ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

INDEPENDENT REVIEW AND TECHNICAL EVALUATION OF THE SOIL SAMPLING PROTOCOLS FOR SITE CHARACTERIZATION AND CLEANUP CONFIRMATION

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Contents

Abbreviations and Acronyms

Ac	Actinium
AF	Area Factor (outside area dose factor)
AL	Action Level
Am	Americium
AME	Actinide Migration Evaluation
AMS	Actinide Migration Studies
BLUE	Best linear unbiased estimator
BRA	Baseline Risk Assessment
BZ	Buffer Zone
BZSAP	Buffer Zone Sampling and Analysis Plan
CCP	Cleanup Confirmation Plan
CCP/EIS	Comprehensive Conservation Plan/Environmental Impact Statement
CDM	Camp Dresser & McKee Inc.
CDPHE	Colorado Department of Public Health and Environment
CDSR	Characterization Data Summary Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHWA	Colorado Hazardous Waste Act
COC	Contaminant of Concern
CRA	Comprehensive Risk Assessment
CRASAP	Comprehensive Risk Assessment Sampling and Analysis Plan
DOD	United States Department of Defense
DOE	United States Department of Energy
dps	disintegrations per second
DQO	Data Quality Objective
EDDIE	Environmental Data Dynamic Information Exchange
EMC	Elevated Measurement Comparison
EPA	United States Environmental Protection Agency
ERRSOP	Environmental Restoration Routine Standard Operating Procedure
EU	Exposure Unit
FBI	United States Federal Bureau of Investigation
ft	feet

FFCA	Federal Facility Compliance Act
FWS	United States Fish and Wildlife Service
HPGe	High Purity Germanium
HRR	Rocky Flats Historical Release Report
HSWA	Hazardous and Solid Waste Amendments
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
in	inches
KH	Kaiser-Hill Company
LLMW	Low level mixed waste
LLW	Low level (radioactive) waste
Lw	Lawrencium
m	meters
m^2	square meters
m^3	cubic meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mrem/year	millirem per year
NEPA	National Environmental Policy Act
NA	No Action
nCi/g	nanocuries per gram
NFA	No Further Action
NFAA	No Further Remedial Action
NPL	EPA National Priority List of CERCLA sites
NRC	United States Nuclear Regulatory Commission
ORISE	Oak Ridge Institute of Science and Education
OU	Operable Unit
PAC	Potential Area of Concern
pCi/g	picocuries per gram
Pu	Plutonium
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAP	Remedial Action Plan

RCRA	Resource Conservation and Recovery Act
Refuge	Rocky Flats National Wildlife Refuge
Refuge Act	Rocky Flats National Wildlife Refuge Act (2001)
rem	roentgen-equivalent-man
RESRAD	Residual Radioactivity Computer Program
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study
RMPJC	Rocky Mountain Peace and Justice Center
ROD	Record of Decision
RSAL	Radionuclide Soil Action Level
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCP	Site Closure Plan
SOR	Sum-of-Ratios
TRU	Transuranic waste
U	Uranium
UBC	Under-building Contamination
UCL	Upper confidence limit
WIPP	Waste Isolation Pilot Plant, New Mexico

Section 1
Introduction

1.1 Site Background[1]

The Rocky Flats site comprises about 6,500 acres of land located approximately 16 miles northwest of downtown Denver in Jefferson County, Colorado. Between 1952 and 1989, the primary activity at the United States Government-operated site was the processing and machining of plutonium and associated materials into detonators or “triggers” for nuclear weapons. This activity was conducted primarily in about a 300-acre complex at the center of the site referred to as the Industrial Area (IA). The remaining area of the site surrounding the IA is referred to as the Buffer Zone (BZ). Processing and manufacturing operations at Rocky Flats were suspended in November 1989 following a June 1989 raid by the United States Federal Bureau of Investigation (FBI) and the United States Environmental Protection Agency (EPA) to assess alleged environmental violations. Processing and manufacturing activities were never resumed, and the nuclear weapons production mission at Rocky Flats was officially ended in 1993. Since that time, activities at the site have focused on the disposition of plutonium and other hazardous materials left in various stages of processing and storage, along with the cleanup of contaminated materials and remediation of environmental impacts resulting from routine and accidental releases of contaminants and on-site waste disposal and storage. In 1995, these activities were assumed by the Kaiser-Hill Company (KH) under a contract with the United States Department of Energy (DOE). In 2000, DOE/KH initiated an accelerated cleanup effort with the goal of completing the cleanup and closing the site by the end of 2006.

Waste management activities conducted at Rocky Flats, which the DOE renamed the Rocky Flats Environmental Technology Site (RFETS), include: the shipment of radioactive and other materials to other DOE facilities; the shipment of low level (radioactive) waste (LLW) to the Nevada Test Site for disposal; the shipment of low level mixed waste (LLMW) to Envirocare, a mixed waste repository in Utah; and the shipment of transuranic waste (TRU) to the Waste Isolation Pilot Plant (WIPP) in New Mexico for disposal. In addition, on-site remedial actions have been implemented by DOE/KH at the RFETS.

Soils at the RFETS were impacted by various radioactive and hazardous materials. The primary radioactive elements of concern are uranium (U), plutonium (Pu), and americium (Am). These elements are collectively called actinides because they occur on the Periodic Table of the Elements in a group beginning with the element actinium (Ac) and ending with the element lawrencium (Lw). All actinides are radioactive. An actinide with a particular atomic mass is called a radionuclide. For example, uranium-234 (^{234}U) is the radionuclide of uranium with an atomic mass of 234. A number of different radionuclides of uranium, plutonium, and americium have been identified in the RFETS soils: uranium-234 (^{234}U), uranium-235 (^{235}U), uranium-238 (^{238}U), plutonium-239/240 ($^{239/240}Pu$), and americium-241 (^{241}Am). The environmental impacts resulting from these radionuclides have been spread via air, surface water, and groundwater migration pathways.

The United States Government owns the RFETS and the DOE is required by law to perform the cleanup work at the site. Under the terms of the Rocky Flats Cleanup Agreement (RFCA)[2] signed in 1996 and modified in 2003, cleanup activities at the RFETS are managed by the DOE (the lead agency), the EPA, and the Colorado Department of Public Health and Environment (CDPHE). The EPA is the lead regulator for the BZ and the CDPHE is the lead regulator for the IA. The primary United States statutory authorities for EPA regulation are the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) [jointly referred to as CERCLA], and the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) and the Federal Facility Compliance Act (FFCA) [jointly referred to as RCRA]. The primary State of Colorado statutory authorities for CDPHE regulation are CERCLA, RCRA, and the Colorado Hazardous Waste Act (CHWA).

In 2001, the United States Congress passed the Rocky Flats National Wildlife Refuge Act (Refuge Act) to establish portions of the RFETS following cleanup and closure as a National Wildlife Refuge (Refuge) to be managed by the United States Fish and Wildlife Service (FWS). Cleanup and closure of the RFETS requires certification from the EPA prior to the FWS assuming management responsibility. The Refuge will include portions of the BZ, and will exclude an area encompassing the IA, currently anticipated to be about 1,500 acres, which will be retained by DOE for long-term stewardship.

1.2 Report Objectives and Organization

The objective of this report was to provide an independent review and technical evaluation of the soil sampling protocols used at the RFETS for site characterization and cleanup confirmation. This technical evaluation focuses on (1) the BZ, since the Refuge will only include lands contained in the BZ, (2) the surface soils, the primary exposure medium and potential exposure point for Refuge workers and visitors, and (3) the radionuclides of uranium, plutonium, and americium, the contaminants expected to be of primary exposure concern in the Refuge.

Following this introduction (Section 1), this report reviews and evaluates the soil sampling protocols related to two important activities at the RFETS: site characterization (Section 2) and cleanup confirmation (Section 3). In both of these sections, a review of the activities conducted by DOE and the regulators is presented and relevant comments are included where appropriate within the report narrative. The comments emphasize current deficiencies or inadequacies that warrant technical or regulatory resolution, along with recommendations of important items that should be included in future documents; they are intended to provide the public with a framework for evaluating whether the characterization and confirmation sampling meet established standards prior to land being released by the DOE to the FWS for use as the Refuge. Recommendations and a list of items or issues that warrant inclusion and evaluation in subsequent documents are provided in Section 4. Finally, the report lists the pertinent references used in conducting this independent review and technical evaluation (Section 5), which, if available electronically, are included in Appendix A (on the CD ROM).

Section 2
Site Characterization

2.1 Regulatory Framework

As discussed in Section 1.1, the EPA regulates the RFETS, including the BZ, under the authority of CERCLA, commonly known as the Superfund law, and RCRA. CERCLA was enacted to provide a system for identifying and cleaning up hazardous substances released into the environment. RCRA was enacted to control disposal of wastes and to mandate procedures for management and handling of hazardous waste materials. In the context of this technical evaluation, CERCLA is the primary applicable regulation, since the identification and cleanup of hazardous substances (radionuclides) released into the BZ soils is of primary concern.

Generally, hazardous waste sites are investigated under CERCLA according to a standardized approach that begins with inclusion of the site on the EPA's nation-wide list of sites requiring cleanup, which is called the National Priorities List (NPL). The RFETS was placed on the NPL in 1989. The approach continues with development of a Sampling and Analysis Plan (SAP) and a Quality Assurance Project Plan (QAPP) to support site characterization activities, with the goal of characterizing the nature and extent of contamination. For large or complex sites, the site is typically divided into operable units (OUs) which are then characterized individually. Characterizing the nature and extent of contamination is critical for two reasons: (1) assessing the risks to human health and the environment posed by the site, and (2) evaluating appropriate remedial action alternatives, which are a set of long-term or permanent cleanup remedies for reducing the risks to acceptable levels.

