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09-AMCP-0203

AUG 31 2009

Mr. D. A. Faulk, Program Manager
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Dear Mr. Faulk:

BC CRIBS AND TRENCHES EXCAVATION-BASED TREATABILITY TEST REPORT, DOE/RL-2009-36, DRAFT A

This letter transmits the BC Cribs and Trenches Excavation-Based Treatability Test Report, DOE/RL-2009-36, Draft A, for your review. This report provides the results of all four phases of the treatability test work described in the Excavation Based Treatability Test Plan for the BC Cribs and Trenches Area Waste Sites, DOE/RL-2007-15, Revision 0 (Test Plan). The treatability test results provide information to refine estimates of worker dose and cost for partial excavation of near surface contamination.

The Test Plan provides for conclusion of the test activities without completion and/or initiation of one or more of the test phases identified in the plan when sufficient data have been collected to complete assessment of the feasibility of the partial removal, treatment, and disposal alternative. As described in the report, not all of the test plan phases were completed; however, the U.S. Department of Energy, Richland Operations Office believes adequate information has been obtained.

Comments, if any, are requested within 45 days of receipt, in accordance with the secondary document review and comment process described in Section 9.2 of the Tri-Party Agreement Action Plan. If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:GLS

Attachment

cc: See Page 2

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DOE/RL-2009-36
Draft A

BC Cribs and Trenches Excavation-Based Treatability Test Report

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2009-36
Draft A

BC Cribs and Trenches Excavation-Based Treatability Test Report

Date Published
August 2009

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

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Richland, Washington 99352

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Executive Summary

An excavation-based treatability test[1] was conducted at selected BC Cribs and Trenches area waste sites in fiscal year 2007 (FY07) and FY08. This treatability test was designed to refine the estimates of worker dose and cost for partial excavation of near-surface contamination that were contained in the focused feasibility study[2]. The previous worker dose and cost estimates were based on limited characterization data and assumptions regarding excavation details, both of which were addressed by this treatability test.

The treatability test was divided into four phases; the first two phases were conducted at the same waste site. Three different waste sites were selected for the test based on their construction differences, methods of waste discharge, and waste stream characteristics. Characterization of all three selected waste sites was conducted to refine the conceptual models of the nature and extent of the contaminant distribution.

- Phase 1: Characterize the near-surface cesium-137 and strontium-90 contamination in the 216-B-26 Trench.
  - The 216-B-26 Trench received 5,880,000 L (1,550,000 gal) of liquid waste primarily containing cesium-137. The base of the trench is 152.4 m (500 ft) long and 3 m (10 ft) wide. During construction of the 216-B-26 Trench, berms were used to divide the trench into three working sections that did not receive equal contaminant loads.
  - During the treatability test, 63 boreholes were installed to a depth of 7.6 m (25 ft) using a direct-push technology. Geophysical logging was conducted at 55 of the boreholes, and soil sampling was conducted at the other 8 boreholes. The elevated cesium-137 contamination was found to be concentrated in a relatively thin zone, 3.3 to 3.6 m (11 to 12 ft) below ground surface, which corresponds to the bottom of the trench. The cesium-137 inventory estimated for the western one-third of the trench (28 Ci) is an order of magnitude lower than the inventories estimated for the middle and eastern thirds of the trench (267 Ci and 374 Ci, respectively). Based on the characterization results, the potential dose to

[1] DOE/RL-2007-15, 2008, *Excavation-Based Treatability Test for the BC Cribs and Trenches Area Waste Sites*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[2] DOE/RL-2004-66, 2005, *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

workers during excavation of the trench was estimated to be lower than the dose predicted in the focused feasibility study.

- Phase 2: Excavate the near-surface contamination in the 216-B-26 Trench.
  - During the test, approximately 43 percent of the western section of the trench and approximately 57% of the center section of the trench were excavated. Less contaminated overburden was mixed with deeper contaminated soil to ensure that container transportation requirements were met. The potential radiation dose to workers during excavation of the trench was generally half that predicted in the focused feasibility study.
  - The production rates to excavate a portion of the 216-B-26 Trench were slower than predicted in the focused feasibility study; therefore, the cost to excavate one-third of the 216-B-26 Trench was higher than predicted. Based on lessons learned and process refinements, the actual cost for full-scale excavation may be reasonably close to the costs predicted in the focused feasibility study.
- Phase 3: Characterize the near-surface cesium-137 and strontium-90 contamination in the 216-B-14 Crib.
  - The 216-B-14 Crib received 8,710,000 L (2,300,000 gal) of liquid waste primarily containing cesium-137 contamination. The crib includes a square waste dispersion structure, 3 m (10 ft) long on each side, set on a square bed of gravel that is 12.2 m (40 ft) long on each side.
  - During the treatability test, 19 boreholes were installed to a depth of approximately 7.6 m (25 ft) using a direct-push technology. Geophysical logging was conducted at all 19 of the boreholes. The elevated cesium-137 contamination at the 216-B-14 Crib is found over a relatively thick interval. Based on geophysical logging previously conducted in an existing well, the contamination may extend much deeper; however, only this one borehole penetrated deeper than 7.9 m (26 ft). Therefore, the cesium-137 inventory estimation was restricted to the upper 7.9 m (26 ft). The cesium-137 inventory within 7.9 m (26 ft) of ground surface was estimated to be approximately 740 Ci.

- Phase 4: Characterize the near-surface transuranic and cesium-137 contamination in the 216-B-53A Trench.
  - The 216-B-53A Trench received 550,000 L (145,000 gal) of liquid waste containing plutonium-239 contamination that could potentially result in soil concentrations greater than 100 nCi/g. The waste stream also contained cesium-137. The base of the trench is 18.3 m (60 ft) long and 3.0 m (10 ft) wide. An earthen dam divided the trench into two sections.
  - During the treatability test, 16 boreholes were installed to a depth of 7.6 m (25 ft) using a direct-push technology. Geophysical logging was conducted at all 16 of the boreholes. Characterization of this trench indicates that it does not appear to have any detectable plutonium contamination and it has very little cesium-137 contamination. Although cesium-137 concentrations as high as 2,240 pCi/g were detected in the log data, the total cesium-137 inventory associated with the 216-B-53A Trench is less than 0.2 Ci. The minimum detectable level (MDL) for plutonium was generally about 20 nCi/g, but high cesium-137 concentrations did affect the plutonium MDL. For each point, the actual MDL for plutonium was calculated, and there is an interval from 0 to 1.5 m (5 ft) thick at the base of the trench where plutonium levels may exceed 100 nCi/g. It is estimated that a maximum of 38 m^3 (50 yd^3) of soil may be present with a plutonium-239 concentration in excess of 100 nCi/g.

The following recommendations are made based on the evaluation of the treatability test results:

- Use the cost and dose data collected during excavation of the 216-B-26 Trench to refine the evaluation of alternatives in the focused feasibility test for the BC Cribs and Trenches area.
- Use the contaminant distribution data collected during characterization of the 216-B-26 Trench, 216-B-14 Crib, and 216-B-53A Trench to refine the conceptual model in the focused feasibility test for the BC Cribs and Trenches area.

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Terms

bgs	below ground surface
CFR	*Code of Federal Regulations*
dpm	disintegrations per minute
DPT	direct-push technology
DQA	data quality assessment
DQO	data quality objective
ERDF	Environmental Restoration Disposal Facility
FFS	focused feasibility study
FY	fiscal year
HPGe	high-purity germanium
MDA	minimum detectable activity
MDL	minimum detectable level
N/A	not applicable
NA	not available
RCT	radiological control technician
SGLS	spectral gamma logging system
Tri-Party Agreement	Ecology, et al., 1989, *Hanford Federal Facility Agreement and Consent Order*

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1 Introduction

An excavation-based treatability test (DOE/RL-2007-15, *Excavation-Based Treatability Test for the BC Cribs and Trenches Area Waste Sites*) was conducted at the BC Cribs and Trenches area waste sites in fiscal year 2007 (FY07) and FY08 to collect data for refining the focused feasibility study (FFS) (DOE/RL-2004-66, *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites*) estimates for worker dose and excavation cost.

1.1 Issues

Worker dose and cost estimates in the FFS were based on limited characterization data and assumptions regarding excavation details, both of which are addressed by the treatability test. There was no assertion in the *Proposed Plan for the BC Cribs and Trenches Area Waste Sites* (DOE/RL-2004-69) that worker dose would exceed legal limits (there is considerable experience to demonstrate that high-hazard work can be performed safely), only that the dose could be avoided entirely if the excavation were not performed. Also, because the excavation cost was based on industry excavation practice with adjustment for the expected highly contaminated soil, that estimate was subject to substantial uncertainty. This treatability test was designed to refine worker dose and cost estimates for the partial excavation element of the potential remedy to remove the near-surface contamination and subsequently install an evapotranspiration cap.

1.2 Background

The proposed plan (DOE/RL-2004-69) for the BC Cribs and Trenches area waste sites identified the preferred alternative (for all but four of the trenches and for all of the cribs) as "leave the waste in place and provide a protective surface barrier (such as an evapotranspiration barrier) over the contaminated waste site." Installation of a recharge-limiting cap over these sites would reduce water from infiltrating into the waste and driving contaminants to the groundwater, and it would also deter or prevent intrusion by animals and humans at the surface from coming into contact with the contaminated material below. The preferred alternative identified in the proposed plan for the other four trenches, the pipeline, and the siphon tank is excavation. Uncertainty regarding the estimates of remediation worker dose and excavation cost contributed to the inability to select a remedy.

Figure 1-1 depicts the three waste sites that were the focus of the treatability test. The 216-B-26 Trench and 216-B-14 Crib both received the same waste stream, but they are expected to have different contaminant distribution patterns based on construction differences and the methods of waste discharge. Each is expected to possess near-surface regions with high concentrations of cesium-137 and strontium-90, as well as deeper regions of technetium-99 and nitrate. The 216-B-53A Trench received a very different waste stream that predicted the potential for waste to have concentrations of transuranic constituents greater than 100 nCig.

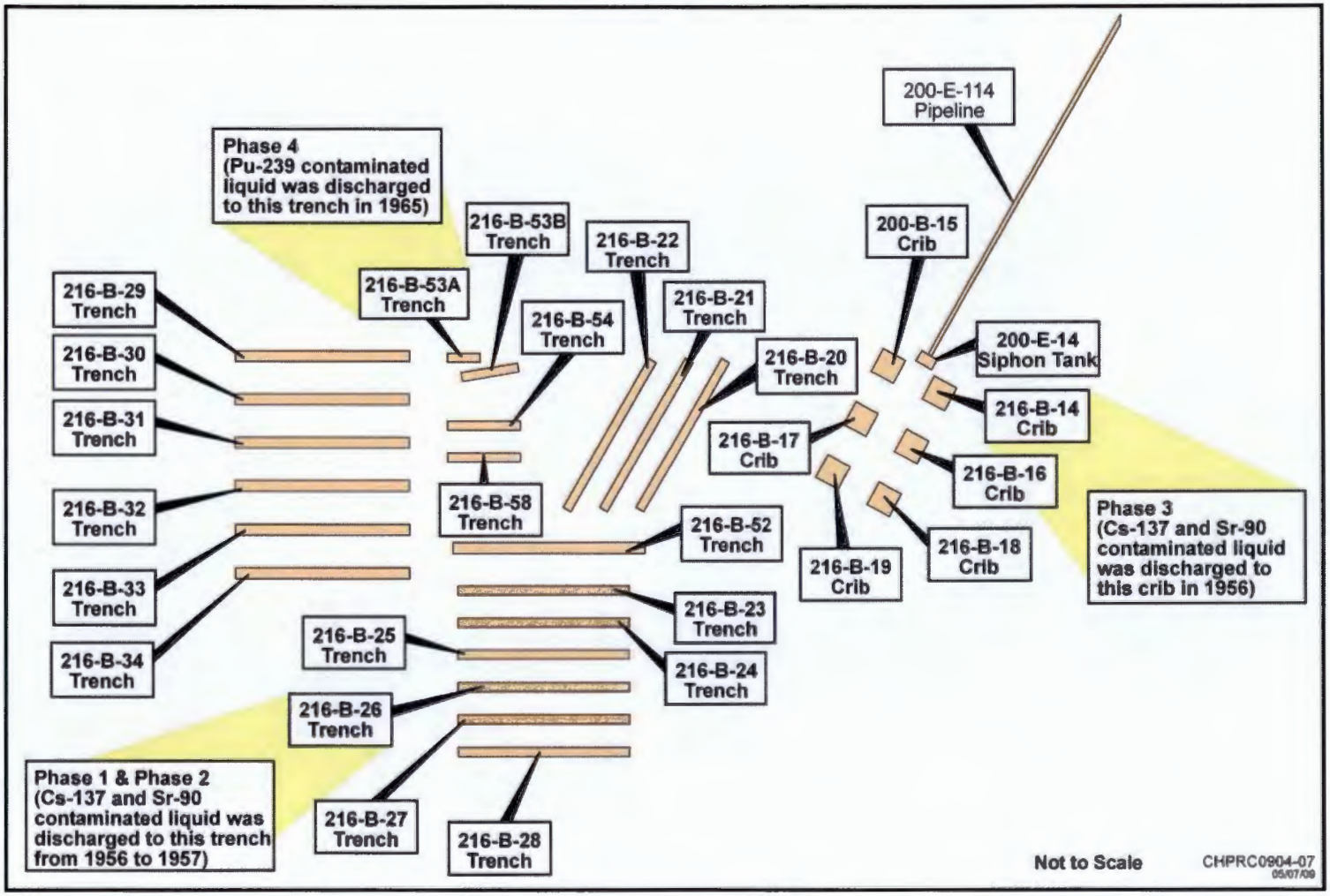

Figure 1-1. Focus of Treatability Test in the BC Cribs and Trenches Area

Characterization of the 216-B-26 Trench was previously reported in the *BC Cribs and Trenches Excavation-Based Treatability Test – Phase 1 Report* (DOE/RL-2008-26). Approximately five dozen direct-push technology (DPT) holes were installed in and adjacent to the trench and were logged to determine the nature and extent of cesium-137 contamination. Twenty-four sediment samples were collected to supplement the logging data and to provide data for strontium-90 concentrations. A highly contaminated region was found approximately 3.3 to 3.6 m (11 to 12 ft) deep that corresponds to the bottom of the trench during its operational period. The thickness of this contaminated region is approximately 0.3 m (1 ft), and the peak cesium-137 concentrations exceed 1E+06 pCi/g. The cesium-137 concentration varied considerably in the three sections of the trench created by two berms, resulting in inventory estimates (based on logging data) of 28 Ci, 267 Ci, and 374 Ci for the west, center, and east trench sections, respectively.

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2 Treatability Study Approach

The treatability study approach allowed the work to be completed in phases. If data collected during one or more phases of the test were deemed to provide sufficient information to update the FFS (DOE/RL-2004-66), subsequent phases of the test could be determined unnecessary. The approach also allowed activities common to multiple phases to be conducted simultaneously.

2.1 Treatability Test Objectives and Rationale

The treatability test plan divides the overall test into four phases:

- Phase 1: Characterize near-surface cesium-137 and strontium-90 contamination in the 216-B-26 Trench.
- Phase 2: Excavate near-surface contamination in the 216-B-26 Trench. Collect data to refine worker dose and cost estimates. Begin with excavation of one-third of the total length of the 216-B-26 Trench.
- Phase 3: Characterize near-surface cesium-137 and strontium-90 contamination in the 216-B-14 Crib. Establish whether the contaminant distribution in the crib differs from that in the trench. In addition, evaluate the potential for surface subsidence at the BC Cribs caused by failure of the crib structure. Excavate near-surface contamination from the crib and collect data to refine worker dose and cost estimates.
- Phase 4: Characterize the near-surface contamination in the 216-B-53A Trench, which received a unique waste stream that may have included significant transuranic radionuclides. Excavate near-surface contamination and collect data to refine worker dose and cost estimates. The potential for concentrations of transuranic radionuclides greater than 100 nCi/g could significantly alter the excavation practice and waste disposal.

Table 2-1 summarizes objectives and completion criteria for Phases 2, 3, and 4.

Table 2-1. Test Activities, Objectives, and Criteria Used to Demonstrate Completion of Treatability Test

Phase	Activity	Objective	Criteria
2	Excavate near-surface contamination from one-third of 216-B-26 Trench.	Collect sufficient data to compare worker dose with predicted dose.	Collect worker dose data for excavation activities for all personnel associated with the process (e.g., excavator operator, associated radiation control technician, water sprayer, spotter, and ERDF transport vehicle driver).
		Collect sufficient data to update excavation cost estimates.	Collect data that define the time to perform the following operations: • Remove overburden and fill ERDF container • Down-blend highly contaminated soil associated with high dose rates and transfer to ERDF container • Remove/stage another ERDF container • Evaluate all other factors that impact costs associated with excavation of the trenches.

Table 2-1. Test Activities, Objectives, and Criteria Used to Demonstrate Completion of Treatability Test

Phase	Activity	Objective	Criteria
2 (cont'd)		Collect sufficient data to ensure the capability to down-blend highly contaminated soil associated with high dose rates.	Demonstrate the capability to down-blend soil to meet ERDF waste acceptance criteria using minimal ERDF containers and having none that exceed the ERDF waste acceptance criteria for radiation protection after loading.
3	Install shallow boreholes and perform gamma logging and soil sampling[a] in the 216-B-14 Crib.	Define the nature and extent of Cs-137 and Sr-90 contamination.	If necessary, revise conceptual site model for the Cs-137 and Sr-90 nature and extent.
		Calculate Cs-137 and Sr-90 inventories and compare with soil inventory model[b] values.	Calculate Cs-137 and Sr-90 inventories based on measurement data.
		Recalculate worker dose estimate.	Use the revised source term determined through characterization.
	Excavate the 216-B-14 Crib to expose crib structure.[c]	Demonstrate subsidence potential by determining the status of the remnant crib structure.	Use the condition of the exposed crib structure to qualitatively evaluate the potential for subsidence at other cribs.
	Excavate near-surface contamination from the 216-B-14 Crib.[c]	Demonstrate capability to down-blend highly contaminated soil that is associated with high dose rates with overburden, including large-diameter gravel.	Demonstrate capability to down-blend soil/gravel to meet ERDF waste acceptance criteria using minimal ERDF containers and having none exceed the ERDF waste acceptance criteria for radiation protection after loading.
		Demonstrate ability to excavate contaminated crib "gravel."	Determine contamination level of crib gravel.
		Collect sufficient data to update excavation cost estimates.	Collect data that define the time to perform following operations: • Remove overburden and fill ERDF container • Down-blend high dose soil/gravel and transfer to ERDF container • Remove/stage another ERDF container • Evaluate all other factors that impact costs associated with excavation of trenches.

Table 2-1. Test Activities, Objectives, and Criteria Used to Demonstrate Completion of Treatability Test

Phase	Activity	Objective	Criteria
4	Install shallow boreholes, perform gamma and passive neutron logging, and perform soil sampling at 216-B-53A Trench.[a]	Define the nature and extent of transuranic (plutonium and americium) contamination in the 216-B-53A Trench.	Prepare conceptual site model for the nature and extent of transuranic contamination in the 216-B-53A Trench.
		Calculate the inventory of Pu-239 and compare with soil inventory model[a] values.	Calculate transuranic inventory based on measurement data.
		Refine/update conceptual site model.	Prepare conceptual site model for near-surface contamination.
	Excavate near-surface contamination from the 216-B-53A Trench.	Demonstrate the capability to safely excavate soil that has high levels of transuranic contamination.	Perform excavation while meeting all applicable health and safety requirements.

a. Sampling not performed.

b. From RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

c. Excavation not performed.

ERDF = Environmental Restoration Disposal Facility

The test plan provided for decision-maker data review as the test was conducted to permit cessation of portions of the test after sufficient data were collected and evaluated. Accordingly, much of the planned test was not performed. Table 2-2 summarizes the status of the treatability test.

Table 2-2. Treatability Test Status

Test Phase	Activity	Status
1	Characterize 216-B-26 Trench.	Complete. Installed/logged 55 DPT holes; collected/analyzed 24 soil samples from 8 additional DPT holes for Cs--37 and Sr-90 concentration. Report: DOE/RL-2008-26
2	Excavate one-third of the 216-B-26 Trench.	Complete. Excavated approximately 43% of western section of trench and approximately 57% of center section; collected selected production rate and operation-specific worker dose data. Report: This report
3	Characterize and excavate near-surface contamination from the 216-B-14 Crib.	Installed/logged 19 DPT holes. Additional activities terminated; no samples collected and no excavation performed. Report: This report

Table 2-2. Treatability Test Status

Test Phase	Activity	Status
4	Characterize and excavate near-surface contamination from the 216-B-53A Trench.	Installed/logged 16 DPT holes. Additional activities terminated; no samples collected and no excavation performed. Report: This report

NOTE: DOE/RL-2008-26, *BC Cribs and Trenches Excavation-Based Treatability Test Plan – Phase 1 Report.*
DPT = direct-push technology

2.2 Experimental Design

The experimental design is described in detail in the treatability test plan (DOE/RL-2007-15) and in the two sampling and analysis plans prepared in support of the test (DOE/RL-2007-14, *Sampling and Analysis Plan for Phase 1 of the BC Cribs and Trenches Area Waste Sites Excavation-Based Treatability Test*; DOE/RL-2007-15, Appendix B). These sampling and analysis plans reflect the sampling design developed for the test through the data quality objectives (DQO) process, which was used to define the test objectives and data collection requirements (DOE/RL-2007-15, Appendix A).

The sampling design for the characterization activities used geophysical logging of boreholes installed through the waste sites to collect data on contaminant concentration and distribution. In Phase 1, the geophysical logging data were supplemented by analyses of soil samples. The sampling design for the excavation activities leveraged recent excavation experience at the Hanford Site to determine the best approach to be used.

2.3 Equipment

The primary heavy equipment items needed for the excavation activities included the following:

- Komatsu™ PC600 track-mounted excavator with a 3.0 m^3 (3.9-yd^3) capacity bucket
- Environmental Restoration Disposal Facility (ERDF) waste cans
- ERDF waste can transporter (shuttle truck)
- Front-end loader (3.8 m^3 [5-yd^3] capacity)
- Water truck
- Water-spraying equipment
- Soil fixative
- Dump trucks to bring in soil to backfill the excavation to grade.

2.4 Sampling and Analysis

The specific sampling and analysis requirements for characterization of the 216-B-26 Trench during Phase 1 of the treatability test are provided in DOE/RL-2007-14. The sampling and analysis requirements for the remaining phases of the treatability test are found in DOE/RL-2007-15, Appendix B.

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2.5 Data Analysis and Interpretation

Characterization data were collected using down-hole geophysical logging to determine the nature and extent of radioactive contamination at the waste sites and the associated radionuclide inventory. Small-diameter total gamma logs were run at the 216-B-26 Trench and 216-B-14 Crib, with the results presented in units of "equivalent cesium-137" (eCs). The concern regarding plutonium in the 216-B-53A Trench led to the use of larger diameter DPT casing to accommodate the high-resolution spectral gamma log, which is capable of detecting characteristic decay gammas for specific radionuclides. Cesium-137 is detected and assayed from gamma activity at 662 keV, with a minimum detectable level (MDL) of less than 0.5 pCi/g. Plutonium-239 is detected and assayed on the basis of the decay gamma at 375 keV, with an MDL of approximately 20 nCi/g. The spectral gamma logging system (SGLS) data provide a vertical profile of the gamma activity at each borehole. The gamma activity data are collected at pre-determined (e.g., 15 cm [6-in.])-depth intervals. The gamma activity at each depth interval is used to calculate the eCs or cesium-137 inventory in that interval. The methodology for analyzing the gamma activity at characteristic energy levels in order to interpret the presence and quantity of contaminants (e.g., cesium-137) is described in the *Hanford Geophysical Logging Project Data Analysis Manual* (GJO-HGLP 1.6.3), prepared by S. M. Stoller Corporation, which is the company that conducted the logging. The general approach for analyzing the nature and extent of contamination and the radionuclide inventory, using the cesium-137 profiles provided by S. M. Stoller Corporation, is described in the test plan (DOE/RL-2007-15).

Excavation data were collected to evaluate the cost, dose, and excavation techniques associated with excavation and disposal of radioactively contaminated soil in the waste sites. The approach for analyzing and interpreting the excavation-related data is described in the test plan (DOE/RL-2007-15).

2.6 Data Management

Data collected during the treatability test were managed and stored in accordance with approved procedures. Field data were recorded in logbooks and on forms. Analytical data packages and geophysical logging data were stored electronically, and the results are available via database (e.g., the Hanford Environmental Information System or a project-specific database).

2.7 Deviations from the Test Plan

There were no deviations from the test plan during the treatability test. However, as allowed by the test plan, portions of Phases 3 and 4 were not conducted because sufficient data had been collected (Table 2-2).

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3 Data Analysis and Interpretation

3.1 Phase 1 – Characterization of the 216-B-26 Trench

The objective of Phase 1 of the treatability test was to characterize the nature and extent of contamination in the 216-B-26 Trench. The collected data would be used to estimate the amount of material requiring removal (i.e., define the lateral and vertical extent of the excavations) and to calculate a predicted dose that remediation workers might receive during Phase 2 trench excavation. Data from this phase of the test would also be used to correlate the total curie content of cesium-137 in the trench, as determined by measurements and estimates of the contaminated volume with the total curie content predicted by the *Hanford Soil Inventory Model, Rev. 1* (RPP-26744).

A summary of the results of Phase 1 of the treatability test are provided below. Details of the field work and data evaluation are provided in Phase 1 report (DOE/RL-2008-26).

3.1.1 Process Description

Sixty-three shallow (approximately 7.6 m [25-ft]-deep) DPT holes were installed in the footprint and to the side of the 216-B-26 Trench to determine the extent of lateral contamination spread. Fifty-five of the boreholes were logged to estimate the equivalent cesium-137 concentration profile with depth. Eight of these boreholes were selected for soil sampling, which led to the installation of eight new boreholes adjacent to those that were logged. Twenty-four samples were collected from those boreholes at depths ranging from 2.4 to 5.2 m (8 to 17 ft).

3.1.2 Results

A highly contaminated region was found approximately 3.3 to 3.6 m (11 to 12 ft) deep that corresponds with the bottom of the trench during its operational period. This region is approximately 0.3 m (1 ft) thick and contains peak equivalent cesium-137 concentrations greater than 1 million pCi/g. Equivalent cesium-137 concentrations varied considerably along the length of the trench, with a maximum of approximately 2.9 million pCi/g near the west end of the center section of the trench. The estimated volume of soil contaminated with greater than 750 pCi/g of cesium-137 (less than 4.6 m [15 ft] bgs) is 1,481 m^3 (1,937 yd^3). Contaminant distribution varied by an order of magnitude among the three sections of the trench that are separated by berms. Equivalent cesium-137 inventories derived from logging data for the western, middle, and eastern sections of the trench are estimated at 28 Ci, 267 Ci, and 374 Ci, respectively, for a total inventory of 669 Ci. When soil sampling data are considered, the cesium-137 inventory is estimated at 569 Ci. The strontium-90 inventory, based on soil sampling data, is between 389 and 498 Ci, and these values are in agreement with RPP-26744. The cesium-137 inventory is approximately one-half of the amount predicted in the FFS (DOE/RL-2004-66) based on limited logging and sampling data. With the reduced inventory and thinner layer of high contamination, worker dose for excavation/transportation/disposal activity in Phase 2 is estimated at approximately one-half of the dose predicted in the FFS.

3.1.3 Lessons Learned and Discussion

Because the highly contaminated soil interval is relatively thin and often sharply defined, it was difficult to obtain the discrete laboratory samples at the depth of the hot layer (DOE/RL-2008-26). This difficulty was further complicated by (1) the small sample size (approximately 30 g) required to limit worker exposure, and (2) the random (rather than focused) sampling approach developed during the DQO process. In contrast, geophysical logging provided a relatively continuous and integrated vertical profile of contamination. As a result, in some cases, the gamma-logging instrument registered high count rates, but the soil at the same depth in a nearby borehole had almost no contamination. Because the gamma

logging provided a continuous profile that defined the hot layer, and it proved difficult to obtain soil samples from the hot layer, further soil sampling was not conducted at the 216-B-26 Trench.

3.2 Phase 2 – Excavation of 216-B-26 Trench

Phase 2 of the treatability test focused on excavating near-surface contamination from the 216-B-26 Trench. The test plan provided for beginning with the excavation of one-third of the trench to allow for terminating excavation if sufficient data were collected. Excavation was limited to one-third of the trench (see Section 2.1).

The 152.4 m (500-ft)-long 216-B-26 Trench is divided into three sections of equal length by two berms. Characterization of the trench during Phase 1 of the treatability test showed that the inventory is not equally distributed within the three sections, with the western section having an order of magnitude less inventory than the center and eastern sections (DOE/RL-2008-26). Excavation began within the western section of the trench to allow procedures and radiological controls to be tested and revised, if necessary, as well as to provide experience to the field crew while excavating more manageable contamination than that associated with the center or eastern sections of the trench. The adequacy of the selected equipment was evaluated, leading to modifications prior to potential exposure of personnel and equipment to contamination levels an order of magnitude greater. Also, monitoring and data-collection strategies were validated to ensure that proper data would be collected during the subsequent portion of the treatability test focusing on the region of highest contamination. Approximately 43 and 57 percent of the western and center sections, respectively, were excavated. Figure 3-1 shows the placement of the excavation within the trench.

3.2.1 Process Description

Although an excavation scenario was previously developed for the purpose of preparing a cost estimate for the FFS (DOE/RL-2004-66), a revised excavation process was used for the treatability test that was based on recent experience gained from excavation at the 200-W-42 pipeline (in Hanford's 200 West Area). The basic approach was to begin removing overburden (nominally 1.2 m [4 ft]) and setting it aside to be used later (either for down-blending the deeper highly contaminated layer or for backfilling the hole after the excavation was completed). Instead of using two excavators (i.e., a high-capacity machine for overburden removal and a lower capacity machine for down-blending and removing the contaminated soil), excavation was accomplished with a single, high-capacity, large bucket excavator that was used for overburden removal, contaminated soil down-blending and removal, and subsequent backfilling of the hole. (The FFS assumed that excavation would use a long-reach excavator with a small bucket to down-blend and transfer contaminated soil to the ERDF can.) Contaminated soil was loaded into standard ERDF roll-off cans previously placed on a truck bed specifically designed for such use (i.e., shuttle truck). The loaded cans were then processed for disposal by placing the can liner over the top of the soil, weighing the can, tack welding the liner with a heat gun, placing the ERDF tarp over the can, surveying the container and truck for radionuclide contamination, and then staging the can for later pickup by ERDF operations personnel. A process summary that includes incorporated refinements is provided below:

1. Soil was excavated from the trench using a Komatsu PC600 track-mounted excavator with a 3.0 m^3 (3.9-yd^3)-capacity bucket. As necessary, less-contaminated overburden soil was blended with highly contaminated soil to ensure that waste container transportation requirements would be satisfied. Figure 3-2 shows a bucket being emptied into the ERDF can that is mounted on a shuttle truck (note the instrument on the excavator arm positioned to measure the soil dose rate within the bucket).

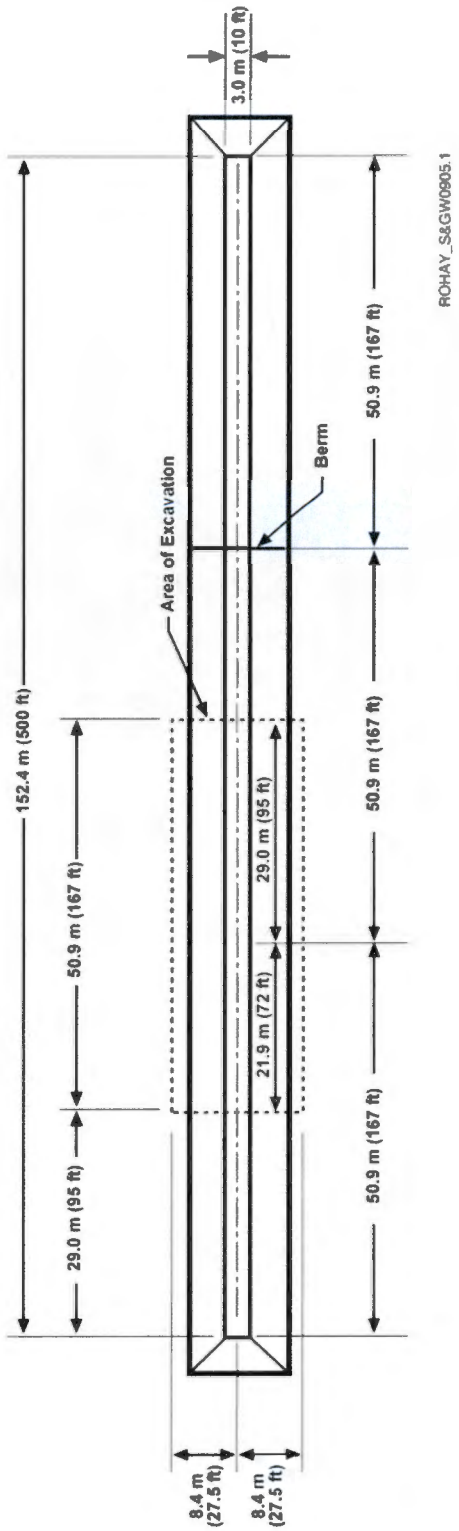

Figure 3-1. Location of Excavation in the 216-B-26 Trench

Figure 3-2. Contaminated Soil Loaded from Excavator Bucket into Environmental Restoration Disposal Facility Can

2. The dose rate of each loaded bucket was manually measured prior to emptying the bucket into the plastic-lined ERDF can to ensure that adequate mixing/down-blending had been performed.

   NOTE: This step was not performed initially. This step was introduced following a can exhibiting excessive dose rate that was loaded with inadequately down-blended soil.

3. The ERDF can liner was folded over the loaded soil, and a preliminary survey of the can was performed.

4. The shuttle truck moved the can to the survey station where the truck and can were weighed, and the can liner was "tack welded" using an industrial heat gun mounted on an extension pole. The tarp was pulled over the open top of the ERDF can and secured to hooks on the side of the can.

5. The ERDF can was surveyed to ensure that the exterior was contamination-free and to document the exterior dose rate.

6. The shuttle truck moved the ERDF can to the queue, where it was unloaded from the truck and staged on the ground.

7. ERDF personnel picked up the loaded ERDF can and transported it to ERDF, where the can was then emptied.

8. An empty can was returned to the project queue for empty ERDF cans.

9. The empty can exterior was surveyed to ensure that it was free of smearable contamination.

10. A plastic liner was placed in the empty ERDF can.

11. The lined can was picked up by shuttle truck and moved to the excavation site for loading.

3.2.2 Results

A total of 181 ERDF cans were loaded with soil removed from one-third (approximately 50.9 linear m [167 linear ft]) of the 216-B-26 Trench. The total quantity of contaminated soil disposed to the ERDF was approximately 3.2 million kg (7.0 million lb). Excavation was focused on the region 0 to 4.6 m (0 to 15 ft) bgs, directly above the footprint of the trench bottom. Because it was anticipated that the overburden would be used for down-blending the highly contaminated layer, it was removed and placed on the north side of the trench. Overburden not used for down-blending was returned to the excavation following removal of the target contamination. Table 3-1 summarizes excavation activity during Phase 2.

Table 3-1. Summary of Phase 2 Excavation Activities

Date	Activity
05/01/08	Began removal of overburden to gain experience with new excavator. Removed approximately 6.1 linear m (20 linear ft) of the top 1.2 m (4 ft) vertically (excavation design is to bench down 1.2 m (4 ft) to provide a platform for the excavator).
05/05/08	Removed approximately 16.8 linear m (55 linear ft) of overburden.
05/06/08	Removed approximately 22.9 linear m (75 linear ft) of overburden.
05/06/08-05/15/08	Focused on mobilization activities. On the May 15, resumed removal of overburden and advanced another 6.1 linear m (20 linear ft).
05/18/08	Completed overburden removal.
05/19/08–05/29/08	Focused on completing mobilization activities (i.e., improving haul road to ERDF, training, etc.).
06/02/08	Loaded first can of contaminated soil, starting at the center of the berm separating the west and center sections of the trench. As expected, this soil was minimally contaminated because excavation depth had not reached the contamination. The can contained five bucketfuls.
06/03/08	Reviewed yesterday's excavation and loading of the first can and related activities. Cloudburst/windstorm interrupted excavation and limited progress to two cans loaded. Each can contained five bucketfuls.
06/04/08	High wind prevented excavation and loading.
06/05/08	High wind limited progress to three cans loaded. Each can contained low-activity soil, as indicated by <0.5 mrem/hr dose rates on contact. Each can contained five bucketfuls. Encountered unexpected object approximately 0.9 m long by 20 cm (3 ft long by 8 in.) in diameter that was later determined to be a plug of bentonite used to seal borehole C4196 that was drilled/decommissioned in 2003.
06/06/08	High wind prevented excavation and loading.
06/08/08	Excavated/loaded five cans. Each can contained five bucketfuls. Later cans exhibited contact dose rates >0.5 mrem/hr as the contaminated layer was reached. Can #0731 had one spot that measured 20 mrem/hr. Spilled small quantity of contaminated soil on south side of truck onto the ground during loading. Cleanup consumed approximately 2.5 hours.

Table 3-1. Summary of Phase 2 Excavation Activities

Date	Activity
06/09/08	High wind limited excavation and loading to four cans.
06/10/08	High wind prevented excavation and loading.
06/11/08	High wind prevented excavation and loading.
06/12/08	Excavated and loaded 11 cans. The eleventh can had four rather than five bucketfuls.
06/13/08	Excavated and loaded eight cans. Revised process to load four bucketfuls (rather than five) in each can to compensate for poor excavator operator visibility into can as the bucket was being emptied. Intermittent interruptions because of high wind.
06/15/08	Excavated and loaded 10 cans. Stopped mid-afternoon because no empty cans had been delivered.
06/16/08	Excavated and loaded six cans. Completed excavation of the western section of the trench associated with Phase 2. Total of 50 cans loaded. It should be noted that down-blending was performed almost incidentally, as the less-contaminated soil above and below the highly contaminated layer was excavated along with that layer. Prepared excavator for the initial 100-hour maintenance by thoroughly washing down the bucket. Performed maintenance.
06/17/08	Backfilled the excavation associated with the western section of the trench.
06/18/08	Conducted comprehensive review of activities to date with the entire crew to capture lessons learned in preparation for excavating the more highly contaminated center section of the trench. Significant comments were as follows: • Exterior of excavator bucket has many features that hold up soil that can become dislodged during can loading, resulting in contamination of the shuttle truck and/or ground. • Excavator operator has poor visibility when emptying the bucket into the can.
06/19/08	Began excavation of the center section. Revised process to load five bucketfuls into each ERDF can (while excavating the west portion of the trench, roadway sloped up away from the excavator, which aggravated the visibility problem for the excavator operator). The initial cans of the day were loaded with soil from the relatively shallow portion of the trench. The fourth can (#1953) exhibited an excessive "hot spot," measuring approximately 450 mrem/hr on contact. Excavation and loading were halted to stabilize conditions and develop a recovery plan. Subsequently, the can was processed through the normal steps and staged for later disposition in a high radiation area established within the queue for full cans.
06/23/08	No excavation was performed. The AMP-100[a] position on the excavator boom was extended to be approximately 46 cm (18 in.) above the plane of the bucket (it previously was approximately 91 cm [36 in.]). A dirt pad was constructed to elevate the excavator relative to the ERDF can to improve operator visibility.
06/24/08	High wind limited excavation and loading until after lunch; three cans were loaded. The excavation process was modified by increasing the amount of intentional soil blending as measured by monitoring the AMP-100 output that measured the dose rate of the surface of the loaded bucket. The excavator operator would not present the loaded bucket for loading until the AMP-100 reading of the surface of the loaded bucket indicated that significant blending had been performed. Then, the radiological control technician, using a device that enabled him/her to extend the detector up to 3 m (10 ft), measured dose rate through the sides and end of the loaded bucket to assess homogeneity. Sometimes this process indicated insufficient blending and the bucket load was returned to the excavation for additional blending. The lips of the excavator bucket were modified to slope them inward to reduce soil holdup.
06/25/08	Excavated and loaded five cans.

