSITE |
|---|---|---|---|---|
| IN | OUT | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Note: This form is to be completed on a daily basis by all personnel working on the site

# WORK ZONE ENTRY AND EXIT LOG (JOB EXPOSURE REPORT)

PROJECT:____________________
PROJECT NO.:____________________
SITE LOCATION:____________________
HSO:____________________
DATE:____________________

| TIME IN | TIME OUT | NAME/FIRM | SIGNATURE | HNU/OVA READINGS (IN BREATHING ZONE) | LEVEL PPE (D/C/B) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**This Page Intentionally Left Blank**

# Distribution

**Federal Agencies**

3 U.S. Department of Energy
Office of Technology Development
Attn: J. Paladino, EM-521
Cloverleaf Center
19901 Germantown Rd.
Germantown, MD 20874-12901

1 U. S. Department of Energy
Albuquerque Operations Office
ETN
Attn: Dennis Olona
Pennsylvania/H Street
Albuquerque, NM 87116

1 U. S. Department of Energy
Albuquerque Operations Office
DOE AL ETD
Attn: J. Lenhert
Pennsylvania/H Street
Albuquerque, NM 87116

**Corporations**

Westinghouse Savannah River Company
Savannah River Technology Center
Environmental Sciences Section
P.O. Box 616 / 730-2B
Aiken, SC 29802
1 Attn: Pete Zionkowski
1 Attn: Ahmet Seur
1 Attn: Thomas Gaughan

**Corporations (Continued)**

3 Tech Reps, Inc.
Attn: Ralph D. Gruebel
5000 Marble NE
Albuquerque, NM 87110

**Libraries**

1 Thomas Branigan Library
Attn: D. Dresp
106 W. Hadley St.
Las Cruces, NM 88003

1 Government Publications
Zimmerman Library
University of New Mexico

| | MS | Org | |
|---|---|---|---|
| 1 | 0719 | 6621 | Library |
| 3 | 0719 | 6621 | C.V. Williams |
| 1 | 0986 | 2663 | R.A. Norman |
| 1 | 1159 | 9311 | G.J. Lockwood |
| 2 | 0719 | 6621 | T. Burford |
| 1 | 0756 | 6607 | G. Allen |
| 5 | 0899 | 4414 | Technical Library |
| 1 | 9018 | 8523-2 | Central Technical Files |
| 2 | 0619 | 12630 | Review & Approval Desk for DOE/OSTI |

**This Page Intentionally Left Blank**