Under CERCLA, the results of the site characterization and remedial alternatives evaluation are provided in a Remedial Investigation/Feasibility Study (RI/FS) report. One alternative that is always included in the evaluation is the No Action (NA) alternative. The results of the risk assessment are provided in a Baseline Risk Assessment (BRA) report. In the BRA report, cumulative risks are assessed for "baseline" or pre-remediation conditions, i.e., the current risks at the site assuming the NA alternative. Generally, where the BRA indicates that a cumulative human health risk using reasonable maximum exposure assumptions for either current or future site use exceeds a 1×10^{-4} lifetime excess cancer risk, remedial action at the site under CERCLA is warranted. The 1×10^{-4} lifetime excess cancer risk criterion means that 1 out of every 10,000 humans would be expected to develop cancer from a lifetime of exposure at the site given a particular use assumption. At most CERCLA sites, the BRA assumes residential use. The RI/FS and the BRA are necessarily integrated because both depend on the same site characterization data and the same site use assumption. The SAP and QAPP are critical components of the site characterization process because they serve to ensure that the quantity and quality of data collected, known as the data quality objectives (DQOs), will meet the requirements of both the RI/FS and the BRA.

Following completion of the RI/FS and the BRA, a cost-effective, implementable, and effective remedial alternative is selected, which is called the preferred remedial alternative, together with Action Levels (ALs) for the contaminants of concern (COCs) at the site. The ALs, which represent the concentrations of the COCs that where exceeded will prompt remedial action, are typically selected based on a cumulative lifetime excess cancer risk between 1×10^{-4} and 1×10^{-6} (1 in 10,000 to 1 in 1,000,000 excess cancers) for humans exposed to average concentrations of the COCs at the site represented by the ALs. Selection of the preferred remedial alternative and the associated ALs are officially documented in a Record of Decision (ROD). Upon approval of the ROD, the preferred remedial alternative becomes the selected remedial action (RA), which is then implemented according to a Remedial Action Plan (RAP), Cleanup Confirmation Plan (CCP), and Site Closure Plan (SCP). Numerous EPA guidance documents are available for each phase or component of the CERCLA site characterization process.

Generally, the EPA attempts to get the responsible party and/or the state or local government to assume responsibility for the cleanup actions and costs at CERCLA sites. Essentially, this is what occurred at the RFETS, as embodied by the RFCA. As discussed in Section 1.1, the RFCA is the legally-binding document which incorporates the principal CERCLA and RCRA requirements in one regulatory framework. The approach the DOE has followed at the RFETS is a modification of the typical CERCLA site investigation approach, in that it incorporates a streamlined or accelerated strategy. The accelerated strategy allows for in-process or intermediate cleanup actions. Nevertheless, in the end the site must meet the conditions deemed necessary by the EPA for RI/FS, BRA, and ROD compliance. The EPA is therefore the final regulatory authority at the RFETS to certify cleanup and closure prior to the transfer of a portion of the BZ to the FWS for management of the Refuge.

At CERCLA sites, the ROD and SCP provide the plans for closure (following cleanup, if necessary) and post-closure activities at the site, which may include post-closure monitoring and/or institutional controls. Post-closure monitoring is conducted to ensure that the remedial action remains effective in the future, and thus a plan for periodic evaluation of the post-closure monitoring data is an essential component of the SCP. Post-closure institutional controls are legal and/or regulatory barriers that may be required to ensure that future use of the site does not endanger human health or the environment.

Typically, how the site will (or may) be used is established in the ROD and SCP near the end of the CERCLA process. At the RFETS, the decision was made earlier that post-closure use of a portion of the BZ will be as the Refuge and that the remaining area encompassing the IA will be retained by DOE for long-term stewardship. The Refuge Act requires certification from the EPA that the cleanup at the RFETS was completed satisfactorily and that post-closure activities are operating successfully before a “yet-to-be-determined” portion of the BZ can be transferred to the FWS for management of the Refuge. This means that in addition to cleanup confirmation, DOE/KH will likely need to provide documentation to EPA that any required post-closure monitoring and/or institutional controls are in place and operating successfully before the site can be deemed ready for use as the Refuge.

2.2 Refuge Management

Passage of the Refuge Act set in motion several activities by the FWS. The FWS has prepared a Comprehensive Conservation Plan/Environmental Impact Statement (CCP/EIS)[3] in compliance with the National Environmental Policy Act (NEPA) and FWS planning policies. The CCP/EIS evaluates the environmental impacts associated with various Refuge management alternatives and presents the FWS plan for managing the Refuge under these alternatives during the first 15 years following establishment of the Refuge. The ROD for the CCP/EIS, finalized in early 2005, selected the preferred alternative, Alternative B, a combination of habitat management, improving habitat conditions, wildlife management, public use, and establishing public use facilities. As set forth in the ROD, the Refuge will include portions of the BZ, and will exclude an area encompassing the IA (currently anticipated to be approximately 1,500 acres), which will be retained by DOE for long-term stewardship. The CCP/EIS recommends institutional controls (fencing and warning signs) to separate the Refuge from DOE retained lands.

Public comments were received by the FWS during preparation of the CCP/EIS. The FWS only considered those comments directly related to management of the Refuge, and did not address comments related to concerns over potentially contaminated soils that might remain due to ineffective or insufficient cleanup (either in the IA, which may provide future contamination to the BZ, or in the BZ itself). These issues were considered outside of the scope of the CCP/EIS, under the assumption that the cleanup and closure of the area to become the Refuge will be certified by the EPA as having been completed satisfactorily according to RFCA criteria. In other words, the FWS will assume that the site meets the cleanup criteria and will manage the Refuge accordingly. The FWS will therefore have no involvement in evaluating the cleanup; this will be the responsibility of the DOE, the EPA, and the CDPHE.

The information that the EPA will require in order to certify a portion of the BZ for FWS management of the Refuge will likely need to be contained in the RI/FS, BRA, ROD, and SCP. An important component of the certification will be the plans for ensuring that the Refuge (following cleanup and closure of the RFETS) remains compliant with the cleanup criteria. Therefore, the SCP will need to contain plans for post-closure monitoring and/or institutional controls, as well as plans for notification and action related to any future release of contamination into the Refuge and any existing contamination that may be identified within the Refuge in the future as the result of routine Refuge operation by the FWS.

2.3 Historical Information

Characterization of the RFETS was initiated by DOE in the early 1990's with the gathering of historical information on material and waste handling practices at the site via review of site documents and employee interviews, culminating in the 1992 Rocky Flats Historical Release Report (HRR)[4]. The original HRR information was evaluated, updated with additional information as it became available, and verified with targeted sampling, the results of which are provided in annual HRR update reports.

The gathering of historical information is an important component of pre-characterization activities at CERCLA sites because it provides a foundation for development of site characterization plans such as the SAP and QAPP. In addition, existing analytical data obtained during historical sample collection, if any, can be used in the subsequent detailed site characterization provided that the data meet prescribed DQOs. Historical information is also used to establish OUs, and was used for this purpose at the RFETS. Historical information is of course generally limited and usually insufficient for complete characterization of the nature and extent of contamination. Thus, historical information serves only as a guide for developing the SAP and QAPP. An additional guide to SAP and QAPP development is information about the geochemical migration behavior of the COCs in the environmental. Such information is provided by a Fate and Transport Analysis. The Fate and Transport Analysis conducted for the radionuclides at the RFETS is discussed in Section 2.8.

Besides establishing OUs, HRR information was used by DOE/KH to initially identify hundreds of what are referred to as Potential Release Sites. These are essentially areas or locations at the RFETS where potentially hazardous materials were believed to be processed, handled, or disposed. It should be noted that although the HRR information is extensive, there remains the possibility that not all potentially contaminated areas or locations were identified prior to site characterization. Nevertheless, DOE/KH evaluated the Potential Release Sites and determined that they could be categorized into three types: Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), and Under-building Contamination (UBC) sites. Approximate boundaries for the IHSS/PAC/UBC sites were established initially based on HRR information. However, these boundaries were considered temporary pending further site characterization. In addition, with updates of the HRR and with the addition of other information obtained by DOE/KH, the list of IHSS/PAC/UBC sites has undergone periodic modification. Areas outside of IHSS/PAC/UBC boundaries, which may contain unknown or unidentified Potential Release Sites or potentially contaminated areas, and which are therefore not guaranteed to be uncontaminated, are generally referred to by DOE/KH as White Space Areas.

The information DOE/KH gathered from the HRR resulted in the identification of an initial 95 IHSSs/PACs in the BZ (no UBC sites were identified) contained within six OUs: the 881 Hillside Area (OU1), the Woman Creek Priority Drainage (OU5), the Walnut Creek Priority Drainage (OU6), the Present Landfill (OU7), the West Spray Fields (OU11), and a group of various other IHSSs/PACs (collectively grouped into what is called the BZOU). DOE/KH then proceeded to determine the disposition of each IHSS/PAC with regard to their need for accelerated remedial action. The following is a brief summary of the steps taken by DOE/KH with regard to the disposition of the IHSSs/PACs:

- Prior to 2001, 36 of the initial 95 IHSSs/PACs identified in the BZ were designated by DOE/KH as requiring No Further Action (NFA). The NFA designation means that these sites were determined to require no accelerated remedial action based on available information documented in the HRR updates. The NFA designation is essentially equivalent to the NA alternative under CERCLA.