Table 3-1. Summary of Phase 2 Excavation Activities

Date	Activity
06/26/08	Excavated and loaded eight cans.
06/27/08	Excavated and loaded 10 cans.
06/29/08	Excavated and loaded nine cans. Noted that the excavation side slope on the north side of the trench is approximately 1:1 versus approximately 2:1 on the south side.
06/30/08	Wind storm the previous night caused minor infrastructure damage. Excavated and loaded eight cans. Gusty winds after lunch interrupted loading for approximately 45 minutes.
07/01/08	Excavated and loaded three cans. Stand down after a full ERDF can partially slipped off the rails of the shuttle truck while attempting to load it for transport to ERDF. Following investigation and development of recovery plan, the tilted can was lowered to the ground. Excessive wind halted excavation and loading.
07/02/08	Excavated and loaded 11 cans.
07/03/08	Excavated and loaded 10 cans. New excavator operator who had no experience with soil down-blending.
07/07/08	Excavated and loaded 13 cans. "Regular" excavator operator back.
07/08/08	Excavated and loaded 13 cans. Two cans had less than the regular five bucket loads: the first can of the day contained three bucket loads; the ninth contained two bucket loads. In each case, the portion of can liner hanging over the top edge and down the outside was being drawn into the can as soil was loaded.
07/09/08	ERDF personnel notified the project that their support to the project was on hold because of contamination measuring approximately 2 million dpm beta/gamma found on an ERDF can load elsewhere onsite. A fact-finding meeting concluded that the contamination could have originated at the 216-B-26 Trench. Additional in-process surveys were mandated. While the fact-finding meeting was in progress, all ERDF cans, shuttle trucks, and traffic patterns (including the queue areas) associated with the project were surveyed. No contamination was found. Following the meeting, two cans were loaded while being observed by ERDF; Washington Closure Hanford; and U.S. Department of Energy, Richland Operations Office personnel. Additional surveys were performed at the conclusion of can loading and again at the survey station. No contamination was found. At the conclusion of the day, ERDF personnel notified the project that they would resume support. Excavated and loaded two cans.
07/10/08	High wind limited excavation and loading to two cans. Loading of the first can was stopped after loading only three bucketfuls because of wind. A destructive wind storm that occurred in the late afternoon after operations had ceased toppled the survey station. Wind also caused the spread of contamination outside of the trench.
07/11/08	Entire day was consumed with recovery from previous day's severe windstorm. The survey station was toppled. Also, an area approximately 26 m by 35 m (85 ft by 115 ft) east (downwind) of the excavation was contaminated with up to 35,000 dpm/100 cm^2. The contaminated area was covered with 15 to 20 cm (6 to 8 in.) of compacted clean soil. No other loss of contamination control was observed. Excavation and loading were not performed.

Table 3-1. Summary of Phase 2 Excavation Activities

Date	Activity
07/13/08	Excavated and loaded nine cans. In mid-afternoon, the excavator uncovered what looked like a garbage can at a depth of approximately 3.9 m (13 ft) and about 6.7 m (22 ft) east of the center of the berm separating the west and center sections of the trench. Many photographs were taken. The can contained several solid metal rods similar to rebar and estimated to be approximately 1.3 cm (0.5 in.) in diameter.
07/14/08	Examination of the photos taken of the anomalous item yesterday showed it to be a drum that had apparently been converted to a garbage can by attaching handles to its sides. When it was brought to the surface in the excavator bucket, it did not exhibit any unexpected activity relative to the surrounding contaminated soil, nor did it exhibit any off-gas when evaluated by the industrial hygiene technician. Gusty winds forced premature shutdown at 3:00 p.m. Excavated and loaded eight cans.
07/15/08	Following a job-specific tailgate pre-job, ERDF can #1953 was uneventfully emptied into the excavation (this was the can that exhibited excessive dose rate on 6/19/08). Can contents were thoroughly down-blended, and then excavation and loading resumed. Excavated and loaded eight cans.
07/16/08	Following lubrication of the excavator, the Phase 2 portion of the treatability test excavation was completed. The last few cans had little activity as measured by dose rate. Excavated and loaded five cans.
07/22/08	Excavation backfilling was completed, except for the bench area that excavator used.

a. AMP-100 Area Monitor Probe, Rotem Industries, Ltd., Israel.
dpm = disintegrations per minute
ERDF = Environmental Restoration Disposal Facility

3.2.2.1 Excavation of Western Section

Excavation began at the location of the berm separating the western and center sections of the trench and proceeded to the west so the prevailing wind would direct potential airborne contamination away from personnel. Following removal of overburden (approximately 1.2 m [4 ft]), down-blending the highly contaminated layer was accomplished in an almost incidental manner as the path of the excavator bucket passed through it. In-process down-blending was guided by monitoring the dose rate of the soil within the excavator bucket using a gamma detector with remote readout[3] that was mounted on the arm of the excavator. Experience was gained on other elements of the process (e.g., dust control, ERDF can handling, and general operations). After excavating this portion of the trench, a lessons-learned meeting was held with the entire work crew. Significant recommendations were made in regard to modifying the excavator bucket to reduce the opportunity for soil holdup (to minimize contaminated soil spills during ERDF can loading) and to raise the excavator relative to the ERDF can to improve excavator operator visibility during can loading. This section of the trench was then backfilled prior to moving to the more highly contaminated center section.

[3] AMP-100 Area Monitor Probe, Rotem Industries, Ltd., Israel.

3.2.2.2 Excavation of Center Section

Excavation began at the east end of the planned excavation section following modification of the excavator bucket and building a pad to elevate the excavator to a position where the operator had a better view of the bucket-emptying activity.

On the first day of excavation, at least one bucket of excessively contaminated soil was unexpectedly encountered and loaded, resulting in a waste container exhibiting a localized dose rate (450 mrem/hr on contact) that exceeded shipping criteria. The can was closed up and set aside for later disposition. The contents of this can were ultimately dumped back into the excavation where additional blending was performed. Review concluded that the primary cause of this unexpected condition was failure to rigorously revisit the hazards analysis, with overconfidence resulting from the ease of excavating the western section being a contributing factor.

Subsequent down-blending was guided by two sets of radiological data: (1) the detector with remote read-out capability mounted on a bracket attached to the excavator arm that enabled the excavator operator to assess down-blending progress; and (2) manual measurements of dose rate through the bucket sides and end, and over the top of the exposed soil in the bucket. The top measurement supplemented the remotely obtained measurement that was focused on a relatively small portion of the exposed soil. This approach effectively prevented the loading of soil that was not sufficiently down-blended throughout the duration of the project. Approximately 12 percent of the buckets presented to the radiological control technician (RCT) for dose measurement prior to loading needed to be returned to the hole for additional down-blending due to discovery of a "hot spot."

One of the objectives of the treatability test was to minimize the quantity of waste sent to disposal by refining the down-blending process so the ratio of relatively "clean" soil to highly contaminated soil resulted in ERDF cans that exhibited external dose rates approaching the limit. For this activity, the limit corresponded to transportation low specific activity requirements (defined by 49 *Code of Federal Regulations* [CFR] 100–185, "Pipeline and Hazardous Materials Safety Administration, Department of Transportation"), or 10 mrem/hr at a point 2 m (6.6 ft) from the sides of the container. For the portion of the western section of the trench that was excavated, down-blending may not have been necessary. Down-blending was performed mostly by incorporating adjacent soil into the highly contaminated layer as it was excavated. After excavation entered the center section of contamination and the can containing an unacceptable hot spot was loaded, down-blending became more meticulous. Following that incident, increased dose rate measurements were obtained for each bucketful before it was emptied into the ERDF can. The data, in conjunction with the dose rate data obtained from the instrument mounted on the excavator, were used to assess down-blending adequacy. In order to avoid loading another can that could not be transported to the ERDF without special handling, the criteria were conservative. Nevertheless, there was substantial variability in the dose rates of loaded cans. Table 3-2 summarizes the ERDF can dose rates (maximum values measured at 2 m [6.6 ft]) and the average low and average high dose rates of full buckets of contaminated soil that were removed from the center section of the trench and emptied into ERDF cans. The focus was on the maximum ERDF can dose rate measured at 2 m (6.6 ft) because it is the basis for the application transportation requirement (49 CFR 173.441[b][3]).

Table 3-2. Summary Data for Excavator Bucket Dose Rate and Resulting Environmental Restoration Disposal Facility Can Dose Rate

Maximum ERDF Can Dose Rate at 2 m[a] (mrem/hr)	Bucket Dose Rate[b] (mrem/hr)		Soil Contact Dose Rate[c] (mrem/hr)		Soil Dose Rate[d] (mrem/hr)		Number of ERDF Cans[e]
	Low[f]	High[g]	Low[f]	High[g]	Low[f]	High[g]	
3	9.3	16.8	28.4	54.4	14.3	21.7	18
4	8.3	18.7	28.8	55.8	15.8	24.2	26
5	7.4	18.3	28.3	55.9	15.2	24.6	35
6	7.5	20.7	25.9	63.8	14.7	24.0	17
7	8.1	19.4	33.3	67.8	18.0	26.3	9
8	8.2	20.1	31.8	59.1	17.3	29.6	11
9	3.0	12.0	25.0	70.0	8.0	22.0	1
10	5.0	25.0	35.0	40.0	16.0	21.0	1

a. Maximum dose rate measured at 2 m (6.6 ft) from side of ERDF can.

b. Contact dose rate measured by RCT through bucket side wall.

c. Contact dose rate of soil at top of full excavator bucket, as measured by RCT.

d. Dose rate of soil at top of full excavator bucket, as measured by the area monitor probe AMP-100 (Rotem Industries, Ltd., Israel.) instrument, located 46 cm (18 in.) above plane of bucket top.

e. Number of ERDF cans associated with population of measurement.

f. Average of low readings taken from the four to five excavator buckets loaded into ERDF can.

g. Average of high readings taken from the four to five excavator buckets loaded into ERDF can.

ERDF = Environmental Restoration Disposal Facility

RCT = radiological control technician

The dose rates provided in Table 3-2 are plotted in Figure 3-3. Only maximum dose rates are considered because of the transportation focus on maximum shipping container dose rate. A "hot spot" observed during a survey of the excavator bucket and/or exposed soil would be expected to contribute to the maximum ERDF can dose rate. The correlations between the bucket/soil dose rates and the maximum ERDF can dose rate were not as robust as desired (note the relatively flat relationship between the bucket and ERDF can dose rates), which resulted in the conservative can-loading process. It was expected that the overall waste quantity could be minimized by maximizing the activity in each can, which was done to the extent practical; however, the project did not want to spend time and dose rate to workers dumping cans that exceeded shipping dose rate limits. The self-shielding properties of the soil, and the size and wall thickness of the bucket, resulted in an inconsistent correlation between the various bucket dose rates and the ERDF can dose rates. It is believed that soil down-blending was generally adequate for the last 100 cans, as evidenced by the variability in the ERDF can contact dose rate. It should be noted, however, that eight cans in this grouping exhibited at least 40 mR/h variability (see Appendix A for dose rate data for each loaded and shipped ERDF can). Without question, process improvements (whether in the form of using a different size excavator bucket, or optimizing full bucket dose-measuring capability, or something else) would lead to a method of maximizing waste container activity.

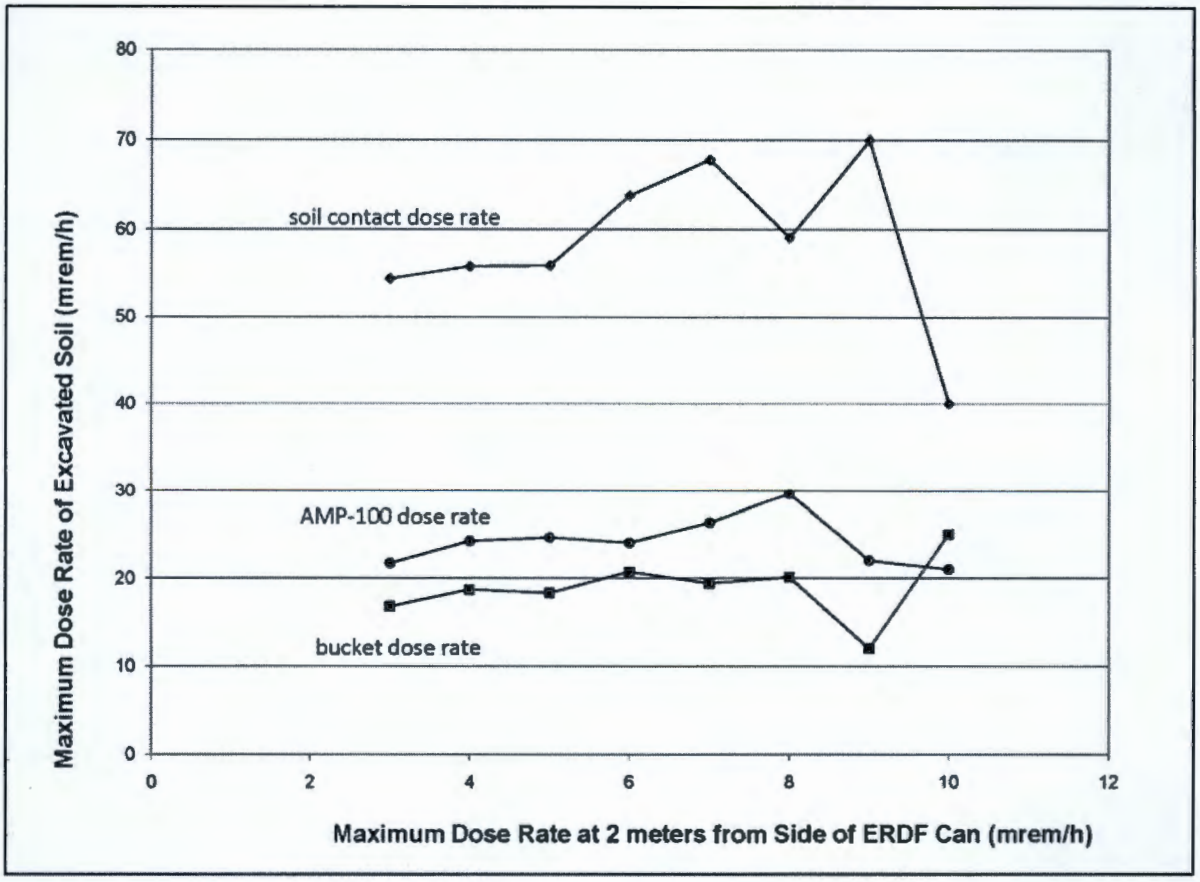

Figure 3-3. Comparison of Dose Rates Measured on Environmental Restoration Disposal Facility Cans and on Excavated Soil

3.2.2.3 Contamination Control

Site standard radiological control practices were employed to ensure contamination control for protect personnel and equipment. During excavation, the open hole and surrounding area were periodically sprayed with water to hold down dust and prevent contamination spread. Also, a commercial product (by Earth Bound[4]) was used to fix disturbed and potentially contaminated soil at the conclusion of each day's activities, with focus on the excavation site.

Because of the potential for contaminated soil to fall from the excavator bucket as it was moved from the excavation to the ERDF can, the path was designated and controlled as a contamination area, with the ERDF can/shuttle truck located in a radiological area. The portion of the radiological area between the ERDF can and the contamination area was protected from inadvertent contamination by a large plastic "bib" that was magnetically affixed to the side of ERDF can and extended into the contamination area.

Despite these efforts, excavation and waste shipping were briefly halted on July 9, 2008, when an ERDF can being loaded elsewhere onsite was observed to possess high-activity cesium-137 contamination on a horizontal surface near the can's tailgate. Recent history for this particular can revealed that it had been loaded with contaminated soil at the 216-B-26 Trench and then shipped to ERDF for disposal. Because

[4] Earth Bound Environmental, LLC, Litchfield Park, Arizona.

of the potential for the contamination to have been on the can when it left the 216-B-26 Trench excavation site, the following process modifications were incorporated to minimize the potential for contamination of ERDF cans: (1) the excavator bucket load was reduced so the surface was no less than approximately 15 cm (6 in.) below the lip of the bucket; (2) when the bucket was emptied into the ERDF can, dedicated personnel observed the emptying process to spot any soil that dropped outside of the bucket and onto the can; and (3) additional radiological surveys were performed on the can, with particular focus on the horizontal surfaces. Subsequently, analysis of the contamination raised suspicion that the source of contamination observed may not have been from the 216-B-26 Trench because strontium-90 was not present.

Contamination control was compromised by a severe wind storm on July 10, 2008, after work had been shut down for the day. Shortly after 5 p.m., wind toppled the survey station platform where workers stood to tack weld the ERDF can liner and complete tarp installation on the cans. The combination of pierced netting installed to provide shade and the section of solid platform had evidently provided sufficient area to catch the wind and render the scaffold structure unstable. Other less-significant structures were also damaged. Of greater consequence, however, was contamination spread from the excavation, which resulted in a contaminated area approximately 26.5 m by 35.8 m (85 ft by 115 ft) east of the excavation that exhibited up to 35,000 disintegrations per minute (dpm) beta/gamma. The Hanford Meteorological Station (near the Integrated Disposal Facility and approximately 1.8 km [5,700 ft] from the excavation site) recorded peak wind gusts between 77.3 and 80.6 km/hr (48.03 and 50.1 mph) between 5:00 and 5:30 p.m. Following recovery, which involved covering the contaminated area with clean soil obtained elsewhere, excavation resumed on July 12, 2008.

A downwind composite portable air sampler (sampler N570, located approximately 110 m [350 ft] southeast of the excavation) collected a sample for the period of July 1 through October 23, 2008, showing a cesium-137 "hit" exceeding 10 percent of the concentration listed in Table 2 of 40 CFR 61, Appendix E ("National Emission Standards for Hazardous Air Pollutants," "Appendix E to Part 61 – Compliance Procedures Methods for Determining Compliance with Subpart I"); however, no violation occurred. The value was reported to the Washington State Department of Health in accordance with a Hanford Site air operating permit requirement to make a notification for analytical results that are greater than 10 percent of the Table 2 concentrations. It is believed that the July 10 wind storm that spread contamination from the excavation likely carried contamination to the air sampler.

Because the wind storm disabled the survey station, subsequent cans were placed on the ground for loading rather than leaving them on the shuttle truck. Can liner tack welding and tarp installation activities, which had been performed on the platform associated with the survey station, were now performed on the ground. This slowed the overall excavation process in regard to the time required to unload/reload the ERDF cans from and then onto the shuttle truck.

On July 15, 2008, additional reports were received describing contamination associated with ERDF cans that had previously been loaded with contaminated soil from the 216-B-26 Trench. This contamination was observed on both the inner and outer surfaces of the tarp that is placed over the can after the liner is tack welded over the contaminated soil. The evaluation noted the potential for such contamination to result from contaminated soil dispersal during the dumping operation at the ERDF. When the back of the tarp is unhooked and folded back to allow the can back door to be opened, the can is tipped up and the contents are dumped into the pit. Occasionally the can liner rips as the contents slide out of the can. Even though water spray is used during the dumping operation to control dust, there is opportunity for some "dusting" to occur, which could result in the observed contamination.

At the conclusion of the excavation, from July 24 to July 29, 2008, when the excavator was surveyed for radiological decontamination, it became apparent that virtually every oily surface of the excavator (including the closed engine compartment) was contaminated, up to a maximum of 20,000 dpm/100 cm^2. While accessible surfaces could be decontaminated, it was determined that complete decontamination was impractical. A review by operations and radiological control personnel concluded that the most likely cause of the extensive contamination was the wind storm that occurred July 10, which also spread contamination outside of the excavation in a general area (see previous discussion).

3.2.2.4 Evaluation of Excavation Cost Parameters

The cost of excavating one-third of the 216-B-26 Trench includes not only the cost of the excavation, but also the cost of the characterization (Phase 1 of the treatability test), which led to better definition of the hazards and provided updated information for waste disposition.

The cost for Phase 1 of the treatability test was approximately $1,100,000. This cost covered preparing regulatory documentation, renting equipment, installing logging/sampling holes, acquiring geophysical data, analyzing samples, and reporting.

The cost of Phase 2 of the treatability test was approximately $3,600,000. This cost covered acquisition of equipment and infrastructure, personnel training, labor to perform the excavation and associated activities, ERDF waste disposal, and support (supervision, radiological control, safety, accounting, etc.). Some of the cost may have been associated with elements of the treatability test not associated with Phase 2, such as completing the Phase 1 report and planning for Phase 3 and 4 activities. Also, the cost may not include all expenditures (e.g., final equipment rental or waste disposal charges). Considering all of the down-time due to excessive wind and slow startup, the $3,600,000 cost is plausible.

The total quantity of waste disposed to the ERDF is 3,182,321 kg, or 3,182.3 metric tons (7,015,816 lb, or 3,507.9 tons). (Note that the ERDF record did not include the weight for two ERDF cans, each of which contained five buckets. The average waste weight per five-bucket can was added to the ERDF record.) This results in a cost of $1,130/metric ton (approximately $1,025/ton) based on a Phase 2 cost of $3,600,000. When the Phase 1 cost (approximately $1,100,000) is included in the total project cost, the cost increases to approximately $1,475/metric ton ($1,340/ton). On a volume basis, assuming the average quantity of soil in the 3.0 m^3 (3.9-yd^3) capacity bucket was 2.87 m^3 (3.75 yd^3) to avoid spillage during loading, and a total of 854 buckets loaded into ERDF cans, the Phase 2 cost is $1,470 m^3 (approximately $1,125/$yd^3$). When the Phase 1 cost (approximately $1,100,000) is included in the total project cost, the cost increases to approximately $1,920/$m^3$ ($1,470/$yd^3$). Apparent density of the waste is calculated to be approximately 1,300 kg/m^3 (3,182,321 kg ÷ 2,451 m^3 = 1,298 kg/m^3). When multiplied by a factor of 1.25 to account for the difference between a "loose density" and in situ density, soil density is approximately 1,625 kg/m^3, which is in the range for Hanford sediment.

In accordance with the treatability test plan, the production rates of various elements of the overall excavation process were tracked. As the process matured (if that can be claimed, considering that only about one-third of a single trench was excavated), rate data were increasingly collected in an effort to refine the cost estimate. The parameter receiving the most attention (because it paced all other activities) was the time to load an individual ERDF can. Other activities (e.g., tack welding the liner/installing the tarp, surveying the can, etc.) were integral but were found to require less time. Because these activities did not control the overall production rate, they did not receive much emphasis for improving their efficiency. Tables 3-3 and 3-4 summarize the activity steps and rate data, respectively, for the excavation. Table 3-4 also provides, as applicable, the rate used in the FFS to prepare the worker dose estimate.

Table 3-3. Excavation Scenario Comparison

Activity	Excavation Process	Focused Feasibility Study Cost Scenario	Focused Feasibility Study Dose Scenario
Remove overburden	Used excavator with a 3.1 m^3 (4-yd^3) bucket to remove the top 1.2 m (4 ft) of soil and place at side of the trench beyond the point of anticipated excavation. Controlled dust with single water truck during excavation process and a fixative application at end of the workday.	Use single 1.5- to 2.3 m^3 (2- to 3-yd^3) excavator to remove the top 3 m (10 ft) of soil. Load soil into two haul trucks that haul the soil to a temporary spoil pile. Control dust with one water truck. Remove top 3 m (10 ft) of soil.	NA
Down-blend and load ERDF can	Two laborers installed "bib" on side of can (and removed it after can was filled) and monitored loading to be certain that spills were not overlooked. Used excavator with a 3.0 m^3 (3.9-yd^3) bucket to down-blend highly contaminated soil within the excavation. RCT in remote location provided data from AMP-100 instrument on excavator to guide down-blending process. RCT supervisor interpreted AMP-100 and bucket dose rate data to disposition bucket load. Another RCT measured the dose of each bucket before emptying the bucket into the ERDF can. Loaded four to five buckets into each ERDF can. Dust controlled by water truck and laborer directing focused water spray into excavation.	Use excavator with 1.5- to 2.3 m^3 (2- to 3-yd^3) bucket to down-blend highly contaminated soil with available overburden. Down-blending performed within the excavation. RCT measures dose of each bucket before emptying it into ERDF can. Dust controlled by water truck and laborer directing focused water spray into excavation. ERDF can capacity assumed to be 8.4 bank m^3, or 9.7 loose m^3 (11 bank yd^3, or 12.7 loose yd^3).	Same as cost estimate, except as follows: • Excavator operator protected by leaded glass shield • RCT measured dose of every bucket before emptying bucket into ERDF can • 9 m^3 (12 yd^3) in each ERDF can.
Tack weld liner/install tarp	After loading, the liner was folded over and the shuttle truck moved the can to the survey station, where the can was weighed. Two laborers tack-welded the liner and folded the tarp over the open end of the ERDF can and secured it.	After loading, two laborers fold the liner over. A driver then moves the can a short distance away, where the liner is tack welded and the container is secured (tarp is folded over and fastened).	Same as cost estimate.
Survey can	The can was moved from the survey station to facilitate access to the can perimeter. A single RCT collected dose data at contact and 30 cm (11.8 in.) from three points on each side and one point on each end. The RCT also collected data at 2 m (6.6 ft) from a single point previously shown to have the highest dose.	Survey performed in survey building by a team of three RCTs. Following survey, the can is weighed.	An RCT surveys the can.

ERDF = Environmental Restoration Disposal Facility
NA = not available
RCT = radiological control technician

Table 3-4. Excavation Rate Summary

Activity	Duration (min)	Focused Feasibility Study Duration (min)
Remove overburden	Removed overburden from 51.8 linear m (170 linear ft) of trench in four partial workdays (see Table 3-1). Estimated volume of soil removed is 1,058.9 m^3 [(20 ft + 55 ft + 75 ft + 20 ft) x 55 ft x 4 ft x (1 yd^3/27 ft^3) = 1,385 yd^3]. Unable to determine number of hours worked on this activity because of multiple activities performed. Estimate first day approximately 4 hours (slow start), second and third days approximately 6 hours each, fourth day approximately 2 hours yields 58.8 m^3/hr (approximately 77 yd^3/hr).	Cost estimate: 97.1 m^3/hr (127 yd^3/hr) Dose estimate: Not addressed.
Down-blend and load ERDF can	Approximately 27.1 min/can, which (assuming 2.87 m^3/bucket [3.75 yd^3/bucket]) translates to (14.34 m^3 ÷ 0.45 hour (18.75 yd^3 ÷ 0.45 hour) = 32.1 m^3/hr (41.5 yd^3/hr).	Cost estimate: 42.1 m^3/hr (55 yd^3/hr) Dose estimate: 31.3 m^3/hr (41 yd^3/hr)[a]
Remove/stage another ERDF container	Approximately 10 minutes to remove bib on side of can where excavator approached, fold over liner, and perform survey, drive truck away, and stage another can for loading.	Cost estimate: Included in overall can loading rate. Dose estimate: Not addressed.
Tack weld liner/install tarp	Approximately 5 minutes to tack weld liner and install tarp.	Cost estimate: Not addressed Dose estimate: 2 minutes[a]
Survey can	Approximately 5 minutes plus another 5 minutes to complete paperwork.	Cost estimate: Not addressed Dose estimate: 5 minutes[a]

a. From DOE/RL-2004-66, *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites*, Appendix F, Section F3.4.

ERDF = Environmental Restoration Disposal Facility

The FFS assumed that trenches would be excavated to a depth of 4.6 m (15 ft) bgs and that one-half of the soil in the 3.4 to 4.6 m (11- to 15-ft)-bgs region would require down-blending at a 7:1 ratio to ensure that transportation requirements and ERDF acceptance criteria were met. The relatively uncontaminated soil above the highly contaminated layer was considered overburden, available either as source material for down-blending or for filling the excavation prior to cap installation. Both the cost and dose estimates assumed an efficient and mature process.

Obviously, this treatability test did not use a work flow representing a mature and efficient process. Equipment selection was based on the best judgment of personnel having recent excavation experience; a similar approach led to the layout of the detailed work flow. Excavator/bucket selection also considered the needs of a follow-up project unrelated to the treatability test. Because of the limited nature of the excavation, a single work station (for excavation and can loading) was employed. If the layout permitted a second truck/ERDF can to be staged while the first truck/ERDF can was loaded, the 10 minutes used to remove/stage another ERDF container could be devoted to excavation. Also, there was not an opportunity to evaluate equipment variables. Thus, the project was largely "stuck" with its initial assumptions and was able to make only minor adjustments.

Table 3-5 provides unit cost data for significant process elements. It should be noted that the total of these costs is a small fraction of the overall cost per ERDF can obtained by dividing total Phase 1 and Phase 2 costs by the number of cans disposed ($4,700,000 ÷ 180 cans = $26,100/can). Much of the total cost was associated with characterizing the 216-B-26 Trench (Phase 1 cost was $1,100,000), installing the infrastructure (e.g., personnel and equipment trailers, queue area for empty and loaded ERDF cans, and roadways), instrumentation, equipment rental, personnel training, down-time due to excessive wind, planning and safety meetings, and inefficiency resulting from learning on the job. Table 3-5 also includes unit costs predicted by the FFS for comparison.

Table 3-5. Cost for Each Environmental Restoration Disposal Facility Can for Significant Operations

Operation	Treatability Test Unit Cost[a] ($)	FFS Unit Cost[b] ($)
Prepare ERDF can for loading	37.50	30.26
Stage can and load	324.99	122.06
Weigh and survey can; close liner; install tarp	41.00	53.21
Prepare for shipment	66.80	N/A
Transport to ERDF, ERDF disposal	876[c]	980

a. Basis is average time for crew to perform operation.

b. Assumes multiple ERDF can work stations to keep supporting operations busy

c. The total ERDF-related costs were $157,670.33. Based on the total quantity of waste disposed to the ERDF of 3,182.3 metric tons (7,015,816 lbs), the ERDF costs were $49.5/metric ton ($44.9/ton).

ERDF = Environmental Restoration Disposal Facility

FFS = focused feasibility study

N/A = not applicable.

The most significant differences correspond to the ERDF can staging and loading operations. Besides taking longer to load a can than estimated by the FFS (32.1 m^3/hr [41.5 yd^3/hr] during the treatability test compared to 42.1 m^3/hr [55 yd^3/hr] estimated by the FFS) (Table 3-4), additional personnel were required during the treatability test. An additional RCT was required to support use of the AMP-100 dose meter mounted on the excavator that provided assessment of down-blending progress, a radiological control supervisor interpreted the AMP-100 and bucket dose rate data to disposition the bucket (it was either dumped into the ERDF can or returned to the excavation hole for additional down-blending), and two additional laborers were required to install the bib on the side of the can and monitor loading to ensure that spills were not overlooked. It is not unreasonable to assume that process improvements could eliminate the need for personnel devoted to looking for spills and extra personnel to assess down-blending adequacy, thereby approaching the staffing assumed in the FFS cost estimate.

3.2.2.5 Worker Radiation Dose

The excavation removed approximately 43 percent of the western third and 57 percent of the center section of the trench. If the excavation were designed to remove lateral contamination spread, this translates to approximately 164 Ci of cesium-137, based on logging data gathered during Phase 1 of the treatability test (43 percent of the 28 Ci in the west section, plus 57 percent of the 267 Ci in the center section), or approximately 25 percent of the entire trench inventory. By operation, worker dose can be

assigned as shown in Table 3-6. Table 3-6 also includes the worker dose predicted in the FFS after normalizing the values to 25 percent of the entire trench inventory.

The focus was to excavate a path at least 3.1 m (10 ft) wide and 4.6 m (15 ft) deep down the trench centerline, which would leave some of the inventory outside of the trench footprint. Because the excavation had a variable side-slope between 1:1 and 1:1.5, and the excavation width exceeded 3.1 m (10 ft) by approximately 0.5 m (1 or 2 ft), some portion of the inventory outside of the trench footprint was excavated. Assuming that worker dose is proportional to inventory, the estimated dose to excavate near-surface contamination from the entire trench is 789 mrem/0.25 (assuming that all contamination associated with the target section of the trench were excavated) = 3,156 mrem. If only one-half of the contamination associated with the target section of the trench were excavated, the estimated dose for the entire trench is 78 mrem/0.125 = 6,312 mrem. The worker dose predicted in the FFS is 8,000 mrem (8 rem).

Significant differences between the recorded dose and the FFS-predicted worker dose are noted for the excavator operator (recorded dose is approximately one-tenth of the predicted dose), dust control (recorded dose is approximately one-fifth of predicted dose), tack welding the ERDF can liner and installing the tarp (recorded dose is approximately one-third of the predicted dose), and ERDF can transport (recorded dose is approximately one-third of predicted dose). Note that more than 40 percent of the dose was incurred by ERDF personnel. This is essentially the same as the 37 percent predicted by the FFS estimate.

The Phase 1 report (DOE/RL-2008-26) predicted that the excavation dose would be approximately one-half of the dose predicted by the FFS based on the revised cesium-137 inventory estimate. Noting that it is considerably less than one-half of the FFS dose (see Table 3-6) may reflect, in part, that not all of the contamination in the target section of the trench was excavated. Also, the excavation scenario differed from the dose estimate scenario in that the highly contaminated layer was seldom exposed, resulting in the dramatic dose reduction for the excavator operator and for the person spraying water for dust control. In contrast, the FFS dose estimate scenario assumed that a 3.1 m by 3.9 m (10-ft by 12.5-ft) plane of highly contaminated soil was exposed.

Table 3-6. Worker Dose

Activity	Worker Dose (mrem)	
	Treatability Test	FFS[c]
Operate excavator to down-blend and remove contaminated soil	38.9	328
Survey loaded excavator bucket	30.6	4.2
Control excavation dust via water spray; install ERDF can bib	48.0[a]	286
Drive shuttle truck carrying loaded ERDF can to survey station	35.4	34.2
Tack weld ERDF can liner; install can tarp	92.9	251
Survey can	98.6	196
Complete can survey; verify queue not contaminated	41.1	Not analyzed
Install placards on ERDF cans	16.5	Not analyzed

Table 3-6. Worker Dose

Activity	Worker Dose (mrem)	
	Treatability Test	FFS[c]
Miscellaneous (waste specialist, supervision and management, and routine radiological surveys)	53.3	Not analyzed
ERDF can transport to/from ERDF	53.6[b]	173
ERDF can dumping/pit operations	279.9[b]	732
Totals	**788.8**	**2,004.4**

a. The majority of dose was incurred by personnel installing/removing ERDF can bib.

b. Data provided by contractor operating the ERDF.

c. DOE/RL-2004-66, *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites*. These values were normalized to 25 percent of trench inventory assumed in the focused feasibility study (8,000 mrem).

ERDF = Environmental Restoration Disposal Facility

FFS = focused feasibility study

3.2.2.6 Excavation Rate

Detailed information was collected for nearly every ERDF can loaded and processed, with emphasis on actual loading time. For most ERDF cans, the time was recorded when it was placed and ready for loading, as well as the time that each bucket was emptied into the can. Data recording for can survey or other processing activities were infrequent because they were judged to be less relevant to the overall excavation rate. The overburden removal rate was estimated because only general (rather than specific) data were collected. Project records do not provide the actual amount of time that overburden removal was conducted.

The above-average excavation rates were compared with the rates in the FFS. In all cases, the FFS excavation rate was faster, as expected. However, it is believed that if the process were continued, further process improvements would allow the FFS excavation estimate to be achieved. The excavation rates could, however, be limited overall by the strontium-90 rolling inventory established at ERDF. During the treatability test, the ERDF limits for strontium-90 and the lower priority at ERDF for disposal of the treatability test wastes combined to limit the production rate to that which was achieved. The full-scale production rate could be further compromised by other projects/facilities introducing wastes with high strontium values to ERDF, which could further limit production capabilities, depending on the priority established at ERDF for disposal of wastes from the various projects.

3.2.3 Lessons Learned and Discussion

Based on the experience gained during the treatability test, it is believed that considerable improvement could be made in the excavation activities, if a remedy that includes partial excavation is selected for the BC Cribs and Trenches within the constraints as discussed in Section 3.2.2. In the category of equipment selection, with focus on the excavator, the following recommendations are offered:

- For down-blending the highly contaminated soil located approximately 3.1 to 3.7 m (10 to 12 ft) bgs and loading the soil into ERDF cans, a smaller and differently shaped bucket would facilitate emptying the soil into the ERDF can with minimal spillage and facilitate dose assessment. Additionally, the design of the bucket would be preferable without recesses or pockets that have the

potential to capture/hold contaminated soil, which also increases the likelihood of spilling and exacerbates the complexity of decontamination. . The approximate 3.1 m^3 (4-yd^3)-capacity bucket used for the test barely fit inside the ERDF can. Also, the shape and construction of the bucket was such that assessing the dose of contained soil was constrained by the thickness of the bucket's sidewalls and the amount of soil within relative to the area of bucket sidewall available for dose measurement. The bucket could still be approximately 2.3 m^3 (3-yd^3) capacity, but it should be narrower to provide ample clearance between bucket and can, and also provide more sidewall area per mass of soil within, which would improve the assessment of down-blending. Although a smaller bucket would load less material per evolution, it could be emptied more quickly and might not adversely affect the loading rate. The excavator used for this test was best suited for overburden removal. With the very large bucket and moderate reach length, the excavator was effective in mass soil removal.

- Consider developing a remote system to measure the dose of the loaded bucket. This would provide consistent measurement not subject to variations by individual RCTs. It could also (depending on the system) take less time.

- Select an excavator that positions the operator high enough so lowering of the bucket into the ERDF can be observed to minimize spilling.

Other equipment-related recommendations are as follows:

- Expand the capability to assess down-blending progress while the excavator bucket is still within the hole. The single remote-reading instrument employed was very helpful, but approximately 12 percent of the buckets presented to the RCT for dose measurement prior to loading needed to be returned to the hole for additional down-blending due to discovery of a "hot spot." This could be accomplished using an instrument with expanded capability, or perhaps multiple instruments.