- In 2001, the remaining 59 IHSSs/PACs (minus the NFA-designated sites) were combined by DOE/KH into eight BZ Characterization Groups based on an assessment of similar disposal methods, common COCs, and their mutual proximity. The grouping into BZ Characterization Groups was designed to enhance the efficiency of site characterization and accelerated remedial action.

- In 2001 and 2002, initial site characterization conducted by DOE/KH for the BZ Characterization Groups (at selected IHSSs/PACs) resulted in further NFA designations and expansion of the total number of IHSSs/PACs in the BZ to 99.

- In 2002, DOE/KH determined that 34 of the 99 IHSSs/PACs required site characterization to evaluate their need for accelerated remedial action. These 34 IHSSs/PACs are listed in **Table 2-1**. DOE/KH then proceeded to characterize these IHSSs/PACs according to a SAP and QAPP established for the BZ (see Section 2.5).

- Following site characterization, if DOE/KH determined that an IHSS/PAC or BZ Characterization Group did not require accelerated remedial action, then DOE/KH provided the resulting site characterization data in Characterization Data Summary Reports (CDSRs)[5] and designated the sites or groups as NFA.

- Following site characterization, if DOE/KH determined that an IHSS/PAC or BZ Characterization Group did require accelerated remedial action, then DOE/KH issued Environmental Restoration Standard Operating Protocols for Routine Soil Remediation (ERRSOP) Notifications[6] or Interim Measure/Interim Remedial Action (IM/IRA) Decision Documents[7], which specify the protocols for the site-specific accelerated remedial action. For sites determined to be contaminated with radionuclides, the accelerated remedial action was removal of the contaminated soils and replacement with clean (uncontaminated) soils.

- Following accelerated remedial action, DOE/KH provided both the initial site characterization data (collected to determine the need for accelerated remedial action) and the resulting cleanup confirmation data (collected during or following the accelerated remedial action to confirm the cleanup) in Closeout Reports[8] and designated the sites or groups as requiring No Further Accelerated Action (NFAA). The NFAA designation means that the accelerated remedial action was determined by DOE/KH to have been completed successfully.

Table 2-1 Buffer Zone Characterization Groups

BZ Group	OU	IHSS/PAC	Description
000-5	7	114	Present Landfill
900-11	BZ	SE-1602	East Firing Range
	BZ	112	903 Pad
	BZ	140	Hazardous Disposal Area
	BZ	155	903 Lip Area
300-3	BZ	NW-1505	
900-2	BZ	153	Oil Burn Pit No. 2
	BZ	154	Pallet Burn Site
NE-1	6	142.1	Pond A-1
	6	142.2	Pond A-2
	6	142.3	Pond A-3
	6	142.4	Pond A-4
	6	142.12	Pond A-5
	6	142.5	Pond B-1
	6	142.6	Pond B-2
	6	142.7	Pond B-3
	6	142.8	Pond B-4
	6	142.9	Pond B-5
	5	142.10	Pond C-1
	5	142.11	Pond C-2
NE-2	BZ	111.4	Trench 7
	BZ	109	Ryan's Pit (Trench 2)
NE/NW	BZ	NE-1407	OU2 Treatment Facility
	BZ	NE-1412	Trench T-12 Located at OU2 East Trenches
	BZ	NE-1413	Trench T-13 Located at OU2 East Trenches
	BZ	174a	PU&D Yard - Drum Storage
	BZ	216.2	East Spray Field-Center Area
	BZ	216.3	East Spray Field-South Area
	6	NE-1404	Diesel Spill at Pond B-2 Spillway
SW-1	5	SW-1702	Recently Identified Ash Pit
	5	133.1	Ash Pit 1
	5	133.2	Ash Pit 2
	5	133.4	Ash Pit 4
	5	133.6	Concrete Wash Pad

Source: Modified from 2002 Final BZSAP.

DOE/KH relied upon the historical information to develop site characterization plans designed to evaluate the need for accelerated remedial actions. As such, the resulting NFA/NFAA designations relate specifically to the accelerated remedial action process and do not officially eliminate these areas from future or final remedial action consideration. It is likely that in order for EPA to certify that the BZ is ready for use as the Refuge, DOE/KH will need to reevaluate all of the accelerated remedial actions and comprehensively evaluate all IHSSs/PACs and White Space Areas in the BZ, regardless of whether they have undergone accelerated remedial action and regardless of their NFA/NFAA designation. The evaluation/reevaluation will likely need to be included in the final RI/FS.

The actual portion of the BZ that will be certified by EPA as ready for use as the Refuge has not yet been determined. Currently, it is not possible to establish which, if any, of the IHSSs/PACs identified in the BZ are candidates for inclusion in the Refuge, versus which of the IHSSs/PACs are candidates for inclusion in the area to be retained by DOE for long-term stewardship. This determination will likely only be possible following completion of the final RI/FS.

DOE/KH have used historical information to target site characterization sampling approaches (see Sections 2.5 and 2.6) based on the likelihood of radionuclide soil contamination in the BZ. This approach was deemed necessary by DOE/KH due to the large size of the BZ and the perceived technical impracticality of characterizing the entire BZ in an equivalent fashion. Such a targeted approach is not uncommon at large complex CERCLA sites.

2.4 Radionuclide Soil Action Levels

Attachment 5 of the RFCA specifies the ALs for COCs at the RFETS. For the radionuclides in soils, the ALs are referred to as Radionuclide Soil Action Levels (RSALs). The RSALs were selected from risk calculations provided in a 2002 document titled *Results of the Interagency Review of Radionuclide Soil Action Levels*. This document determines the average radionuclide levels in surface soils whereby exposure to the soils at these levels would represent a lifetime excess cancer risk of $1x10^{-5}$ to a hypothetical Refuge worker and $1x10^{-4}$ to a hypothetical rural resident. These average levels, which were selected as the RSALs, are provided in **Table 2-2**.

Table 2-2 Radionuclide Soil Action Levels

Radionuclide	Depth Interval (ft)	Action Level (pCi/g)
Uranium-234	0 – 0.5	300
Uranium-235	0 – 0.5	8
Uranium-238	0 – 0.5	351
Plutonium-239/240	0 – 3	116/50(1)
Americium-241	0 – 3	76

(1) Note that the actual risk-based RSAL for $^{239/240}Pu$ is 116 pCi/g. However, the DOE, EPA, and CDPHE have agreed to characterize the RFETS according to a practical RSAL of 50 pCi/g.

The RSALs are expressed in units of picocuries per gram of soil (pCi/g) because what is of concern is the radioactive decay rate or radioactivity [1]. The radioactivity can be expressed in either disintegrations per second (dps) or pCi (1 pCi = 0.037 dps). An important factor in assessing radioactivity is dose, the total amount of ionizing radiation received by an individual organism. For humans, dose is measured in roentgen-equivalent-man (rem) units (1 rem represents a dose equivalent of about 1 roentgen of X-ray or gamma-ray radiation). According to the RFCA, a hypothetical Refuge worker or rural resident exposed to the ionizing radiation emitted from surface soils with radionuclide levels at the RSALs (Table 2-2) would receive a dose of less than 25 millirem per year (mrem/year), which represents the annual dose limits in the Colorado Radiation Control Regulations, *Radiological Criteria for License Termination*, 6 CCR 1007-1 RH 4.61.

The RFCA does not specify a particular size or area of surface soils (generally referred to as a "hot spot") that, if found to exceed the RSALs, would prompt remedial action. This means, on the one hand, that any site characterization result exceeding any of the RSALs would prompt remedial action. However, on the other hand, since site characterization is limited and cannot practically sample and analyze all surface soils, a hot spot size specification is generally required. The hot spot size specification for surface soils is provided by DOE/KH in the SAP and QAPP established for the BZ (see Sections 2.5 and 2.6).

The RFCA specifies a process for evaluating radionuclide contamination below surface soil depths (0 – 0.5 ft for uranium and 0 – 3 ft for plutonium and americium). The process relies upon what is called a Subsurface Soil Risk Screen, which is provided in Figure 3 of the RFCA Attachment 5. For subsurface soils determined to require remedial action based on the Subsurface Soil Risk Screen, the RFCA specifies remedial criteria for $^{239/240}$Pu and ^{241}Am as shown in **Table 2-3**.

Table 2-3 Subsurface Soil[1] Remedial Criteria for $^{239/240}$Pu and ^{241}Am

Action Level (pCi/g)	Area Extent Limit (m^2)	Volume Extent Limit (m^3)	Step-Out Distance (m)
7,000	0	0	0
6,000	40	25	5
5,000	50	31	6
4,000	60	37	7.5
3,000	80	50	10

[1] 3 – 6 ft depth.

This means, for example, that if $^{239/240}$Pu or ^{241}Am at the 3 – 6 ft depth exceeds 7,000 pCi/g (or 7 nCi/g), then the soil will be remediated (removed) regardless of the area or volume of the contamination. Alternatively, for example, if the subsurface concentrations exceed 3,000 pCi/g (but not 4,000 pCi/g), then the soil will be removed only if the area extent of contamination limit (80 m^2) or volume extent of

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[1] $radioactivity = \frac{-dN}{dt} - KN$ where *N* is the number of atoms of the radionuclide present, *t* is the time, and *K* is a decay constant, which is specific to the particular radionuclide.

contamination limit (50 m^3), i.e., hot spots of these sizes, are also exceeded. As shown in Table 2-3, "step-out" sampling is to be conducted to determine the hot spot sizes. This means that, once a subsurface soil sample is determined to be above the RSALs (Table 2-2) and to require remedial action based on the Subsurface Soil Risk Screen, four additional samples are to be collected around the original sample location, at 90 degree angles from each other and at the specified distances from the original sample location shown in Table 2-3. The RFCA further specifies that once a remedial action is prompted based on any of the criteria in Table 2-3, the soil must be remediated to levels below 1,000 pCi/g. This means that, once a subsurface hot spot meeting the concentration/size criteria in Table 2-3 has been identified, it must be further characterized for remediation purposes according to the 1,000 pCi/g remediation criterion, which may require additional step-out sampling.

The RSALs (Table 2-2) are meant to be applied on an individual radionuclide basis. That is, for example, exposure to surface soils contaminated only with $^{239/240}$Pu at a concentration of 116 pCi/g (the RSAL) would result in a lifetime excess cancer risk of $1x10^{-5}$ to a hypothetical Refuge worker with a corresponding dose of ionizing radiation of less than 25 mrem/year. It is possible, however, that a surface soil may be below the RSALs for all five radionuclides while at the same time the cumulative concentrations may result in a lifetime excess cancer risk exceeding $1x10^{-5}$ or a dose exceeding 25 mrem/year. Therefore, to account for the cumulative affect, the RFCA further specifies that the total risk from multiple radionuclides be calculated using the Sum-of-Ratios (SOR) method [2]. An SOR ≥ 1 would prompt remedial action. Note that the RSAL for $^{239/240}$Pu used in the SOR calculation is 116 pCi/g, the actual risk-based RSAL, and not 50 pCi/g, the agreed upon RSAL to be used in practice. The SOR method was also used for remedial action screening in subsurface soils.

The RSALs (Table 2-2) were established based on risks calculated for exposure at the surface. However, if subsurface contamination is subsequently moved to the surface by natural or anthropogenic processes, the risk factors ($1x10^{-5}$ or $1x10^{-4}$) may be exceeded. Within the CERCLA process, this scenario is typically addressed by specifying institutional controls in the SCP. For the RFETS, for example, one would expect the SCP to (1) specify an institutional control involving restrictions on excavation in areas known to contain subsurface contamination and (2) given subsequent surface exposure of subsurface soils, plans for testing such exposed soils and evaluating the associated risk, if any.

As indicated in Table 2-2, different soil depths are specified for uranium (0 – 0.5 ft) versus plutonium and americium (0 – 3 ft). This difference imposes a corresponding difference in the sample collection methods required for site characterization (see Section 2.7). DOE/KH address this issue by specifying the collection or compilation of discrete grab sample data at common depths of 0 – 0.5 and 0.5 - 3 ft for all five radionuclides. The 0 – 0.5 ft samples are obtained primarily using hand tools while the 0.5 – 3 ft samples are obtained using subsurface coring equipment. Samples at

[2] $SOR = \sum_{i=1}^{n} C_i / RSAL_i$ where C_i and $RSAL_i$ are the concentration and RSAL, respectively, for radionuclide i of n measured radionuclides.

depths greater than 3 ft are also obtained using coring equipment and are evaluated for plutonium and americium only. None of the documents reviewed during this technical evaluation provide an acceptable level of detail regarding how data that may have been obtained using a variety of sample collection methods (see Sections 2.6 and 2.7) were actually compiled for site characterization purposes. This level of detail is important and will likely be a necessary component of the final RI/FS and risk assessment.

2.5 Sampling Areas

In 2002, DOE/KH issued a Buffer Zone Sampling and Analysis Plan (BZSAP)[9] that describes surface and subsurface characterization and accelerated remedial action (if necessary) confirmation sampling protocols for the potential release sites (IHSSs/PACs) identified in the RFETS BZ (see Table 2-1). The BZSAP contains the DQOs established for characterization and accelerated remedial action of the BZ soils, together with the sampling strategy and the data analysis and data management procedures.

The BZSAP provides the general soil sampling approach to be conducted by DOE/KH in the BZ, which is based on dividing the BZ into three types of sampling areas:

(1) Potentially Contaminated Areas – Areas known to be contaminated or potentially contaminated (i.e., the IHSSs/PACs listed in Table 2-1);

(2) Areas Not Expected to Exceed Actions Levels – White Space Areas near the IA in what DOE/KH refers to as the Inner BZ; and

(3) Outer BZ Areas – White Space Areas surrounding the Inner BZ.

The boundary between area types 2 and 3 (the Inner BZ and the Outer BZ) is not well-defined physically. Conceptually, or from a sampling area perspective, the boundary appears to distinguish between lands that may be retained by DOE for long-term stewardship (the Inner BZ) and lands that may be included in the Refuge (the outer BZ). By default, the White Space Areas (area types 2 and 3) are to be characterized with regard to surface soil RSALs (Table 2-2) under the assumption that since the White Space Areas by definition do not contain any IHSSs/PACs, there is essentially no need to characterize the subsurface soils in the White Space Areas. This assumption is supported by the fate and transport analyses (see Section 2.8) which indicate that radionuclide contamination in White Space Areas should be restricted to surface soils because the only source of contamination in these areas is aerial dispersion and deposition. However, should an IHSS/PAC be eventually included in the area to become the Refuge, then area or volume-based subsurface soil criteria (Table 2-3) would apply.

2.6 Sampling Methods

Given the three types of sampling areas (see Section 2.5), the BZSAP specifies one or a combination of three site characterization sampling methods: geostatistical-based sampling, standard statistical-based sampling, and biased sampling.

2.6.1 Geostatistical-based Sampling

The BZSAP specifies that geostatistical-based sampling may be conducted in any area (area types 1, 2, or 3) where Existing Data indicate that contaminant concentrations have or may have been dispersed in a spatial distribution pattern. The approach combines an analysis of spatial contaminant distribution, called variography, with a mapping technique, called kriging.

Variography seeks to characterize the relationship between contaminant variability and the distance between sampling points. The fundamental idea is that if the contamination is distributed spatially in a pattern or "plume" emanating from a source, such as would be expected from windblown dispersion and deposition, then the concentrations at sampling points located closer together will tend to be more similar (smaller variability) than the concentrations at sampling points located farther apart (larger variability). The product of variography is a plot called a variogram on which a model curve is fitted that defines the variability versus distance relationship. From a sampling standpoint, the site characterization data must be sufficient (in quantity and spacing) to enable fitting of the model curve to the variogram. Thus, the ability to fit a model curve to the variogram establishes the quantity and spacing of the site characterization data required under the geostatistical-based sampling approach.

Once a variogram has been generated and a model curve has been fit to it, a weighted moving-averaging technique called kriging is used to map the contaminant concentrations in the spatially-distributed area of contamination. The kriging technique uses the variability versus distance model curve fit to the variogram, the actual distances from samples, and the degree of clustering of samples to establish a set of weights to be used in estimating an average statistic (e.g., the mean concentration) in a series of local grid points or areas across the site. When the estimation is for local areas, called "blocks", the technique is called ordinary block kriging. In practice, ordinary block kriging involves making a series of equally-spaced point estimates within a block and then averaging them to obtain the estimated value for the block. Ordinary kriging, as opposed to other mapping techniques, is highly regarded because it is considered to be a "best linear unbiased estimator" (BLUE). It is "linear" because the estimates are weighted linear combinations of the available data, "unbiased" because it seeks an average residual (difference between the estimate and the true value) of zero, and "best" because it seeks to minimize the variability of the residuals.

Geostatistical-based Sampling (variogram analysis and kriging) is commonly used at large CERCLA sites where the spatial distribution of a COC in surface soils has resulted from aerial (windblown) dispersion. For the RFETS BZ, DOE/KH applied this approach to surface soil characterization for BZ Group 900-11 (the 903 Lip Area and vicinity, the Windblown Area, and the 881 Hillside [OU1]) as described in the associated IM/IRA Decision Document. The actual ordinary block kriging approach conducted by DOE/KH in the area corresponding to BZ Group 900-11 is known as indicator kriging. The basic idea with indicator kriging is to select a cutoff or threshold concentration value, then to assign each data point with a concentration below or above the selected threshold a value of 0 or 1, respectively. The transformed data values (0s or 1s) are called indicators. The next step is to construct a variogram for the indicators and fit a model curve to the variogram. Then, ordinary block kriging is conducted to map the local average values of the indicators across the site. The threshold values selected for the indicators at BZ Group 900-11 were the RSALs, e.g., 50 pCi/g for $^{239/240}$Pu. The local block sizes were 20×20 ft. Hence, the result was a series of 20×20 ft blocks covering the site, each with an associated average estimate of the indicator. For example, for $^{239/240}$Pu, a block with an indicator estimate of 0.10 means that on average 10 out of 100 samples randomly collected from the block would be expected to exceed 50 pCi/g, and likewise 90 out of 100 samples would not be expected to exceed 50 pCi/g. In fact, DOE/KH used the 0.10 average indicator estimate as the decision value for the accelerated remedial action, whereby soils in blocks with indicator estimates above 0.10 were to be removed. [3]

2.6.2 Standard Statistical-based Sampling

Standard statistical-based sampling may be conducted by DOE/KH in Potentially Contaminated Areas (area type 1) or Areas Not Expected to Exceed Action Levels (area type 2). The BZSAP specifies that the standard statistical-based sampling approach is to be used in areas where there are an insufficient number of samples to apply the geostatistical-based sampling approach, or where contaminants do not exhibit a spatial distribution pattern. In practice, this approach was applied to all IHSSs/PACs in the BZ earmarked for site characterization (Table 2-1) except for BZ Group 900-11 (as described above). The standard statistical-based sampling approach involves establishing a triangular sampling grid designed to identify a radionuclide hot spot of a certain size with 90% confidence, meaning that on average 90 out of 100 such sampling grids would accurately identify the hot spot. A hot spot is defined as an area of a certain size with concentrations exceeding the RSALs (Tables 2-2 and 2-3). The "certain size" qualifier means that the actual size of the hot spot may vary from site to site, as discussed further below.