- Because the ERDF can liner tended to billow in the wind until loading was well underway (despite the elastic hold-down cord encircling the can and overlapped liner), a better method of holding the liner in place is needed. The sandbags tossed in the bottom immediately following liner installation achieved this purpose, but they tended to slide to the can end when the can was picked up by the shuttle truck. Then, if the wind was sufficient, the liner will billow out and pull out of the restraining cord.

- A stable of dedicated ERDF cans is recommended to provide a reliable source of cans and to eliminate uncertainty regarding the source of contamination on the cans (when encountered).

The overall layout would be improved by the following recommendations:

- Positioning the ERDF can directly behind the excavator required the excavator to make a 180-degree swing from the excavation to the can in order to empty the bucket. Shortening the swing required by the excavator by positioning the ERDF can perpendicular to the excavator (90-degree arc) would reduce the overall loading time and decrease the surface area for potential contamination spread.

- Providing multiple loading stations for the same excavator, if feasible, would increase excavator usage. The single loading station used for the treatability test essentially stopped excavator activity while a loaded can was prepared for removal and another can was being staged for loading.

Assuming that reasonable equipment and process improvements are adopted, the production rates observed during the treatability test could likely be increased to the rates assumed by the cost estimate in the FFS for a large-scale, mature partial excavation involving contaminated soil requiring down-blending.

At this point, there is no basis for revising that portion of the cost estimate associated with excavation and disposal. Similarly, process improvements should result in further dose reduction to workers. For smaller operations, rates and costs observed during this treatability test may be more appropriate.

3.3 Phase 3 – Characterization of the 216-B-14 Crib

The focus of Phase 3 of the treatability test was to characterize the nature and extent of contamination in the 216-B-14 Crib, similar to testing conducted in Phase 1 for the 216-B-26 Trench.

3.3.1 Process Description

The 216-B-14 Crib consists of a square, wood and steel crib structure that is 3.1 m by 3.1 m (10 ft by 10 ft) and was set on a gravel bed in a excavated area 12.2 m by 12.2 m (40 ft by 40 ft) at the base (Figure 3-4). The effluent pipeline discharged contaminated liquids to the crib structure.

Nineteen shallow (approximately 7.6 m [25-ft]-deep) DPT holes were installed in the vicinity of the crib to determine the vertical and lateral extent of cesium-137 contamination greater than 750 pCi/g (Figure 3-4). The test plan specified that eight boreholes would be installed through the floor of the crib (DOE/RL-2007-15). Six of these eight boreholes were installed at the locations indicated in the test plan; two of the borehole locations were moved to accommodate an exclusion area around the crib structure (*Hanford Federal Facility Agreement and Consent Order* [Tri-Party Agreement] [Washington State Department of Ecology et. al 1989], Change Notice TPA-CN-237, *Change Notice for Modifying Approved Documents/Workplans in Accordance with the Tri-Party Agreement Action Plan, Section 9.0, Documentation and Records, DOE/RL-2007-15, Rev. 0, Excavation-Based Treatability Test Plan for the BC Cribs and Trenches Area Waste Sites*, signed September 2008). The test plan further specified that at least one set of step-out boreholes (adaptive cluster boreholes) would be installed near (but outside of) the area of the crib floor to determine the lateral extent of contamination. A total of 11 step-out boreholes, grouped in four sets, were installed beyond the 216-B-14 Crib floor (Figure 3-4). Small-diameter total gamma logs were run in all 19 of the boreholes. Following geophysical logging, all of the boreholes were decommissioned.

Borehole installation was conducted from September 11, 2008, through September 24, 2008. Geophysical logging was conducted from September 15 through September 24, 2008. Each borehole was installed using a hydraulic hammer rig mounted on a backhoe tractor, which facilitated movement between push locations. Each installed borehole consisted of a 6.4 cm (2.5-in.)-diameter, 1.0 cm (0.375-in.)-thick casing left in place to allow geophysical logging.

Geophysical logging was conducted using a 2GHA-1000 Triple Gamma[5] logging tool to measure total gamma activity. The probe was lowered to the bottom of the borehole, and data were collected at 15 cm (6-in.) intervals.

[5] 2GHA-1000 Triple Gamma tool is a product of Mount Sopris Instrument Co., Inc., Golden, Colorado.

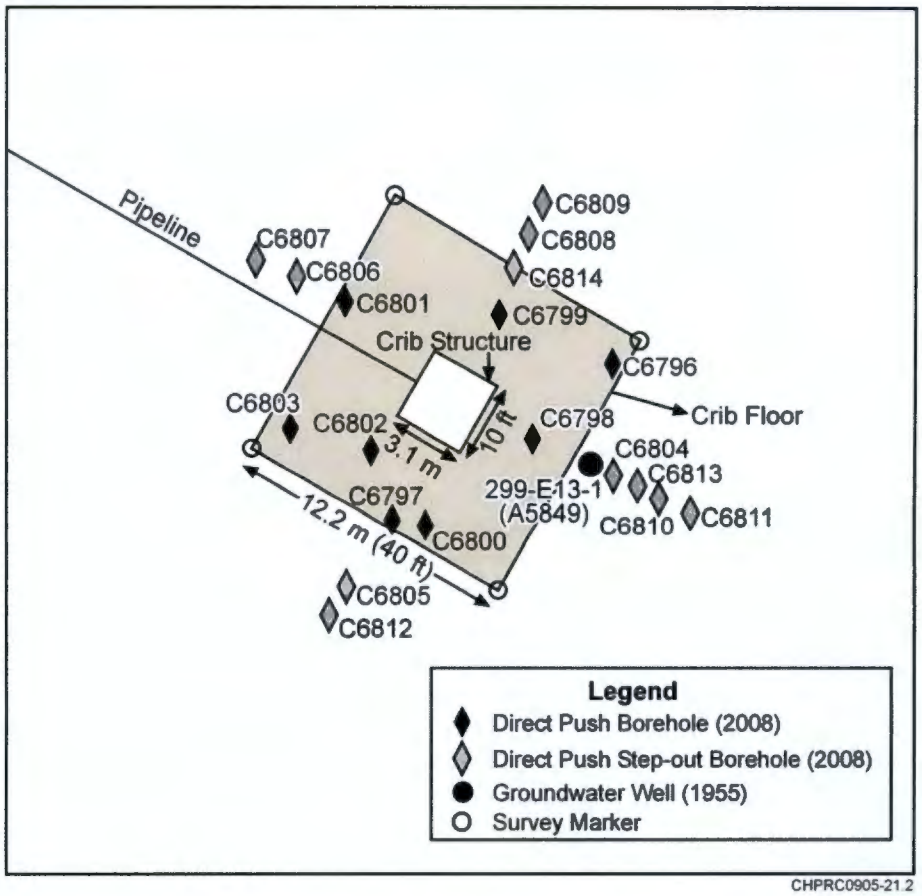

Figure 3-4. Location of Boreholes at the 216-B-14 Crib

Geophysical logging also was conducted in well 299-E13-1 (A5849), a nearby groundwater well that was drilled in 1955 (Figure 3-4). The same Triple Gamma logging tool was used to measure the gamma activity profile to a depth of 15.2 m (50 ft) bgs. This well, which is 15.6 cm (6.1 in.) in diameter, was logged in April 2005 using the high-resolution SGLS. The SGLS uses a high-purity germanium (HPGe) detector to record the gamma energy spectrum with an energy resolution of 2 to 4 keV. With this detector, it is possible to identify characteristic gamma emissions for specific radionuclides. Each radionuclide can be assayed from net counts at a specific energy level, with corrections for borehole conditions. Because the size of the detector used on the SGLS requires a minimum borehole diameter of 10.2 cm (4 in.) for deployment, the SGLS could not be used in the hydraulic hammer rig push holes. The Triple Gamma logging tool uses a combination of sodium iodide and Geiger-Mueller detectors to measure gamma activity over a wide range of activity levels. However, the detectors count all gamma activity without regard to energy level and, thus, are unable to identify specific radionuclides. Count rates are converted to units of "equivalent radium" (eRa) or "equivalent cesium" (eCs). In either case, the assumption is that the observed level of gamma activity is equivalent to that emitted by a uniform concentration of either radium-226 or cesium-137. Equivalent radium is generally assumed to be representative of naturally occurring radioactivity, and it includes the effects of radium daughters in secular equilibrium, as well as contributions from potassium-40 and the thorium-232 decay series. Equivalent cesium is assumed to be representative of man-made contamination.

Bremsstrahlung in the casing resulting from high concentrations of strontium-90 will contribute to gamma activity in the borehole, with the result that the reported equivalent cesium values include a contribution

from strontium-90, if present. However, it is not possible to estimate relative cesium-137 and strontium-90 concentrations from total gamma data.

The SGLS data collected at well 299-E13-1 in 2005 indicated that the gamma activity was dominated by cesium-137, with a maximum concentration of 2.1 million pCi/g at 12.2 m (40 ft) bgs (12.5 m [41 ft] below top of casing). Comparison between the small-diameter Triple Gamma and the SGLS data was good.

The 2008 geophysical logging data for the 19 DPT boreholes and for the existing groundwater well are provided in Appendix B.

3.3.2 Results

The 216-B-14 Crib is approximately square and is oriented 30 degrees clockwise with respect to north (Figure 1-1, Figure 3-4). For convenience, a local grid was established for visualization (Figure 3-5). The local grid is defined by "X" and "Y" axes in the horizontal plan parallel to the crib structure, with the Y-axis oriented at north 30 degrees east; the Z-axis is vertical. All local coordinates are expressed in feet (for consistency with the original design drawings and the log data). The X and Y coordinates are expressed in terms of distance in feet from the southwest corner of the gravel layer (i.e., the crib floor footprint). The coordinates of this point in the Washington State Plane Coordinate System (south zone) are easting at 573640.68 m and northing at 134405.49 m.

The Z coordinate is expressed in terms of elevation in feet above mean sea level (based on the Hanford plant coordinate system.) The conversion was made by noting that top of casing elevation for well 299-E13-01 is reported as 226.1 m (741.9 ft) in Hanford wells (PNL-8800, *Hanford Wells*). The elevation listed in the Hanford Well Information System is 227.778 m (747.301 ft). These elevations are based on different vertical data; however, on a small scale, a conversion can be made as shown in Equation 3-1:

$$Z\ (ft) = 3.28083\ (ft/m) \times Elev\ (m) - 5.40\ ft = 742\ ft \qquad \textbf{(Equation 3-1)}$$

This assumes that the casing has not been modified. The conversion is in agreement with elevations shown on the construction drawings. For each borehole, the reported surface elevation is converted to feet, and log data are converted from depth to elevation. Elevations are rounded to the nearest 0.15 m (0.5 ft).

For a gamma log, the area under the log curve represents the product of the average concentration (grade) over the measurement interval, multiplied by the thickness of the interval. This is known as the grade thickness product. For each borehole, the grade thickness product is computed for 0.3–m (1-ft) intervals and expressed in terms of pCi/g - ft.

Geophysical logging of 19 shallow boreholes indicated that the highly contaminated layer at the 216-B-14 Crib is much thicker than the layer at the 216-B-26 Trench. Figure 3-6 shows a three-dimensional plot of the data for all 19 boreholes in the 216-B-14 Crib. Each borehole is shown as a blue line, and equivalent cesium values are plotted as spheres, with the size and color of the sphere indicative of the logarithm of contamination concentration at that point. The average depth of the maximum cesium-137 concentration in the eight boreholes within the 216-B-14 Crib floor footprint is 4.9 m (16 ft), which is 1 m (3 ft) below the base of the crib (Table 3-7). The average depth of the maximum cesium-137 concentration in the 11 boreholes beyond the 216-B-14 Crib floor footprint is 5.5 m (18 ft) (Table 3-7). The zone of relatively high cesium-137 concentrations (greater than 1,000 pCi/g) tends to be 2.1 to 3.5 m (7 to 12 ft) thick within the area of the crib floor and 0.2 to 3.0 m (1 to 10 ft) thick beyond the area of the crib floor.

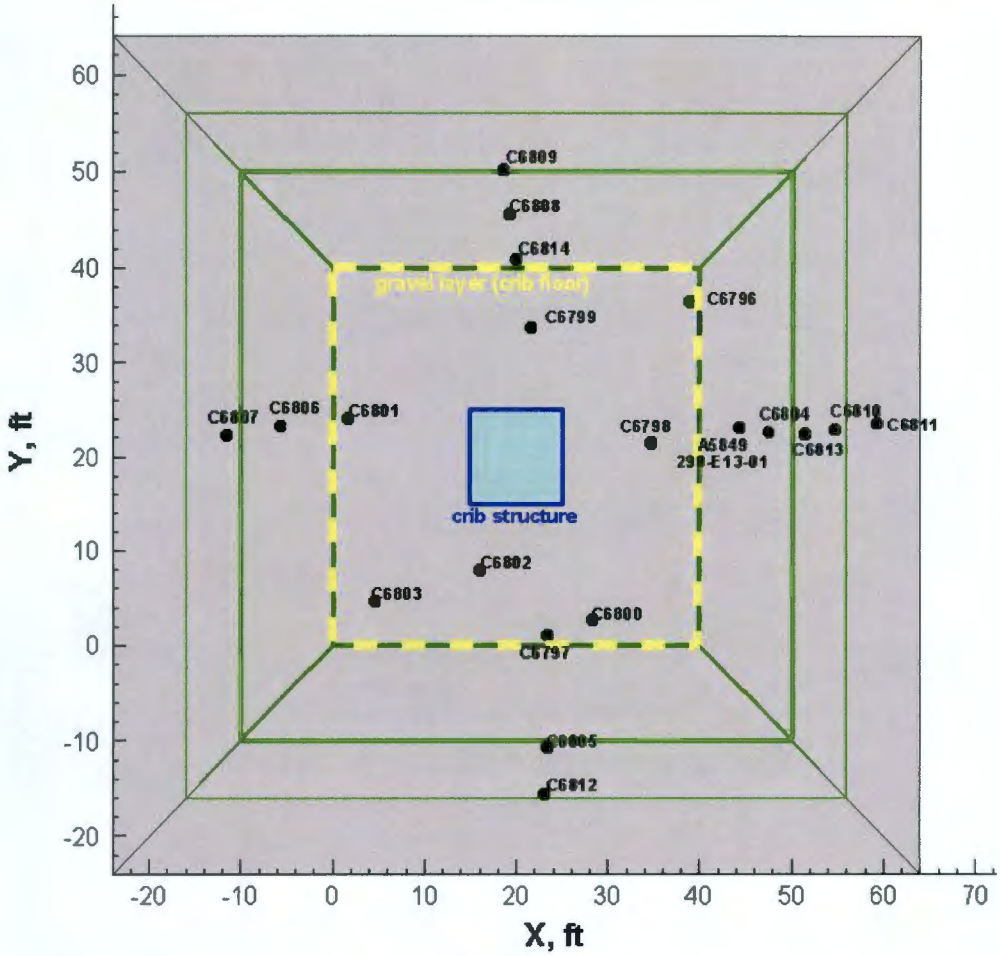

Figure 3-5. Local Grid at the 216-B-14 Crib

In the upper 4.6 m (15 ft) of the soil column, the maximum equivalent cesium-137 concentration was greater than 750 pCi/g in all eight initial boreholes drilled through the crib floor footprint (Table 3-7); however, the addition of the step-out boreholes was successful in delineating the lateral extent of the cesium-137 contamination greater than 750 pCi/g within this upper 4.6 m- (15-ft)-thick zone. Within each set of step-out boreholes (Figure 3-4), one pair defines the lateral extent of the cesium-137 contamination greater than 750 pCi/g in the upper 4.6 m (15 ft) of the soil column (i.e., the cesium-137 contamination changes from greater than 750 pCi/g to greater than 750 pCi/g between the two boreholes in each pair) (Table 3-8).

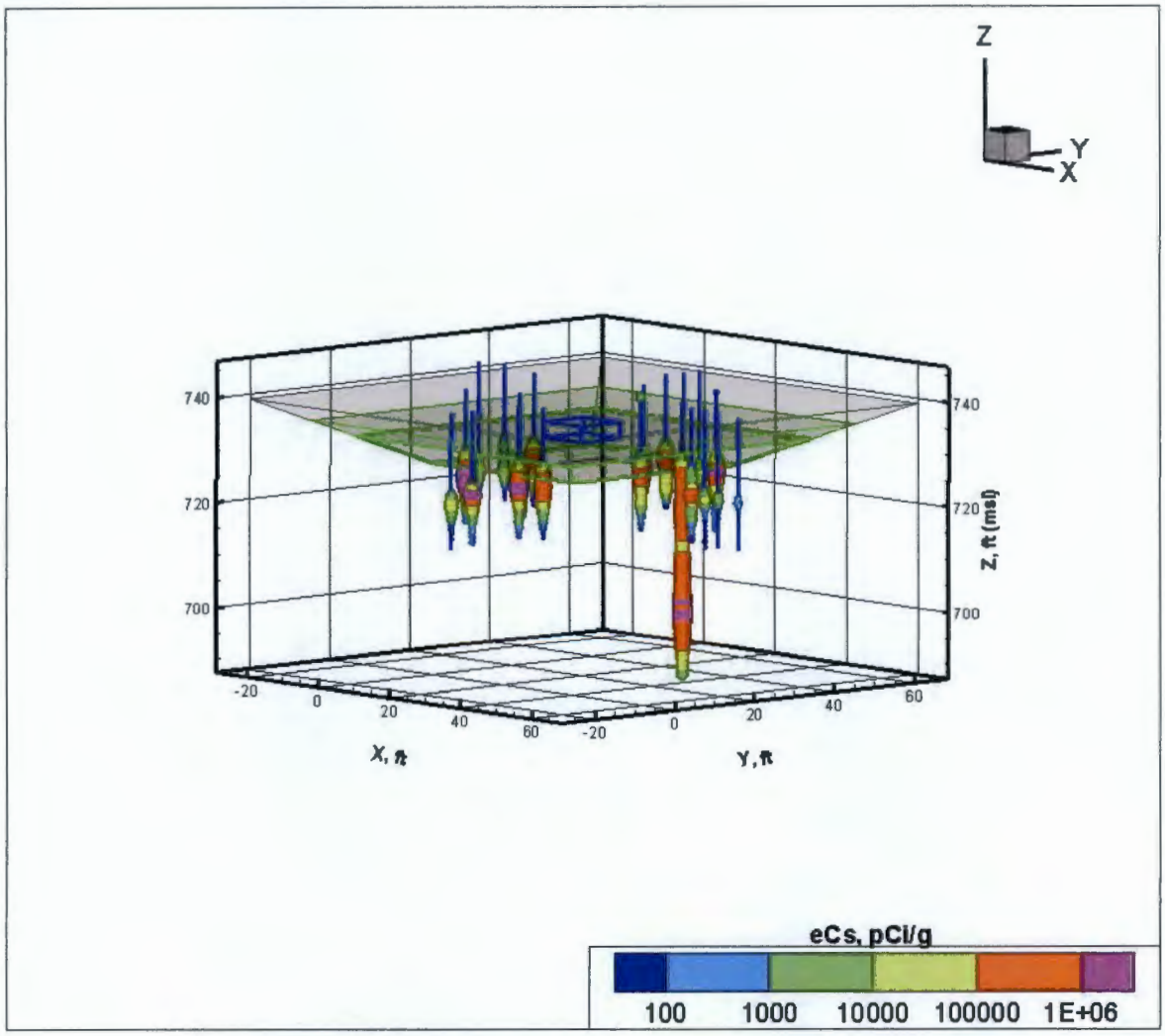

Figure 3-6. Distribution of Cesium-137 Contamination at the 216-B-14 Crib

At the 216-B-26 Trench, most of the contaminated soil was found in a thin layer, 0.3 m (1 ft) thick, at a depth of 3.4 to 3.7 m (11 to 12 ft) bgs (DOE/RL-2008-26). The most likely explanation for the different distributions of cesium-137 at these two sites is that the 216-B-14 Crib received a larger volume of liquid discharged over a much smaller area of infiltration. The 216-B-26 Trench, which received 5.9 million L (1.6 million gal) of liquid, is 152 m (500 ft) long and 3 m (10 ft) wide at its floor. The 216-B-14 Crib, which received 8.7 million L (2.3 million gal) of liquid, is 12.2 m by 12.2 m (40 ft by 40 ft) at its floor. Waste was discharged to the crib in batches of 41.7 m^3 (11,000 gal) via a 35 cm (14-in.)-diameter pipe from the nearby siphon tank. The gravel ensured relatively uniform distribution of waste over the crib footprint; the rapid discharge of waste to the crib contributed to deeper penetration into the vadose zone.

Table 3-7. Maximum Cesium-137 Concentrations at the 216-B-14 Crib

216-B-14 Crib Borehole	Maximum Cs-137 Concentration (pCi/g)	Depth of Maximum Cs-137 Concentration		Maximum Cs-137 Concentration in Upper 4.6 m (15 ft) (pCi/g)
		ft	m	
Within Crib Floor Footprint				
C6796	2.24E+06	15	4.6	2.24E+06
C6797	2.10E+06	16	4.8	1.04E+06
C6798	6.63E+05	15	4.6	6.63E+05
C6799	8.49E+05	16	4.9	2.28E+05
C6800	8.95E+05	16	4.8	8.09E+05
C6801	1.08E+06	17	5.1	1.73E+05
C6802	1.09E+06	16	4.8	3.42E+05
C6803	4.35E+06	18	5.5	3.02E+05
Beyond Crib Floor Footprint				
C6804	2.84E+05	17	5.2	4.44E+03
C6805	1.27E+06	17	5.1	2.42E+04
C6806	1.74E+04	20	6.1	2.08E+03
C6807	1.60E+04	21	6.3	1.71E+02
C6808	2.44E+04	20	5.9	1.41E+02
C6809	1.51E+04	20	6.1	ND
C6810	6.08E+03	17	5.2	2.66E+01
C6811	1.17E+03	17	5.0	1.97E+01
C6812	4.60E+04	18	5.3	1.34E+02
C6813	2.37E+04	17	5.2	6.32E+01
C6814	7.24E+05	16	4.9	1.51E+05
299-E13-1	2.11E+06	41	12.5	3.21E+05

ND = not detected

Table 3-8. Pairs of Boreholes that Define the Lateral Extent of Cesium-137 Contamination at the 216-B-14 Crib

Step-Out Borehole Pair	Maximum Cesium-137 Concentration in Upper 4.6 m (15 ft) (pCi/g)	Approximate Distance from Center of 216-B-14 Crib Structure	
		m	ft
C6806	2.08E+03	7.9	26
C6807	1.71E+02	9.8	32
C6805	2.42E+04	9.1	30
C6812	1.34E+02	10.7	35
C6804	4.44E+03	7.6	25
C6813	6.32E+01	8.8	29
C6814	1.51E+05	6.1	20
C6808	1.41E+02	7.6	25

All of the 216-B-14 Crib boreholes terminated at approximately 7.6 to 7.9 m (25 to 26 ft) bgs. None of these boreholes showed cesium-137 activity greater than 750 pCi/g at total depth; however, logging of well 299-E13-1 to 15.2 m (50 ft) indicates that the contamination may extend much deeper.

Examination of the log data indicates that little or no contamination was encountered above Z = 223.4 m (733 ft), which corresponds to the top of the gravel layer on which the crib is constructed. The total depth of the DPT holes constrains the inventory estimate to $Z \geq 218.2$ m (716 ft). Inspection suggests that the bulk of the contamination occurs in the region $-4.9 \text{ m} \leq X \leq 18.3$ m and $-6.1 \text{ m} \leq Y \leq 15.8$ m ($-16 \text{ ft} \leq X \leq 60$ ft and $-20 \text{ ft} \leq Y \leq 52$ ft). A three-dimensional grid was established within these dimensions for estimating total cesium-137 inventory. Figure 3-7 shows the extent of this grid. Each point on the grid represents a volume of 0.6 m by 0.6 m by 0.3 m (2 ft by 2 ft by 1 ft), or about 0.11 m^3 (0.13 yd^3).

Simplifying assumptions for the cesium-137 inventory estimate include the following:

- Because contamination is reported in terms of activity per unit mass (e.g., pCi/g), the estimated inventory is proportional to the soil density. In this estimate, a soil bulk density of 1.9 g/cm^3 is assumed. A higher or lower bulk density will have a linear effect on the results.
- The estimated inventory is proportional to the horizontal extent of the contamination. The limit of the horizontal extent was estimated based on data from the DPT boreholes.
- The volume between the ground surface (Z = 226.2 m [742 ft]) and Z = 223.4 m (733 ft) is presumed to be clean. This is a reasonable assumption, as Z = 223.4 m (733 ft) corresponds to the top of the coarse gravel layer through which contamination is presumed to have been distributed. It is possible, however, that some contamination will be encountered above this level in the immediate vicinity of the crib structure.
- The vertical extent of the contamination was limited to the total depth of the 19 DPT boreholes (7.6 to 7.9 m [25 to 26 ft]). However, data from existing groundwater well 299-E13-1 indicate that the contamination may extend much deeper.

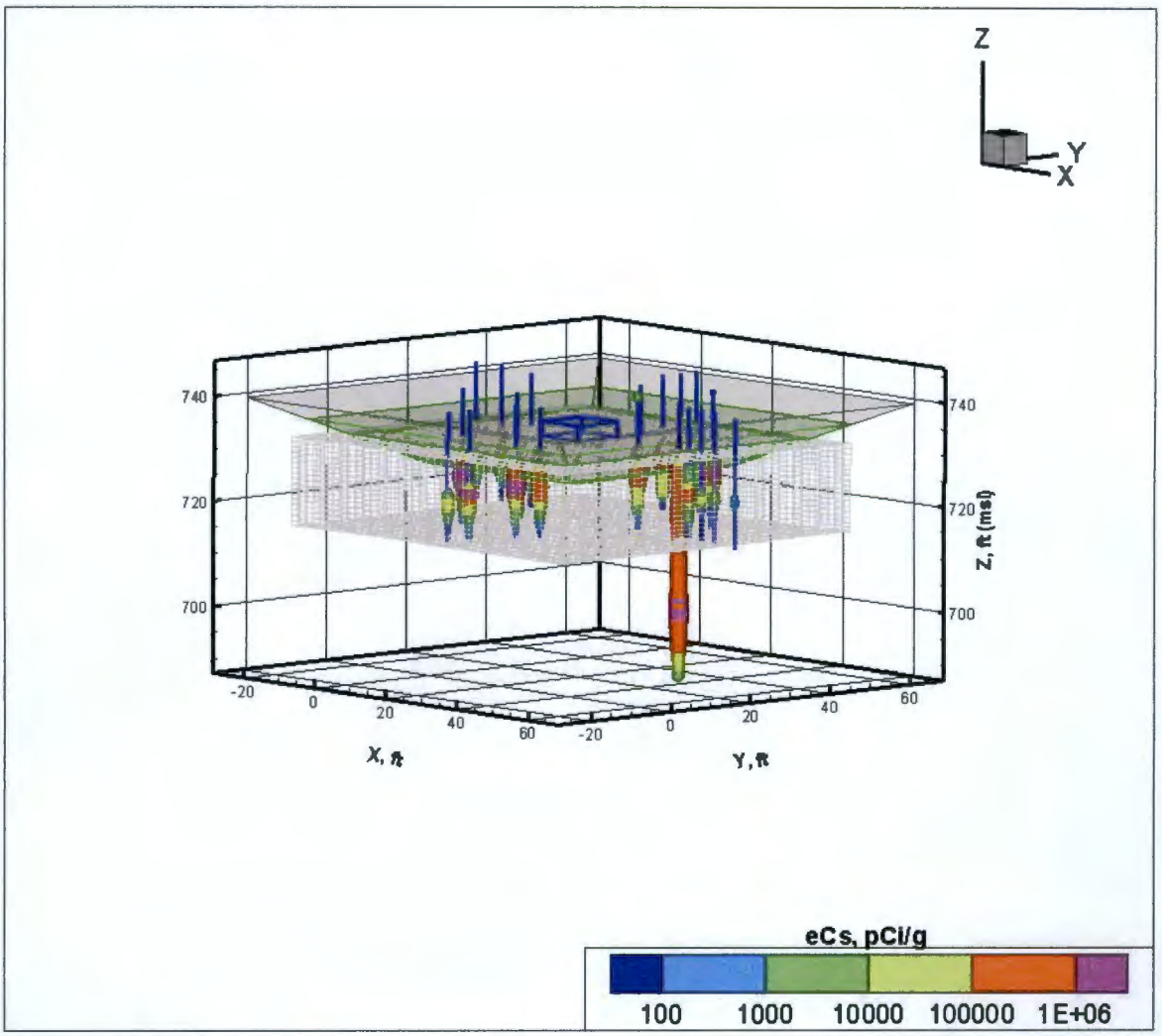

Figure 3-7. Extent of Grid for Inventory Estimate at the 216-B-14 Crib

Borehole data can be interpolated to estimate equivalent cesium values at the grid points (Figure 3-7). This process is complicated by the relatively thick interval of high contamination encountered in borehole C6803 and the high contamination values encountered in borehole C6796. Since there are no other boreholes between these holes and the corners of the grid, high contamination values tend to propagate toward the corners of the grid during the interpolation calculations. After experimenting with a number of interpolation approaches, an inverse-distance squared algorithm was chosen as providing the most reasonable contaminant distribution. For each grid point, the estimated equivalent cesium concentration was calculated from the nearest 32 points, distributed by octants within the local coordinate system. The exponent was set at 2. Figures 3-8, 3-9, and 3-10 show views of the estimated equivalent cesium contamination profile in the X-Y, X-Z, and Y-Z planes, respectively.

Table 3-9 lists the estimated cesium-137 inventory as a function of elevation and depth below ground surface (bgs). The total quantity of cesium-137 in the volume encompassed by the grid is estimated to be 740 Ci. This assumes that all gamma activity within the grid volume is attributed to cesium-137.

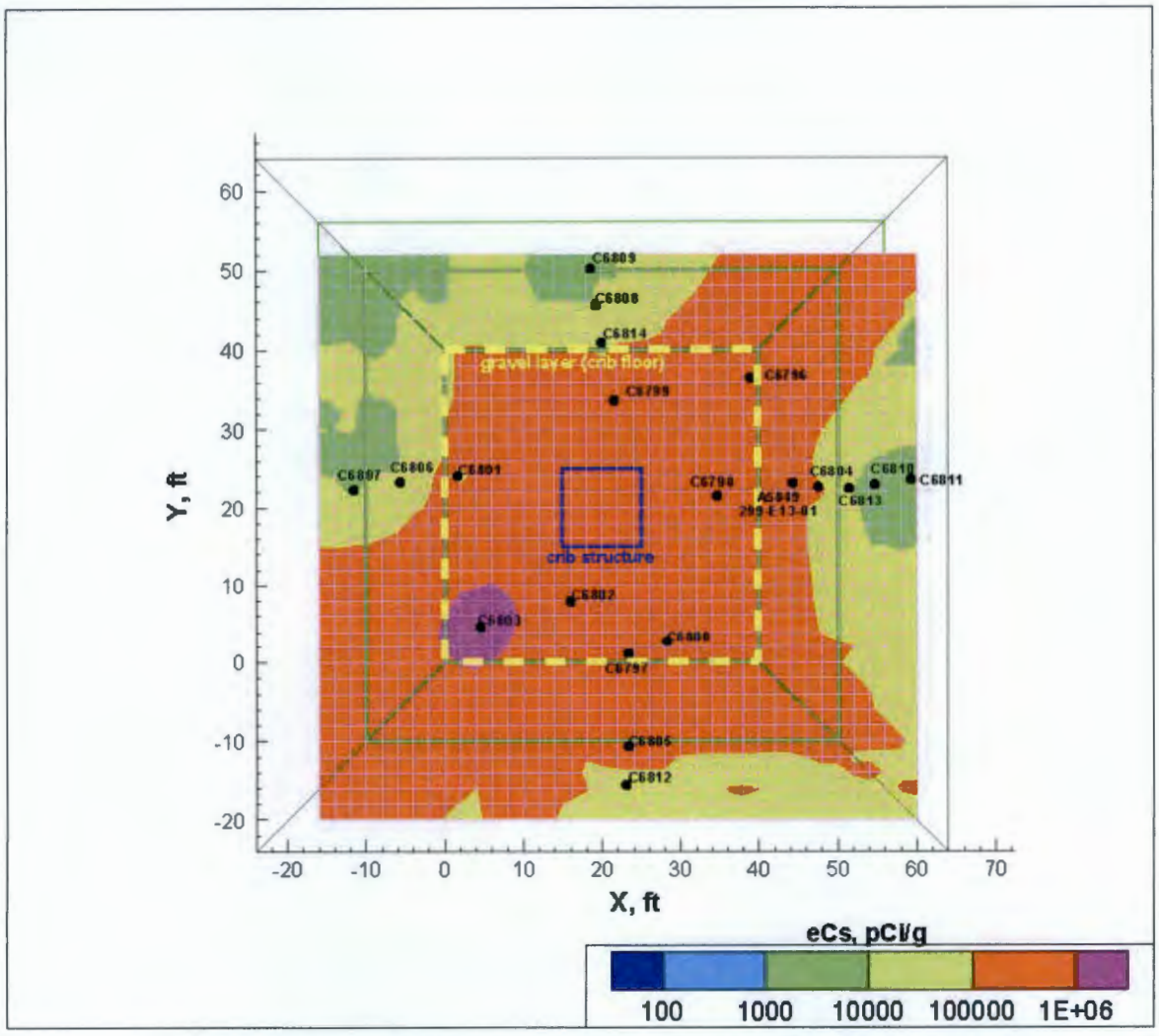

Figure 3-8. Equivalent Cesium Distribution in the X-Y Plane at the 216-B-14 Crib

The inventory estimate described above is suspected of being somewhat high because of the effects of the high equivalent cesium detected in borehole C6803 and, to a lesser degree, in borehole C6796. Most of 19 DPT boreholes fall near orthogonal sections parallel to the X and Y axes, passing through the center of the crib; however, boreholes C6803 and C6796 occur along a diagonal (Figure 3-5), which more or less bisects the two sections. There are no step-out boreholes close to either of these two boreholes. Borehole C6803 encountered a maximum equivalent cesium concentration of 4.3 million pCi/g at 5.5 m (18 ft) depth, which was the highest concentration encountered during the investigation. The interval in this borehole where equivalent cesium exceeds 1 million pCi/g extends from 4.7 to 5.6 m (15.5 to 18.5 ft). There are no other boreholes in the immediate vicinity, and the lateral extent of the high concentration interval is poorly known. More importantly, there are no step-out boreholes along the diagonal, and values in borehole C6803 have an inordinate influence along the diagonal. This results in interpolation of high contaminant values out to the corner of the contaminated volume. To a lesser degree, a similar phenomenon occurs in the vicinity of borehole C6796. The net effect is that, based on the interpolation, relatively high equivalent cesium levels appear to extend beyond the contaminated volume along the diagonal.

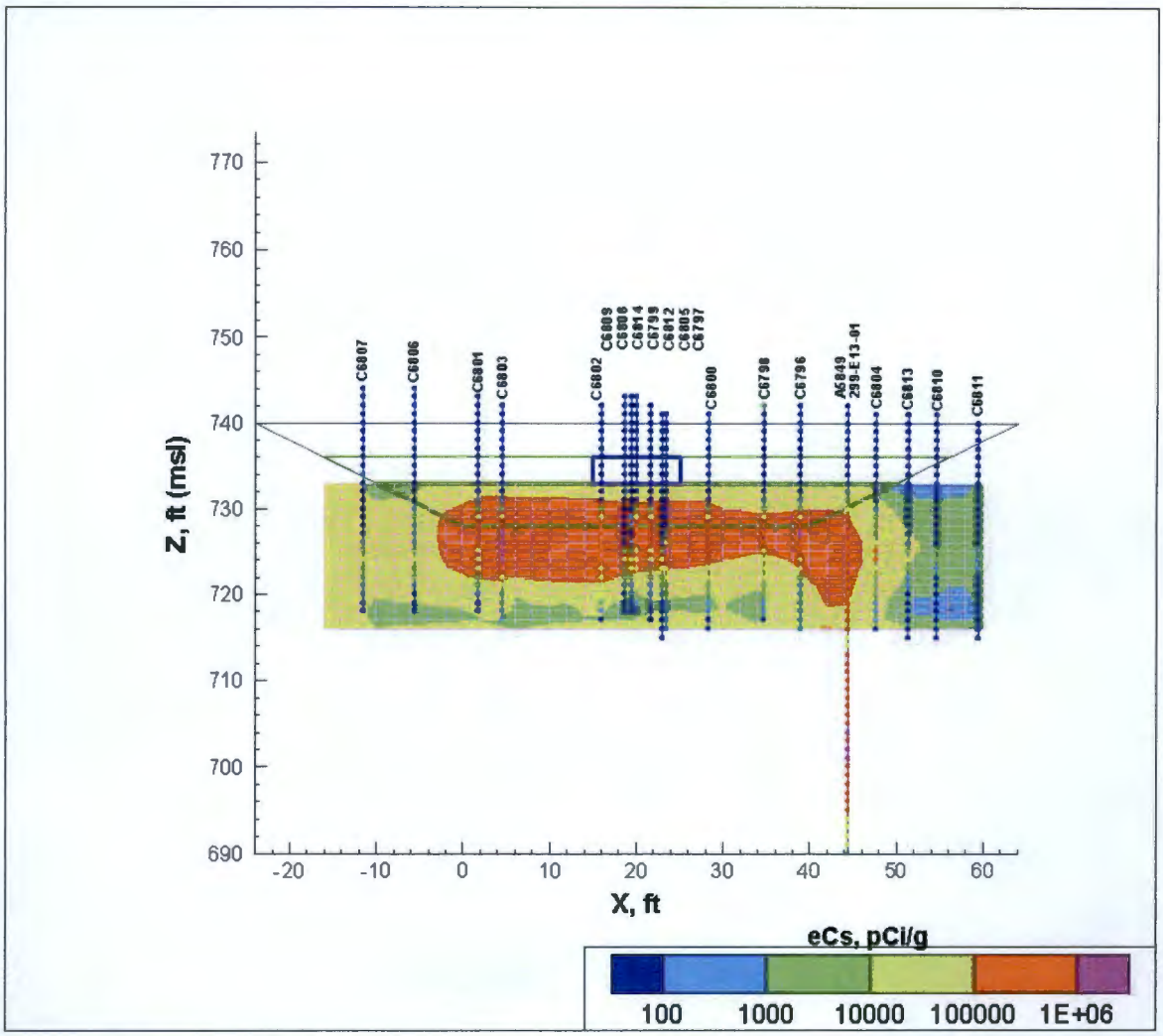

Figure 3-9. Equivalent Cesium Distribution in the X-Z Plane at the 216-B-14 Crib

Step-out boreholes were successful in delimiting the lateral extent of contamination in the X and Y directions. It is likely that similar conditions limiting the lateral extent of contamination also occur along the diagonal. To test this hypothesis and to estimate the effect of boreholes C6803 and C6796 along the diagonal, two "dummy" boreholes were positioned at the corners of the 216-B-14 site. The two dummy boreholes consist of a string of zero values for equivalent cesium at each depth. When the two dummy holes are included in the data set, the interpolated equivalent cesium values are significantly affected. Figure 3-11 shows the results of the interpolation (using the two dummy boreholes) on the X-Y section. For comparison, Figure 3-8 shows the results of the interpolation without the dummy boreholes. With inclusion of the dummy boreholes, the total cesium-137 inventory in the volume encompassed by the grid is reduced from 740 Ci to 578 Ci. This should be considered as an estimate of the lower bound, as there is no evidence to confirm (or refute) the assumption that boreholes at points A and B would not encounter contamination.