According to the BZSAP, the size of hot spot that the standard statistical-based sampling approach is designed to identify is determined based on the type of area. In Potentially Contaminated Areas (i.e., IHSSs/PACs), the approach is first to determine whether sufficient information (based on the HRR) is available to establish beforehand the approximate size of the hot spot expected to be present in the area. Assuming that sufficient information is available for this purpose, the approach then is to design a triangular sampling grid that will identify the hot spot of that size with 90% confidence. Since the sizes of the hot spots within the IHSSs/PACs will

[3] DOE/KH tends to interpret the indicator block estimates as representing the "probability" or "confidence level" that the block exceeds the RSAL. The more accurate interpretation is that the indicator block estimates represent the "proportion" of the block that exceeds the RSAL.

generally vary, the dimensions of the sampling grid and therefore the number of samples collected across the IHSS/PAC will also tend to vary from site to site. Conversely, if information is insufficient to establish the expected size of the hot spot within an IHSS/PAC, then a default hot spot size of approximately 36-ft diameter is established, and again a triangular sampling grid is used to identify the 36-ft diameter hot spot with 90% confidence. In Areas Not Expected to Exceed Action Levels (i.e., White Space Areas in the Inner BZ), the sampling approach is designed to identify an approximately 10,000-m^2 hot spot. The "approximate" qualifier in either case is used to denote that the shape of the hot spot is assumed to be circular. The bottom-line with regard to the standard statistical-based sampling approach conducted at the IHSSs/PACs is that the assumed hot spot size (based on available information) is allowed to vary from site to site, and therefore the spacing of sample points in the prescribed triangular grid is likewise allowed to vary from site to site.

It is important to note that the standard statistical-based sampling approach, which was applied at essentially all IHSSs/PACs in the BZ, will not identify all hot spots of any size. In fact, the approach is highly dependent on the accuracy of information used to establish the likely hot spot size. If this information is not accurate, and for example the actual hot spot is smaller than the available information indicates it should be, then the confidence of identifying it will be less than 90%. Essentially, the confidence of identifying a smaller-than-expected hot spot will decrease with the difference between the expected size and true size of the hot spot. This means that there will always be a certain probability that localized contamination will not be identified. On the other hand, the confidence in accurately identifying hot spots larger than the assumed or estimated size will increase above 90% as the true hot spot size increases. Once a hot spot has been identified, regardless of its actual size and the actual probability of identifying it, it is earmarked by DOE/KH for accelerated remedial action. Documentation of the actual size of hot spots is currently insufficient; this information will likely need to be provided in the RI/FS.

It is also important to note that the sampling approaches described in the BZSAP are deficient in addressing White Space Areas in the Outer BZ. This deficiency, however, is addressed by DOE/KH in another SAP, the Comprehensive Risk Assessment Sampling and Analysis Plan (CRASAP)[10]. The Comprehensive Risk Assessment (CRA) is the risk assessment, equivalent in technical scope to a BRA, that will be conducted in association with, and integrated into, the final RI/FS. In other words, the CRA will assess the risks at the RFETS, including the BZ, following the accelerated remedial actions, i.e., the calculated risks will be representative of post-accelerated remedial action conditions. Therefore, the data used in the CRA will be a combination of site characterization data and cleanup confirmation data, or any other post-accelerated remedial action data that meets the DQOs prescribed in the CRASAP (see Section 3). It should be noted, however, that not all site characterization data will be usable. In cases where a site characterization sample corresponds with soil that was subsequently removed, the original site characterization data point will not be used in the CRA because that data point no longer exists with regard to post-accelerated remedial action conditions.

To ensure that White Space Areas in the Outer BZ are adequately characterized for purposes of the CRA, the CRASAP specifies a 30-acre square grid block sampling pattern, where individual discrete samples (called "grab" samples) are collected from each corner of the block plus one in the center of the block. The five grab samples are then composited (mixed together) and the composite sample analyzed. In cases where composite samples exhibit unexpectedly elevated concentrations, each of the five individual grab samples may also be analyzed. The "unexpectedly elevated" qualifier is meant to be assessed based on professional judgment, by either DOE/KH or EPA/CDPHE oversight personnel.

The purpose of allowing for individual analysis of the five grab samples making up the 30-acre composite is to allow additional site characterization based on the chance that one of the grab samples happens to hit a previously unknown or unidentified IHSS/PAC or hot spot. Note, however, that on the one hand, unless the unknown or unidentified IHSS/PAC or hot spot is fairly large (greater than say 5 – 10 acres) the probability of hitting it with this approach is low. On the other hand, the available information indicates that hot spots of any size are not expected to be present in the Outer BZ White Space Areas, and therefore the approach that DOE/KH has taken is that more dense sampling in these areas would not be cost-effective or technically warranted.

As discussed previously, the BZSAP Addenda are generally deficient in providing the justification for determining the hot spot sizes targeted for standard statistical-based sampling. This information will likely need to be included in the final RI/FS and CRA.

2.6.3 Biased Sampling

According to the BZSAP, biased sampling may be conducted by DOE/KH in Potentially Contaminated Areas (area type 1) or Areas Not Expected to Exceed Action Levels (area type 2) where professional judgment is deemed useful to replace or augment standard statistical-based sampling. Biased sampling essentially means the placement of sampling points based on professional judgment and knowledge about the contamination in the area. In practice, biased sampling provides a means of "filling in" or adding sampling points between standard statistical-based sampling points where field evidence of localized contamination has been identified.

2.7 Sample Collection, Analysis, and Data Compilation

Subsequent Addenda to the BZSAP were issued by DOE/KH that provide BZ Group-specific details of the sampling approach. For the geostatistical-based, standard statistical-based, and biased sampling approaches, the BZSAP and Addenda specify a sampling technique whereby either discrete (grab) samples are collected and analyzed or in-situ field measurements are taken at discrete points. As discussed above, the CRASAP specifies a composite sampling approach for Outer BZ White Space Areas, whereby 5 grab samples are collected in a 30-acre area and then mixed together to create a single composite sample.

From a technical standpoint, the critical concern with any sampling technique is its ability to capture the actual contaminant variability in the sampled area. This is a function of the number of samples collected and the size or physical dimensions of the sample unit. The size or physical dimensions of the sample unit is termed the sample "support". When an estimate of variability is made based on a sample data set, the result is an estimate of the actual variability of an area for the same support as the sample support. In other words, if the sample support is provided by discrete soil grab samples of, say, 500-g unit sizes, then the estimated variability of the area is for 500-g soil units. Similarly, if the sample support is provided by composite soil samples representing 30-acre blocks, then the estimated variability of the area is for 30-acre blocks.

Once the sample support is established for an area, one may be interested in estimating the average or mean concentration of the area. For example, from a risk assessment standpoint, one may be interested in estimating the mean soil concentration of $^{239/240}Pu$ in a certain area that a Refuge worker may be exposed to. In risk assessment, such exposure usually requires placing an upper confidence limit (UCL) on the estimated mean exposure concentration (to represent reasonable maximum exposure). This requires an estimate of the variability of the estimated mean, which is a function of the variability of the concentrations in the area and the number of samples collected. The lower the concentration variability and/or the higher the number of samples collected, the more certain will be the mean estimate and therefore the lower will be the UCL. This means that in areas such as the Outer BZ White Space Areas, where DOE/KH expects (based on available information) concentrations to be relatively low and to not exhibit significant variability, the number of samples required is relatively small. Thus composite sampling on 30-acre blocks in the Outer BZ White Space Areas is justified by DOE/KH because: (1) it leads to a smaller but statistically-defensible number of samples, and (2) the variability for 30-acre composites (the sample support) is not expected to differ significantly from the actual variability of the area. On the other hand, composite sampling would not be a good choice for an IHSS/PAC in the BZ because the number of samples collected would tend to be too low and/or the actual variability too high in such an area. This is why the BZSAP and Addenda specify discrete rather than composite sampling in these areas for site characterization.

Although the sample collection approach for the BZ is regarded by DOE/KH as technically appropriate, as discussed above, this does not mean that there are no technical concerns. One such concern involves how estimates are made in areas where a variety of different sample supports may have been used. One must be aware of the potential implications of compiling data obtained under different sample supports. For example, a careful examination of the data used to generate the indicator block estimates in BZ Group 900-11 reveals that the data have been compiled for a number of different sample supports (grab samples taken at various depths, in-situ field measurements, etc.). Technically, such compilation of data obtained under different sample supports tends to increase the uncertainty of actual concentration (or indicator) estimates. A deficiency of the IM/IRA for BZ Group 900-11 is lack of discussion or evaluation of the potential impacts of the way the data were compiled for site characterization purposes. This deficiency will need to be addressed in the RI/FS and the CRA.

The BZSAP and Addenda specify that for discrete grab sampling, surface soil samples are collected from 0 – 6 in using stainless steel hand tools, and that subsurface soil samples are collected in 2-ft increments using various coring devices. The discrete samples are then analyzed at either an off-site laboratory using conventional analytical methods, or they are analyzed on-site using field analytical methods. The difference in analytical methods potentially represents another concern regarding data compilation or change in sample support (discussed further below). Furthermore, the difference in sampling depths relative to the RSALs (Table 2-2) and the subsurface remedial criteria (Table 2-3) are not well-defined in terms of data compilation and accelerated remedial action. This also will need to be addressed in the RI/FS and the CRA.

For the on-site radionuclide measurements, the BZSAP specifies gamma-ray spectroscopy using a high-purity germanium detector (HPGe). The HPGe instrumentation may be used in one of two ways: either in a field laboratory mode whereby discrete grab samples are physically collected and analyzed, or in a field in-situ mode whereby the soil surface is analyzed to a depth of a few centimeters over a particular field of view (generally 36-ft diameter). The first of these uses has been reserved by DOE/KH primarily for site characterization, while the second has been reserved for cleanup confirmation of accelerated remedial actions (see Section 3).

Because the HPGe technique is a field method, it must be calibrated and verified using corresponding laboratory analyses. This is necessary in order to provide data in units (pCi/g) comparable to the RSALs and to verify that such data are accurate. The BZSAP and Addenda specify the DQOs required, which are generally consistent with CERCLA guidelines. However, the Data Summary Reports and Closeout Reports reviewed during this technical evaluation are deficient in providing the necessary calibration and verification data with which to assess the data relative to the established DQOs. This information and assessment will likely be a necessary requirement of the final RI/FS and CRA, and will therefore be required by EPA before the BZ can be certified as ready for use as the Refuge.

Information and data used to make decisions regarding subsequent site soil characterization activities were obtained by DOE/KH primarily from historical information and associated sample analytical data contained in the HRR and other historical reports. For the BZ, these data are summarized in the Buffer Zone Data Summary Report[11] and are generally referred to during subsequent site characterization activities as Existing Data. The Existing Data, which are typically presented in tables or appendices in BZSAP and CDSR documents, were used as the basis for developing site characterization sampling and analysis plans, i.e., the BZSAP and the CRASAP.

Existing Data, data obtained concurrently by EPA or CDPHE, and BZSAP-generated characterization data must pass a data usability and validation screen, called the Data Quality Filter, before they are used by DOE/KH to actually characterize the nature and extent of contamination at an IHSS/PAC or White Space Area in the BZ. The Data Quality Filter, presented in Figure 3 of the BZSAP, is a component of the DQO process and serves to ensure that only data of sufficient quality will be used. The Data Quality Filter provides a screening level validation that leads to assigning one of three possible quality status flags to the data: (1) data usable without qualification, (2) data usable with qualification, and (3) data not usable. This approach is generally consistent with the methods used at other CERCLA sites. A number of different sample supports (discrete grab samples, composite samples, different depth intervals, etc.) have been used by DOE/KH for site characterization purposes. This is justified because it corresponds with the various targeted sampling approaches. However, there is a tendency for DOE/KH to compile the resulting data in a way that may add uncertainty to the site characterization. This additional uncertainty will likely need to be addressed and evaluated in the final RI/FS and CRA.

2.8 Fate and Transport Analyses

In 1996, the Actinide Migration Studies (AMS) Group, also called the Actinide Migration Evaluation (AME) Advisory Group, was established to study issues concerning actinide chemistry, geochemistry, transport, and migration at the RFETS. The results of the studies are presented in the 2002 AME Pathway Analysis Report[12]. The AMS/AME Group used Existing Data to evaluate radionuclide concentrations in surface soils at the RFETS and produce associated geostatistical-based maps, which indicate a spatial distribution of radionuclide concentrations emanating primarily from the 903 Pad area. As the radionuclide concentrations extend into the BZ, this information is applicable for characterization of the BZ.

In the context of CERCLA, the work conducted by the AMS/AME Group constitutes what are called Fate and Transport Analyses, which are common and important components of the RI/FS and BRA. Essentially, such studies are necessary to enable a comprehensive evaluation of the environmental behavior of the radionuclides in the BZ soils.

Section 3
Cleanup Confirmation

3.1 Regulatory Framework

As discussed in Section 2.1, site characterization sampling is conducted to assess the risks to human health and the environment (to be provided in the CRA in the case of the RFETS) and to evaluate remedial action alternatives (to be provided in the RI/FS). Under CERCLA, risk assessment and evaluation of remedial action alternatives does not necessarily require that the contamination be characterized to the same degree as will be required for the actual remedial action. The actual remedial action (which is officially selected in the ROD) is implemented under CERCLA according to a Remedial Action Plan (RAP) and Cleanup Confirmation Plan (CCP). The RAP details how the selected remedial action will be implemented, which may include the collection of samples in addition to the site characterization samples. The CCP details how, after the remedial action is completed, cleanup will be confirmed. Often the RAP and CCP are combined such that the sample data collected under both plans ultimately serves to confirm the cleanup.

At the RFETS, the remedial action selected for radionuclide contaminated soil is removal or excavation of the soil followed by replacement with clean soil. After the contaminated soil has been removed, and before replacement with clean soil, the resulting "hole", which may be referred to as the excavation "invert", must be sampled in order to confirm the cleanup. At CERCLA sites, the confirmation sampling approach, which is usually either random sampling or systematic sampling (or some combination of the two), is specified based on DQOs established in the CCP. The resulting confirmation dataset is then used to calculate a statistic (typically the mean concentration) for comparison with the ALs. The statistical criteria for the comparison are also specified based on DQOs established in the CCP. For soils cleanup, the most common approach is to calculate an upper confidence limit (UCL) of the mean COC concentration in the sampled invert, which is then compared with the AL. If the calculated UCL is less than the AL, then the remedial action is confirmed to have been completed satisfactorily. Conversely, if the calculated UCL exceeds the AL, then further remedial action is required, i.e., additional soils removal followed by additional cleanup confirmation sampling. Numerous EPA guidance documents are available for each phase or component of the CERCLA cleanup confirmation process.

The streamlined or accelerated remedial action strategy conducted by DOE/KH, which allows for in-process or intermediate cleanup actions, has effectively resulted in the combining of site characterization, remedial action, and cleanup confirmation sampling. Under CERCLA, accelerated remedial actions are considered interim measures, and are typically conducted in response to an imminent threat to human health or the environment. At the RFETS, the accelerated remedial actions were conducted more with the goal of accelerating the cleanup process and therefore closing the site more rapidly. In any case, however, the final condition of the "yet-to-be-determined" portion of the BZ that will become the Refuge will still need to be determined in the final RI/FS and CRA, regardless of the degree to which previous accelerated remedial actions have been conducted. Thus, the RI/FS and CRA are likely to be critical documents in assessing whether the site ultimately requires remedial action (or further remedial action) and the degree of cleanup confirmation required.

3.2 Accelerated Remedial Action

The strategy that DOE/KH has followed at the RFETS allows for in-process or intermediate cleanup actions, which are referred to as accelerated remedial actions. The accelerated remedial action strategy requires that the site characterization sampling data, as augmented by additional remedial action sampling data, if necessary, be used to guide the accelerated remedial action (soils removal). The site characterization data plus accelerated remedial action data then serve as confirmation or partial confirmation of the cleanup. The "partial" qualifier is meant to indicate that in certain cases additional confirmation sampling data is required. Due to the number and variety of IHSSs/PACs requiring cleanup in the RFETS BZ, varying combinations of characterization, accelerated remedial action, and confirmation sampling have been conducted by DOE/KH depending on the particular site. Generally, the following approaches were conducted:

(1) At most of the IHSSs/PACs, DOE/KH established the cleanup boundaries using site characterization data (typically discrete grab samples) obtained via standard statistical-based sampling. The contaminated soil within the boundary or "cut-line" was then removed to a certain depth or "lift" using various earthmoving equipment. Following removal, the excavation invert was scanned for gamma ray radiation using the HPGe instrument in in-situ field mode (see Section 3.3). Further soil removal was conducted at locations where the in-situ scans exceeded the RSALs, followed by additional in-situ scanning. This was repeated until all scanning data were determined to be below the RSALs. The result of this approach is a set of HPGe scanning data that serves as cleanup confirmation. Additional discrete samples were collected and analyzed at an off-site laboratory using conventional methods to verify the calibration and accuracy of the HPGe method.

(2) At some of the IHSSs/PACs, DOE/KH followed the same protocol as approach 1 except that the HPGe instrument was used in field laboratory mode. Instead of scanning the surface of the invert for gamma ray radiation, discrete grab samples collected at the nodes of a triangular sampling grid were analyzed for gamma ray radiation in the field laboratory. The triangular grid was established for site characterization (see Section 2.6). In cases where soil was not removed at a grid sample location, the original site characterization sample also served as a cleanup confirmation sample. In cases where the original site characterization sample exceeded the RSALs, soil was removed and an additional discrete sample collected. This was repeated until all data were determined to be below the RSALs. The result of this approach is a set of HPGe field laboratory data for discrete samples collected on a triangular grid

that serves as cleanup confirmation. Some of the discrete samples were also analyzed at an off-site laboratory using conventional methods to verify the calibration and accuracy of the HPGe field laboratory method.

(3) A modification of approach 2 was used for the Inner Lip Area (the area closest to the 903 Pad) at BZ Group 900-11. In this case, DOE/KH conducted remedial action sampling via collection of 5-point composites within 42×42 ft blocks covering the area. The depth of sampling was 6 in. The composite samples were analyzed for gamma ray radiation using the HPGe instrument in field laboratory mode. Blocks where composite samples exceeded the RSALs were removed via 6-in lifts, followed by collection of another composite at the remediated block. This process was repeated until all confirmation data for all blocks were below the RSALs. The result of this approach is a set of HPGe field laboratory data for composite samples collected from 42×42 ft blocks that serves as cleanup confirmation. Again, some of the composite samples were analyzed at an off-site laboratory using conventional methods to verify the calibration and accuracy of the HPGe field laboratory method.