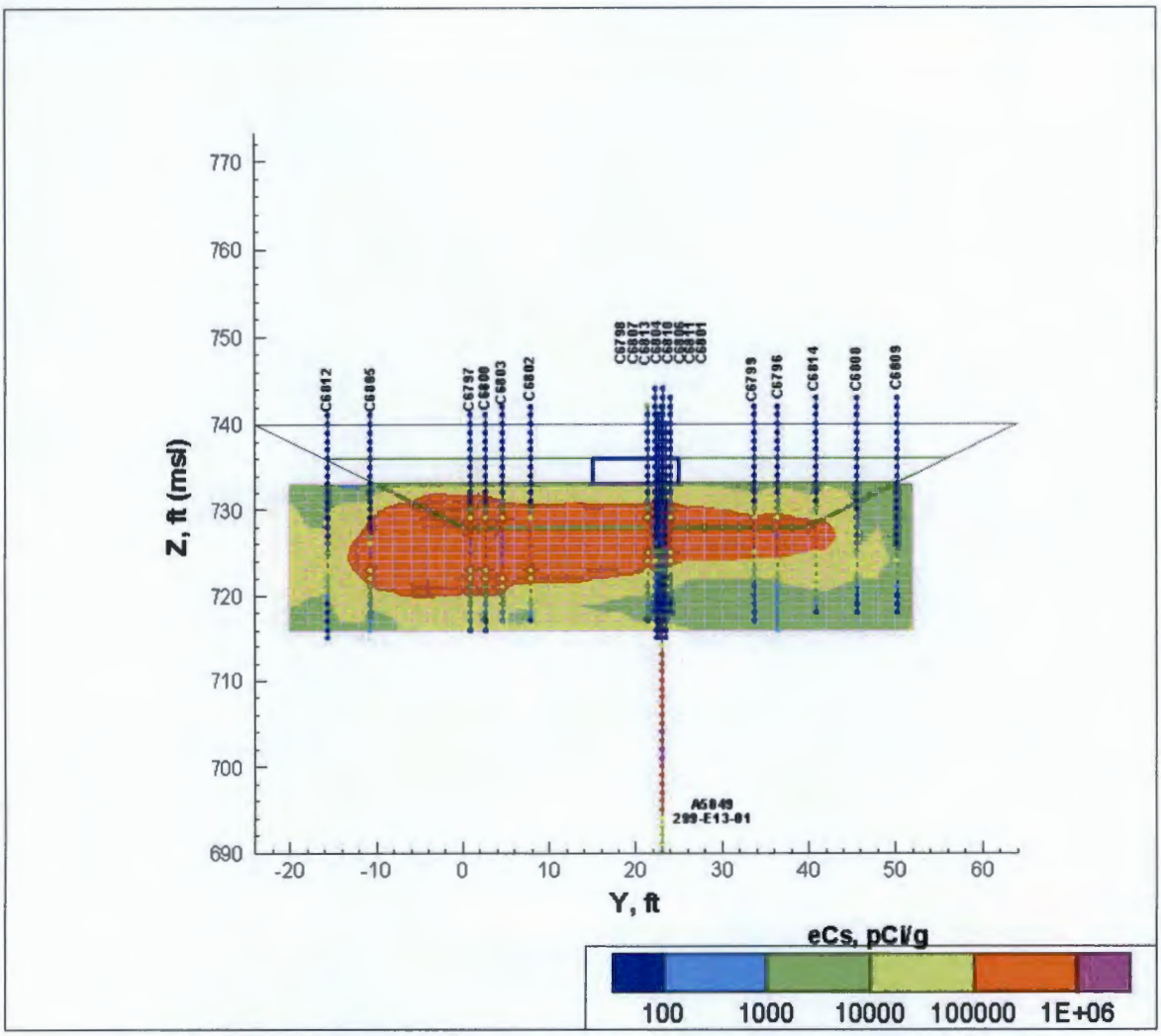

Figure 3-10. Equivalent Cesium Distribution in the Y-Z Plane at the 216-B-14 Crib

3.3.3 Lessons Learned and Discussion

Characterization of the vertical extent of contamination would have been improved by installing deeper boreholes to allow logging to greater depths. Evaluation of the SGLS results from 2005 obtained from deeper, nearby well 299-E13-1 during the DQO process may have resulted in a modified sampling design to obtain deeper characterization data.

Table 3-9. Estimated Cesium-137 Inventory at the 216-B-14 Crib

Elevation		Depth		Estimated Cs-137 Inventory, Ci	
ft	m	ft	m	By Level	Cumulative
Ground Surface at 742 ft (227.8 m) Elevation					
742	227.8	0	0	0	0
734	225.4	8	2.4	0	0
Crib Floor (Top of the Gravel Layer) at 733 ft (225.1 m) elevation					
733	225.1	9	2.7	12.9	13
732	224.8	10	3.0	23.7	37
731	224.5	11	3.4	36.3	73
730	224.2	12	3.7	48.4	121
729	223.8	13	4.0	57.0	178
728	223.5	14	4.3	63.7	242
727	223.2	15	4.6	68.6	311
726	222.9	16	4.9	70.9	382
725	222.6	17	5.2	69.5	451
724	222.3	18	5.5	64.5	515
723	222.0	19	5.8	56.1	572
722	221.7	20	6.1	46.5	618
721	221.4	21	6.4	35.3	653
720	221.1	22	6.7	24.7	678
719	220.8	23	7.0	16.7	695
718	220.5	24	7.3	14.1	709
717	220.2	25	7.6	13.0	722
716	219.9	26	7.9	17.7	740

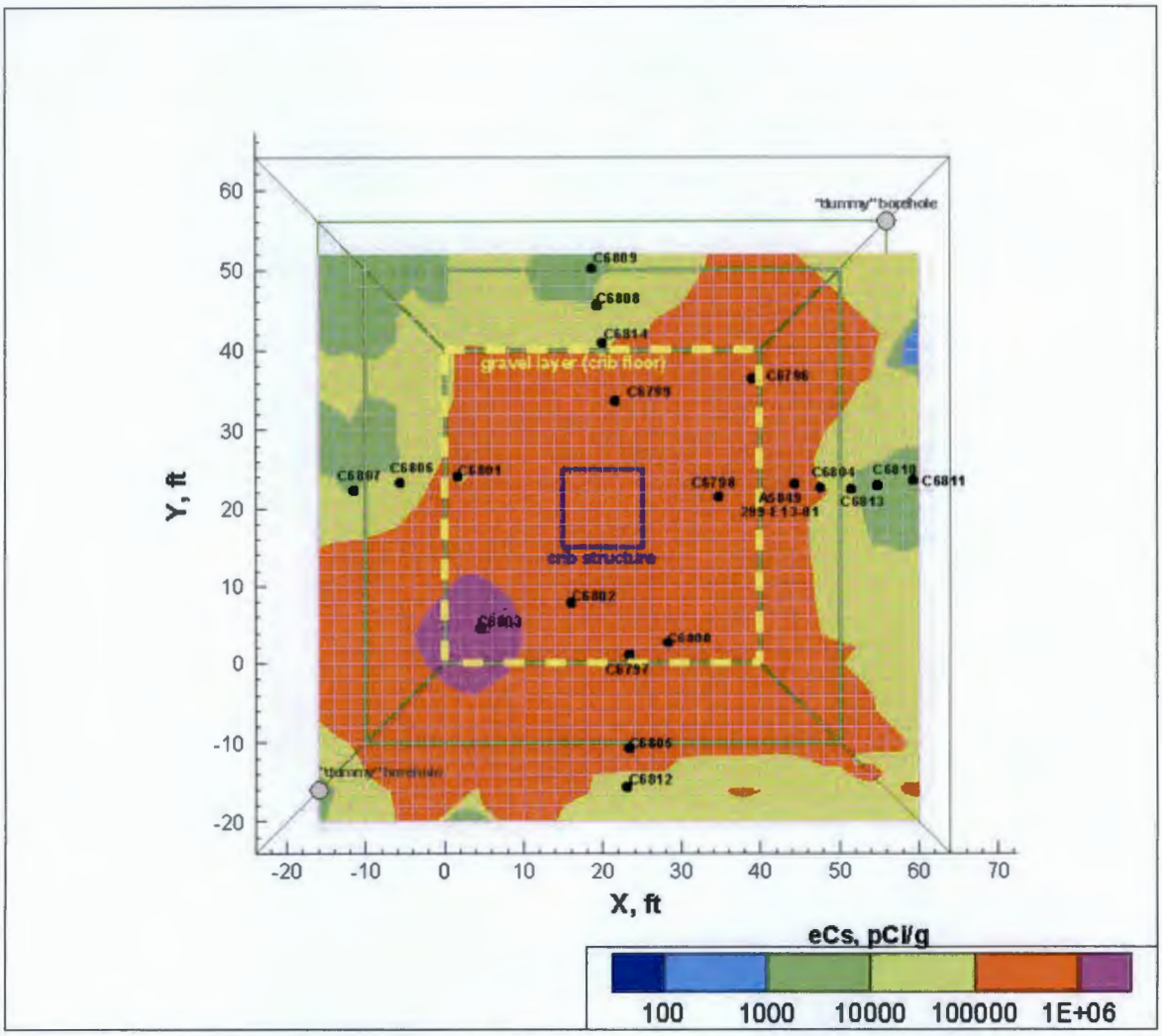

Figure 3-11. Effect of "Dummy Boreholes" on Contaminant Distribution at the 216-B-14 Crib

3.4 Phase 4 – Characterization of the 216-B-53A Trench

The focus of Phase 4 of the treatability test was to characterize the nature and extent of contamination of the 216-B-53A Trench, similar to testing conducted in Phase 1 for the 216-B-26 Trench.

3.4.1 Process Description

The 216-B-53A Trench is 18.3 m by 3 m (60 ft by 10 ft) at the base (Figure 3-12). It was divided into two sections by an earthen dam at the center that is 1.5 m (5 ft) high and 1.7 cm (5 in.) wide at the top. The site received waste from a liquid release at the Plutonium Recycle Test Reactor in the 300 Area, during which secondary cooling water became contaminated with plutonium and mixed fission products. Of all of the specific retention trenches in the BC Cribs and Trenches area, only this trench was considered to have the potential to contain concentrations of transuranic constituents greater than 100 nCi/g.

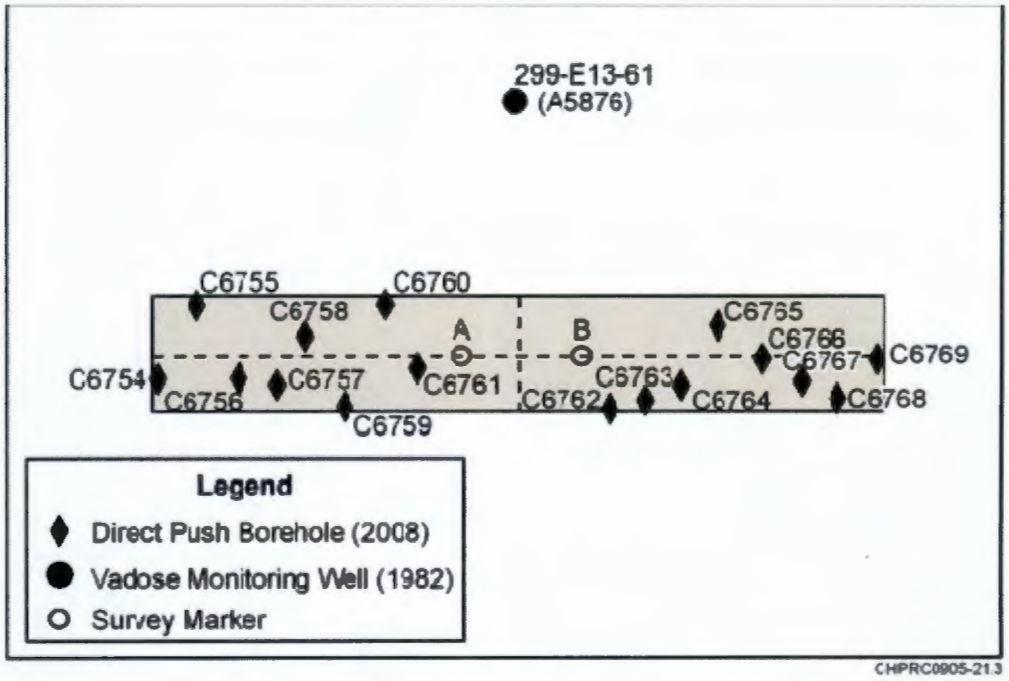

Figure 3-12. Location of Boreholes at the 216-B-53A Trench

Sixteen shallow DPT holes, approximately 7.6 m (25-ft)-deep, were installed along the length of the trench to determine the vertical and lateral extent of plutonium-239 contamination greater than 430 pCi/g within the upper 4.6 m (15 ft) (Figure 3-12). The test plan specified that eight boreholes would be installed through the bottom of each half of the trench (DOE/RL-2007-15). A systematic, random sampling design was used to ensure adequate representation of the trench floor. The locations of the 16 boreholes were specified in the sampling and analysis plan (DOE/RL-2007-15, Appendix B, Table B-8). All of the boreholes were logged to estimate the plutonium-239 and cesium-137 concentration profiles with depth.

Borehole installation was conducted from August 18 through August 21, 2008. Geophysical logging was conducted from August 22 through September 10, 2008. Each borehole was installed using a diesel-casing hammer rig. Each installed borehole consisted of a 17.8 cm (7-in.)-diameter, 1.43 cm (0.56-in.)-thick casing that was left in place to allow geophysical logging. The larger diameter casing was required for boreholes at the 216-B-53A Trench to support deployment of the high-resolution SGLS to detect plutonium-239. The SGLS is very different from the small-diameter total-gamma logging system used at the 216-B-26 Trench and 216-B-14 Crib. High-resolution gamma-energy spectra are collected with a HPGe detector. Characteristic photopeaks in the gamma-energy spectra are used to identify and assay specific radionuclides. For cesium-137, the photopeak at 661.61 keV is used. Plutonium analyses are based on the plutonium-239 decay gamma at 375.05 keV. A passive neutron log was also used to detect neutron activity originating from (alpha, n) reactions between transuranic and light elements (e.g., oxygen and nitrogen) and, to a lesser degree, from spontaneous fission (e.g., of plutonium-240). Following geophysical logging, all of the boreholes were decommissioned.

The 2008 geophysical logging data for the 16 DPT boreholes are provided in Appendix C.

3.4.2 Results

Spectral gamma geophysical logging of the 16 boreholes along the length of the 216-B-53A Trench did not detect any transuranic radionuclides (Table 3-10). Only relatively low concentrations of cesium-137 were detected.

Table 3-10. Maximum Plutonium-239 and Cesium-137 Concentrations at the 216-B-53A Trench

216-B-53A Trench Borehole	Plutonium-239		Cesium-137	
	Maximum Concentration[a] (pCi/g)	Depth of Maximum Concentration	Maximum Concentration (pCi/g)	Depth of Maximum Concentration
Western Section of the Trench				
C6754	ND	N/A	265	4.7 m (15.5 ft)
C6755	ND	N/A	391	4.6 m (15.0 ft)
C6756	ND	N/A	9	1.2 m (4.0 ft)
C6757	ND	N/A	20	5.6 m (18.5 ft)
C6758	ND	N/A	102	4.7 m (15.5 ft)
C6759	ND	N/A	692	4.6 m (15.0 ft)
C6760	ND	N/A	2,340	4.9 m (16.0 ft)
C6761	ND	N/A	2,745	4.9 m (16.0 ft)
Eastern Section of the Trench				
C6762	ND	N/A	1,077	4.9 m (16.0 ft)
C6763	ND	N/A	1,003	4.9 m (16.0 ft)
C6764	ND	N/A	1,180	4.9 m (16.0 ft)
C6765	ND	N/A	2,707	5.0 m (16.5 ft)
C6766	ND	N/A	800	4.9 m (16.0 ft)
C6767	ND	N/A	1,535	4.9 m (16.0 ft)
C6768	ND	N/A	1,928	4.9 m (16.0 ft)
C6769	ND	N/A	1,165	4.9 m (16.0 ft)

a. The method detection limit was typically 20,000 pCi/g in these boreholes. In zones of relatively high gamma activity (e.g., zones of maximum Cs-137), the Pu-239 detection limit increased to values ranging from approximately 60,000 to 1,000,000 pCi/g, depending on the level of gamma activity. The method detection limits for Pu-239 are provided in Table C-3.

N/A = not applicable

ND = not detected

The cesium-137 inventory was estimated using the same approach as described for the 216-B-14 Crib (Section 3.3). The total cesium-137 inventory in the 216-B-53A Trench is estimated to be less than 0.2 Ci.

No evidence of plutonium-239 was detected by SGLS in any of the 16 DPT boreholes. For all spectra, the region at 375 keV was examined and the minimum detectable activity (MDA) was determined. This was converted to the MDL by accounting for detector efficiency, borehole corrections, and the yield for the 375.05 characteristic decay gamma from plutonium-239. This gamma was chosen for analysis because it is the most intense decay gamma within the practical energy range of the SGLS (about 180 to 2,650 keV). Lower energy gammas (e.g., the more intense gamma line at 129 3 keV) are not recommended for assay in borehole logging because of uncertainties in the casing correction function and the detector efficiency function below 180 keV. An MDL for plutonium-239 was reported for each log point (Appendix C, Table C-3). For low gamma activity, the MDL was about 20,000 pCi/g, or 20 nCi/g. However, the plutonium MDL is affected by gamma activity resulting from cesium-137, and plutonium MDLs exceeded 1,000,000 pCi/g (1,000 nCi/g) at some points near the bottom of the trench. Evaluation of the plutonium MDL data showed that MDLs exceeded 100 nCi/g in a zone that varied from 0 to 1.5 m (5 ft) thick in the western half of the trench and 0.3 to 0.9 m (1 to 3 ft) thick in the eastern half. Using an average thickness of 0.6 m (2 ft) in the western half and 0.8 m (2.5 ft) in the eastern half, the total volume of soil where plutonium concentrations could be greater than 100 nCi/g is estimated to be about 38 m^3 (50 yd^3) in the 216-B-53A Trench.

The passive neutron logging also did not detect any evidence of transuranic radionuclides. The passive neutron logging detects ambient neutrons generated from interactions between alpha particles and light elements (e.g., oxygen or nitrogen) and, to a lesser extent, neutrons generated from spontaneous fission of elements (e.g., plutonium-240). A proof-of-principle demonstration of a passive neutron log for detection of transuranic-contaminated soil at the 216-Z-1A Tile Field was conducted in 2000 (BHI-01436, *Proof-of-Principle Demonstration of a Passive Neutron Tool for Detection of TRU-Contaminated Soil at the 216-Z-1A Tile Field*). Based on the demonstration, it was concluded that the passive neutron log could detect transuranic-contaminated soil at or near the 100 nCi/g level. However, this result may be subject to question, because subsequent evaluation of spectral gamma data in 2009 suggests that at least some of the plutonium discharged to the 216-Z-1A Tile Field was combined with fluorine (SGW-42002, *Summary Report for Selected Boreholes Within the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-12 Crib*). Plutonium fluoride has long been known to have a much higher neutron generation rate than plutonium oxide or nitrate. Therefore, results from the demonstration may be overly optimistic when applied to more conventional situations.

In the 216-B-53A Trench, the passive neutron log was run with a count time of 60 seconds, and measurements were made at 15.2 cm (0.5-ft) increments. With few exceptions, the passive neutron log detected fewer than two counts over the 60-second time period. This level of activity is consistent with background. The exceptions tended to occur at the ground surface and at a few isolated occurrences where SGLS logs exhibited low MDLs for plutonium-239 and little or no cesium-137 was present. These isolated occurrences are interpreted as "noise." Logging at borehole 299-W10-73, which is located near the 216-T-32 Crib, provides a basis for evaluating the passive neutron logging results. Logging using SGLS in this borehole detected plutonium-239, with a maximum concentration of approximately 60 nCi/g. Only traces of cesium-137 and europium were present, so the plutonium assay was relatively unaffected. A passive neutron log in the borehole showed a weak, but distinct, peak that coincided with plutonium-239 concentration. The maximum neutron count rate was about 0.14 counts/second (or about 8 to 9 counts in a 60-second interval). Because the background for the passive neutron log is effectively zero, even relatively small increases in count rate are significant. The total absence of detectable neutron

activity in the 216-B-53A Trench boreholes implies that little or no transuranic-contaminated soil (greater than 100 nCi/g) is present, even in intervals where the plutonium MDL is relatively high.

3.4.3 Lessons Learned and Discussion

The action limit for assessing the lateral extent of contamination in the 216-B-53A Trench was 430 pCi/g, which is less than the typical method detection limit of 20,000 pCi/g for high-resolution, spectral gamma logging in these boreholes. As a result, the logging data could not be used to evaluate contamination at the action limit. Collection of soil samples for analysis in the laboratory would have refined the evaluation of the presence of lower concentrations of transuranic radionuclides in the trench.

Experience with passive neutron logging at other Hanford waste sites suggests that it may be affected by the chemical compound in which the transuranic radionuclide is incorporated. The proof-of-principle demonstration in the 216-Z-1A tile field was likely affected by the presence of fluoride compounds, which are known to have a much higher neutron generation rate than oxides or nitrates. Without process knowledge indicating the nature of the alpha-emitting radionuclides and light elements (oxygen, nitrogen, fluorine) with which they may be combined, passive neutron logging may not be useful for quantitative measurements. However, the ambient neutron flux in uncontaminated soil is effectively zero, and even very neutron low count rates may be significant. In the case of the 216-B-53A Trench data, there was sufficient gamma activity associated with cesium-137 to affect plutonium assay, but there was a complete absence of detectable neutron activity, even in the presence of the maximum cesium-137 levels. This implies that transuranic radionuclides are not likely present at significant concentrations (i.e., greater than 100 nCi/g).

The SGLS data from the 216-B-53A Trench indicate that cesium-137 levels as low as 30 to 100 pCi/g are enough to raise the MDL for plutonium above the criterion of 100 nCi/g. Experience at other sites where much higher levels of gamma activity were encountered indicates that cesium-137 levels on the order of 100,000 pCi/g affect the passive neutron count rate. Since the neutron "background" in uncontaminated soil is effectively zero, any statistically significant neutron counts may be useful, at least in a qualitative sense. Experience at borehole 299-W10-73 indicates the detection threshold for the passive neutron log is lower than 60 nCi/g in a typical waste site. Additional work is required to more accurately determine the plutonium detection threshold and to better quantify the interference effects related to extremely high gamma activity.

3.5 Quality Assurance/Quality Control

The data quality assessment (DQA) presents the results of the data evaluation generated as part of this treatability test. Although different types of data were collected during the treatability test, the DQA only quantitatively considers the sample analysis data. The environmental sample analysis data were generated by soil sampling and borehole spectral gamma logging in and around the 216-B-26 Trench.

The data and interpretation included in the DQA include an assessment of the completion of the planned experimental design and the quantity and quality of chemical analysis data. The assessment was performed in accordance with guidance found in *Data Quality Assessment: A Reviewer's Guide*, EPA QA/G-9R (EPA/240/B-06/002); and in *Data Quality Assessment: Statistical Methods for Practitioners*, EPA QA/G-9S (EPA/240/B-06/003). The DQA for the BC Cribs and Trenches excavation-based treatability test is provided in Appendix D of this report.

4 Conclusions, Cost, Schedule, and Recommendations

The cost and schedule for the excavation portion of the treatability test are included in this section because these parameters were one of the data needs of the testing.

4.1 Conclusions

The conclusions for Phases 2, 3, and 4 of the treatability test are as follows:

- The actual potential dose to workers generally was half that predicted in the FFS (DOE/RL-2004-66).
- The cost to characterize and excavate one-third of the 216-B-26 Trench was \$1,920/m^3 (\$1,470/yd^3). It is anticipated that, based on lessons learned and process refinements, the actual cost for full-scale excavation may be reasonably close to the costs predicted in the FFS. Although the cost to stage and load an ERDF can was nearly three times that estimated by the FFS (\$325 during the test compared to \$122 estimated in the FFS), it is believed that most of the difference could be eliminated by automating the method of assessing adequacy of down-blending and other process improvements. Other elements of the process that were examined had similar costs.
- During construction of the 216-B-26 Trench, berms were used to divide the trench into three working sections that did not receive equal contaminant loads. The inventory estimated for the western third of the trench is an order of magnitude lower than the inventories estimated for the middle and eastern thirds of the trench. The cesium-137 contamination is concentrated in a relatively thin zone, 3.4 to 3.7 m (11 to 12 ft) bgs, which corresponds to the bottom of the trench.
- The elevated cesium-137 contamination at the 216-B-14 Crib is found over a relatively thick interval, potentially extending much deeper than 7.9 m (26 ft) bgs.
- No plutonium was detected, and relatively low levels of cesium-137 were detected, at the 216-B-53A Trench. The total cesium-137 inventory is estimated to be less than 0.2 Ci. The presence of cesium-137 affected the plutonium MDL, and there is an interval from 0 to 1.5 m (5 ft) thick at the base of the trench where plutonium levels may exceed 100 nCi/g. It is estimated that approximately 38 m^3 (50 yd^3) of soil may contain plutonium at levels in excess of 100 nCi/g.
- The treatability test plan provided for decision-maker data review as the test was conducted to permit field activities to be terminated when sufficient information had been collected and evaluated. The following activities were not conducted:
  - Soil sampling was not conducted at the 216-B-14 Crib or the 216-B-53A Trench. Based on characterization work completed at the 216-B-26 Trench, where the geophysical logging provided a vertical contamination profile that defined the highly contaminated layer and it was difficult to obtain soil samples at the depth of the highly contaminated layer, it appeared that soil sampling at these two waste sites was unlikely to add significant information to supplement the geophysical logging as part of this treatability test.
  - Excavation testing was not conducted at the 216-B-14 Crib and, as a result, observations were not made of the 216-B-14 remnant crib structure to evaluate its potential for subsidence. However, field work at other sites in FY08 determined that the potential for subsidence is best addressed by the use of control density fill. Although excavation at this site may have encountered construction materials different from those used at the 216-B-26 Trench (e.g., a gravel layer in addition to soil), it is believed that any excavation and remediation of gravel layers could be successfully completed without a treatability test.

- Excavation testing was not conducted at the 216-B-53A Trench. Because geophysical logging indicated that this trench was relatively clean, it appeared that treatability testing to evaluate excavation of potential transuranic waste could not be accomplished.

4.2 Costs and Schedule for Performing the Treatability Test

The costs for performing the treatability test are summarized in Table 4-1. Elements included in the cost estimate for characterization and excavation of the 216-B-26 Trench are discussed in Section 3.2.4 of this report.

Table 4-1. Costs for Performing the Treatability Test

Phase of the Test	Cost
Phase 1 – Characterization of 216-B-26 Trench	~$1,100,000
Phase 2 – Excavation of 216-B-26 Trench	~$3,600,000
Phase 3 – Characterization of 216-B-14 Crib Phase 4 – Characterization of 216-B-53A Trench	~$900,000 (combined total for Phases 3 and 4)
Total	**~$5,600,000**

The schedule for performing the treatability test is summarized in Figure 4-1.

4.3 Recommendations

The following recommendations are made based on the evaluation of the treatability test results:

- Use the cost and dose data collected during excavation of the 216-B-26 Trench (Phase 2) to refine the evaluation of alternatives in the FFS for the BC Cribs and Trenches area (DOE/RL-2004-66).
- Use the contaminant distribution data collected during characterization of the 216-B-26 Trench (Phase 1), 216-B-14 Crib (Phase 3), and 216-B-53A Trench (Phase 4) to refine the conceptual model in the FFS for the BC Cribs and Trenches area.

Task-specific recommendations are provided in Section 3 of this report as part of the detailed discussions of each phase of the treatability test.

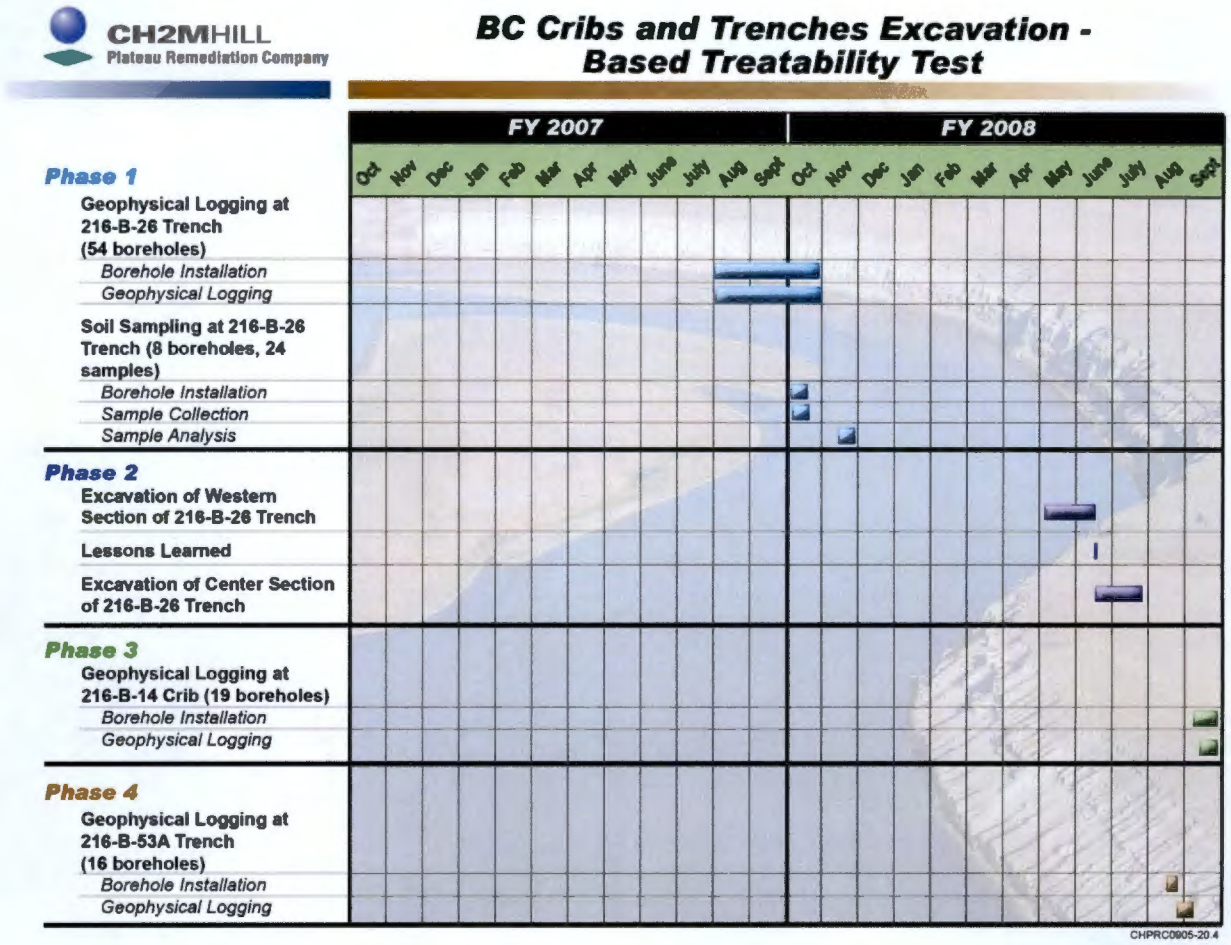

Figure 4-1. Treatability Test Schedule

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Appendix A

Summary of Environmental Restoration Disposal Facility Can Data

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Summary of Environmental Restoration Disposal Facility Can Data

The dose rates measured on each Environmental Restoration Disposal Facility can are summarized in Table A-1. Dose rates were measured at contact and at a distance of 30 cm (12 in.) in eight different zones on each can. The locations of the eight zones are shown in Figure A-1. Table A-1 also includes the dose rate measured on the soil at the top of the full excavator bucket using the AMP-100[1] instrument located 46 cm (18 in.) above plane of the bucket top.

[1] AMP-100 Area Monitor Probe, Rotem Industries, Ltd., Israel.

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Table A-1. Summary of Environmental Restoration Disposal Facility Can Data

Can Parameters				Can Dose Rate at Contact (by Zone[a]) (mrem/hr)								Can Dose Rate at 30 cm (by Zone[a]) (mrem/hr)								AMP-100[b] Data for Each Bucket Loaded into ERDF Can (mrem/hr)				
Can#	Pack Date	Ship Date	ERDF Waste Weight (lb)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
608	6/02/08	6/04/08	31,853	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	<0.5
1957	6/03/08	6/04/08	33,629	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8.5	<0.5	<0.5	<0.5	<0.5
1706	6/03/08	6/04/08	37,784	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
901	6/05/08	6/05/08	32,013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
955	6/05/08	6/05/08	38,679	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
344	6/05/08	6/05/08	40,734	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1900	6/08/08	6/09/08	34,927	<0.5	<0.5	<0.5	<0.5	7	<0.5	0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	N/A
731	6/08/08	6/09/08	41,233	1	1	2.5	1	2	2	20	<0.5	1	1	1	1	0.6	0.6	6	<0.5	<0.5	<0.5	0.5	<0.5	0.5
334	6/08/08	6/09/08	40,814	1	8	3	1	1.5	3	2.5	1.8	1.5	4.8	2	0.6	1	1.8	1.5	1.3	5	0.5	2	1	1.5
792	6/08/08	6/09/08	38,679	9	6	4	2	3	10	7	1	3	3	2	1	2	5	2.5	0.5	4	0.5	1	2.5	2.5
771	6/08/08	6/09/08	25,087	2	25	2	<0.5	1	2	1.5	<0.5	1.5	7	1.5	<0.5	<0.5	0.6	0.6	<0.5	1	2	<0.5		
715	6/09/08	6/10/08	41,692	1.7	3.5	1.7	1.5	2.5	2.5	2	2	1.2	1.9	0.8	1	1.2	1.2	0.6	0.6	1	1	0.5	1.5	2
791	6/09/08	6/10/08	40,734	5	11	1	<0.5	0.9	1.2	0.5	1.1	3.4	5	0.6	<0.5	0.5	0.7	<0.5	0.6	0.5	<0.5	2	<0.5	<0.5
768	6/09/08	6/10/08	40,335	2	10	15	2	5	7	0.5	7	1	7	7	1	2	2.2	<0.5	3.3	1	<0.5	<0.5	1	1
2933	6/09/08	6/10/08	40,734	1.5	2	1	0.5	2.2	1.8	0.8	<0.5	0.8	1.2	0.5	<0.5	1.1	1.1	0.5	<0.5	<0.5	0.5	0.5	1	1.5
2917	6/12/08	6/12/08	40,774	9	14	10	7	8	7	1	2	3.5	8	7	3	3	3.5	1.5	1.5	4	<0.5	0.5	4	10
2961	6/12/08	6/12/08	39,816	0.8	2.2	1	<0.5	1		1	0.5	<0.5	0.7	0.6	<0.5	0.5	6	0.5	<0.5	1	1	1	0.5	0.5
988	6/12/08	6/12/08	40,615	8	20	2	0.5	1	2.5	12	2.5	4	8	0.8	<0.5	0.7	1.5	4	1.5	1	2	1	0.5	0.5
157	6/12/08	6/12/08	40,196	3.5	3.5	4.8	10	8	5	3	5	1.7	1.7	2.3	5	4	2.5	2	1	15	1.5	1.5	1	5
300	6/12/08	6/12/08	42,131	7	10	1.5	4.2	7	10	8	2	3	6	1	1.5	4.5	6	4	1	2	2	1.5	0.3	3
1912	6/12/08	6/12/08	33,090	0.5	1	<0.5	<0.5	1.5	3.5	1.5	0.5	<0.5	0.5	<0.5	<0.5	1	1.5	1	<0.5	0.1	0.5	0.2	0.2	N/A
706	6/12/08	6/12/08	40,076	6	4.7	13	21	8	3.6	5	2	3.5	2	3	10	4	2	2.5	1	1	2	1	3	2
415	6/12/08	6/12/08	41,333	1.5	6	8	2.9	0.5	1.5	1	<0.5	0.5	3.5	2	1.5	<0.5	0.5	0.5	<0.5	<0.5	1.2	0.5	<0.5	<0.5
998	6/12/08	6/12/08	40,415	10	5	0.5	<0.5	2	2.5	0.8	3	5	3	<0.5	1.3	1	1.5	<0.5	2	1.2	<0.5	0.5	1.6	<0.5
1939	6/12/08	6/12/08	40,954	3.2	20	7	<0.5	1.5	3	6	3	2	6	2.8	<0.5	0.8	2	2	1	6	1.4	<0.5	1	<0.5
969	6/12/08	6/12/08	34,787	4	1.5	1.2	1.6	1.5	3	8	1	2	0.9	0.7	0.9	0.8	2	3.5	<0.5	<0.5	<0.5	<0.5	<0.5	N/A
2985	6/13/08	6/13/08	33,470	1	8	2	1	2	3	1	1	<0.5	4	1	<0.5	1	2	<0.5	<0.5	3.7	1.6	2.4	<0.5	N/A

Table A-1. Summary of Environmental Restoration Disposal Facility Can Data

Can Parameters				Can Dose Rate at Contact (by Zone[a]) (mrem/hr)								Can Dose Rate at 30 cm (by Zone[a]) (mrem/hr)								AMP-100[b] Data for Each Bucket Loaded into ERDF Can (mrem/hr)				
Can#	Pack Date	Ship Date	ERDF Waste Weight (lb)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
931	6/13/08	6/13/08	33,190	2	2	2	2	2	4	2	10	1.5	1.5	1	1	1	2	1	5	2.1	3.1	3.8	1.1	N/A
912	6/13/08	6/13/08	31,174	3	5	20	2	1	2	1	1	1.5	1.5	7	1.5	1	1	0.5	0.5	2	3.4	1.4	0.8	N/A
1931	6/13/08	6/13/08	32,931	1.5	15	1	<0.5	15	2	2	2	<0.5	6	<0.5	<0.5	4	1	1	1	1.1	2.7	0.9	1.5	N/A
940	6/13/08	6/13/08	33,689	3	2	1	2	6	2	1	1	1	1	0.5	1	2	1	0.5	0.5	2.1	2.6	0.6	0.6	N/A
292	6/13/08	6/13/08	16,346	1	4	1	0.5	0.5	2	0.5	0.5	0.5	2	0.5	<0.5	<0.5	1	<0.5	<0.5	0.5	0.8	N/A	N/A	N/A
723	6/13/08	6/13/08	32,691	3	12	2	0.5	3	2	2	1	2	5	1	<0.5	2	1	1	0.5	2.7	2.7	0.9	0.8	N/A
1926	6/13/08	6/13/08	33,270	3	1	0.5	0.5	1	4	2	7	1	0.5	<0.5	<0.5	0.5	1	0.5	2	2.7	2	0.5	2.4	N/A
1988	6/15/08	6/16/08	33,071	2.5	8	1.5	2.5	12	1	6.5	5	1	2	0.8	1	4	<0.5	3.5	2	<0.5	0.7	0.6	2.2	N/A
925	6/15/08	6/16/08	31,853	3	8	5	2.5	10	6	0.5	0.6	1.2	3.5	2	0.8	2	2.8	<0.5	<0.5	1.7	1.3	1.5	1.9	N/A
1995	6/15/08	6/16/08	32,472	0.5	4	4.5	2	9	1.5	4	2	<0.5	1	0.6	0.8	2	<0.5	1	0.6	<0.5	1.2	1.1	1.5	N/A
1985	6/15/08	6/16/08	33,869	5.0	6.0	4.0	2.8	2.0	1.5	1.5	3.5	2.0	1.8	2.0	0.5	1.5	0.1	.0.7	1.0	1.4	1.2	2.2	1.0	N/A
939	6/15/08	6/16/08	33,771	0.5	0.6	3.0	2.0	2.0	1.0	2.0	<0.5	<0.5	0.5	1.0	0.8	1.0	0.5	1.0	<0.5	<0.5	0.5	1.1	1.1	N/A
1964	6/15/08	6/16/08	35,166	1.5	18.0	4.0	0.8	1.5	8.0	1.5	0.7	1.0	5.0	1.5	<0.5	1.0	3.0	1.0	0.5	1.2	<0.5	2.4	0.7	N/A
1911	6/15/08	6/16/08	33,544	8.0	15.0	9.0	1.5	8.0	15.0	8.0	9.0	3.5	6.0	3.0	0.8	3.5	6.0	3.5	5.5	0.5	<0.5	2.6	1.0	N/A
1961	6/15/08	6/16/08	33,450	20.0	5.0	3.0	3.0	3.0	3.0	3.0	3.0	7.0	3.0	1.0	1.0	1.0	1.0	1.0	1.0	1.7	0.7	<0.5	4.9	N/A
706	6/15/08	6/16/08	34,907	17.0	1.5	1.5	1.0	10.0	1.0	1.0	1.0	7.0	1.0	1.0	0.5	0.3	0.5	0.5	0.5	<0.5	0.7	<0.5	3.1	N/A
1956	6/15/08	6/16/08	33,609	0.7	30.0	6.0	<0.5	<0.5	2.8	8.9	2.0	0.5	5.0	2.0	<0.5	<0.5	0.8	3.5	0.8	0.9	0.5	<0.5	<0.5	N/A
917	6/16/08	6/16/08	32,691	7.0	5.0	5.0	<0.5	<0.5	<0.5	1.0	12.0	4.0	3.0	3.0	<0.5	<0.5	<0.5	<0.5	5.0	0.5	0.5	2.0	0.5	N/A
1921	6/16/08	6/16/08	32,851	12.0	1.0	<0.5	<0.5	<0.5	1.0	9.0	15.0	5.0	1.0	<0.5	<0.5	<0.5	1.0	3.0	5.0	<0.5	1.5	0.5	0.5	N/A
2942	6/16/08	6/16/08	33,031	1.0	4.0	5.0	<0.5	10.0	3.0	3.0	<0.5	0.7	2.0	2.0	<0.5	1.0	1.0	1.0	<0.5	1.0	0.5	1.5	0.5	N/A
782	6/16/08	6/16/08	31,454	2.0	2.0	4.0	<0.5	9.0	3.0	4.0	<0.5	1.0	1.0	2.0	<0.5	2.0	1.0	2.0	<0.5	1.5	1.0	1.0	1.0	N/A
988	6/16/08	6/16/08	33,510	3.0	3.0	10.0	<0.5	8.0	8.0	1.0	4.0	1.0	1.0	4.0	<0.5	3.0	3.0	1.0	2.0	3.5	0.5	1.0	<0.5	N/A
781	6/16/08	6/16/08	33,090	10.0	8.0	8.0	<0.5	1.0	1.0	5.0	3.0	4.0	3.0	3.0	<0.5	<0.5	<0.5	2.0	2.0	1.5	1.5	1.0	0.5	N/A
1983	6/19/08	6/19/08	31,833	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	10	70	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3	20	<0.5	1.5	<0.5	<0.5	N/A
2976	6/19/08	6/19/08	39,417	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2964	6/19/08	6/19/08	38,978	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
790	6/24/08	6/24/08	45,165	10	12	13	10	10	14	12	12	8	9	10	6	7	9	8	8	15	10	10	10	10
923	6/24/08	6/24/08	45,125	10	10	15	8	20	20	20	10	6	7	8	5	14	13	13	8	8	10	15	22	12

Table A-1. Summary of Environmental Restoration Disposal Facility Can Data

Can Parameters				Can Dose Rate at Contact (by Zone[a]) (mrem/hr)								Can Dose Rate at 30 cm (by Zone[a]) (mrem/hr)								AMP-100[b] Data for Each Bucket Loaded into ERDF Can (mrem/hr)				
Can#	Pack Date	Ship Date	ERDF Waste Weight (lb)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
2927	6/24/08	6/24/08	42,531	15	28	38	30	17	15	30	14	10	16	20	15	10	10	16	8	17	13	13	12	30
1944	6/25/08	6/25/08	42,371	20	25	35	20	19	25	18	15	12	14	16	14	12	18	12	10	14	15	17	21	13
708	6/25/08	6/25/08	43,588	20	20	20	18	44	44	22	22	12	15	15	10	25	25	14	15	15	13	20	24	27
328	6/25/08	6/25/08	34,887	20	23	26	10	26	28	23	10	12	17	15	5	16	20	16	6	20	23	25	22	N/A
726	6/25/08	6/25/08	43,588	30	30	32	25	28	35	25	34	20	20	22	10	18	25	20	25	25	24	23	28	23
1913	6/25/08	6/25/08	44,583	34	39	25	17	47	25	25	25	22	24	9	11	21	19	17	17	24	23	28	23	26
717	6/26/08	6/26/08	46,283	24	24	24	20	22	22	24	20	19	19	15	12	16	16	17	12	18	15	20	32	22
714	6/26/08	6/26/08	44,706	30	30	35	25	27	27	28	30	25	24	21	13	21	19	21	22	17	20	22	25	17
2980	6/26/08	6/26/08	42,750	30	32	35	25	30	32	36	25	25	21	22	16	19	24	18	18	21	25	23	25	13
1936	6/26/08	6/26/08	43,628	21	20	25	15	20	22	21	20	16	16	18	11	16	16	16	15	14	17	13	17	14
975	6/26/08	6/26/08	–	24	28	24	17	28	22	22	28	16	19	16	10	18	17	16	18	19	18	18	13	11
2976	6/26/08	6/26/08	41,633	20	20	20	20	30	25	18	12	15	16	15	10	19	18	14	7	25	29	23	16	22
754	6/26/08	6/26/08	42,910	38	35	30	24	20	42	34	30	25	27	23	15	15	30	26	22	18	23	21	16	17
1933	6/26/08	6/26/08	43,349	25	25	22	22	20	20	19	20	17	20	16	14	16	16	15	14	15	18	20	13	20
2914	6/27/08	7/02/08	44,467	20	25	22	18	17	18	17	22	9	12	10	6	8	8	7	12	20	27	18	16	20
715	6/27/08	6/30/08	43,469	28	31	21	17	31	36	32	18	11	12	12	9	18	21	19	12	20	26	22	26	20
1997	6/27/08	7/01/08	35,146	30	23	21	17	21	22	21	10	20	12	10	8	11	12	11	9	21	15	23	18	16
1944	6/27/08	6/30/08	43,184	21	20	21	20	30	35	30	26	10	9	10	9	12	20	12	18	23	22	17	25	33
1962	6/27/08	6/30/08	43,269	35	26	24	18	22	21	20	24	25	15	14	9	12	11	10	14	23	26	19	21	18
969	6/27/08	6/30/08	44,167	30	43	35	15	30	28	26	24	12	22	14	7	14	11	9	13	26	30	26	23	20
921	6/27/08	6/30/08	42,690	25	35	25	20	23	40	26	25	11	12	10	8	7	22	12	18	25	30	30	16	25
2926	6/27/08	7/01/08	44,906	40	30	28	20	24	25	21	28	20	17	14	10	13	14	12	20	15	18	35	24	28
951	6/27/08	6/30/08	45,285	32	31	28	30	35	40	36	29	20	18	16	15	22	22	19	20	35	34	29	26	23
355	6/27/08	6/30/08	45,185	15	20	20	18	18	20	18	16	12	14	16	12	12	10	12	11	17	14	17	16	12
964	6/29/08	7/01/08	45,804	15	20	22	18	18	20	22	16	10	14	16	10	10	15	16	12	16	19	17	25	27
2955	6/29/08	6/30/08	41,752	20	20	24	60	30	24	24	16	11	15	15	30	21	15	15	8	20	20	21	22	27
2906	6/29/08	6/30/08	42,990	20	24	26	26	24	22	20	18	15	18	18	18	16	16	6	10	26	19	23	22	21
1943	6/29/08	6/30/08	43,089	24	20	24	20	22	22	26	22	18	18	16	10	16	16	18	16	21	23	23	23	20

Table A-1. Summary of Environmental Restoration Disposal Facility Can Data

Can Parameters				Can Dose Rate at Contact (by Zone[a]) (mrem/hr)								Can Dose Rate at 30 cm (by Zone[a]) (mrem/hr)								AMP-100[b] Data for Each Bucket Loaded into ERDF Can (mrem/hr)				
Can#	Pack Date	Ship Date	ERDF Waste Weight (lb)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
764	6/29/08	6/30/08	43,548	20	20	24	30	22	26	20	22	16	16	18	22	16	16	15	14	20	18	27	25	20
319	6/29/08	7/02/08	41,772	20	26	30	22	22	28	20	13	16	20	22	14	16	20	14	9	24	22	18	22	22
983	6/29/08	7/02/08	41,952	18	20	24	25	26	22	32	20	16	16	18	18	18	16	22	14	21	16	17	24	20
342	6/29/08	6/30/08	35,585	20	25	26	18	24	27	20	19	12	20	22	12	20	22	18	10	21	18	19	25	N/A
2963	6/29/08	7/02/08	41,672	23	20	26	22	28	26	22	12	16	16	20	15	22	18	14	8	30	20	19	20	18
708	6/30/08	7/01/08	42,950	25	25	30	35	30	28	25	25	12	12	15	12	15	15	15	10	22	22	23	28	27
1706	6/30/08	7/01/08	43,449	35	45	32	25	35	35	30	30	18	25	20	10	18	18	12	12	25	24	27	40	26
775	6/30/08	7/01/08	43,988	30	30	55	35	30	30	30	28	12	12	20	15	15	18	15	12	21	17	24	24	26
1964	6/30/08	7/02/08	42,112	35	40	60	35	30	32	28	35	15	18	20	15	14	14	12	18	23	31	26	25	22
700	6/30/08	7/01/08	40,854	26	35	30	28	28	25	30	26	12	15	12	10	10	12	15	12	20	23	21	13	21
722	6/30/08	7/02/08	42,531	30	40	30	30	28	30	30	35	15	20	12	15	14	15	15	20	32	24	24	17	26
2939	6/30/08	7/01/08	40,894	35	40	30	25	25	30	40	15	15	20	14	14	12	12	12	20	25	21	25	22	21
913	6/30/08	7/02/08	42,531	32	30	65	20	30	30	28	30	16	15	20	10	12	15	12	15	27	24	29	25	27
750	7/01/08	7/02/08	41,253	25	35	35	30	50	25	25	30	12	20	18	10	12	10	10	15	19	18	19	19	21
2908	7/01/08	7/02/08	41,094	40	35	35	20	30	40	30	30	18	18	15	8	18	18	12	10	29	25	24	22	17
304	7/01/08	7/02/08	40,655	28	35	55	26	30	30	28	26	12	20	25	10	15	15	12	14	18	23	16	22	17
953	7/02/08	7/02/08	40,914	22	25	28	25	35	20	28	35	10	12	14	12	18	15	15	15	24	20	22	25	23
332	7/02/08	7/02/08	40,555	25	40	40	35	30	28	18	20	10	20	18	12	15	12	8	6	15	26	27	34	30
2965	7/02/08	7/02/08	41,154	20	20	22	25	25	25	25	18	12	12	14	12	12	10	10	8	21	20	19	20	22
777	7/02/08	7/02/08	–	20	20	20	28	25	20	20	15	9	10	12	12	15	10	8	5	18	21	20	17	20
736	7/02/08	7/02/08	41,333	26	28	28	20	28	25	22	15	10	12	10	7	12	12	10	6	19	19	20	22	24
1961	7/02/08	7/02/08	42,072	38	42	25	35	45	30	30	28	15	20	12	18	20	12	15	12	32	25	34	29	11
1941	7/02/08	7/02/08	40,435	28	30	30	28	45	30	32	25	14	12	15	8	20	18	15	10	22	28	23	23	23
948	7/02/08	7/02/08	40,136	30	30	25	25	25	30	30	20	12	15	12	10	12	15	12	8	19	19	20	22	24
1948	7/02/08	7/02/08	41,034	30	40	40	40	28	32	32	30	20	18	12	18	12	15	15	20	25	25	20	22	17
1921	7/02/08	7/02/08	39,357	18	18	20	18	20	20	20	20	10	8	8	10	10	10	10	15	18	19	19	22	20
2988	7/02/08	7/02/08	39,158	15	18	15	30	15	25	20	20	8	10	10	14	10	10	8	15	19	23	19	18	31
1966	7/03/08	7/07/08	42,431	22	23	21	22	25	24	22	36	9	8	8	9	10	10	9	20	14	21	20	21	20

Table A-1. Summary of Environmental Restoration Disposal Facility Can Data

Can Parameters				Can Dose Rate at Contact (by Zone[a]) (mrem/hr)								Can Dose Rate at 30 cm (by Zone[a]) (mrem/hr)								AMP-100[b] Data for Each Bucket Loaded into ERDF Can (mrem/hr)				
Can#	Pack Date	Ship Date	ERDF Waste Weight (lb)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
1987	7/03/08	7/07/08	40,685	60	90	20	15	25	20	40	25	25	30	9	8	11	10	17	18	8	13	12	13	22
2998	7/03/08	7/07/08	38,000	20	50	22	12	15	14	12	5	11	24	12	6	8	7	6	3	9	11	10	8	14
2909	7/03/08	7/07/08	33,150	25	18	30	27	20	70	25	25	11	9	14	13	9	25	10	10	20	12	17	31	N/A
2950	7/03/08	7/07/08	40,395	20	35	25	15	8	12	10	20	8	14	9	8	2	6	5	5	11	35	17	13	15
1903	7/03/08	7/07/08	41,872	10	20	20	20	18	30	12	15	3	9	8	9	7	20	4	6	8	16	18	14	8
793	7/03/08	7/07/08	40,196	12	11	12	12	14	20	12	20	5	4	5	4	6	10	5	10	7	22	10	12	10
705	7/03/08	7/07/08	42,930	18	30	19	22	21	20	19	15	7	18	7	10	10	9	7	10	5	6	5	9	9
758	7/03/08	7/07/08	42,032	15	25	30	42	20	30	10	25	7	9	11	20	8	11	3	10	3	7	5	3	9
733	7/03/08	7/07/08	40,914	12	15	20	8	70	17	15	30	4	5	7	3	27	6	5	12	20	15	17	6	10
1954	7/07/08	7/07/08	39,996	30	34	25	25	30	36	30	32	14	20	14	14	16	20	16	18	27	26	24	21	22
1906	7/07/08	7/07/08	41,533	24	26	25	32	38	30	30	32	16	16	14	20	24	22	22	22	22	19	23	25	28
735	7/07/08	7/07/08	42,012	20	30	25	25	35	25	25	25	12	15	12	12	20	18	18	16	17	22	25	26	28
2943	7/07/08	7/07/08	40,435	20	22	20	22	34	35	20	22	15	16	15	15	22	22	18	15	18	18	20	18	22
707	7/07/08	7/07/08	40,455	22	22	18	20	25	33	24	20	15	15	12	12	18	22	18	16	23	27	21	17	18
1926	7/07/08	7/07/08	41,014	18	22	24	20	22	24	18	18	12	12	14	12	14	14	12	12	16	18	21	22	20
1989	7/07/08	7/07/08	40,016	26	32	30	30	32	30	30	30	16	20	18	20	22	20	20	20	23	22	17	25	21
946	7/07/08	7/07/08	39,657	25	34	25	35	30	32	30	25	14	20	14	22	20	20	18	18	20	20	27	18	22
1971	7/07/08	7/07/08	41,114	25	25	26	45	40	30	32	28	12	14	14	30	28	22	22	18	27	24	22	23	21
412	7/07/08	7/07/08	39,776	30	40	30	25	25	32	28	30	18	28	20	18	20	22	20	22	17	26	26	25	25
1997	7/07/08	7/07/08	40,395	26	24	26	40	32	30	28	26	18	16	16	20	18	16	16	12	22	17	22	25	28
773	7/07/08	7/07/08	40,714	24	26	26	32	30	28	22	24	14	14	12	18	16	12	12	14	18	23	23	20	25
1973	7/07/08	7/07/08	40,774	35	80	50	40	35	40	35	30	22	50	35	25	22	24	22	18	18	24	24	26	29
1976	7/08/08	7/09/08	41,333	30	32	45	28	32	32	28	32	22	22	30	16	20	22	20	22	21	17	24	26	23
1983	7/08/08	7/09/08	40,994	25	30	36	20	28	28	26	26	16	18	25	15	16	16	14	14	13	25	22	25	15
970	7/08/08	7/10/08	41,672	26	28	26	22	28	30	26	24	18	16	16	14	14	24	14	14	22	17	14	21	18
792	7/08/08	7/09/08	41,952	32	34	30	25	32	32	40	32	22	22	20	15	22	22	24	20	21	16	23	28	18
328	7/08/08	7/10/08	24,948	30	34	15	5	15	35	30	30	20	22	10	2	10	25	20	20	26	22	23	N/A	N/A
313	7/08/08	7/09/08	41,493	32	30	26	32	50	34	32	34	22	20	20	22	28	24	22	24	27	29	23	18	27

Table A-1. Summary of Environmental Restoration Disposal Facility Can Data

Can Parameters				Can Dose Rate at Contact (by Zone[a]) (mrem/hr)								Can Dose Rate at 30 cm (by Zone[a]) (mrem/hr)								AMP-100[b] Data for Each Bucket Loaded into ERDF Can (mrem/hr)				
Can#	Pack Date	Ship Date	ERDF Waste Weight (lb)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
998	7/08/08	7/09/08	42,251	32	44	32	30	32	34	34	30	22	30	20	18	22	24	22	18	24	25	28	21	21
2930	7/08/08	7/11/08	42,072	30	32	30	26	34	30	22	26	20	20	18	16	26	20	22	18	22	24	23	21	N/A
1981	7/08/08	7/09/08	16,625	40	34	22	10	28	35	30	28	26	22	16	5	16	25	22	16	25	23	21	N/A	N/A
2908	7/08/08	7/09/08	42,371	20	22	22	18	30	28	28	20	12	12	10	8	20	16	16	12	14	14	17	22	31
2923	7/08/08	7/10/08	41,672	16	20	18	15	25	22	22	24	7	8	7	7	18	16	14	16	6	5	8	12	10
1963	7/08/08	7/09/08	41,473	30	32	20	45	34	34	32	30	20	2	18	32	20	22	20	18	18	26	17	20	25
329	7/08/08	7/11/08	42,151	32	32	45	35	35	36	24	20	22	22	30	26	24	24	18	12	20	17	22	19	25
173	7/09/08	7/11/08	41,593	30	32	28	30	30	35	28	26	18	26	18	20	22	25	18	18	13	23	23	24	27
2979	7/09/08	7/09/08	41,134	20	22	22	30	24	26	20	25	16	16	16	20	18	16	14	14	23	17	15	20	18
2980	7/10/08	7/11/08	22,792	26	22	20	5	10	28	24	22	14	14	12	2	5	20	18	16	19	17	24	N/A	N/A
1940	7/10/08	7/11/08	38,479	35	65	30	25	30	25	30	35	12	30	10	10	12	10	10	10	16	23	21	24	19
964	7/13/08	7/14/08	37,701	35	31	28	27	20	28	27	26	20	16	15	12	12	15	13	12	20	16	13	15	18
1934	7/13/08	7/14/08	39,357	30	31	30	35	28	28	28	34	15	15	17	15	15	14	13	13	20	15	17	20	20
1926	7/13/08	7/14/08	37,461	35	30	27	28	28	28	28	30	13	13	12	12	12	14	15	15	20	22	18	17	18
931	7/13/08	7/14/08	38,579	27	27	30	29	27	27	28	22	15	15	20	15	16	15	16	17	18	21	18	22	25
2954	7/13/08	7/14/08	39,996	20	22	27	30	30	27	25	15	12	15	12	15	13	15	15	10	20	16	21	22	16
2959	7/13/08	7/14/08	38,499	25	30	35	27	27	27	20	15	15	20	20	16	14	15	12	6	20	27	19	23	14
969	7/13/08	7/14/08	25,586	27	25	27	7	28	28	25	22	15	15	15	3	12	13	12	10	24	24	20	N/A	N/A
2953	7/13/08	7/14/08	41,014	32	30	27	27	27	28	29	28	17	15	15	12	14	18	16	15	26	24	21	23	23
977	7/13/08	7/14/08	40,255	20	30	25	27	28	27	28	25	12	18	15	10	12	15	15	15	21	25	19	21	25
2967	7/14/08	7/14/08	41,054	30	30	20	30	30	30	30	30	15	15	10	15	12	15	15	15	21	18	23	17	19
1932	7/14/08	7/14/08	39,018	30	30	10	25	25	20	20	20	12	12	5	10	10	10	10	10	17	15	23	17	19
730	7/14/08	7/14/08	39,277	35	30	25	35	50	30	25	25	20	15	10	15	27	12	10	10	22	19	20	23	26
1911	7/14/08	7/15/08	37,821	30	25	40	70	30	25	25	30	12	12	10	30	10	10	10	12	19	19	15	17	21
762	7/14/08	7/15/08	39,457	20	20	20	20	25	25	25	25	10	10	10	6	10	10	10	10	15	16	12	16	15
2910	7/14/08	7/15/08	39,697	30	25	25	30	25	25	30	30	10	10	10	10	10	10	12	10	15	21	21	19	23
1999	7/14/08	7/15/08	37,761	25	25	25	25	25	25	30	30	10	10	10	10	10	10	12	12	12	20	14	16	18
744	7/14/08	7/15/08	38,878	35	30	30	25	30	30	35	30	15	12	10	9	13	12	20	12	21	17	24	17	16

Table A-1. Summary of Environmental Restoration Disposal Facility Can Data

Can Parameters				Can Dose Rate at Contact (by Zone[a]) (mrem/hr)								Can Dose Rate at 30 cm (by Zone[a]) (mrem/hr)								AMP-100[b] Data for Each Bucket Loaded into ERDF Can (mrem/hr)				
Can#	Pack Date	Ship Date	ERDF Waste Weight (lb)	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
1901	7/15/08	7/15/08	39,138	20	23	27	20	23	23	21	15	12	15	16	11	12	15	13	9	15	19	22	15	16
1953	7/15/08	7/15/08	38,579	29	20	10	10	15	10	25	25	14	10	7	7	8	7	10	10	6	12	9	9	12
755	7/15/08	7/15/08	38,659	15	23	32	15	23	22	17	25	10	16	17	8	17	15	9	12	12	11	19	14	12
940	7/15/08	7/15/08	40,275	30	30	30	40	25	25	25	25	15	18	12	15	12	14	12	12	17	25	19	17	21
317	7/15/08	7/15/08	39,198	22	20	75	75	28	25	20	5	10	12	18	20	12	12	10	3	16	18	16	18	27
721	7/15/08	7/15/08	37,940	22	25	28	20	25	20	22	20	14	12	14	10	12	12	12	10	18	16	18	21	19
417	7/15/08	7/15/08	39,058	25	22	25	30	25	25	25	25	14	14	12	15	13	15	15	15	18	18	20	15	19
1965	7/15/08	7/15/08	38,878	16	20	22	22	25	22	25	20	7	15	15	10	10	12	10	10	16	15	12	14	13
340	7/16/08	7/17/08	41,932	22	15	16	12	15	15	15	5	15	10	10	8	10	10	10	3	16	10	11	11	7
2958	7/16/08	7/16/08	31,893	10	11	23	15	10	10	2	1	5	9	12	9	7	7	1	0.5	4	8	5	6	N/A
753	7/16/08	7/16/08	40,225	12	21	15	3	10	15	6	5	8	11	10	1	6	10	3	3	6	6	5	4	3
1972	7/16/08	7/16/08	39,138	3	4	3	2	3	5	2	2	1	1	2	1	2	3	1	1	3	3	4	2	2
913	7/16/08	7/16/08	38,539	5	3	<0.5	<0.5	7	<0.5	<0.5	<0.5	2	1	N/A	N/A	3	N/A	N/A	N/A	2	2	1	1	N/A
		Total	**6,938,294**																					

a. The locations on the can of zones 1 through 8 are shown in Figure A-1.

b. AMP-100 Area Monitor Probe, Rotem Industries, Ltd., Israel.

ERDF = Environmental Restoration Disposal Facility

N/A = not applicable

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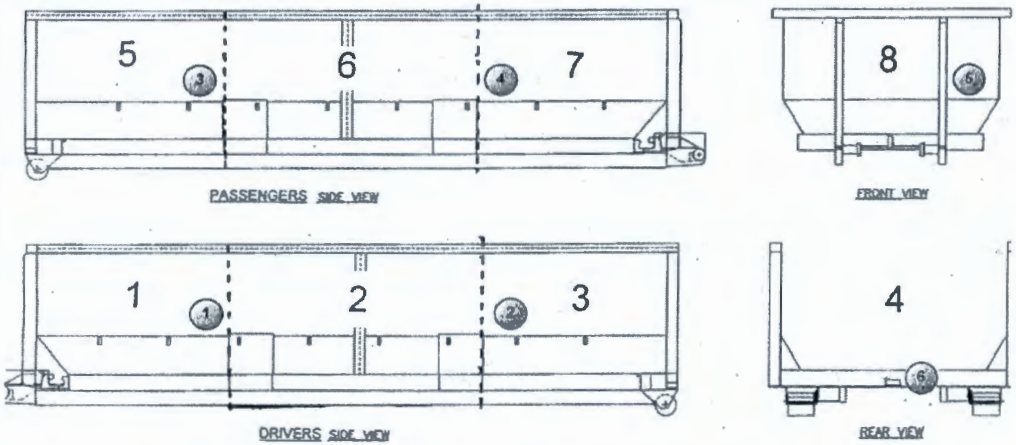
OWTF RCT FORM
(Cab Reading Performed by WCH)

Radiological Data for OWTF #: 200W-08-0247

Surface Dose Rate of Package	Dose Rate @ 1 Meter from Surface of Package	Dose Rate @ 30 cm from Surface of Package	Smears of Outer Container	TRUCK LOAD OR EXCLUSIVE USE
☐ <0.005 or _____ mSv/hr	☐ <0.005 or _____ mSv/hr	☐ <1.0 or _____ mSv/hr	☐ <0.4 Bq (22 dpm) $\beta\gamma$ / cm²	Surface @ 2 meters ☒ <2 mSv/hr (200 mrem/hr) ☒ <0.1 mSv/hr (10 mrem/hr)
<0.5 or 28 mrem/hr (N + $\beta\gamma$)	<0.5 or 9 mrem/hr (N + $\beta\gamma$)	<100 or 19 mrem/hr (N + $\beta\gamma$)	☐ <0.04 Bq (2.2 dpm) α / cm²	Inside cab reading will be performed by WCH per WCH RadCon Program
			☒ < Tbl. 2-2 HSRCM Onsite Limits	

Additional Data and Instructions (Include Readings on Internal Packaging):



2 Meter reading: 6 mrem/hr

Circled numbers indicated radiological smear locations, see survey report

Amp 100 set point 25		
Amp 100 Readings (Max)		
Bucket #	1	19
	2	18
	3	18
	4	13
	5	11
	6	N/A

Max Dose Rate per Zone		
At Contact	Zone #	At 30cm
24	1	16
28	2	19
24	3	16
17	4	10
28	5	18
22	6	17
22	7	16
28	8	18

ERDF Can # 0975

Front axle wt. 24,000 lbs

Rear axle wt 43,340 lbs

List additional contents inventory as applicable:

Signature - Radiation Monitoring	Bldg.	Survey No.	Date
R [signature]	216-B-26	RBC-080147	6-26-08

Attach to the OWTF.

Completed by the Radiological Control Technician (RCT) including surface dose rate in Sieverts, dose rate at 1 meter, removeable contamination smear surveys in becquerels, vehicle dose rates in Sieverts, along with the RCT's signature, the building, survey number and date.

NOTE: For onsite shipments requiring HNF-5173 release limits, check appropriate box to verify application of Table 2-2 limits.

A-6004-472 (REV 0)

Figure A-1. Location of Eight Measurement Zones on Environmental Restoration Disposal Facility Cans

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Appendix B

Geophysical Logging Data for the 216-B-14 Crib

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Geophysical Logging Data for the 216-B-14 Crib

The fiscal year 2008 geophysical logging results for the eight boreholes in the 216-B-14 Crib floor footprint are provided in Table B-1. The results for the 11 boreholes beyond the 216-B-14 Crib floor footprint are provided in Table B-2.

Table B-1. Geophysical Logging Results for the Boreholes Within the 216-B-14 Crib Floor Footprint

Borehole parameters		C6796	C6797	C6798	C6799	C6800	C6801	C6802	C6803
Maximum concentration (pCi/g)		2. 245E+06	2.10E+06	6.63E+05	8.49E+05	8.95E+05	1.08E+06	1.09E+06	4.35E+06
Depth of maximum concentration (ft bgs)		15.0	15.5	15.0	16.0	15.5	16.5	15.5	18.0
Depth of Cs-137 Concentration		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs								
0.0	0.0	9.16E+01	--	2.38E+03	0.00E+00	ND	0.00E+00	ND	ND
0.5	0.2	ND	ND	ND	ND	ND	ND	ND	ND-
1.0	0.3	ND	ND	ND	ND	ND	ND	ND	ND-
1.5	0.5	ND	ND	ND	ND	ND	ND	ND	ND
2.0	0.6	ND	ND	ND	ND	ND	ND	ND	ND
2.5	0.8	ND	ND	ND	ND	ND	ND	ND	ND
3.0	0.9	ND	ND	ND	ND	ND	ND	ND	ND
3.5	1.1	ND	ND	ND	ND	ND	ND	ND	ND
4.0	1.2	ND	ND	ND	ND	ND	ND	ND	ND
4.5	1.4	ND	ND	ND	ND	ND	ND	ND	ND
5.0	1.5	ND	ND	ND	ND	ND	ND	ND	ND
5.5	1.7	ND	ND	ND	ND	ND	ND	ND	ND
6.0	1.8	ND	ND	ND	ND	ND	ND	ND	ND
6.5	2.0	ND	ND	ND	ND	ND	ND	ND	ND
7.0	2.1	ND	ND	ND	ND	ND	ND	ND	ND
7.5	2.3	ND	ND	ND	ND	ND	ND	ND	ND

Table B-1. Geophysical Logging Results for the Boreholes Within the 216-B-14 Crib Floor Footprint

Borehole parameters		C6796	C6797	C6798	C6799	C6800	C6801	C6802	C6803
Maximum concentration (pCi/g)		2. 245E+06	2.10E+06	6.63E+05	8.49E+05	8.95E+05	1.08E+06	1.09E+06	4.35E+06
Depth of maximum concentration (ft bgs)		15.0	15.5	15.0	16.0	15.5	16.5	15.5	18.0
Depth of Cs-137 Concentration		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs								
8.0	2.4	ND	ND	ND	ND	ND	ND	ND	ND
8.5	2.6	ND	ND	ND	ND	ND	ND	ND	ND
9.0	2.7	ND	ND	ND	ND	ND	ND	ND	ND
9.5	2.9	ND	ND	ND	ND	ND	ND	ND	ND
10.0	3.0	ND	ND	ND	ND	ND	ND	ND	ND
10.5	3.2	2.43E+01	3.53E+01	2.00E+01	ND	3.05E+01	ND	ND	ND
11.0	3.4	8.33E+01	1.44E+02	8.44E+01	ND	1.49E+02	ND	2.09E+01	1.88E+01
11.5	3.5	4.18E+02	8.05E+02	4.77E+02	2.56E+01	8.34E+02	ND	8.13E+01	5.38E+01
12.0	3.7	2.36E+03	4.20E+03	2.74E+03	1.33E+02	4.28E+03	ND	5.11E+02	2.77E+02
12.5	3.8	1.28E+04	2.15E+04	1.73E+04	7.01E+02	2.23E+04	5.75E+01	3.27E+03	1.69E+03
13.0	4.0	6.42E+04	9.45E+04	7.60E+04	3.59E+03	9.69E+04	3.06E+02	1.86E+04	9.24E+03
13.5	4.1	2.23E+05	2.47E+05	2.06E+05	2.02E+04	2.46E+05	1.85E+03	8.37E+04	4.62E+04
14.0	4.3	2.84E+05	2.61E+05	2.21E+05	8.69E+04	2.73E+05	1.11E+04	2.10E+05	1.74E+05
14.5	4.4	1.02E+06	3.36E+05	2.97E+05	2.22E+05	3.42E+05	5.70E+04	2.03E+05	3.02E+05
15.0	4.6	2.24E+06	1.04E+06	6.63E+05	2.28E+05	8.09E+05	1.73E+05	3.42E+05	2.96E+05
15.5	4.7	1.22E+06	2.10E+06	4.09E+05	4.58E+05	8.95E+05	2.91E+05	1.09E+06	7.70E+05

Table B-1. Geophysical Logging Results for the Boreholes Within the 216-B-14 Crib Floor Footprint

Borehole parameters		C6796	C6797	C6798	C6799	C6800	C6801	C6802	C6803
Maximum concentration (pCi/g)		2. 245E+06	2.10E+06	6.63E+05	8.49E+05	8.95E+05	1.08E+06	1.09E+06	4.35E+06
Depth of maximum concentration (ft bgs)		15.0	15.5	15.0	16.0	15.5	16.5	15.5	18.0
Depth of Cs-137 Concentration									
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
16.0	4.9	2.76E+05	1.54E+06	1.33E+05	8.49E+05	3.72E+05	4.93E+05	7.32E+05	3.25E+06
16.5	5.0	1.31E+05	1.88E+06	3.57E+04	2.18E+05	6.72E+05	1.08E+06	5.11E+05	3.82E+06
17.0	5.2	1.21E+05	9.09E+05	1.91E+04	1.12E+05	4.46E+05	2.75E+05	6.86E+05	2.64E+06
17.5	5.3	1.15E+05	2.72E+05	2.79E+04	3.31E+04	2.14E+05	1.05E+05	7.62E+05	3.31E+06
18.0	5.5	8.66E+04	1.12E+05	2.40E+04	1.93E+04	8.99E+04	2.97E+04	2.85E+05	4.35E+06
18.5	5.6	2.71E+04	5.45E+04	1.59E+04	2.50E+04	5.76E+04	1.97E+04	1.28E+05	1.51E+06
19.0	5.8	8.65E+03	2.58E+04	1.58E+04	1.43E+04	3.26E+04	2.98E+04	6.72E+04	2.64E+05
19.5	5.9	2.89E+03	1.47E+04	1.48E+04	5.43E+03	2.09E+04	4.16E+04	7.30E+04	1.39E+05
20.0	6.1	1.62E+03	1.02E+04	1.30E+04	1.68E+03	1.17E+04	3.00E+04	4.62E+04	7.83E+04
20.5	6.2	8.91E+02	2.39E+03	9.37E+03	8.90E+02	5.60E+03	1.67E+04	2.30E+04	4.48E+04
21.0	6.4	7.47E+02	2.17E+03	6.45E+03	6.33E+02	2.53E+03	8.46E+03	3.41E+04	1.75E+04
21.5	6.6	6.71E+02	1.77E+03	2.80E+03	3.93E+02	8.82E+02	3.60E+03	2.17E+04	8.84E+03
22.0	6.7	7.56E+02	4.61E+02	1.13E+03	1.55E+02	3.62E+02	1.84E+03	2.53E+04	5.19E+03
22.5	6.9	8.82E+02	1.63E+03	4.71E+02	1.22E+02	9.22E+02	9.35E+02	8.44E+03	4.10E+03
23.0	7.0	7.41E+02	7.43E+02	2.37E+02	1.79E+02	2.94E+02	5.46E+02	3.05E+03	3.14E+03
23.5	7.2	6.87E+02	3.68E+02	2.23E+02	1.57E+02	1.30E+02	4.41E+02	7.90E+02	1.59E+03

Table B-1. Geophysical Logging Results for the Boreholes Within the 216-B-14 Crib Floor Footprint

Borehole parameters		C6796	C6797	C6798	C6799	C6800	C6801	C6802	C6803
Maximum concentration (pCi/g)		2. 245E+06	2.10E+06	6.63E+05	8.49E+05	8.95E+05	1.08E+06	1.09E+06	4.35E+06
Depth of maximum concentration (ft bgs)		15.0	15.5	15.0	16.0	15.5	16.5	15.5	18.0
Depth of Cs-137 Concentration		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs								
24.0	7.3	4.82E+02	3.50E+02	1.48E+02	9.02E+01	6.09E+01	1.96E+02	1.22E+02	1.31E+03
24.5	7.5	3.20E+02	1.78E+02	1.36E+02	5.46E+01	2.42E+01	6.42E+01	5.61E+01	4.97E+02
25.0	7.6	2.10E+02	5.95E+01	8.95E+01	5.74E+01	ND	5.21E+01	3.59E+01	3.97E+02
25.5	7.8	2.41E+02	4.81E+01	7.50E+01	6.58E+01	1.85E+01	3.86E+01	3.64E+01	2.57E+02
26.0	7.9	2.74E+02	5.35E+01	--	--	2.33E+01	--	--	4.22E+02

-- = not measured
bgs = below ground surface
ND = not detected

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Table B-2. Geophysical Logging Results for the Boreholes Beyond the 216-B-14 Crib Floor Footprint