(4) A somewhat different approach was taken for the Outer Lip Area and vicinity (all areas except the Inner Lip Area) at BZ Group 900-11. In this case, the cut-line was established using the geostatistical-based site characterization data. Essentially, the cut-line was established as the 0.10 indicator line around the area (see Section 2.6). Soil within the 0.10 indicator cut-line was then removed to a certain depth (i.e., 3-in lifts). Following removal, the excavation invert was sampled via collection of discrete grab samples at the nodes of a 52-ft square grid. The samples were analyzed using the HPGe instrument in field laboratory mode. The result of this approach is a set of HPGe field laboratory data for discrete samples collected on a 52-ft square grid that serves as cleanup confirmation. Again, some of the discrete samples (10%) were analyzed at an off-site laboratory using conventional methods to verify the calibration and accuracy of the HPGe method. Statistical analysis (see Section 3.5) was then used to confirm that the remediated area on the whole met the cleanup criteria.

Since all of the above approaches rely heavily on the accuracy of the HPGe instrument (either in in-situ scanning or field laboratory mode), it is critical that the verification of the field method be documented. Such documentation, which to date has not been provided, will likely need to be fully evaluated in the RI/FS and CRA. This will be especially critical for the in-situ scanning data because of the need to convert the analytical units from an area to a mass basis (i.e., pCi/m^2 to pCi/g).

Due to the variety of accelerated remedial action and confirmation sampling approaches conducted by DOE/KH, it will likely be necessary to evaluate each remediated area on an individual basis in the final RI/FS and CRA. These documents will therefore need to provide the information necessary to evaluate whether further remedial action in the BZ is required. If the determination is made that further remedial action is required, then a corresponding RAP and CCP will likely need to be developed. However, if the determination is made that further remedial action is not required, then these plans are not expected to be necessary, i.e., they may be considered to have already been implemented.

3.3 Sampling Methods

The BZSAP specifies the general approach for cleanup confirmation sampling and analysis. The approach for radionuclide-remediated soils at most IHSSs/PACs (approach 1 and 2 in Section 3.2) is to use a triangular sampling grid with analysis of gamma ray radiation using a field HPGe instrument. As noted earlier, the HPGe instrument may be operated in either in-situ scanning mode or field laboratory mode.

Operation of the HPGe instrument in in-situ scanning mode was conducted by DOE/KH in a manner designed to provide approximately 90% coverage of the surface of the excavation invert. The 90% coverage value is derived from the use of a 36-ft grid spacing in combination with a 36-ft diameter field of view of the instrument. This combination is expected to leave approximately 10% of the invert unscanned, as illustrated in **Figure 3-1**.

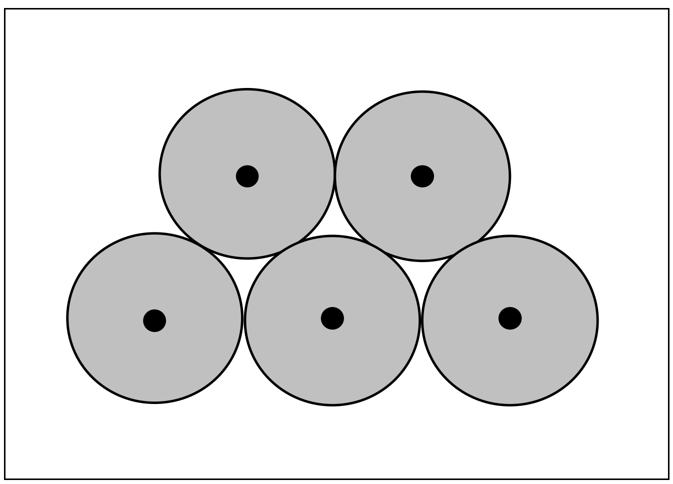

Figure 3-1. Illustration of HPGe In-situ Scanning. Black dots represent nodes on the 36-ft triangular grid; gray circles represent the HPGe field of view; and the enclosed white space represents the unscanned portion.

At sites where discrete samples were collected and analyzed using the HPGe instrument in field laboratory mode, the samples were collected as grab samples from the nodes of a triangular (primarily) or square sampling grid, or as composite samples in the case of the Inner Lip Area at BZ Group 900-11. Essentially, the grid density for the confirmation samples matches the grid density for the site characterization samples (see Section 2.6). The sampling protocols are specified in the BZSAP and Addenda.

The details of the sampling approaches employed for cleanup confirmation have not been well documented to date. In some cases it appears that a combination of HPGe in in-situ and field laboratory modes have been employed at certain IHSSs/PACs. For example, in some cases analysis of the side-walls of the inverts may have required the collection of discrete samples, whereas analysis of the floors of the inverts may have used the in-situ scanning method. The differences in respective sample supports may effectively increase the uncertainty of the cleanup confirmation in such cases. A detailed description of the sampling data and a thorough evaluation of the uncertainty of the confirmation data will likely need to be included in the final RI/FS and CRA.

It is important to reiterate that since the HPGe method is a field screening method, it requires adequate calibration and verification against standard laboratory methods to ensure that the resulting data are usable, as is required for any field screening method employed at CERCLA sites. Such calibration/verification, which is currently not adequately documented, will likely need to be included and evaluated in the final RI/FS and CRA.

The BZSAP acknowledges that the HPGe method may provide biased analytical data. In fact, the primary purpose of validation of a percentage of the samples is to define the bias relationship using linear regression. The BZSAP, however, does not adequately describe how the field analytical data may be adjusted to account for the bias. Overall, the confirmation protocols and data reviewed during this technical evaluation do not seem to address this issue. A detailed description of the analytical bias and the method used, if any, to adjust the data will likely be an important component of the RI/FS and CRA.

Finally, it is important to note that the accelerated remedial actions conducted by DOE/KH may not require the same level of quality as is necessary to support final RI/FS and CRA analysis under CERCLA. Therefore, the burden will be on DOE/KH to assess where the cleanup confirmation of the accelerated remedial actions do not meet the more stringent requirements of the final RI/FS and CRA. Additional confirmation sampling may be required in these cases.

3.4 Sample Collection, Analysis, and Data Compilation

The sample collection and analysis for cleanup confirmation conducted by DOE/KH are generally the same as that for site characterization (see Section 2.7). Following accelerated remedial actions, IHSS/PAC closeouts, and/or NFAA designation of all potential release sites, a database containing soil sample data is expected to be available for use in evaluating the post-accelerated remedial action condition of the RFETS BZ. The relevant data for this purpose will likely include: (1) Existing Data consisting of pre-accelerated remedial action historical data not affected by the accelerated remedial actions, (2) BZSAP-generated characterization data not affected by the accelerated remedial actions, (3) BZSAP-generated confirmation data, (4) characterization/confirmation data collected concurrently by EPA or CDPHE, and (5) data from other studies. These data will be used to characterize the nature and extent of contamination (post-accelerated remedial action) according to the CERCLA process, i.e., to develop a BZ RI/FS, CRA, and ROD (as described in Section 2.1).

It is important that the BZ soils database be comprehensive with regard to the above sources. Furthermore, the database must provide all relevant information, including the type of sample (discrete or composite), sampling depth, and analytical method (in-situ, field laboratory, or standard method). The method of compilation of the various sample supports for cleanup confirmation will likely need to be detailed in the RI/FS and CRA.

As discussed previously, at IHSSs/PACs where an accelerated remedial action (soil removal) has been implemented, DOE/KH have collected and analyzed confirmation samples to evaluate the effectiveness of the remedial action in reducing COC concentrations to levels below the RSALs. When the characterization sampling point has been removed or disturbed during the remedial action, DOE/KH have indicated that the confirmation data replacing the original characterization data will be "flagged" accordingly in the database. In addition, DOE/KH have indicated that the confirmation data are required to pass the same Data Quality Filter applied to the site characterization data before it can be used to confirm cleanup.

DOE/KH is anticipating that the accelerated remedial action data (both site characterization and cleanup confirmation) will meet the QAPP/DQO requirements that will be established for the RI/FS and CRA. However, these requirements may not be identical to those established in the BZSAP and Addenda because, whereas the BZSAP-related requirements are specific to accelerated remedial actions at individual IHSSs/PACs, the RI/FS and CRA-related requirements will need to address the BZ as OUs and/or Exposure Units (EUs). It is important that the possibly more stringent QAPP/DQO requirements be fully discussed and evaluated in the RI/FS and CRA, so that if any data gaps are identified, such as insufficient characterization of White Space Areas or inadequate data quality, such gaps have the opportunity to be filled via additional data collection before the ROD is approved or EPA certifies that the BZ is ready for use as the Refuge.

3.5 Statistical Analysis

Generally, DOE/KH have not conducted statistical analysis to confirm accelerated remedial action cleanups. This is because the approaches taken at most of the IHSSs/PACs require that all soil sampling data be below the RSALs (see approaches 1, 2, and 3 in Section 3.2). In such cases, statistical analysis for cleanup confirmation is not required. The only exception appears to be the Outer Lip Area and vicinity at BZ Group 900-11 (approach 4 in Section 3.2). A statistical approach was deemed necessary in this area because cleanup confirmation data may be allowed to vary, with radionuclide concentrations exceeding the RSALs for some samples but with the overall site mean concentrations being below the RSALs at a 95% confidence level. Conceptually, this statistical approach is comparable to that applied at other CERCLA sites. The statistical approach apparently conducted by DOE/KH (based on the

BZSAP) is referred to as an Elevated Measurement Comparison (EMC) [4]. The EMC is similar to the SOR calculation (see Section 2.4) in that it incorporates a summation of the radionuclides. Thus, an EMC ≥ 1 would prompt further remedial action. The two most important factors in the EMC calculation are the 95% UCL of the mean concentration and a radionuclide-specific area weighting factor (AF), both of which are discussed further below.