Borehole parameters		C6804	C6805	C6806	C6807	C6808	C6809	C6810	C6811	C6812	C6813	C6814	299-E13-1
Maximum concentration (pCi/g)		2.84E+05	1.27E+06	1.74E+04	1.60E+04	2.44E+04	1.51E+04	6.08E+03	1.17E+03	4.60E+04	2.37E+04	7.24E+05	2.11E+06
Depth of maximum concentration (ft bgs)		17.0	16.5	20.0	20.5	19.5	20.0	17.0	16.5	17.5	17.0	16.0	40.5
Depth of Cs-137 Concentration		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs												
0.0	0.0	–	–	–	–	–	–	–	–	–	–	–	–
0.5	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1.0	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1.5	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2.0	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.08E+01
2.5	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.77E+01
3.0	0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.28E+01	ND	ND
3.5	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.98E+01	ND	ND
4.0	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4.5	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5.0	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5.5	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6.0	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6.5	2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7.0	2.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.74E+01
7.5	2.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.01E+01
8.0	2.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.35E+01
8.5	2.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.06E+01
9.0	2.7	ND	ND	ND	1.92E+01	ND	ND	ND	ND	ND	ND	ND	4.00E+01
9.5	2.9	ND	ND	ND	5.34E+01	ND	ND	ND	ND	ND	ND	ND	6.42E+01
10.0	3.0	ND	ND	ND	1.30E+02	ND	ND	ND	ND	ND	ND	ND	1.07E+02
10.5	3.2	ND	ND	ND	1.71E+02	ND	ND	ND	ND	ND	ND	ND	2.13E+02

Table B-2. Geophysical Logging Results for the Boreholes Beyond the 216-B-14 Crib Floor Footprint

Borehole parameters		C6804	C6805	C6806	C6807	C6808	C6809	C6810	C6811	C6812	C6813	C6814	299-E13-1
Maximum concentration (pCi/g)		2.84E+05	1.27E+06	1.74E+04	1.60E+04	2.44E+04	1.51E+04	6.08E+03	1.17E+03	4.60E+04	2.37E+04	7.24E+05	2.11E+06
Depth of maximum concentration (ft bgs)		17.0	16.5	20.0	20.5	19.5	20.0	17.0	16.5	17.5	17.0	16.0	40.5
Depth of Cs-137 Concentration													
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
11.0	3.4	5.80E+01	ND	ND	8.59E+01	ND	ND	ND	ND	ND	ND	ND	5.32E+02
11.5	3.5	2.73E+02	ND	ND	3.78E+01	ND	ND	ND	ND	ND	ND	ND	1.79E+03
12.0	3.7	1.19E+03	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.22E+01	8.48E+03
12.5	3.8	3.24E+03	ND	1.78E+01	ND	ND	ND	ND	ND	ND	ND	1.01E+02	4.82E+04
13.0	4.0	4.44E+03	2.46E+01	5.50E+01	ND	ND	ND	ND	ND	ND	ND	5.87E+02	2.02E+05
13.5	4.1	4.20E+03	9.17E+01	1.93E+02	ND	2.34E+01	ND	ND	ND	ND	ND	3.26E+03	3.18E+05
14.0	4.3	2.82E+03	5.34E+02	4.88E+02	ND	5.84E+01	ND	ND	ND	ND	ND	1.75E+04	3.21E+05
14.5	4.4	1.77E+03	3.53E+03	1.36E+03	ND	1.21E+02	ND	ND	ND	2.72E+01	1.72E+01	8.41E+04	2.79E+05
15.0	4.6	2.10E+03	2.42E+04	2.08E+03	ND	1.41E+02	ND	2.66E+01	1.97E+01	1.34E+02	6.32E+01	1.51E+05	1.65E+05
15.5	4.7	9.10E+03	1.52E+05	1.53E+03	ND	1.22E+02	ND	1.47E+02	8.08E+01	7.96E+02	3.92E+02	3.53E+05	8.71E+04
16.0	4.9	5.62E+04	7.67E+05	9.27E+02	ND	1.05E+02	ND	9.18E+02	5.17E+02	5.36E+03	2.48E+03	7.24E+05	7.68E+04
16.5	5.0	2.65E+05	1.27E+06	3.98E+02	ND	7.43E+01	ND	4.80E+03	1.17E+03	2.05E+04	1.31E+04	2.95E+05	1.28E+05
17.0	5.2	2.84E+05	8.07E+05	1.71E+02	ND	5.59E+01	ND	6.08E+03	2.76E+02	3.89E+04	2.37E+04	1.43E+05	1.82E+05
17.5	5.3	8.80E+04	2.71E+05	1.30E+02	ND	9.12E+01	2.02E+01	1.52E+03	5.57E+01	4.60E+04	1.15E+04	5.21E+04	1.57E+05
18.0	5.5	2.36E+04	1.23E+05	3.65E+02	5.67E+01	4.33E+02	8.54E+01	3.58E+02	2.85E+01	2.38E+04	4.02E+03	2.19E+04	1.03E+05
18.5	5.6	9.99E+03	4.34E+04	1.96E+03	2.95E+02	2.55E+03	4.93E+02	1.19E+02	1.73E+01	1.09E+04	1.01E+03	1.96E+04	1.13E+05
19.0	5.8	6.26E+03	2.54E+04	7.06E+03	1.75E+03	1.09E+04	3.01E+03	3.60E+01	ND	6.53E+03	2.61E+02	3.20E+04	1.60E+05
19.5	5.9	1.77E+03	1.61E+04	1.71E+04	7.03E+03	2.44E+04	1.20E+04	1.83E+01	ND	2.59E+03	1.47E+02	3.41E+04	1.73E+05
20.0	6.1	6.29E+03	5.40E+03	1.74E+04	1.59E+04	2.22E+04	1.51E+04	ND	ND	9.70E+02	1.31E+02	2.34E+04	1.91E+05
20.5	6.2	2.73E+03	2.63E+03	7.84E+03	1.60E+04	1.66E+04	6.30E+03	ND	ND	5.28E+02	9.23E+01	1.88E+04	2.02E+05
21.0	6.4	3.42E+03	2.16E+03	4.51E+03	7.37E+03	1.02E+04	2.87E+03	ND	ND	2.63E+02	5.03E+01	2.23E+04	1.90E+05
21.5	6.6	2.44E+03	7.68E+02	2.43E+03	3.47E+03	4.67E+03	1.37E+03	ND	ND	1.40E+02	3.26E+01	1.89E+04	2.48E+05
22.0	6.7	8.49E+02	3.62E+02	7.77E+02	1.36E+03	1.32E+03	5.18E+02	ND	ND	9.32E+01	2.75E+01	1.47E+04	2.34E+05
22.5	6.9	3.78E+02	2.91E+02	3.17E+02	5.80E+02	7.26E+02	2.10E+02	ND	ND	6.35E+01	4.36E+01	6.49E+03	1.97E+05
23.0	7.0	2.33E+02	3.52E+02	1.52E+02	3.29E+02	3.06E+02	1.07E+02	ND	ND	4.32E+01	3.73E+01	1.71E+03	1.53E+05

Table B-2. Geophysical Logging Results for the Boreholes Beyond the 216-B-14 Crib Floor Footprint

Borehole parameters		C6804	C6805	C6806	C6807	C6808	C6809	C6810	C6811	C6812	C6813	C6814	299-E13-1
Maximum concentration (pCi/g)		2.84E+05	1.27E+06	1.74E+04	1.60E+04	2.44E+04	1.51E+04	6.08E+03	1.17E+03	4.60E+04	2.37E+04	7.24E+05	2.11E+06
Depth of maximum concentration (ft bgs)		17.0	16.5	20.0	20.5	19.5	20.0	17.0	16.5	17.5	17.0	16.0	40.5
Depth of Cs-137 Concentration													
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
23.5	7.2	1.47E+02	2.29E+02	7.99E+01	1.91E+02	9.78E+01	4.02E+01	ND	ND	2.80E+01	5.09E+01	5.44E+02	1.45E+05
24.0	7.3	1.19E+02	1.25E+02	3.45E+01	9.68E+01	5.40E+01	2.57E+01	ND	ND	2.46E+01	3.53E+01	3.33E+02	1.42E+05
24.5	7.5	1.02E+02	1.71E+02	2.17E+01	4.65E+01	3.59E+01	1.73E+01	ND	ND	1.87E+01	3.27E+01	1.49E+02	1.23E+05
25.0	7.6	9.16E+01	1.08E+02	1.88E+01	2.86E+01	2.92E+01	ND	ND	ND	1.77E+01	5.41E+01	5.93E+01	1.13E+05
25.5	7.8	1.02E+02	1.08E+02	1.75E+01	2.35E+01	2.75E+01	ND	ND	ND	ND	4.87E+01	–	1.12E+05
26.0	7.9	8.18E+01	–	ND	1.93E+01	2.92E+01	ND	ND	–	ND	3.77E+01	–	1.08E+05
26.5	8.1	–	–	–	–	–	–	–	–	–	–	–	9.66E+04
27.0	8.2	–	–	–	–	–	–	–	–	–	–	–	1.09E+05
27.5	8.4	–	–	–	–	–	–	–	–	–	–	–	5.90E+04
28.0	8.5	–	–	–	–	–	–	–	–	–	–	–	3.06E+04
28.5	8.7	–	–	–	–	–	–	–	–	–	–	–	2.90E+04
29.0	8.8	–	–	–	–	–	–	–	–	–	–	–	5.29E+04
29.5	9.0	–	–	–	–	–	–	–	–	–	–	–	1.11E+05
30.0	9.1	–	–	–	–	–	–	–	–	–	–	–	1.88E+05
30.5	9.3	–	–	–	–	–	–	–	–	–	–	–	2.69E+05
31.0	9.4	–	–	–	–	–	–	–	–	–	–	–	2.41E+05
31.5	9.6	–	–	–	–	–	–	–	–	–	–	–	2.02E+05
32.0	9.8	–	–	–	–	–	–	–	–	–	–	–	2.28E+05
32.5	9.9	–	–	–	–	–	–	–	–	–	–	–	2.43E+05
33.0	10.1	–	–	–	–	–	–	–	–	–	–	–	2.23E+05
33.5	10.2	–	–	–	–	–	–	–	–	–	–	–	2.28E+05
34.0	10.4	–	–	–	–	–	–	–	–	–	–	–	2.19E+05
34.5	10.5	–	–	–	–	–	–	–	–	–	–	–	4.28E+05
35.0	10.7	–	–	–	–	–	–	–	–	–	–	–	4.50E+05
35.5	10.8	–	–	–	–	–	–	–	–	–	–	–	4.18E+05

Table B-2. Geophysical Logging Results for the Boreholes Beyond the 216-B-14 Crib Floor Footprint

Borehole parameters		C6804	C6805	C6806	C6807	C6808	C6809	C6810	C6811	C6812	C6813	C6814	299-E13-1
Maximum concentration (pCi/g)		2.84E+05	1.27E+06	1.74E+04	1.60E+04	2.44E+04	1.51E+04	6.08E+03	1.17E+03	4.60E+04	2.37E+04	7.24E+05	2.11E+06
Depth of maximum concentration (ft bgs)		17.0	16.5	20.0	20.5	19.5	20.0	17.0	16.5	17.5	17.0	16.0	40.5
Depth of Cs-137 Concentration													
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
36.0	11.0	–	–	–	–	–	–	–	–	–	–	–	5.08E+05
36.5	11.1	–	–	–	–	–	–	–	–	–	–	–	7.87E+05
37.0	11.3	–	–	–	–	–	–	–	–	–	–	–	9.33E+05
37.5	11.4	–	–	–	–	–	–	–	–	–	–	–	8.93E+05
38.0	11.6	–	–	–	–	–	–	–	–	–	–	–	1.06E+06
38.5	11.7	–	–	–	–	–	–	–	–	–	–	–	1.17E+06
39.0	11.9	–	–	–	–	–	–	–	–	–	–	–	9.27E+05
39.5	12.0	–	–	–	–	–	–	–	–	–	–	–	9.20E+05
40.0	12.2	–	–	–	–	–	–	–	–	–	–	–	1.80E+06
40.5	12.3	–	–	–	–	–	–	–	–	–	–	–	2.11E+06
41.0	12.5	–	–	–	–	–	–	–	–	–	–	–	1.59E+06
41.5	12.6	–	–	–	–	–	–	–	–	–	–	–	1.19E+06
42.0	12.8	–	–	–	–	–	–	–	–	–	–	–	9.09E+05
42.5	13.0	–	–	–	–	–	–	–	–	–	–	–	8.65E+05
43.0	13.1	–	–	–	–	–	–	–	–	–	–	–	5.93E+05
43.5	13.3	–	–	–	–	–	–	–	–	–	–	–	5.30E+05
44.0	13.4	–	–	–	–	–	–	–	–	–	–	–	5.38E+05
44.5	13.6	–	–	–	–	–	–	–	–	–	–	–	5.05E+05
45.0	13.7	–	–	–	–	–	–	–	–	–	–	–	5.25E+05
45.5	13.9	–	–	–	–	–	–	–	–	–	–	–	4.45E+05
46.0	14.1	–	–	–	–	–	–	–	–	–	–	–	3.86E+05
46.5	14.2	–	–	–	–	–	–	–	–	–	–	–	2.33E+05
47.0	14.3	–	–	–	–	–	–	–	–	–	–	–	1.10E+05
47.5	14.5	–	–	–	–	–	–	–	–	–	–	–	5.39E+04
48.0	14.6	–	–	–	–	–	–	–	–	–	–	–	2.34E+04

Table B-2. Geophysical Logging Results for the Boreholes Beyond the 216-B-14 Crib Floor Footprint

Borehole parameters		C6804	C6805	C6806	C6807	C6808	C6809	C6810	C6811	C6812	C6813	C6814	299-E13-1
Maximum concentration (pCi/g)		2.84E+05	1.27E+06	1.74E+04	1.60E+04	2.44E+04	1.51E+04	6.08E+03	1.17E+03	4.60E+04	2.37E+04	7.24E+05	2.11E+06
Depth of maximum concentration (ft bgs)		17.0	16.5	20.0	20.5	19.5	20.0	17.0	16.5	17.5	17.0	16.0	40.5
Depth of Cs-137 Concentration													
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
48.5	14.8	–	–	–	–	–	–	–	–	–	–	–	1.75E+04
49.0	14.9	–	–	–	–	–	–	–	–	–	–	–	1.79E+04
49.5	15.1	–	–	–	–	–	–	–	–	–	–	–	1.93E+04
50.0	15.2	–	–	–	–	–	–	–	–	–	–	–	1.15E+04
50.5	15.4	–	–	–	–	–	–	–	–	–	–	–	1.08E+04
51.0	15.5	–	–	–	–	–	–	–	–	–	–	–	1.12E+04
51.5	15.7	–	–	–	–	–	–	–	–	–	–	–	8.10E+03
52.0	15.8	–	–	–	–	–	–	–	–	–	–	–	9.52E+03

– = not measured
bgs = below ground surface
ND = not detected

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Appendix C

Geophysical Logging Data for the 216-B-53A Trench

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Geophysical Logging Data for the 216-B-53A Trench

The fiscal year 2008 geophysical logging results for cesium-137 in the eight boreholes in the western section of the 216-B-53A Trench are provided in Table C-1. The results for cesium-137 in the eight boreholes within the eastern section of the 216-B-53A Trench are provided in Table C-2. Plutonium-239 was not detected in any of these 16 boreholes.

All of the geophysical logging results for the eight boreholes in the western section of the 216-B-53A Trench are provided in Table C-3. All of the geophysical logging results for the eight boreholes in the eastern section of the 216-B-53A Trench are provided in Table C-4.

Table C-1. Geophysical Logging Results for the Boreholes Within the Western Section of the 216-B-53A Trench (4 pages)

Borehole parameters		C6754	C6755	C6756	C6757	C6758	C6759	C6760	C6761
Maximum Cs-137 (pCi/g)		264.76	390.50	9.24	19.87	101.75	692.49	2,340.12	2,744.94
Depth of maximum Cs-137 ft bgs)		15.5	15.0	4.0	18.5	15.5	15.0	16.0	16.0
Depth									
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
0.0	0.0	ND	ND	ND	ND	ND	ND	ND	ND
0.5	0.2	ND	ND	ND	ND	ND	ND	ND	ND
1.0	0.3	ND	ND	ND	ND	ND	ND	0.21	ND
1.5	0.5	ND	ND	ND	ND	ND	ND	ND	ND
2.0	0.6	ND	ND	ND	ND	ND	ND	ND	0.24
2.5	0.8	ND	0.30	ND	ND	0.33	ND	ND	ND
3.0	0.9	0.73	0.87	0.88	0.65	0.67	0.38	ND	ND
3.5	1.1	1.71	1.72	4.99	0.96	0.82	0.92	0.44	0.45
4.0	1.2	4.25	0.91	9.24	1.56	1.46	2.58	1.11	0.64
4.5	1.4	1.88	0.74	7.06	0.82	2.21	2.46	1.44	2.05
5.0	1.5	1.05	1.36	1.91	1.12	1.47	1.16	2.70	4.67
5.5	1.7	0.41	0.61	0.74	0.69	1.32	1.12	1.84	3.38
6.0	1.8	0.26	ND	0.26	0.42	0.56	0.81	0.71	1.63
6.5	2.0	0.31	0.33	ND	ND	ND	0.31	0.39	0.57
7.0	2.1	ND	0.22	ND	ND	ND	ND	ND	ND
7.5	2.3	ND	ND	ND	ND	ND	ND	ND	0.26

Table C-1. Geophysical Logging Results for the Boreholes Within the Western Section of the 216-B-53A Trench (4 pages)

Borehole parameters		C6754	C6755	C6756	C6757	C6758	C6759	C6760	C6761
Maximum Cs-137 (pCi/g)		264.76	390.50	9.24	19.87	101.75	692.49	2,340.12	2,744.94
Depth of maximum Cs-137 ft bgs)		15.5	15.0	4.0	18.5	15.5	15.0	16.0	16.0
Depth									
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
8.0	2.4	0.24	ND	ND	ND	ND	ND	ND	ND
8.5	2.6	ND	ND	0.22	ND	ND	ND	ND	ND
9.0	2.7	ND	ND	ND	ND	ND	ND	ND	ND
9.5	2.9	0.35	ND	ND	ND	0.24	ND	ND	ND
10.0	3.0	ND	ND	ND	ND	0.25	ND	ND	ND
10.5	3.2	ND	ND	ND	ND	0.23	ND	ND	ND
11.0	3.4	ND	ND	0.24	ND	ND	ND	0.26	ND
11.5	3.5	ND	ND	ND	0.26	ND	ND	ND	0.18
12.0	3.7	ND	0.28	ND	ND	ND	ND	ND	ND
12.5	3.8	ND	ND	ND	ND	0.25	ND	ND	0.29
13.0	4.0	ND	0.31	ND	0.24	ND	0.40	ND	0.21
13.5	4.1	0.44	1.94	0.42	0.29	0.29	2.21	0.18	ND
14.0	4.3	3.63	18.06	1.21	ND	2.57	18.54	1.11	0.54
14.5	4.4	36.78	140.41	0.44	ND	17.03	158.92	11.58	6.33
15.0	4.6	245.22	390.50	0.52	ND	72.70	692.49	113.35	73.85
15.5	4.7	264.76	187.30	ND	ND	101.75	567.40	891.74	803.32

Table C-1. Geophysical Logging Results for the Boreholes Within the Western Section of the 216-B-53A Trench (4 pages)

Borehole parameters		C6754	C6755	C6756	C6757	C6758	C6759	C6760	C6761
Maximum Cs-137 (pCi/g)		264.76	390.50	9.24	19.87	101.75	692.49	2,340.12	2,744.94
Depth of maximum Cs-137 ft bgs)		15.5	15.0	4.0	18.5	15.5	15.0	16.0	16.0
Depth									
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
16.0	4.9	80.11	60.17	ND	ND	44.65	216.22	2,340.12	2,744.94
16.5	5.0	21.69	23.24	ND	ND	13.55	121.93	1,362.80	2,116.51
17.0	5.2	11.28	10.58	ND	0.32	10.22	92.87	584.11	1,528.73
17.5	5.3	7.36	10.39	0.31	2.41	17.26	112.87	497.67	1,149.88
18.0	5.5	14.47	6.07	2.59	11.70	41.82	173.64	583.11	778.66
18.5	5.6	21.17	3.58	3.89	19.87	46.68	110.36	421.56	427.41
19.0	5.8	9.93	3.81	1.98	10.35	19.98	39.56	149.80	212.42
19.5	5.9	3.54	2.44	0.75	3.53	6.59	12.55	53.21	109.66
20.0	6.1	1.86	1.66	0.25	1.46	3.15	6.39	22.59	72.93
20.5	6.2	0.92	0.78	ND	0.45	1.16	5.22	15.85	54.95
21.0	6.4	0.28	0.68	ND	0.27	0.58	2.42	9.08	28.77
21.5	6.6	0.51	ND	ND	ND	0.36	0.62	6.59	13.93
22.0	6.7	0.38	ND	ND	ND	ND	ND	3.03	8.33
22.5	6.9	0.32	ND	0.23	ND	ND	0.30	0.97	4.26

Table C-1. Geophysical Logging Results for the Boreholes Within the Western Section of the 216-B-53A Trench (4 pages)

Borehole parameters		C6754	C6755	C6756	C6757	C6758	C6759	C6760	C6761
Maximum Cs-137 (pCi/g)		264.76	390.50	9.24	19.87	101.75	692.49	2,340.12	2,744.94
Depth of maximum Cs-137 ft bgs)		15.5	15.0	4.0	18.5	15.5	15.0	16.0	16.0
Depth									
ft bgs	m bgs	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
23.0	7.0	ND	ND	ND	ND	ND	0.62	0.68	1.41
23.5	7.2	ND	ND	ND	ND	ND	0.51	0.48	0.83
24.0	7.3	0.38	ND	ND	ND	0.47	ND	ND	1.05
24.5	7.5	--	--	--	ND	0.39	0.95	--	--

-- = not measured
bgs = below ground surface
ND = not detected

Table C-2. Geophysical Logging Results for Cesium-137 for the Boreholes within the Eastern Section of the 216-B-53A Trench

Borehole parameters		C6762	C6763	C6764	C6765	C6766	C6767	C6768	C6769
Maximum Cs-137 (pCi/g)		1,076.78	1,002.57	1,180.02	2,707.23	800.35	1,534.84	1,927.82	1,164.89
Depth of maximum Cs-137 (ft bgs)		16.0	16.0	16.0	16.5	16.0	16.0	16.0	16.0
Depth		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs								
0.0	0.0	ND	ND	ND	ND	ND	ND	ND	ND
0.5	0.2	ND	ND	ND	ND	ND	ND	ND	ND
1.0	0.3	ND	ND	ND	ND	ND	ND	ND	ND
1.5	0.5	ND	ND	ND	ND	ND	ND	ND	ND
2.0	0.6	ND	ND	ND	ND	ND	ND	ND	ND
2.5	0.8	ND	ND	ND	ND	0.31	ND	0.51	ND
3.0	0.9	ND	0.24	ND	0.64	0.75	0.90	5.07	0.87
3.5	1.1	0.64	0.76	0.95	1.36	1.41	1.37	2.29	1.42
4.0	1.2	1.05	1.04	1.22	1.63	1.38	1.35	0.72	0.79
4.5	1.4	0.51	0.99	1.41	1.72	3.72	3.86	0.36	1.38
5.0	1.5	0.27	1.18	2.52	4.58	7.44	7.49	0.69	4.53
5.5	1.7	ND	0.44	4.61	2.88	4.02	3.11	1.26	4.69
6.0	1.8	0.43	0.32	1.24	1.62	3.73	1.54	2.07	2.30
6.5	2.0	0.99	1.15	1.24	1.64	3.69	1.05	1.12	0.87
7.0	2.1	0.58	0.84	0.98	1.07	7.62	0.35	0.35	0.60
7.5	2.3	ND	0.29	0.35	0.45	14.42	0.34	ND	ND

Table C-2. Geophysical Logging Results for Cesium-137 for the Boreholes within the Eastern Section of the 216-B-53A Trench

Borehole parameters		C6762	C6763	C6764	C6765	C6766	C6767	C6768	C6769
Maximum Cs-137 (pCi/g)		1,076.78	1,002.57	1,180.02	2,707.23	800.35	1,534.84	1,927.82	1,164.89
Depth of maximum Cs-137 (ft bgs)		16.0	16.0	16.0	16.5	16.0	16.0	16.0	16.0
Depth		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs								
8.0	2.4	ND	0.37	0.26	0.32	2.11	ND	ND	ND
8.5	2.6	ND	ND	ND	ND	ND	ND	ND	ND
9.0	2.7	0.24	ND	ND	ND	ND	0.25	ND	ND
9.5	2.9	ND	ND	ND	0.24	ND	ND	ND	ND
10.0	3.0	ND	ND	ND	ND	ND	ND	ND	ND
10.5	3.2	ND	ND	ND	ND	0.41	ND	ND	ND
11.0	3.4	ND	ND	ND	0.18	0.48	ND	ND	ND
11.5	3.5	ND	ND	ND	ND	0.32	ND	0.32	ND
12.0	3.7	ND	ND	0.25	ND	0.33	ND	ND	ND
12.5	3.8	ND	ND	ND	ND	0.84	ND	ND	ND
13.0	4.0	ND	ND	ND	ND	0.82	ND	ND	0.68
13.5	4.1	ND	ND	ND	ND	0.36	ND	ND	0.59
14.0	4.3	0.85	0.37	ND	0.34	0.62	0.46	0.72	0.70
14.5	4.4	9.65	4.41	2.35	2.30	4.95	3.78	6.93	4.45
15.0	4.6	115.09	50.54	29.88	26.81	55.49	45.19	81.08	51.26
15.5	4.7	836.10	442.82	338.16	335.69	496.44	467.05	795.21	296.99

Table C-2. Geophysical Logging Results for Cesium-137 for the Boreholes within the Eastern Section of the 216-B-53A Trench

Borehole parameters		C6762	C6763	C6764	C6765	C6766	C6767	C6768	C6769
Maximum Cs-137 (pCi/g)		1,076.78	1,002.57	1,180.02	2,707.23	800.35	1,534.84	1,927.82	1,164.89
Depth of maximum Cs-137 (ft bgs)		16.0	16.0	16.0	16.5	16.0	16.0	16.0	16.0
Depth		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs								
16.0	4.9	1,076.78	1,002.57	1,180.02	2,179.38	800.35	1,534.84	1,927.82	1,164.89
16.5	5.0	370.18	489.19	548.81	2,707.23	532.10	826.48	721.81	746.15
17.0	5.2	108.22	194.99	182.66	1,360.64	402.85	261.05	264.88	270.75
17.5	5.3	42.49	64.40	62.05	437.11	149.51	87.99	110.22	76.99
18.0	5.5	17.73	32.01	23.34	154.75	18.24	35.01	53.29	24.69
18.5	5.6	14.44	17.75	14.43	57.09	5.70	13.92	39.17	10.60
19.0	5.8	14.04	15.03	7.91	33.24	2.85	6.70	24.05	7.48
19.5	5.9	13.43	13.39	4.02	12.49	2.43	3.24	9.93	6.25
20.0	6.1	5.02	5.54	2.62	9.29	1.45	2.54	12.80	6.42
20.5	6.2	3.66	2.80	1.32	6.91	1.33	2.25	6.91	6.69
21.0	6.4	2.15	2.25	1.78	5.38	0.88	1.78	5.22	3.19
21.5	6.6	1.98	1.62	1.61	3.53	0.41	1.09	4.25	2.72
22.0	6.7	1.64	1.41	1.14	2.85	0.35	0.27	4.34	3.13
22.5	6.9	0.79	0.71	1.24	3.02	0.29	ND	4.12	2.61
23.0	7.0	0.42	0.29	0.88	1.82	ND	ND	1.93	2.45

Table C-2. Geophysical Logging Results for Cesium-137 for the Boreholes within the Eastern Section of the 216-B-53A Trench

Borehole parameters		C6762	C6763	C6764	C6765	C6766	C6767	C6768	C6769
Maximum Cs-137 (pCi/g)		1,076.78	1,002.57	1,180.02	2,707.23	800.35	1,534.84	1,927.82	1,164.89
Depth of maximum Cs-137 (ft bgs)		16.0	16.0	16.0	16.5	16.0	16.0	16.0	16.0
Depth		Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)	Cs-137 (pCi/g)
ft bgs	m bgs								
23.5	7.2	0.34	ND	0.76	1.74	0.25	ND	1.86	2.11
24.0	7.3	0.48	ND	1.11	2.22	0.24	ND	6.53	2.11
24.5	7.5	--	--	0.50	1.46	--	--	--	--

-- = not measured
bgs = below ground surface
ND = not detected

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Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6754							C6755						
0.0	0.0			0.17			1.69E+04	0.12			0.21			2.08E+04	0.22
0.5	0.2			0.23			2.39E+04	0.07			0.20			2.35E+04	0.03
1.0	0.3			0.27			2.23E+04	0.02			0.19			2.27E+04	0.02
1.5	0.5			0.20			2.43E+04	0.00			0.24			2.43E+04	0.02
2.0	0.6			0.23			2.43E+04	0.02			0.24			2.19E+04	0.07
2.5	0.8			0.26			1.96E+04	0.03	0.30	0.16	0.23			2.73E+04	0.00
3.0	0.9	0.73[a]	0.18	0.22			2.85E+04	0.00	0.87[a]	0.20	0.24			2.58E+04	0.00
3.5	1.1	1.71[a]	0.26	0.28			3.20E+04	0.03	1.72[a]	0.25	0.27			2.66E+04	0.00
4.0	1.2	4.25[a]	0.34	0.21			3.16E+04	0.00	0.91[a]	0.22	0.29			2.54E+04	0.00
4.5	1.4	1.88[a]	0.25	0.24			2.62E+04	0.02	0.74[a]	0.19	0.25			2.69E+04	0.00
5.0	1.5	1.05[a]	0.22	0.28			2.73E+04	0.00	1.36[a]	0.23	0.25			2.58E+04	0.00
5.5	1.7	0.41[a]	0.16	0.23			2.69E+04	0.00	0.61[a]	0.17	0.22			2.54E+04	0.00
6.0	1.8	0.26	0.16	0.24			2.54E+04	0.00			0.24			2.31E+04	0.00
6.5	2.0	0.31	0.16	0.24			2.39E+04	0.00	0.33	0.15	0.23			2.39E+04	0.00
7.0	2.1			0.22	2.54E+04	1.37E+04	2.12E+04	0.00	0.22	0.14	0.21			2.43E+04	0.02
7.5	2.3			0.23			2.39E+04	0.00			0.25			2.66E+04	0.00
8.0	2.4	0.24	0.14	0.22			2.73E+04	0.00			0.26			2.35E+04	0.00
8.5	2.6			0.29			2.35E+04	0.00			0.25			2.69E+04	0.00
9.0	2.7			0.25			2.50E+04	0.00			0.20			2.54E+04	0.00
9.5	2.9	0.35[a]	0.14	0.18			2.31E+04	0.00			0.26			2.35E+04	0.00
10.0	3.0			0.24			2.46E+04	0.00			0.26			2.50E+04	0.00
10.5	3.2			0.25			2.73E+04	0.02			0.26			2.31E+04	0.02
11.0	3.4			0.26			2.35E+04	0.00			0.20			2.62E+04	0.00
11.5	3.5			0.24			2.27E+04	0.00			0.25			2.39E+04	0.00
12.0	3.7			0.28			2.58E+04	0.00	0.28	0.16	0.25			2.50E+04	0.00
12.5	3.8			0.29			2.39E+04	0.00			0.22			2.35E+04	0.00
13.0	4.0			0.26			2.46E+04	0.00	0.31	0.16	0.25			2.93E+04	0.00

Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6754							C6755						
13.5	4.1	0.44	0.18	0.26			2.69E+04	0.00	1.94[a]	0.27	0.28			3.81E+04	0.02
14.0	4.3	3.63[a]	0.34	0.28			4.50E+04	0.00	18.06[a]	0.73	0.52			7.20E+04	0.00
14.5	4.4	36.78[a]	1.03	0.67			9.16E+04	0.00	140.41[a]	2.02	1.06			1.60E+05[b]	0.00
15.0	4.6	245.22[a]	2.70	1.35			1.88E+05[b]	0.02	390.50[a]	3.51	1.73			2.36E+05[b]	0.00
15.5	4.7	264.76[a]	2.81	1.32			1.88E+05[b]	0.00	187.30[a]	2.32	1.13			1.58E+05[b]	0.00
16.0	4.9	80.11[a]	1.48	0.79			1.04E+05[b]	0.00	60.17[a]	1.26	0.60			8.55E+04	0.00
16.5	5.0	21.69[a]	0.77	0.44			6.24E+04	0.00	23.24[a]	0.78	0.41			5.31E+04	0.00
17.0	5.2	11.28[a]	0.55	0.33			4.58E+04	0.00	10.58[a]	0.53	0.31			3.77E+04	0.00
17.5	5.3	7.36[a]	0.47	0.36			4.23E+04	0.00	10.39[a]	0.52	0.28			3.70E+04	0.00
18.0	5.5	14.47[a]	0.63	0.39			4.93E+04	0.00	6.07[a]	0.42	0.31			3.20E+04	0.00
18.5	5.6	21.17[a]	0.75	0.42			5.47E+04	0.00	3.58[a]	0.32	0.25			2.73E+04	0.00
19.0	5.8	9.93[a]	0.52	0.31			4.12E+04	0.00	3.81[a]	0.32	0.22			2.81E+04	0.00
19.5	5.9	3.54[a]	0.32	0.25			3.20E+04	0.00	2.44[a]	0.29	0.28			2.54E+04	0.00
20.0	6.1	1.86[a]	0.26	0.26			2.93E+04	0.00	1.66[a]	0.24	0.23			2.50E+04	0.02
20.5	6.2	0.92[a]	0.19	0.21			2.62E+04	0.00	0.78[a]	0.19	0.24			2.43E+04	0.02
21.0	6.4	0.28	0.16	0.24			2.12E+04	0.00	0.68[a]	0.17	0.19			2.54E+04	0.00
21.5	6.6	0.51[a]	0.16	0.22			2.50E+04	0.00			0.25			2.00E+04	0.00
22.0	6.7	0.38	0.17	0.25			2.16E+04	0.00			0.23			2.27E+04	0.00
22.5	6.9	0.32	0.16	0.24			2.16E+04	0.00			0.22			2.43E+04	0.02
23.0	7.0			0.23			2.31E+04	0.00			0.22			2.23E+04	0.00
23.5	7.2			0.22			2.27E+04	0.00			0.19			2.04E+04	0.00
24.0	7.3	0.38[a]	0.12	0.14			2.23E+04	0.00			0.21			2.46E+04	0.00
24.5	7.5														

Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6756							C6757						
0.0	0.0			0.19			2.12E+04	0.10			0.22			2.00E+04	0.07
0.5	0.2			0.22			2.62E+04	0.07			0.22			2.00E+04	0.10
1.0	0.3			0.22			2.73E+04	0.03			0.26			2.54E+04	0.05
1.5	0.5			0.23			2.31E+04	0.03			0.28			2.39E+04	0.03
2.0	0.6			0.26			2.73E+04	0.00			0.23			2.62E+04	0.02
2.5	0.8			0.24			2.69E+04	0.00			0.24			2.08E+04	0.00
3.0	0.9	0.88[a]	0.20	0.25			2.54E+04	0.00	0.65[a]	0.19	0.26			2.77E+04	0.00
3.5	1.1	4.99[a]	0.38	0.28			3.54E+04	0.00	0.96[a]	0.21	0.26			2.77E+04	0.03
4.0	1.2	9.24[a]	0.50	0.28			3.62E+04	0.00	1.56[a]	0.25	0.29			2.85E+04	0.02
4.5	1.4	7.06[a]	0.44	0.29			3.39E+04	0.00	0.82[a]	0.20	0.25			2.58E+04	0.00
5.0	1.5	1.91[a]	0.26	0.26			2.89E+04	0.00	1.12[a]	0.22	0.25			2.77E+04	0.00
5.5	1.7	0.74[a]	0.18	0.22			2.50E+04	0.00	0.69[a]	0.20	0.26			2.50E+04	0.00
6.0	1.8	0.26	0.15	0.23			3.04E+04	0.00	0.42[a]	0.15	0.20			2.43E+04	0.00
6.5	2.0			0.28			2.54E+04	0.00			0.24			2.43E+04	0.00
7.0	2.1			0.27			2.35E+04	0.00			0.22			2.43E+04	0.00
7.5	2.3			0.30			2.66E+04	0.00			0.24			2.35E+04	0.00
8.0	2.4			0.28			2.43E+04	0.02			0.25			2.39E+04	0.00
8.5	2.6	0.22	0.14	0.22			2.35E+04	0.00			0.21			2.43E+04	0.00
9.0	2.7			0.25			2.77E+04	0.00			0.25			2.62E+04	0.00
9.5	2.9			0.32			3.62E+04	0.00			0.26			2.39E+04	0.00
10.0	3.0			0.21			2.23E+04	0.00			0.22			2.50E+04	0.00
10.5	3.2			0.20			2.16E+04	0.00			0.21			2.50E+04	0.00
11.0	3.4	0.24	0.13	0.19			2.19E+04	0.00			0.25			2.50E+04	0.00
11.5	3.5			0.30			2.93E+04	0.00	0.26	0.12	0.16			2.43E+04	0.00
12.0	3.7			0.23			2.31E+04	0.00			0.26			2.50E+04	0.00
12.5	3.8			0.29			3.12E+04	0.00			0.26			2.62E+04	0.00
13.0	4.0			0.26			2.73E+04	0.07	0.24	0.15	0.24			2.66E+04	0.00
13.5	4.1	0.42	0.20	0.29			2.77E+04	0.00	0.29	0.15	0.23			2.27E+04	0.00

Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6756							C6757						
14.0	4.3	1.21[a]	0.22	0.24			2.31E+04	0.02			0.24			2.58E+04	0.00
14.5	4.4	0.44[a]	0.18	0.25			2.58E+04	0.02			0.24			2.31E+04	0.00
15.0	4.6	0.52[a]	0.18	0.25			2.89E+04	0.00			0.25			2.39E+04	0.00
15.5	4.7			0.23			2.16E+04	0.00			0.22			2.39E+04	0.00
16.0	4.9			0.18			1.81E+04	1.45			0.22			2.35E+04	0.00
16.5	5.0			0.18			1.50E+04	0.02			0.19			2.39E+04	0.00
17.0	5.2			0.21			2.16E+04	0.00	0.32	0.17	0.26			2.31E+04	0.02
17.5	5.3	0.31	0.18	0.28			2.62E+04	0.02	2.41[a]	0.28	0.26			3.31E+04	0.00
18.0	5.5	2.59[a]	0.29	0.25			2.93E+04	0.02	11.70[a]	0.58	0.41			5.24E+04	0.00
18.5	5.6	3.89[a]	0.34	0.25			2.89E+04	0.00	19.87[a]	0.74	0.47			5.93E+04	0.00
19.0	5.8	1.98[a]	0.25	0.23			2.31E+04	0.00	10.35[a]	0.55	0.41			4.54E+04	0.00
19.5	5.9	0.75[a]	0.19	0.23			2.27E+04	0.02	3.53[a]	0.33	0.28			3.16E+04	0.02
20.0	6.1	0.25	0.15	0.22			2.16E+04	0.00	1.46[a]	0.25	0.28			2.96E+04	0.00
20.5	6.2			0.26			2.54E+04	0.00	0.45	0.18	0.27			2.69E+04	0.00
21.0	6.4			0.29			2.77E+04	0.00	0.27	0.15	0.22			2.81E+04	0.00
21.5	6.6			0.19			2.23E+04	0.00			0.25			2.08E+04	0.00
22.0	6.7			0.27			2.39E+04	0.00			0.25			2.19E+04	0.00
22.5	6.9	0.23	0.14	0.22			2.50E+04	0.00			0.22			2.27E+04	0.00
23.0	7.0			0.25			2.69E+04	0.00			0.24			2.43E+04	0.00
23.5	7.2			0.22			2.08E+04	0.00			0.24			2.04E+04	0.05
24.0	7.3			0.21			2.08E+04	0.00			0.22			2.35E+04	0.00
24.5	7.5										0.22			2.16E+04	0.00

Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6758							C6759						
0.0	0.0			0.22			1.81E+04	0.02			0.20			1.89E+04	0.18
0.5	0.2			0.21			2.31E+04	0.02			0.22			2.31E+04	0.08
1.0	0.3			0.22			2.46E+04	0.13			0.23			2.35E+04	0.02
1.5	0.5			0.25			2.39E+04	0.02			0.21			2.43E+04	0.03
2.0	0.6			0.24			2.50E+04	0.02			0.28			2.27E+04	0.50
2.5	0.8	0.33	0.14	0.19			2.23E+04	0.07			0.21			2.12E+04	0.02
3.0	0.9	0.67[a]	0.19	0.25			2.43E+04	0.00	0.38[a]	0.15	0.21			2.46E+04	0.02
3.5	1.1	0.82[a]	0.20	0.26			2.62E+04	0.03	0.92[a]	0.21	0.26			2.58E+04	0.02
4.0	1.2	1.46[a]	0.23	0.23			2.89E+04	0.00	2.58[a]	0.29	0.26			2.89E+04	0.02
4.5	1.4	2.21[a]	0.26	0.23			2.73E+04	0.78	2.46[a]	0.27	0.23			2.69E+04	0.03
5.0	1.5	1.47[a]	0.24	0.26			2.73E+04	0.05	1.16[a]	0.22	0.26			2.89E+04	0.02
5.5	1.7	1.32[a]	0.22	0.22			2.62E+04	0.02	1.12[a]	0.21	0.24			2.89E+04	0.02
6.0	1.8	0.56[a]	0.19	0.25			2.73E+04	0.02	0.81[a]	0.18	0.21			2.46E+04	0.00
6.5	2.0			0.25			2.35E+04	0.02	0.31	0.16	0.25			2.39E+04	0.00
7.0	2.1			0.23			2.62E+04	0.12			0.25			2.54E+04	0.00
7.5	2.3			0.25			2.31E+04	0.05			0.27			2.62E+04	0.02
8.0	2.4			0.21			2.62E+04	0.02			0.25			2.54E+04	0.00
8.5	2.6			0.25			2.77E+04	0.00			0.24			2.62E+04	0.00
9.0	2.7			0.28			2.62E+04	0.03			0.22			2.50E+04	0.00
9.5	2.9	0.24	0.14	0.22			2.43E+04	0.00			0.24			2.54E+04	0.00
10.0	3.0	0.25	0.13	0.19			2.46E+04	0.00			0.26			2.73E+04	0.02
10.5	3.2	0.23	0.14	0.22			2.46E+04	0.02			0.25			2.58E+04	0.00
11.0	3.4			0.24			2.39E+04	0.00			0.27			2.39E+04	0.00
11.5	3.5			0.22			2.50E+04	0.00			0.23			2.43E+04	0.00
12.0	3.7			0.25			2.43E+04	0.02			0.24			2.27E+04	0.00
12.5	3.8	0.25	0.15	0.22			2.62E+04	0.00			0.29			2.54E+04	0.02
13.0	4.0			0.24			2.77E+04	0.02	0.40	0.17	0.24			2.96E+04	0.00
13.5	4.1	0.29	0.16	0.25			3.08E+04	0.02	2.21[a]	0.27	0.26			4.31E+04	0.00
14.0	4.3	2.57[a]	0.30	0.29			3.70E+04	0.00	18.54[a]	0.74	0.52			7.97E+04	0.02

Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6758							C6759						
14.5	4.4	17.03[a]	0.69	0.45	6.28E+04	3.74E+04	6.04E+04	0.00	158.92[a]	2.21	1.26			1.89E+05[b]	0.00
15.0	4.6	72.70[a]	1.40	0.71			1.03E+05[b]	0.02	692.49[a]	5.19	2.87			3.78E+05[b]	0.00
15.5	4.7	101.75[a]	1.66	0.80			1.12E+05[b]	0.00	567.40[a]	4.54	2.33			3.18E+05[b]	0.00
16.0	4.9	44.65[a]	1.11	0.63			7.93E+04	0.02	216.22[a]	2.51	1.19			1.77E+05[b]	0.02
16.5	5.0	13.55[a]	0.62	0.44			5.04E+04	0.00	121.93[a]	1.82	0.82			1.20E+05[b]	0.00
17.0	5.2	10.22[a]	0.53	0.32			4.58E+04	0.03	92.87[a]	1.57	0.69			1.04E+05[b]	0.00
17.5	5.3	17.26[a]	0.69	0.44			5.85E+04	0.00	112.87[a]	1.77	0.89			1.28E+05[b]	0.00
18.0	5.5	41.82[a]	1.06	0.58			7.74E+04	0.00	173.64[a]	2.22	1.08			1.56E+05[b]	0.00
18.5	5.6	46.68[a]	1.13	0.63			8.35E+04	0.02	110.36[a]	1.80	1.09			1.33E+05[b]	0.00
19.0	5.8	19.98[a]	0.76	0.54			6.35E+04	0.00	39.56[a]	1.07	0.72			8.78E+04	0.00
19.5	5.9	6.59[a]	0.47	0.44			4.58E+04	0.00	12.55[a]	0.63	0.51			5.85E+04	0.00
20.0	6.1	3.15[a]	0.35	0.36			3.66E+04	0.03	6.39[a]	0.48	0.48			4.66E+04	0.00
20.5	6.2	1.16[a]	0.24	0.31			3.16E+04	0.02	5.22[a]	0.44	0.45			4.74E+04	0.00
21.0	6.4	0.58[a]	0.20	0.27			2.50E+04	0.00	2.42[a]	0.33	0.38			3.39E+04	0.00
21.5	6.6	0.36	0.18	0.26			2.54E+04	0.00	0.62[a]	0.21	0.31			3.16E+04	0.00
22.0	6.7			0.25			2.50E+04	0.02			0.27			2.50E+04	0.00
22.5	6.9			0.23			2.31E+04	0.00	0.30	0.17	0.26			2.58E+04	0.02
23.0	7.0			0.22			2.35E+04	0.00	0.62[a]	0.20	0.27			2.58E+04	0.00
23.5	7.2			0.21			2.31E+04	0.00	0.51[a]	0.19	0.27			2.46E+04	0.00
24.0	7.3	0.47[a]	0.16	0.22			2.16E+04	0.00			0.24			2.43E+04	0.00
24.5	7.5	0.39[a]	0.15	0.21			2.43E+04	0.02	0.95[a]	0.21	0.26			2.35E+04	0.02

Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6760							C6761						
0.0	0.0			0.21			2.00E+04	0.07			0.21			1.92E+04	0.28
0.5	0.2			0.18			2.27E+04	0.05			0.24			2.31E+04	0.03
1.0	0.3	0.21	0.14	0.21			2.54E+04	0.02			0.28			2.58E+04	0.00
1.5	0.5			0.22			2.46E+04	0.02			0.25			2.46E+04	0.00
2.0	0.6			0.26			2.58E+04	0.02	0.24	0.12	0.17			2.58E+04	0.03
2.5	0.8			0.25			2.23E+04	0.00			0.21			2.23E+04	0.03
3.0	0.9			0.18			2.39E+04	0.07			0.25			2.46E+04	0.00
3.5	1.1	0.44[a]	0.12	0.18			2.73E+04	0.02	0.45[a]	0.19	0.19			2.58E+04	0.02
4.0	1.2	1.11[a]	0.18	0.21			2.62E+04	0.07	0.64[a]	0.17	0.20			2.62E+04	0.00
4.5	1.4	1.44[a]	0.28	0.19			2.81E+04	0.00	2.05[a]	0.36	0.23			3.12E+04	0.00
5.0	1.5	2.70[a]	0.44	0.19			3.08E+04	0.02	4.67[a]	0.68	0.25			3.46E+04	0.00
5.5	1.7	1.84[a]	0.35	0.25			2.96E+04	0.02	3.38[a]	0.54	0.24			3.39E+04	0.00
6.0	1.8	0.71[a]	0.19	0.21			2.69E+04	0.00	1.63[a]	0.32	0.19			2.96E+04	0.00
6.5	2.0	0.39[a]	0.15	0.17			2.58E+04	0.02	0.57[a]	0.18	0.18			2.66E+04	0.00
7.0	2.1			0.24			2.31E+04	0.00			0.24			2.35E+04	0.00
7.5	2.3			0.27			2.58E+04	0.00	0.26	0.15	0.22			2.35E+04	0.00
8.0	2.4			0.27			2.46E+04	0.00			0.25			2.62E+04	0.00
8.5	2.6			0.26			2.39E+04	0.00			0.22			2.50E+04	0.00
9.0	2.7			0.24			2.46E+04	0.02			0.21			2.39E+04	0.02
9.5	2.9			0.22			2.46E+04	0.00			0.26			2.54E+04	0.00
10.0	3.0			0.28			2.39E+04	0.00			0.23			2.62E+04	0.00
10.5	3.2			0.25			2.39E+04	0.00			0.25			2.46E+04	0.00
11.0	3.4	0.26	0.15	0.18			2.77E+04	0.00			0.25			2.62E+04	0.00
11.5	3.5			0.27			2.46E+04	0.00	0.18	0.12	0.17			2.46E+04	0.00
12.0	3.7			0.26			2.27E+04	0.00			0.27			2.39E+04	0.00
12.5	3.8			0.26			2.39E+04	0.00	0.29	0.14	0.21	2.23E+04	1.40E+04	2.19E+04	0.00
13.0	4.0			0.25			2.62E+04	0.00	0.21	0.13	0.19			2.54E+04	0.00
13.5	4.1	0.18	0.09	0.18			2.89E+04	0.00			0.16			2.62E+04	0.00
14.0	4.3	1.11[a]	0.25	0.25			3.81E+04	0.02	0.54[a]	0.13	0.19			3.31E+04	0.00

Table C-3. All Geophysical Logging Results for the Boreholes within the Western Section of the 216-B-53A Trench

Depth (ft bgs)	m	Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV			
		Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6760							C6761						
14.5	4.4	11.58[a]	1.10	0.37			7.12E+04	0.00	6.33[a]	0.62	0.31			5.85E+04	0.00
15.0	4.6	113.35[a]	6.28	0.92			1.73E+05[b]	0.00	73.85[a]	3.86	0.81			1.49E+05[b]	0.00
15.5	4.7	891.74[a]	23.90	4.25			5.15E+05[b]	0.00	803.32[a]	20.73	3.92			5.13E+05[b]	0.00
16.0	4.9	2340.12[a]	145.79	10.15			1.05E+06[b]	0.00	2744.94[a]	226.73	14.51			1.47E+06[b]	0.00
16.5	5.0	1362.80[a]	44.15	5.00			5.89E+05[b]	0.00	2116.51[a]	135.46	9.84			1.07E+06[b]	0.00
17.0	5.2	584.11[a]	16.53	2.46			3.29E+05[b]	0.00	1528.73[a]	69.86	6.00			7.30E+05[b]	0.00
17.5	5.3	497.67[a]	9.65	2.26			3.03E+05[b]	0.00	1149.88[a]	25.64	4.61			5.53E+05[b]	0.02
18.0	5.5	583.11[a]	14.87	2.22			3.26E+05[b]	0.00	778.66[a]	19.31	3.09			3.99E+05[b]	0.02
18.5	5.6	421.56[a]	8.35	1.95	2.80E+05	1.58E+05	2.58E+05[b]	0.02	427.41[a]	8.72	2.06			2.72E+05[b]	0.00
19.0	5.8	149.80[a]	5.44	1.20			1.57E+05[b]	0.00	212.42[a]	8.14	1.36			1.85E+05[b]	0.00
19.5	5.9	53.21[a]	2.70	0.82			9.97E+04	0.00	109.66[a]	4.27	0.95			1.32E+05[b]	0.00
20.0	6.1	22.59[a]	1.53	0.68			7.82E+04	0.00	72.93[a]	3.60	0.79			1.10E+05[b]	0.00
20.5	6.2	15.85[a]	0.83	0.57			6.70E+04	0.02	54.95[a]	3.20	0.68			9.20E+04	0.00
21.0	6.4	9.08[a]	0.66	0.49			5.54E+04	0.00	28.77[a]	1.72	0.49			6.78E+04	0.00
21.5	6.6	6.59[a]	0.73	0.37			4.35E+04	0.00	13.93[a]	0.59	0.33			5.08E+04	0.00
22.0	6.7	3.03[a]	0.39	0.27			3.35E+04	0.00	8.33[a]	0.79	0.29			3.43E+04	0.00
22.5	6.9	0.97[a]	0.17	0.20			2.69E+04	0.00	4.26[a]	0.47	0.24			3.16E+04	0.00
23.0	7.0	0.68[a]	0.14	0.17			2.50E+04	0.00	1.41[a]	0.29	0.19			2.54E+04	0.00
23.5	7.2	0.48[a]	0.12	0.19			2.23E+04	0.00	0.83[a]	0.22	0.18			2.43E+04	0.00
24.0	7.3			0.17			2.46E+04	0.00	1.05[a]	0.26	0.22			2.46E+04	0.00
24.5	7.5														

a. Reported activity is greater than the method detection limit plus the counting error.

b. Method detection limits for plutonium exceed 100 nCi/g.

bgs = below ground surface

cps = counts per second

MDL = method detection limit

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)				Pu-239 (375 keV)		
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6762							C6763						
0.0	0.0			0.16			2.08E+04	0.28			0.21			2.08E+04	0.13
0.5	0.2			0.24			2.23E+04	0.03			0.22			1.81E+04	0.07
1.0	0.3			0.25			2.50E+04	0.00			0.25			2.35E+04	0.03
1.5	0.5			0.26			2.27E+04	0.00			0.26			2.35E+04	0.00
2.0	0.6			0.26			2.54E+04	0.03			0.25			2.23E+04	0.02
2.5	0.8			0.20	2.23E+04	1.33E+04	2.08E+04	0.03			0.22			2.27E+04	0.00
3.0	0.9			0.22			2.23E+04	0.00	0.24	0.10	0.17			2.62E+04	0.02
3.5	1.1	0.64[a]	0.18	0.23			2.35E+04	0.02	0.76[a]	0.19	0.22			2.50E+04	0.02
4.0	1.2	1.05[a]	0.20	0.22			2.50E+04	0.00	1.04[a]	0.17	0.21			2.81E+04	0.00
4.5	1.4	0.51[a]	0.18	0.25			2.66E+04	0.00	0.99[a]	0.24	0.22			2.85E+04	0.00
5.0	1.5	0.27	0.15	0.23			2.73E+04	0.00	1.18[a]	0.18	0.21			2.66E+04	0.00
5.5	1.7			0.25			2.39E+04	0.00	0.44[a]	0.13	0.21			2.62E+04	0.02
6.0	1.8	0.43[a]	0.16	0.22			2.50E+04	0.00	0.32	0.19	0.19			2.81E+04	0.00
6.5	2.0	0.99[a]	0.20	0.24			2.66E+04	0.00	1.15[a]	0.18	0.19			2.81E+04	0.00
7.0	2.1	0.58[a]	0.18	0.24			2.77E+04	0.00	0.84[a]	0.16	0.22			2.81E+04	0.00
7.5	2.3			0.25			2.62E+04	0.00	0.29	0.11	0.19			2.23E+04	0.00
8.0	2.4			0.22			2.46E+04	0.00	0.37[a]	0.14	0.19			2.58E+04	0.00
8.5	2.6			0.23			2.81E+04	0.00			0.22			2.23E+04	0.00
9.0	2.7	0.24	0.14	0.22			2.62E+04	0.02			0.22			2.54E+04	0.02
9.5	2.9			0.25			2.39E+04	0.00			0.26			2.46E+04	0.00
10.0	3.0			0.24			2.54E+04	0.00			0.25			2.54E+04	0.00
10.5	3.2			0.26			2.35E+04	0.00			0.23			2.54E+04	0.00
11.0	3.4			0.22			2.66E+04	0.00			0.22			2.23E+04	0.00
11.5	3.5			0.25			2.54E+04	0.00			0.25			2.19E+04	0.02
12.0	3.7			0.26			2.50E+04	0.00			0.19			2.43E+04	0.00
12.5	3.8			0.23			2.69E+04	0.00			0.26			2.43E+04	0.00
13.0	4.0			0.25			2.50E+04	0.00			0.22			2.58E+04	0.00
13.5	4.1			0.26			2.58E+04	0.00			0.23			2.81E+04	0.00
14.0	4.3	0.85[a]	0.22	0.28			3.50E+04	0.00	0.37[a]	0.12	0.21			3.12E+04	0.00

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)				Pu-239 (375 keV)		
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6762							C6763						
14.5	4.4	9.65[a]	0.54	0.41			6.54E+04	0.00	4.41[a]	0.48	0.28			5.24E+04	0.00
15.0	4.6	115.09[a]	1.84	1.02			1.64E+05[b]	0.00	50.54[a]	3.52	0.71			1.18E+05[b]	0.02
15.5	4.7	836.10[a]	5.85	3.17			4.16E+05[b]	0.00	442.82[a]	13.24	2.09			3.14E+05[b]	0.00
16.0	4.9	1076.78[a]	6.78	3.57			4.47E+05[b]	0.00	1002.57[a]	24.46	3.76			4.68E+05[b]	0.00
16.5	5.0	370.18[a]	3.37	1.49			2.13E+05[b]	0.00	489.19[a]	14.72	1.87			2.69E+05[b]	0.00
17.0	5.2	108.22[a]	1.69	0.69			1.05E+05[b]	0.00	194.99[a]	9.50	0.97			1.49E+05[b]	0.00
17.5	5.3	42.49[a]	1.04	0.41			6.58E+04	0.02	64.40[a]	3.54	0.48			8.32E+04	0.00
18.0	5.5	17.73[a]	0.68	0.35			4.43E+04	0.02	32.01[a]	2.17	0.36			5.51E+04	0.02
18.5	5.6	14.44[a]	0.61	0.31			3.97E+04	0.00	17.75[a]	1.04	0.31			4.58E+04	0.00
19.0	5.8	14.04[a]	0.61	0.34			4.66E+04	0.00	15.03[a]	1.06	0.29			4.62E+04	0.02
19.5	5.9	13.43[a]	0.58	0.26			4.16E+04	0.00	13.39[a]	0.88	0.30			4.39E+04	0.00
20.0	6.1	5.02[a]	0.39	0.30			3.12E+04	0.00	5.54[a]	0.51	0.23			3.39E+04	0.00
20.5	6.2	3.66[a]	0.33	0.26			3.00E+04	0.00	2.80[a]	0.27	0.22			2.81E+04	0.00
21.0	6.4	2.15[a]	0.27	0.26			3.04E+04	0.00	2.25[a]	0.35	0.20			2.69E+04	0.00
21.5	6.6	1.98[a]	0.25	0.23			2.50E+04	0.00	1.62[a]	0.26	0.21			2.77E+04	0.00
22.0	6.7	1.64[a]	0.24	0.24			2.58E+04	0.00	1.41[a]	0.30	0.21			2.50E+04	0.00
22.5	6.9	0.79[a]	0.19	0.24			2.58E+04	0.00	0.71[a]	0.15	0.18			2.35E+04	0.00
23.0	7.0	0.42[a]	0.15	0.21			2.23E+04	0.00	0.29	0.17	0.15			2.39E+04	0.00
23.5	7.2	0.34	0.17	0.25			2.19E+04	0.00			0.22			2.27E+04	0.00
24.0	7.3	0.48[a]	0.16	0.22			2.31E+04	0.00			0.22			2.23E+04	0.00
24.5	7.5														

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6764							C6765						
0.0	0.0			0.19			1.89E+04	0.07			0.19			1.89E+04	0.07
0.5	0.2			0.23			2.23E+04	0.10			0.17			2.16E+04	0.02
1.0	0.3			0.22			2.39E+04	0.05			0.25			2.35E+04	0.03
1.5	0.5			0.23			2.31E+04	0.03			0.24			2.54E+04	0.02
2.0	0.6			0.25			2.54E+04	0.02			0.22			2.54E+04	0.00
2.5	0.8			0.25			2.43E+04	0.00			0.18			2.19E+04	0.02
3.0	0.9			0.25			2.46E+04	0.00	0.64[a]	0.11	0.18			2.54E+04	0.00
3.5	1.1	0.95[a]	0.19	0.22			2.81E+04	0.03	1.36[a]	0.33	0.16			3.08E+04	0.02
4.0	1.2	1.22[a]	0.22	0.25			2.85E+04	0.02	1.63[a]	0.21	0.19			2.85E+04	0.00
4.5	1.4	1.41[a]	0.23	0.24			2.58E+04	0.00	1.72[a]	0.21	0.21			2.89E+04	0.02
5.0	1.5	2.52[a]	0.29	0.27			3.00E+04	0.00	4.58[a]	0.54	0.26	3.46E+04	1.96E+04	3.08E+04	0.00
5.5	1.7	4.61[a]	0.36	0.27			3.20E+04	0.00	2.88[a]	0.50	0.24			2.96E+04	0.00
6.0	1.8	1.24[a]	0.22	0.25			2.77E+04	0.00	1.62[a]	0.21	0.20			3.00E+04	0.00
6.5	2.0	1.24[a]	0.22	0.24			2.62E+04	0.00	1.64[a]	0.24	0.20			2.69E+04	0.00
7.0	2.1	0.98[a]	0.21	0.26			2.58E+04	0.00	1.07[a]	0.23	0.18			2.77E+04	0.02
7.5	2.3	0.35	0.16	0.24			2.58E+04	0.00	0.45[a]	0.17	0.16			2.81E+04	0.00
8.0	2.4	0.26	0.15	0.22			2.46E+04	0.00	0.32	0.18	0.28			2.43E+04	0.00
8.5	2.6			0.24			2.23E+04	0.00			0.24			2.31E+04	0.02
9.0	2.7			0.23			2.54E+04	0.00			0.28			2.58E+04	0.00
9.5	2.9			0.27			2.35E+04	0.00	0.24	0.14	0.21			2.69E+04	0.00
10.0	3.0			0.26			2.31E+04	0.00			0.24			2.58E+04	0.00
10.5	3.2			0.22			2.46E+04	0.00			0.26			2.43E+04	0.00
11.0	3.4			0.25			2.27E+04	0.00	0.18	0.09	0.18			2.31E+04	0.02
11.5	3.5			0.24			2.46E+04	0.00			0.24			2.50E+04	0.00
12.0	3.7	0.25	0.15	0.22			2.54E+04	0.00			0.26			2.54E+04	0.00
12.5	3.8			0.26			2.50E+04	0.00			0.26			2.35E+04	0.00
13.0	4.0			0.24			2.54E+04	0.00			0.25			2.58E+04	0.00

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6764							C6765						
13.5	4.1			0.22			2.46E+04	0.00			0.24			2.62E+04	0.00
14.0	4.3			0.27			2.77E+04	0.00	0.34[a]	0.14	0.19			3.12E+04	0.02
14.5	4.4	2.35[a]	0.30	0.32			4.23E+04	0.00	2.30[a]	0.25	0.22			4.47E+04	0.00
15.0	4.6	29.88[a]	0.93	0.62			9.89E+04	0.00	26.81[a]	2.24	0.55			1.01E+05[b]	0.00
15.5	4.7	338.16[a]	3.38	1.86			2.64E+05[b]	0.00	335.69[a]	10.21	2.05			3.08E+05[b]	0.00
16.0	4.9	1180.02[a]	7.32	3.91			5.02E+05[b]	0.00	2179.38[a]	160.84	10.85			1.16E+06[b]	0.00
16.5	5.0	548.81[a]	4.34	2.12			2.84E+05[b]	0.00	2707.23[a]	218.74	12.45			1.29E+06[b]	0.00
17.0	5.2	182.66[a]	2.25	0.98			1.44E+05[b]	0.02	1360.64[a]	42.45	4.59			5.54E+05[b]	0.00
17.5	5.3	62.05[a]	1.28	0.59			8.39E+04	0.00	437.11[a]	15.52	1.68			2.30E+05[b]	0.00
18.0	5.5	23.34[a]	0.78	0.39			5.27E+04	0.00	154.75[a]	7.04	0.79			1.22E+05[b]	0.02
18.5	5.6	14.43[a]	0.61	0.31			3.89E+04	0.00	57.09[a]	3.48	0.48			7.43E+04	0.00
19.0	5.8	7.91[a]	0.47	0.32			3.62E+04	0.00	33.24[a]	2.60	0.41			5.62E+04	0.00
19.5	5.9	4.02[a]	0.35	0.28			3.27E+04	0.02	12.49[a]	0.96	0.30			4.12E+04	0.00
20.0	6.1	2.62[a]	0.29	0.25			2.93E+04	0.00	9.29[a]	0.71	0.24			3.54E+04	0.00
20.5	6.2	1.32[a]	0.25	0.31			3.16E+04	0.00	6.91[a]	0.72	0.25			3.16E+04	0.00
21.0	6.4	1.78[a]	0.26	0.27			2.69E+04	0.00	5.38[a]	0.53	0.24			3.39E+04	0.00
21.5	6.6	1.61[a]	0.24	0.25			2.77E+04	0.00	3.53[a]	0.30	0.24			2.77E+04	0.00
22.0	6.7	1.14[a]	0.22	0.25			2.85E+04	0.00	2.85[a]	0.36	0.21			2.77E+04	0.00
22.5	6.9	1.24[a]	0.20	0.19			2.58E+04	0.00	3.02[a]	0.28	0.21			2.77E+04	0.00
23.0	7.0	0.88[a]	0.19	0.23			2.27E+04	0.00	1.82[a]	0.29	0.18			2.66E+04	0.00
23.5	7.2	0.76[a]	0.20	0.26			2.54E+04	0.05	1.74[a]	0.36	0.21			2.35E+04	0.00
24.0	7.3	1.11[a]	0.21	0.24			2.66E+04	0.00	2.22[a]	0.31	0.21			2.73E+04	0.00
24.5	7.5	0.50[a]	0.16	0.21			2.39E+04	0.00	1.46[a]	0.27	0.19			2.35E+04	0.00

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6766							C6767						
0.0	0.0			0.18			1.92E+04	0.08			0.19			2.24E+04	0.05
0.5	0.2			0.25			2.31E+04	0.02			0.21			2.16E+04	0.02
1.0	0.3			0.24			2.39E+04	0.03			0.21			2.35E+04	0.02
1.5	0.5			0.27			2.73E+04	0.00			0.24			2.39E+04	0.00
2.0	0.6			0.22			2.89E+04	0.03			0.22			2.43E+04	0.00
2.5	0.8	0.31	0.15	0.21			2.31E+04	0.02			0.23			2.19E+04	0.00
3.0	0.9	0.75[a]	0.20	0.26			2.69E+04	0.00	0.90[a]	0.19	0.22			2.35E+04	0.00
3.5	1.1	1.41[a]	0.23	0.26			2.73E+04	0.00	1.37[a]	0.24	0.29			2.85E+04	0.03
4.0	1.2	1.38[a]	0.22	0.24			2.73E+04	0.00	1.35[a]	0.25	0.29			2.89E+04	0.00
4.5	1.4	3.72[a]	0.34	0.28			3.50E+04	0.00	3.86[a]	0.34	0.25			3.27E+04	0.00
5.0	1.5	7.44[a]	0.45	0.26			3.77E+04	0.00	7.49[a]	0.46	0.32			3.77E+04	0.00
5.5	1.7	4.02[a]	0.35	0.28			3.39E+04	0.00	3.11[a]	0.31	0.28			3.08E+04	0.00
6.0	1.8	3.73[a]	0.34	0.29			3.39E+04	0.00	1.54[a]	0.23	0.22			2.81E+04	0.02
6.5	2.0	3.69[a]	0.33	0.27			3.12E+04	0.00	1.05[a]	0.21	0.26			2.77E+04	0.00
7.0	2.1	7.62[a]	0.46	0.29			3.43E+04	0.03	0.35	0.19	0.30			2.46E+04	0.00
7.5	2.3	14.42[a]	0.61	0.29			4.12E+04	0.00	0.34	0.17	0.25			2.77E+04	0.00
8.0	2.4	2.11[a]	0.27	0.25			2.69E+04	0.02			0.24			2.66E+04	0.02
8.5	2.6			0.26			2.66E+04	0.00			0.24			2.50E+04	0.00
9.0	2.7			0.22			2.58E+04	0.02	0.25	0.15	0.24			2.35E+04	0.00
9.5	2.9			0.25			2.54E+04	0.00			0.24			2.46E+04	0.00
10.0	3.0			0.25			2.39E+04	0.00			0.26			2.35E+04	0.00
10.5	3.2	0.41	0.17	0.25			2.54E+04	0.02			0.22			2.50E+04	0.02
11.0	3.4	0.48[a]	0.18	0.25			2.54E+04	0.02			0.24			2.35E+04	0.00
11.5	3.5	0.32	0.15	0.22			2.58E+04	0.00			0.22			2.43E+04	0.00
12.0	3.7	0.33	0.17	0.25			2.54E+04	0.00			0.21			2.46E+04	0.00
12.5	3.8	0.84[a]	0.19	0.23			2.69E+04	0.00			0.25			2.35E+04	0.00
13.0	4.0	0.82[a]	0.20	0.24			2.69E+04	0.02			0.24			2.50E+04	0.00
13.5	4.1	0.36	0.16	0.23			2.35E+04	0.00			0.22			2.93E+04	0.00
14.0	4.3	0.62[a]	0.20	0.27			3.31E+04	0.00	0.46[a]	0.17	0.24			2.93E+04	0.02

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6766							C6767						
14.5	4.4	4.95[a]	0.39	0.33			5.16E+04	0.00	3.78[a]	0.35	0.32	5.12E+04	2.95E+04	4.74E+04	0.00
15.0	4.6	55.49[a]	1.26	0.74			1.18E+05[b]	0.02	45.19[a]	1.15	0.72			1.22E+05[b]	0.00
15.5	4.7	496.44[a]	4.17	2.20			3.03E+05[b]	0.00	467.05[a]	4.20	2.41			3.45E+05[b]	0.02
16.0	4.9	800.35[a]	5.60	2.80			3.89E+05[b]	0.02	1534.84[a]	9.67	6.27			6.83E+05[b]	0.00
16.5	5.0	532.10[a]	4.26	1.93			2.91E+05[b]	0.00	826.48[a]	5.79	3.06			3.96E+05[b]	0.00
17.0	5.2	402.85[a]	3.50	1.46			2.19E+05[b]	0.02	261.05[a]	2.77	1.28			1.87E+05[b]	0.00
17.5	5.3	149.51[a]	2.02	0.88			1.31E+05[b]	0.00	87.99[a]	1.52	0.65			1.03E+05[b]	0.00
18.0	5.5	18.24[a]	0.71	0.44			5.81E+04	0.00	35.01[a]	0.95	0.41			6.12E+04	0.00
18.5	5.6	5.70[a]	0.41	0.32			3.73E+04	0.02	13.92[a]	0.61	0.34			4.27E+04	0.00
19.0	5.8	2.85[a]	0.30	0.27			3.23E+04	0.00	6.70[a]	0.44	0.31			3.46E+04	0.00
19.5	5.9	2.43[a]	0.29	0.28			2.93E+04	0.00	3.24[a]	0.31	0.26			3.12E+04	0.00
20.0	6.1	1.45[a]	0.23	0.24			2.54E+04	0.02	2.54[a]	0.29	0.28			2.77E+04	0.00
20.5	6.2	1.33[a]	0.23	0.25			2.50E+04	0.00	2.25[a]	0.28	0.26			2.73E+04	0.00
21.0	6.4	0.88[a]	0.19	0.22			2.58E+04	0.00	1.78[a]	0.25	0.25			2.66E+04	0.00
21.5	6.6	0.41[a]	0.16	0.22			2.50E+04	0.00	1.09[a]	0.22	0.25			2.77E+04	0.00
22.0	6.7	0.35	0.15	0.21			2.19E+04	0.00	0.27	0.16	0.25			2.23E+04	0.00
22.5	6.9	0.29	0.14	0.19			2.23E+04	0.00			0.26	2.08E+04	1.27E+04	1.96E+04	0.02
23.0	7.0			0.22			2.58E+04	0.00			0.26	2.50E+04	1.35E+04	2.08E+04	0.00
23.5	7.2	0.25	0.14	0.21			2.19E+04	0.00			0.24			2.50E+04	0.00
24.0	7.3	0.24	0.15	0.23			2.19E+04	0.00			0.22			2.46E+04	0.00
	7.5														

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6768							C6769						
0.0	0.0			0.18			2.04E+04	0.03			0.19			1.85E+04	
0.5	0.2			0.21			1.96E+04	0.02			0.19			2.12E+04	0.00
1.0	0.3			0.24			2.46E+04	0.00			0.23			2.12E+04	0.03
1.5	0.5			0.25			2.58E+04	0.02			0.19			2.46E+04	0.00
2.0	0.6			0.24			2.43E+04	0.03			0.23			2.16E+04	0.02
2.5	0.8	0.51[a]	0.17	0.22			2.50E+04	0.02			0.25			2.39E+04	0.00
3.0	0.9	5.07[a]	0.38	0.26			3.31E+04	0.05	0.87[a]	0.20	0.25			2.66E+04	0.00
3.5	1.1	2.29[a]	0.28	0.26			2.89E+04	0.00	1.42[a]	0.24	0.26			2.85E+04	0.02
4.0	1.2	0.72[a]	0.21	0.28			2.81E+04	0.00	0.79[a]	0.20	0.25			2.69E+04	0.00
4.5	1.4	0.36	0.18	0.28			2.66E+04	0.00	1.38[a]	0.23	0.26			2.93E+04	0.02
5.0	1.5	0.69[a]	0.19	0.24			2.54E+04	0.00	4.53[a]	0.37	0.32			3.35E+04	0.03
5.5	1.7	1.26[a]	0.22	0.24			2.43E+04	0.00	4.69[a]	0.37	0.27			3.31E+04	0.00
6.0	1.8	2.07[a]	0.26	0.24			2.66E+04	0.00	2.30[a]	0.26	0.21			2.89E+04	0.00
6.5	2.0	1.12[a]	0.22	0.26			2.46E+04	0.00	0.87[a]	0.19	0.21			2.54E+04	0.02
7.0	2.1	0.35	0.18	0.27			2.58E+04	0.00	0.60[a]	0.18	0.24			2.19E+04	0.00
7.5	2.3			0.25			2.27E+04	0.00			0.27			2.27E+04	0.00
8.0	2.4			0.26			2.39E+04	0.00			0.27			2.62E+04	0.00
8.5	2.6			0.25			2.89E+04	0.02			0.23			2.50E+04	0.00
9.0	2.7			0.26			2.54E+04	0.05			0.24			2.54E+04	0.00
9.5	2.9			0.23			2.62E+04	0.00			0.24			2.62E+04	0.00
10.0	3.0			0.25			2.69E+04	0.00			0.23			2.89E+04	0.00
10.5	3.2			0.21			2.66E+04	0.02			0.26			2.19E+04	0.00
11.0	3.4			0.21			2.39E+04	0.00			0.28			2.35E+04	0.00
11.5	3.5	0.32	0.15	0.21			2.66E+04	0.00			0.26			2.58E+04	0.00
12.0	3.7			0.25			2.39E+04	0.02			0.24			2.43E+04	0.00
12.5	3.8			0.22			2.27E+04	0.00			0.26			2.58E+04	0.00
13.0	4.0			0.25			2.35E+04	0.00	0.68[a]	0.20	0.27			2.85E+04	0.00
13.5	4.1			0.26			2.85E+04	0.00	0.59[a]	0.18	0.24			2.81E+04	0.00
14.0	4.3	0.72[a]	0.21	0.28			3.23E+04	0.00	0.70[a]	0.20	0.27			2.89E+04	0.02

Table C-4. All Geophysical Logging Results for the Boreholes within the Eastern Section of the 216-B-53A Trench

Depth		Cs-137 (662 keV)			Pu-239 (375 keV)				Cs-137 (662 keV)			Pu-239 (375 keV)			
ft	m	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Activity (pCi/g)	Counting Error (pCi/g)	MDL (pCi/g)	Passive Neutron (cps)
		C6768							C6769						
14.5	4.4	6.93[a]	0.46	0.35			6.08E+04	0.00	4.45[a]	0.39	0.36			4.93E+04	0.00
15.0	4.6	81.08[a]	1.55	0.91			1.54E+05[b]	0.00	51.26[a]	1.21	0.75			1.16E+05[b]	0.00
15.5	4.7	795.21[a]	5.96	3.62			4.62E+05[b]	0.00	296.99[a]	3.21	1.88			2.73E+05[b]	0.00
16.0	4.9	1927.82[a]	11.37	7.38			7.76E+05[b]	0.00	1164.89[a]	7.69	4.61			5.58E+05[b]	0.00
16.5	5.0	721.81[a]	5.12	2.41			3.49E+05[b]	0.00	746.15[a]	5.45	2.85			4.01E+05[b]	0.00
17.0	5.2	264.88[a]	2.73	1.09			1.73E+05[b]	0.00	270.75[a]	2.87	1.29			2.08E+05[b]	0.00
17.5	5.3	110.22[a]	1.70	0.70			1.02E+05[b]	0.00	76.99[a]	1.45	0.72			1.06E+05[b]	0.02
18.0	5.5	53.29[a]	1.17	0.51			6.85E+04	0.00	24.69[a]	0.82	0.47			5.85E+04	0.00
18.5	5.6	39.17[a]	1.00	0.42			5.70E+04	0.00	10.60[a]	0.54	0.36			4.16E+04	0.00
19.0	5.8	24.05[a]	0.78	0.32			5.08E+04	0.00	7.48[a]	0.46	0.34			3.73E+04	0.00
19.5	5.9	9.93[a]	0.52	0.34			3.85E+04	0.00	6.25[a]	0.41	0.23			3.50E+04	0.00
20.0	6.1	12.80[a]	0.58	0.29			3.93E+04	0.00	6.42[a]	0.42	0.27			3.23E+04	0.02
20.5	6.2	6.91[a]	0.44	0.31			3.31E+04	0.00	6.69[a]	0.42	0.25			3.27E+04	0.00
21.0	6.4	5.22[a]	0.38	0.27			3.31E+04	0.00	3.19[a]	0.32	0.29			2.62E+04	0.00
21.5	6.6	4.25[a]	0.35	0.28			3.00E+04	0.00	2.72[a]	0.30	0.26			2.93E+04	0.02
22.0	6.7	4.34[a]	0.36	0.28			3.04E+04	0.00	3.13[a]	0.31	0.24			2.66E+04	0.00
22.5	6.9	4.12[a]	0.34	0.22			3.04E+04	0.00	2.61[a]	0.29	0.27			2.89E+04	0.00
23.0	7.0	1.93[a]	0.25	0.24			2.81E+04	0.00	2.45[a]	0.28	0.25			2.81E+04	0.00
23.5	7.2	1.86[a]	0.25	0.25			2.66E+04	0.00	2.11[a]	0.28	0.29			2.58E+04	0.00
24.0	7.3	6.53[a]	0.43	0.29			3.12E+04	0.00	2.11[a]	0.27	0.26			2.69E+04	0.00
24.5	7.5														

a. Reported activity is greater than the method detection limit plus the counting error.
b. Method detection limits for plutonium exceed 100 nCi/g.
bgs = below ground surface
cps = counts per second
MDL = method detection limit

Appendix D

Treatability Study Data Quality Assessment

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Treatability Study Data Quality Assessment

D1 Introduction

This data quality assessment (DQA) presents the results of the evaluation of the data generated as part of the BC Cribs and Trenches area treatability test. A number of data streams were collected for borehole geophysical logging, soil sample analysis, radiological dose rate, excavation production rate, and cost calculations. This DQA quantitatively considers only the geophysical logging and soil sample analysis data for the 216-B-26 Trench (i.e., Phase 1 of the treatability test); however, the specific aspect of the Phase 4 borehole geophysical data used to estimate the plutonium inventory in the 216-B-53A Trench is also addressed.

Environmental sample analysis data were generated via soil sampling and borehole gamma logging in and around the 216-B-26 Trench. The field sampling was performed in accordance with Rev. 0 of the *Sampling and Analysis Plan for Phase 1 of the BC Cribs and Trenches Area Waste Sites Excavation-Based Treatability Test* (DOE/RL-2007-14). This work was performed as part of overall treatability test activities, as described in *Excavation-Based Treatability Test Plan for the BC Cribs and Trenches Area Waste Sites* (DOE/RL-2007-15). The treatability test was performed to support appropriate remedy selection for the near-surface contamination at the BC Cribs and Trenches area waste sites.

The data and interpretation in this DQA include assessment of completion of the planned experimental design, as well as the quantity and quality of chemical analysis data. The assessment was performed in accordance with guidance found in *Data Quality Assessment: A Reviewer's Guide*, EPA QA/G-9R (EPA/240/B-06/002); and in *Data Quality Assessment: Statistical Methods for Practitioners*, EPA QA/G-9S (EPA/240/B-06/003).

D2 Data Quality Assessment Summary

D2.1 Phase 1 Summary

The DQA of the cesium-137 and strontium-90 chemical analysis of soil samples shows that the laboratory analyses were performed in accordance with project quality requirements, the samples were collected in accordance with the project sampling design, and there were no anomalies evident within the borehole logging process. In general, the logging data, combined with the analytical data, are of sufficient quality and quantity to estimate the cesium-137 and strontium-90 inventory beneath the 216-B-26 Trench. However, three weaknesses of the soil sample data should be considered before estimating the full subsurface inventory using only laboratory data:

- There were no samples taken outside of the footprint of the trench floor, but the logging results show that significant inventory may exist laterally from the footprint.
- The cesium-137 exists within a thin layer underneath the crib. There are more sample locations within this layer than within the other cesium-137-containing depths. This may bias an inventory calculation unless normalized.
- The very thin cesium-137 layer of highest concentration would likely not have been sampled in many of the boreholes due to the length of the sample (6.4 cm [2.5 in.]) and the spacing of the samples (0.76 m [2.5 ft]).

The borehole logging and sample analysis data also meet the applicable requirements identified in the treatability test plan for use in estimating worker dose rates.

D2.2 Phase 4 Summary

The DQA was limited to the evaluation of borehole geophysical data related to plutonium concentration estimates. All borehole geophysical measurements were made in accordance with the applicable test plan and at borehole locations identified in the treatability test report (main text of this document).

The high-resolution spectral gamma logging system (SGLS) was used in conjunction with passive neutron logging to detect plutonium. Due to the nature of the geophysical measurements, the sensitivity of the SGLS detector to the presence of plutonium-239 is affected by the presence of cesium-137. With respect to the Phase 4 objectives relating to plutonium-239, the following limitations of the data quality were observed:

- In general, the spectral gamma and passive neutron logging are insufficient to demonstrate that the 216-B-53A Trench soils do not contain plutonium-239 in excess of the contamination target level of 430 pCi/g.
- In areas of relatively low contamination, the SGLS can detect plutonium-239 at a level of approximately 20 nCi/g. This is sufficient for comparison against the transuranic criterion of 100 nCi/g.
- The SGLS capability to detect and assay plutonium-239 is affected by gamma activity from other radionuclides (e.g., cesium-137). In areas where the cesium-137 concentration exceeds 100 pCi/g (i.e., the trench floor and a few feet below), SGLS sensitivity was insufficient to demonstrate that the 216-B-53A Trench soils do not contain plutonium-239 in excess of 100 nCi/g. This affected sample measurements associated with approximately 10 percent of the reported data.

D3 Phase 1 Data Quality Assessment

D3.1 Background

The 216-B-26 Trench is one of the trenches known collectively as the "BC Cribs and Trenches" in the Hanford Site's 200 East Area. The 216-B-26 Trench received scavenged waste from the uranium-recovery process and the ferrocyanide processes at the 221/224-U Plant. The trench is roughly 152.4 m (500 ft) in length and 3 m (10 ft) in width at the floor, with side berms sloping upward. The length of the trench was divided into thirds by berms; therefore, it is possible that different amounts of waste were received in each one-third of the trench. The same discharge pipe was used in all of the BC Trenches and moved from one trench to another, but piping was not left in place after closure of the 216-B-26 Trench; thus, the exact discharge points in this trench are not known. Because the nature and extent of the contamination associated with the BC Cribs and Trenches area waste sites was not well known, a treatability test was required to further define the feasibility of a remedial action alternative that includes soil excavation.

More than five dozen direct-push technology (DPT) holes were installed within the footprint of the 216-B-26 Trench and its periphery for borehole geophysical logging to determine the nature and extent of near-surface contamination, with the focus on cesium-137 and strontium-90. The sampling and analysis plan (SAP) (DOE/RL-2007-14) defined 24 initial sampling locations for borehole geophysical logging within the trench footprint. These locations were randomly selected within each section of the trench to provide data along the trench length and width. Based on gamma-logging data from those holes,

additional holes for borehole geophysical logging were installed to locate the two berms known to have divided the trench into thirds and to establish the extent of lateral contamination spread. Finally, soil sampling was performed at selected locations to further establish a correlation between the logging data and cesium-137 concentrations, and to characterize the strontium-90 profile within the trench.

D3.2 Summary of Data Quality Objectives

D3.2.1 Data Quality Objectives

Table D-1 details the activities, objectives, and criteria used to demonstrate completion of Phases 1 and 2 of the treatability test. The table also includes a brief evaluation of the potentially applicable DQA criteria.

D3.2.2 Statement of Problem

Data were collected at the 216-B-26 Trench to determine the nature and extent of cesium-137 and strontium-90 contamination. The data collected during Phase 1 would be used for the following purposes:

- Determine the nature and extent of cesium-137 and strontium-90 contamination within the top 7.6 m (25 ft) of the 216-B-26 Trench footprint
- Calculate the cesium-137 and strontium-90 inventories within the contaminated volume in order to enable estimates the amount of material requiring removal
- Validate predicted Phase 2 remediation worker dose calculations
- Correlate the total curie content of cesium-37 in the trench, as determined by measurements and estimates of contaminated volume with the total cesium-137 content predicted by the *Hanford Soil Inventory Model, Rev. 1* (RPP-26744).

Table D-1. Test Activities, Objectives and Criteria Used to Demonstrate Completion of Treatability Test Phase 1 and 2 and Evaluation of the Potentially-Applicable Data Quality Assessments

Phase/Activity		Objective		Criteria	Data Collected	Quality Assessment Criteria
1	Perform direct-push technology/total gamma-logging/ soil sampling in boreholes	1a	Define the nature and extent of Cs-137 and Sr-90 contamination in the 216-B-26 Trench	If necessary, revise the conceptual site model for Cs-137 and Sr-90 nature and extent	Total gamma logging Laboratory data	Evaluation against PARCC parameters, quality control criteria available in the sampling and analysis plan[b] and overall statistical quality defined in decision rules (see Table D-2).
		1b	Calculate the Cs-137 and Sr-90 inventories and compare with soil inventory model[a]	Update Cs-137 and Sr-90 inventories based on measurement data	Calculated values	Same as above.
		1c	Recalculate worker dose estimate	Use the revised source term determined through characterization	Worker exposure model Worker dose estimate calculations	Error analysis of calculation could be compared to quality criteria, but quality criteria currently do not exist. Could compare against previous estimate. Would need criterion for acceptable difference.
2	Excavate one-third of the 216-B-26 Trench	2a	Collect sufficient data to ensure the capability to down-blend highly contaminated soil that is associated with high dose rates	Demonstrate capability to down-blend soil to meet ERDF waste acceptance criteria using minimal ERDF containers and none that exceed the ERDF waste-acceptance criteria for radiation protection after loading	ERDF container release measurements Number of containers meeting and exceeding criteria	ERDF container counts. No current definition of the amount or type of data required for "adequate demonstration."

Table D-1. Test Activities, Objectives and Criteria Used to Demonstrate Completion of Treatability Test Phase 1 and 2 and Evaluation of the Potentially-Applicable Data Quality Assessments

Phase/Activity		Objective		Criteria	Data Collected	Quality Assessment Criteria
2 (cont'd)		2b	Collect sufficient data to compare worker dose with predicted dose	Collect worker dose data for excavation activities for all personnel associated with the process (e.g., excavator operator, associated radiation control technician, water sprayer, spotter, and ERDF transport vehicle driver)	Dose rate measurements	Evaluation of collected total accumulated dose accuracy, precision, completeness, and comparability. Would need to develop quality criteria for accumulated dose and also dose allocation assumptions to input into an error analysis. Could calculate the difference between prediction and dose. Need criteria for acceptable difference.
		2c	Collect sufficient data to update excavation cost estimates	Collect data that define the time to perform the following operations: • Remove overburden and fill ERDF container • Down-blend high dose soil/gravel and transfer to ERDF container • Remove/stage another ERDF container • Evaluate all other factors that impact costs associated with the excavation of trenches	Activity time-to-perform data Other data that may impact excavation costs	Could identify distribution of source task time data in terms of mean and variance. This could then be used by an estimate error analysis. Error criteria currently do not exist. "Other data" insufficiently defined. If defined, then any quantitative data could be evaluated for PARCC, but criteria currently do not exist for acceptability.

a. RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

b. DOE/RL-2007-14, *Sampling and Analysis Plan for Phase 1 of the BC Cribs and Trenches Area Waste Sites Excavation-Based Treatability Test.*

ERDF = Environmental Restoration Disposal Facility

PARCC = **precision, accuracy, representativeness, comparability, and completeness**

D3.2.3 Decision Rules

The decision rules (DRs) applicable to Phase 1 are provided in Table D-2.

Table D-2. Decision Rules Applicable to Phase 1

DR #	Decision Rule
1	If the field measurements for gamma-emitting radionuclides indicate the presence of Cs-137 at a concentration >750 pCi/g in the first 4.6 m (15 ft) below ground surface, or laboratory measurements for Sr-90 indicate a concentration >90,000 pCi/g in the 216-B-26 Trench, then additional characterization data will be obtained to further establish the nature and extent of contamination. Otherwise, excavation parameters (e.g., volume of material, dimensions, and coordinates of excavated surface) will be determined without precise site characterization data concerning the vertical and lateral extent of contamination.
2	If the true mean concentration for applicable radionuclide constituents agrees with the concentration predicted by using the inventory inputs for the soil inventory model[a] (as represented by the inventory value being within the 95 percent confidence interval around the sample mean), then the soil inventory model will be considered valid for use in determining the inventory present in all of the BC Cribs and Trenches Area waste sites. Otherwise, additional characterization data will be collected or models will be modified to show adequate correlation between characterization data and inventory data.

a. RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

DR = decision rule

D3.3 Sampling Design and Implementation

The 216-B-26 Trench characterization design included three elements:

1. Characterization of soil beneath the floor of the trench using borehole logging.
2. A series of step-out boreholes, using borehole logging, to define the lateral extent of contamination around the trench and also within the internal bermed areas separating the three sections of the trench.
3. A series of 24 soil samples taken from eight boreholes within the footprint of the trench floor to evaluate strontium-90 concentrations that could not be directly measured by borehole logging and attempting to correlate laboratory and logging results.

Table D-3 summarizes the data collection design for Phase 1 of the treatability test from the SAP (DOE/RL-2007-14).

Contamination, for the purposes of this data collection activity, was defined in the data quality objectives process DR #2 (DOE/RL-2007-15, Appendix A) as soil contaminated with cesium-137 at greater than 750 pCi/g and strontium-90 at greater than 90,000 pCi/g. These values represent maximum concentrations that are protective of human health 150 years from the present under an industrial land-use scenario. This action level only applies to the soil down to 4.6 m (15 ft) below ground surface (bgs) because that depth is the point of compliance for human health direct exposure.

Table D-3. Data-Collection Design

Element	Approach	Type of Data	Rationale
1	Systematic random statistical sampling design to determine mean concentration of the contaminant of concern	Logging	Determining the mean concentration in a given volume of soil (determined by understanding the vertical and lateral extent of contamination) and knowing the density of the soil allow calculation of the total inventory of the contaminant of concern present in a trench. This measured inventory then can be compared to inventory predicted by the soil inventory model[a] and a determination of the soil inventory model's accuracy can be made. Also, the random sampling design provides information on the variability of contaminants to support dose estimates based on these measurements.
2	Adaptive cluster sampling design	Logging	The need to determine the lateral extent will be met using a form of biased sampling intended to identify the maximum lateral extent of contamination. The vertical extent of contamination also will be determined in the sampling design selected for addressing DR #2. Therefore, a separate sampling design to resolve vertical extent is not required.
3	Random systematic sampling design	Soil samples	Actual soil samples will be collected from eight randomly selected boreholes advanced adjacent to logging boreholes from design element #1. The soil samples will be submitted for laboratory analysis of Cs-137 and Sr-90. The laboratory results will be used to develop correlations between laboratory and logging data for Cs-137, and also between laboratory Cs-137 and Sr-90 laboratory data, to independently calculate inventory or to support inventory calculations based on the borehole logging data.

a. RPP-26744, *Hanford Soil Inventory Model, Rev. 1.*

DR = decision rule

Another use for the data obtained from soil samples was to determine if a correlation can be established between cesium-137 and strontium-90 activity as a function of depth.

Phase 1 activities involved the characterization of the 216-B-26 Trench using boreholes in accordance with the three-element design.

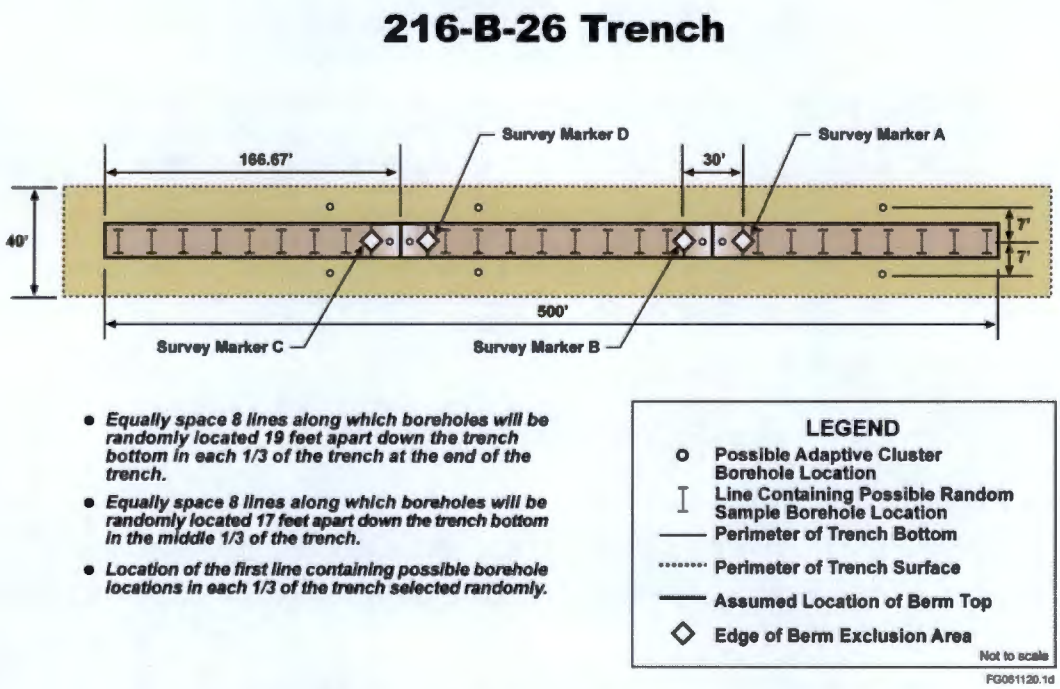
D3.3.1 Borehole Logging

Eight boreholes were installed through the bottom of each one-third of the trench in accordance with the design described in the SAP (DOE/RL-2007-14). Systematic random sampling was chosen to ensure that a large portion of the trench floor would not go unrepresented by the sample collected. To ensure that any variability associated with lateral distance from the centerline of the trench bottom was adequately characterized by the sample, a random component was also added to the sampling design in these directions. The boreholes were located every 5.8 m (19 ft) along the centerline of the eastern and western thirds of the trench, and every 5.2 m (17 ft) along the middle third of the trench. At each centerline location, a random perpendicular offset was applied. Figure D-1 shows the general borehole locations along the centerline in each third of the trench. Figure D-2 shows two of these sampling locations in more detail, with the addition of the nine potential random perpendicular offset locations. Table D-4 provides each of the actual sampling locations, including the random offsets from the centerline, for the 216-B-26 Trench.

D3.3.1.1 Determining the Lateral Extent of Contamination

When the data from all boreholes installed through the bottom of the trench were reviewed, at least one location from each one-third of the trench was used as a benchmark for a set of adaptive cluster sampling boreholes. The determination of which location to use as the benchmark was based on the level of contamination measured in the boreholes. The first two adaptive cluster sampling boreholes were installed approximately 2.1 m (7 ft) away from, and perpendicular to, the centerline of the trench. If cesium-137 activity was detected by logging at a concentration greater than 750 pCi/g in the 0 to 4.6 m (0 to 15 ft) bgs, further step-out boreholes were advanced and logged. This continued until an adaptive cluster sampling borehole was installed where cesium-137 was not detected at greater than 750 pCi/g in the 0 to 4.6 m (0 to15-ft)-bgs interval. Only logging measurements were collected in each of the adaptive cluster boreholes; soil samples were not collected from the adaptive cluster boreholes.

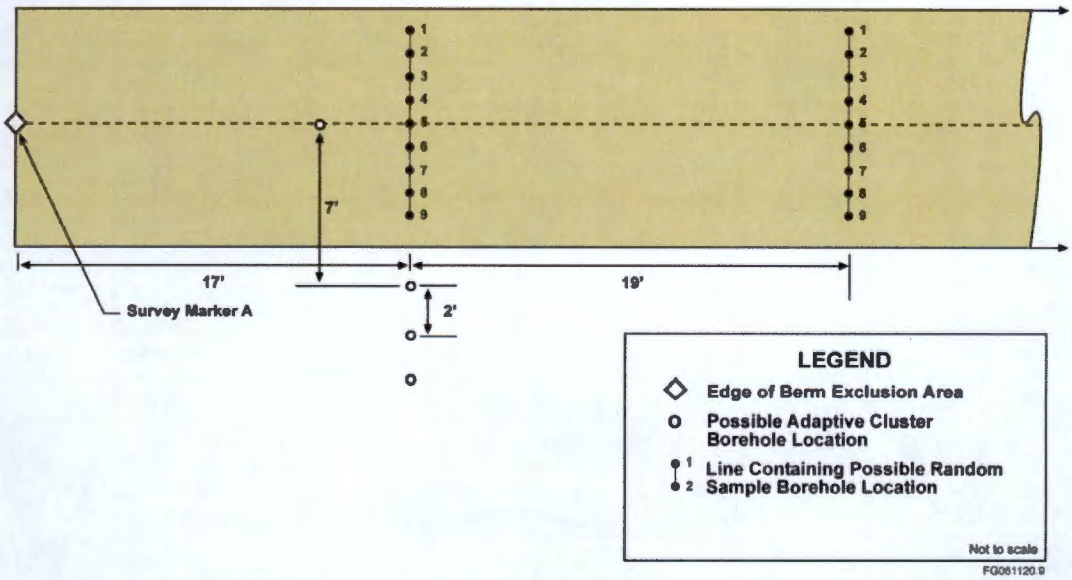
Figure D-2 shows the generic location of one set of the adaptive cluster, lateral-extent boreholes in relation to the trench floor borehole locations.



NOTE: From DOE/RL-2007-14, *Sampling and Analysis Plan for Phase 1 of the BC Cribs and Trenches Area Waste Sites Excavation-Based Treatability Test.*

Figure D-1. Random and Adaptive Cluster Sampling Designs for Trench 216-B-26

216-B-26 Trench



NOTE: From DOE/RL-2007-14, *Sampling and Analysis Plan for Phase 1 of the BC Cribs and Trenches Area Waste Sites Excavation-Based Treatability Test.*

Figure D-2. First Two Sample Node Lines and Randomly Selected Nodes for Locating Boreholes in the Eastern One-Third of the 216-B-26 Trench

Table D-4. Borehole Locations in the 216-B-26 Trench

Borehole Locations in the Eastern One-Third of the 216-B-26 Trench			
Distance of Node Line from Survey Marker A (ft)	**Sample Node**	**Distance From Centerline Node 5 (ft)**	**Direction From Centerline Node 5**
17.0	8	3	South
36.0	4	1	North
55.0	2	3	North
74.0	2	3	North
93.0	9	4	South
112	5	0	N/A
131	7	2	South
150	8	3	South

Table D-4. Borehole Locations in the 216-B-26 Trench

Borehole Locations in the Center One-Third of the 216-B-26 Trench			
Distance of Node Line from Survey Marker B (ft)	**Sample Node**	**Distance From Centerline Node 5 (ft)**	**Direction From Centerline Node 5**
15.0	3	2	North
32.0	5	0	N/A
49.0	3	2	North
66.0	6	1	South
83.0	5	0	N/A
100	2	3	North
117	2	3	North
134	6	1	South
Borehole Locations in the Western One-Third of the 216-B-26 Trench			
Distance of Node Line from Survey Marker C (ft)	**Sample Node**	**Distance From Centerline Node 5 (ft)**	**Direction From Centerline Node 5**
13.0	8	3	South
32.0	6	1	South
51.0	4	1	North
70.0	8	3	South
89.0	7	2	South
108	2	3	North
127	5	0	N/A
146	1	4	North

N/A = not applicable

The same approach was used to define the locations of the two internal trench berms that separate the three trench sections. Additional adaptive cluster sampling boreholes were installed along the centerline of the trench 1.2 m (4 ft) away from the centerline borehole that was closest to the berm in each end section of the trench. These boreholes were installed in the direction toward the berm until borehole logging showed that the cesium-137 concentration was less than 750 pCi/g at a depth of 0 to 4.6 m (0 to 15 ft).

D3.3.2 Soil Sampling

Soil sampling was performed at eight locations, with three samples collected from each location. One of the locations was associated with the trench footprint DPT hole near the eastern end of the trench where the highest cesium-137 activity was observed (based on initial logging results). This hole (logging hole C5886/soil sampling hole C5922) was located near the eastern end of the western section of the trench. The other seven locations were determined randomly from the other 23 DPT holes explicitly located in the SAP (DOE/RL-2007-14) using a random number generator.

Sampling depths were also randomly selected within the eight selected locations. Based on the initial logging data, the first 0.15–m (0.5-ft) sampling depth was randomly selected from the first 0.76 m (2.5-ft) interval that exhibited significant activity. Two additional samples were then collected from the same DPT hole, deeper at 0.76 m (2.5-ft) intervals. This random depth selection, combined with random selection of the sampling holes, spanned a broad range of expected cesium-137 activities and depths, and a total of 24 soil samples were collected from the eight DPT holes. In each case, the sampling holes were located approximately 0.40 m (16 in.) toward the axis of the trench from its associated logging hole. Table D-5 lists the sampling locations and depths.

Table D-5. Soil Sampling Locations and Depths

Logging Hole	Sampling Hole	Sampling Interval (ft)[a]	First Sample Depth (ft)[b]	Second Sample Depth (ft)[c]	Third Sample Depth (ft)[c]
C5893	C5915	11.0 to 13.0	11.0	13.5	16.0
C5894	C5916	10.5 to 12.5	12.0	14.5	17.0
C5898	C5917	10.5 to 12.5	11.5	14.0	16.5
C5899	C5918	10.0 to 12.0	12.0	14.5	17.0
C5876	C5919	9.5 to 11.5	11.5	14.0	16.5
C5881	C5920	9.0 to 11.0	10.0	12.5	15.0
C5885	C5921	9.0 to 11.0	9.5	12.0	14.5
C5886	C5922	NA; focused sampling[d]	8.1	9.6	11.6

a. The shallowest sampling interval displaying significant borehole logging activity.

b. A random 0.5-ft sample interval within the high-activity interval.

c. Samples taken 2.5 ft and 5 ft below the first sample depth.

d. Location C5922 and sampling depths were based judgmentally on a location and depth that displayed high logging cesium-137 results. Footnotes b and c do not apply.

NA = not available

D3.3.2.1 Quality Control Sampling

In accordance with the SAP (DOE/RL-2007-14), no field duplicates, splits, or blanks were collected. Laboratory duplicates were generated by analyzing two subsamples of the soil samples submitted to the laboratory.

D3.4 Laboratory Analysis of Soil Samples

The soil samples were described, packaged, and labeled in accordance with the SAP (DOE/RL-2007-14). The samples were submitted to Eberline Analytical Services of Richmond, California, for analysis of gross alpha, gross beta, total strontium, and gamma emitters (including cesium-137). Twenty-four soil samples collected between October 3 and October 22, 2007, were received at the Eberline laboratory on November 15, 2007. The laboratory selected two samples to duplicate. The laboratory also reported method blanks and laboratory control samples.

D3.4.1 Review of Borehole Logging Data

The DQA of borehole logging data was limited to verification that the logging equipment was operated in accordance with standard operating procedures of the operating company (S. M. Stoller Corporation) and that functional checks were performed as required. No issues with the logging data were identified.

D3.4.2 Review of Laboratory Data

A review of the laboratory results concluded that the laboratory's performance was within expectations and that the data meet most of the SAP requirements (DOE/RL-2007-14). Minor deviations from the SAP requirements are generally due to the very high contamination levels in some of the samples; however, these deviations do not impact the usefulness of the data for the identified project purposes.

D3.4.3 Laboratory Quality Assurance and Quality Control Requirements

Table D-6 shows the target analytes for the soil samples collected at the 216-B-26 Trench (cesium-137 and strontium-90) and provides the analytical performance requirements applicable to the laboratory analyses.

D3.4.4 Implementation of Sample Design

Twenty-four soil samples were identified, as required, as part of the sampling design. All samples were collected as indicated in the design, and all of the required analyses were performed. As the resulting data were evaluated, two limitations of the data set were evident. The two fundamental weaknesses in the simple inventory calculation using only laboratory data were as follows: (1) the sampled volume does not wholly enclose the extent of contamination, and (2) the random sampling design resulted in a sample density that favors some depths over others. Both of these limitations were addressed within the inventory calculations documented in the *Cribs and Trenches Excavation-Based Treatability Test – Phase 1 Report* (DOE/RL-2008-26).

- Incomplete volume: The results of the borehole logging data demonstrate that significant contamination extends laterally beyond the volume within which laboratory samples were collected. While the contamination was very likely to be bounded in the vertical direction, it extends outside of the 3 m (10-ft) shadow of the floor of the trench. This can represent a significant negative bias if the inventory is based only upon the soil samples.

- Depth bias: The analysis results confirm that a large percentage of the cesium-137 and strontium-90 contamination exists within a thin layer that occurs just below the original floor of the 216-B-26 Trench. Nearly all of the contamination exists within the 3.4– to 4–m (11- to 13-ft) interval, and the interval is represented by a greater number of samples than the other 0.6–m (2-ft) intervals (33 percent of the samples, but only 20 percent of the 3 m [10-ft] contaminated soil volume). Because of this, a positive bias in the inventory calculations could result if using the entire data set to represent the cesium-137 and strontium-90 concentrations beneath the trench.

Table D-6. Analytical Performance Requirements for Radiological Laboratory Measurements

COC	Chemical Abstracts Service	Preliminary Action Level[a]		Name/Analytical Technology	Target Required Quantitation Limits			Precision Water (%)	Accuracy Water (%)	Precision Soil (%)	Accuracy Soil (%)
		15 mrem/yr (pCi/g)	GW Protection (pCi/g or mg/kg)		Water[b] Conc. (pCi/L)	Soil Low Activity[c] (pCi/g)	Soil High Activity[d] (pCi/g)				
Cs-137[e]	10045-97-3	23.4	N/A	GEA	N/A	0.1	2,000	N/A	N/A	±35	65-135
Sr-90	Rad-Sr	2,410	N/A	Total radioactive strontium – GPC or LSC	N/A	1	800	N/A	N/A	±35	65-135

a. The preliminary action levels for radionuclides are based on 15 mrem/yr nonradiological worker industrial exposure scenario, 2,000 hr/yr onsite (60 percent indoors, 40 percent outdoors), and are used to determine appropriate analytical requirements.

b. Water values for sampling quality control (e.g., equipment blanks/rinses) or drainable liquid (if recovered).

c. Low activity implies a level of radioactivity such that the radioanalytical methods can be performed as designed. The quantitation limits are the state-of-the-art for a soil-sample matrix using the given technology.

d. High activity implies a level of radioactivity such that the radioanalytical methods cannot be performed as designed. Some method deviation (e.g., use of a smaller aliquot of soil) must be selected to ensure the health and safety of sampling personnel and/or laboratory personnel. The quantitation limits listed are estimated and are provided as an illustration of the variability in the possible quantitation limits that result from high radioactivity in the soil samples collected.

e. Cs-137 is the only gamma-emitting radionuclide with an action level. However, other detected gamma-emitting radionuclides will be reported during analyses conducted by gamma energy analysis.

COC = contaminant of concern
GEA = gamma-energy analysis
GPC = gas-proportional counting
GW = groundwater
LSC = liquid-scintillation counter
N/A = not applicable

- Very thin maximum cesium-137 concentration layer: Within the 0.6 m (2-ft)-high concentration interval, the thickness of the maximum concentration of cesium-137 appears to exist within in a very thin layer. The 6.4 cm (2.5-in.) sample length allows for a significant likelihood that the absolute maximum concentrations were not sampled.

D3.4.5 Validation Summary

Independent third-party validation was not performed as part of this treatability study. All of the samples were submitted as one batch and were reported in a single laboratory report that was reviewed as part of this DQA.

D3.4.6 Accuracy

Accuracy is an assessment of the closeness of the measured value to the true value. The accuracy of chemical test results may be assessed by spiking samples with known standards and establishing the average recovery. A matrix spike is the addition to a sample of a known amount of a standard compound that is similar to the compounds being measured. Radionuclide measurements that require chemical separations use this technique to measure method performance. For radionuclide measurements that are analyzed by gamma spectroscopy, laboratories typically compare the results of blind-audit samples against known standards to establish accuracy. The validity of calibrations is evaluated by comparing results from the measurement of a standard to known values and/or by generating in-house statistical limits based on three standard deviations.

The laboratory reported no problems in the soil sample determinations for total strontium and gamma-emitter analysis. The method blank showed no evidence of any contaminant, and all parameters were below the MDA. Laboratory control samples were recovered between 99 and 119 percent, which is within both laboratory statistical and administrative recovery limits.

Strontium tracer yield was 80 percent to 100 percent, which is well within the 30 percent to 105 percent internal laboratory administrative limits.

D3.4.7 Precision

Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the relative percent difference for duplicate measurements or relative standard deviation for replicate analyses.

Table D-7 provides the results of the analysis of laboratory prepared duplicates of two samples (C5915 at 5.2 to 5.3 m [17 to 17.5 ft] and C5921 at 3.6 to 3.8 m [11.9 to 12.4 ft]). One duplicate was selected to represent a low-level sample, and the other duplicate was selected to represent a highly contaminated sample. For the parameters of interest, duplicate relative percent differences at both analyte levels met the SAP requirements (DOE/RL-2007-14) (Table D-7) and demonstrate that the analytical system was reproducible.

Table D-7. Results of Laboratory Analysis of Duplicate Samples

Parameter (pCi/g)	C5915 (15 to 17.5 ft)			C5921 (11.9 to 12.4 ft)		
	Sample	Duplicate	RPD	Sample	Duplicate	RPD
Cs-137	3.6	4.26	-16.79	1,420,000	1,420,000	0.00
Total radio-strontium	2.14	21	1.89	561,000	577,000	-2.81

RPD = relative percent difference

D3.4.8 Detection Limits

Detection limits are functions of the analytical method used to provide the data and the quantity of the sample available for analyses. The quality objectives and criteria (including analytical methods, detection limits, and precision and accuracy requirements for each analysis to be performed) are summarized in Table D-6 for laboratory analyses.

All cesium-137 MDA exceeded the method reported detection limit of 0.1 pCi/g for the few samples where cesium was reported as nondetectable; however, this did not impact the data for project use. No samples displayed strontium values below detectable limits.

D3.4.9 Field Quality Control

D3.4.9.1 Field Duplicates

Field duplicates are independent samples collected as close as possible to the same point in space and time, taken from the same source, stored in separate containers, and analyzed independently. These samples are not to be homogenized together. Field duplicates provide information regarding the variability of the measurement system attributable to the sample collection procedures, the sample matrix, and the precision of the analysis process.

Because previous characterization data indicated that the soil in the 216-B-26 Trench is quite inhomogeneous, an anticipated high degree of variability was taken into account in the sampling design. A sufficient number of samples were collected to establish the variability of the sample. Therefore, no data use was associated with co-located field duplicates, and none of these samples were collected. For the BC Cribs and Trenches area waste site treatability test, information to aid in assessing laboratory precision was generated by having the analytical laboratory conduct analyses of two aliquots from two collected soil sample, which meets the SAP requirements (DOE/RL-2007-14). The results of the analyses of these duplicates are reported in Section D3.4.7.

D3.4.9.2 Field Splits

No field splits were identified within the sampling design, and none were collected.

D3.4.9.3 Field Blanks

No field blanks were identified within the sampling design, and none were collected.

D3.4.9.4 Equipment Blanks

Equipment blanks are typically collected at the same frequency that the duplicate samples are collected, and they are used to verify the adequacy of sampling equipment decontamination procedures. No equipment blanks were identified within the sampling design, and none were collected. Because the

action levels associated with this treatability test were relatively high, the impact to decisions of not collecting equipment blanks is not as great as in trace-level analyses.

D3.4.10 Completeness

Twenty-four soil samples were identified, as required, as part of the sampling design. All of the samples were collected as designed, and all of the required analyses were performed. There were no rejected or qualified data; the data set is 100 percent complete.

D3.4.10.1 Parameters

Both required parameters (cesium-137 and strontium-90) were successfully determined and reported on all collected samples.

D3.4.10.2 Additional Samples and Analytes

No additional samples were collected for laboratory analysis. Additional radionuclides associated with the gamma-scan analysis were reported, including potassium-40; cobalt-60' radium-226 and -228; europium-152, -154, and -155; thorium-228 and -232; uranium-235 and -238; and americium-241.

D4 Phase 4 Data Quality Evaluation

D4.1 Background

The 216-B-53A Trench is 18.3 m by 3 m (60 ft by 10 ft) at the base (Figure 3-12). It was divided into two sections by an earthen dam at the center that is 1.5 m (5 ft) high and 1.7 cm (5 in.) wide at the top. The site received waste from a liquid release at the Plutonium Recycle Test Reactor in the 300 Area, during which secondary cooling water became contaminated with plutonium and mixed fission products. Of all of the specific retention trenches in the BC Cribs and Trenches area, only this trench was considered to have the potential to contain concentrations of transuranic constituents greater than 100 nCi/g.

Sixteen shallow, direct-push boreholes, approximately 7.6 m (25-ft)-deep, were installed along the length of the trench to determine the vertical and lateral extent of plutonium-239 contamination greater than 430 pCi/g within the upper 4.6 m (15 ft) (Figure 3-12).

Further details of the location of the boreholes and other field activities can be found in the treatability test report (main text of this document).

D4.2 Objectives

The focus of Phase 4 of the treatability test was to characterize the nature and extent of contamination of the 216-B-53A Trench, similar to testing conducted in Phase 1 for the 216-B-26 Trench.

Table D-8 defines the Phase 4 activities and objectives that are relevant to the DQA.

Table D-8. Test Activities, Objectives, and Criteria Used to Demonstrate Completion of Treatability Test

Phase	Activity	Objective	Criteria
4	Install shallow boreholes, perform gamma and neutron logging, and perform soil sampling at 216-B-53A Trench.	Define the nature and extent of transuranic (plutonium and americium) contamination in the 216-B-53A Trench.	Prepare conceptual site model for the nature and extent of transuranic contamination in the 216-B-53A Trench.

D4.3 Assessment

The borehole geophysical measurements enabled an estimate of the MDA associated with plutonium-239 for each measurement within each borehole. This activity was related to a calculated equivalent soil concentration by the geophysical scientist. The minimum detectable concentration data were evaluated with respect to the plutonium-239 detection limit at each individual elevation within each borehole.

The minimum detectable plutonium-239 equivalent concentration data ranged from 17.9 pCi/g to 1,130 nCi/g. The lowest detection limit was well above the 0.430 nCi/g (430 pCi/g) concentration limit target. Therefore, none of the data are sufficiently sensitive to plutonium-239 to be useful for evaluating whether any of the soils underlying the 216-B-53A Trench exceed that threshold.

In addition, even the 100 nCi/g target was not achieved for 40 of 384 individual measurements from the 16 boreholes. Therefore, in the areas of highest cesium-137 content (representing over 10 percent of the observed measurements), the SGLS data are insufficient to unequivocally demonstrate whether any of the soils underlying the 216-B-53A Trench exceed 100 nCi/g. Conversely, nearly 90 percent of the measurements were sufficiently sensitive to estimate that the plutonium-239 concentrations did not exceed the 100 nCi/g threshold.

D5 References

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