The BZSAP specifies that the 95% UCL values to be used in the EMC calculation (one for each radionuclide) be calculated using only those data that are less than the RSALs. DOE/KH states that this is necessary in order to ensure that the UCL complies with normality assumptions. The normality assumption means that the distribution of the data is "normal" or approximates a "bell-shaped" or Gaussian curve. Technically, the statistical basis for this type of "censorship" may be suspect unless the sample size (number of samples) is relatively small. Furthermore, such censorship tends to carry a perception that the higher radionuclide data are being ignored and therefore that the calculated EMC may be biased low. Thus, the EMC approach, particularly the method of censorship employed in its calculation, will need to be justified and described in detail in the RI/FS and CRA, if indeed such a calculation is relied upon for cleanup confirmation.

The BZSAP also specifies that the AF (a type of radionuclide-specific and area-based weighting factor) is to be based on exposure pathway models estimated from Residual Radioactivity (RESRAD) computer code simulations consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)[13]. Essentially, as specified in the MARSSIM, the AF is an outside area dose factor. Since the AF is critical to the EMC calculation, it is also advisable that its calculation be comprehensively evaluated in the RI/FS and CRA, again assuming that the EMC statistical calculation is actually used to confirm cleanup. Documentation that the EMC approach was used to confirm the accelerated cleanup in the Outer Lip Area and vicinity was not obtained during this technical evaluation.

3.6 Final Status Survey

DOE is planning to conduct a Final Status Survey of the RFETS, including the BZ. Generally, the Final Status Survey is the internal process that DOE uses to verify the cleanup at any of its radioactive waste sites. According to the Final Status Survey Plan[14], the process will consist of the following three components:

(1) Aerial Scanning – An array of gamma ray radiation detectors mounted on a helicopter, which will be flown on approximately 30-m spaced flight lines at an altitude of approximately 15 m. This configuration is expected to result in a

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[4] $EMC = \sum_{i=1}^{n} UCL_i / RSAL_i + \sum_{i=1}^{n} \sum_{j=1}^{m} (C_j - UCL_i)/(RSAL_i \times AF)$ where UCL_i and $RSAL_i$ are the 95% UCL of the mean concentration and the RSAL, respectively, for radionuclide i of n measured radionuclides, C_j is the concentration for j of m measurements exceeding the RSAL, and AF is a radionuclide-specific area factor.

field of view or "footprint" of approximately 729 m^2 with an overlap of 10-20%. This approach is designed to identify relatively large areas of surface soil contamination (to very shallow depths). Any potentially contaminated areas (estimated to be above the RSALs) will be confirmed using targeted ground-based scanning (see 2 below) to characterize the extent of contamination and, if necessary, further remediated.

(2) Targeted Ground-based Scanning – Use of the HPGe instrument in in-situ mode at locations adjacent to previously remediated areas or areas identified from aerial scanning (see 1 above). This approach is designed to identify and/or characterize smaller local areas of surface soil contamination (again, to very shallow depths). Any potentially contaminated areas (estimated to be above the RSALs) may be confirmed by discrete sampling to further characterize the extent of contamination and, if necessary, further remediated.

(3) Statistical Sampling – To verify that existing sampling data remain representative of current site conditions, i.e., that the concentrations in surface soils have not changed significantly since they were last sampled. This will be conducted by randomly selecting a subset of the existing soil sampling locations from four different sub-populations of the database: (1) Industrial Area (IA), (2) anticipated DOE retained lands outside of the IA, (3) samples collected during the period 1991 – 1995, i.e., pre-accelerated remedial action, and (4) samples collected during the period 1996 – 2005, i.e., concurrent with accelerated remedial action. Actual field sampling is then conducted at the statistically-selected locations and the samples analyzed by standard laboratory methods. The basic idea is that given no significant change in surface soil conditions, no statistically discernible difference will be observed between the means of these four groups. However, if the means do exhibit a statistically discernible difference, or if any of the individual samples exceed the RSALs, further characterization and possibly additional remedial action will be conducted.

The purpose of the Final Status Survey is to demonstrate that the radionuclide cleanup effort at the RFETS was completed successfully according to the RFCA. DOE also will conduct an independent assessment or verification of the Final Status Survey, which will be conducted by the Oak Ridge Institute for Science and Education (ORISE). The ORISE verification approach will consist of document reviews, confirmatory sampling and analysis, and verification of field surveys. Guidelines for performing or verifying the Final Status Survey are provided in the MARSSIM, which was prepared cooperatively by the Department of Defense (DOD), DOE, EPA, and the Nuclear Regulatory Commission (NRC).

Neither the Final Status Survey itself nor the ORISE verification of the Final Status Survey are specifically required under CERCLA. This means, on the one hand, that the results and data obtained from the Final Status Survey are not required to complete the final RI/FS and CRA. However, the results and data generated from the

Final Status Survey may be used in the RI/FS and CRA, provided that they meet the prescribed DQOs. The issue of using the HPGe data (either in in-situ mode or field laboratory mode) has been raised previously. Currently, DOE/KH have not satisfactorily addressed how or whether the aerial scanning data might be used in the final RI/FS and CRA. DOE/KH have stated, and it seems clear that this is their intent, that the purpose of the Final Status Survey is to provide an additional method of assessing cleanup, aside from the CERCLA-based RI/FS and CRA requirement. Nevertheless, the results and data generated from the Final Status Survey and its verification should be included in the BZ soils database and therefore will likely be available for use in preparation of the final RI/FS and CRA to the extent they are deemed usable.

Various reviews of the DOE/KH Final Status Survey Plan have raised concerns regarding the degree to which the Plan follows the MARSSIM guidelines. Two such concerns are: (1) whether the statistical sampling/comparison should address the entire RFETS (the DOE/KH plan) or whether it should target only locations where contamination changes might be expected since completion of accelerated remedial action and (2) whether independent verification sampling should target only the IA and Inner BZ (the DOE/KH/ORISE plan) or whether it should also include the Outer BZ. On the one hand, since the Final Status Survey is not intended to replace the RI/FS/CRA under CERCLA, such concerns are really an internal DOE issue. On the other hand, the protocols established in the MARSSIM are generally consistent with those required under CERCLA, so that if DOE/KH does intend to use the results and data generated in the Final Status Survey to support the RI/FS and CRA, then it would seem appropriate to follow the MARSSIM guidelines as closely as possible. With regard to the two stated concerns, DOE/KH needs to clarify their reasons for selecting one approach over the other.

One technical issue that has been raised concerns the conversion of radioactivity measured via the aerial survey from an area basis to a mass basis (i.e., pCi/m^2 to pCi/g). It seems clear that such conversion in the case of the aerial survey will not be based on actual calibration or verification sample analyses but rather will be based on theoretical mathematical models. This will likely add an additional level of uncertainty that will need to be fully addressed in the RI/FS and CRA, if the data are indeed used to support these documents.

Another related technical issue concerns the correspondence between the aerial survey measurement or "penetration" depth versus the RSAL-based definition for surface soils (0 – 0.5 ft for U radionuclides and 0 – 3 ft for Pu and Am radionuclides). It seems clear that the penetration depth will be far less than 3 ft. Simply stated, this means that the aerial survey data will not be usable for assessing whether significant contamination exists or the accelerated remedial actions have been completed satisfactorily below a few inches of the surface. In the IA and Inner BZ, where the majority of the remedial actions have occurred, the aerial survey data will only be able to assess whether relatively large areas of surface soil contamination remain which would require further remedial action. In the Outer BZ, however, the aerial survey data could be more useful in a comprehensive sense, if it can be assumed (as DOE/KH and the regulators do) that subsurface contamination in the Outer BZ White Space Areas is restricted to relatively shallow depths (due to the windblown source). However, the size of surface hot spot detectable in the Outer BZ by the aerial survey would of course also be relatively large (small hot spots would not be detectable unless the concentrations are very high). Nevertheless, this is consistent with the sampling conducted to support the CRA in the Outer BZ, which is also limited to detection of relatively large hot spots.

Ultimately, the area of land that will become the Refuge will contain a large amount of data (site characterization and cleanup confirmation) representing a variety of sample supports. A primary task of DOE/KH will be to compile these data for purposes of the final RI/FS and CRA in a comprehensive and technically-defensible manner in order to estimate a reasonable maximum exposure level (typically the 95% UCL of the mean) for radionuclides in surface and subsurface soils that Refuge workers and visitors will or may be exposed to, regardless of the RSALs currently established and the actual accelerated remedial actions conducted. Apparently, DOE/KH is anticipating that for the land that will become the Refuge the reasonable maximum exposure level for $^{239/240}Pu$ (i.e., post-accelerated remedial action conditions) will actually be estimated to be less than 7 pCi/g in surface soils. This value is of course well below the 50 pCi/g RSAL, which could by default enable DOE/KH to state that the surface soils in the Refuge meet the RSAL, though no research for this report has produced documentation for this claim. Currently, it is unknown whether such a condition would enable the EPA to declare the BZ ready for its intended use as the Refuge.

Section 4
Conclusion and Recommendations

This report provided an independent review and technical evaluation of the soil sampling protocols for site characterization and cleanup confirmation at the RFETS BZ. The report is based entirely on information, documents, and plans available to the principal investigator from public archives.

This independent review and technical evaluation resulted in certain comments pertaining to regulatory and technical issues perceived by and representative of the opinion of the principal investigator. Many of the comments concerned current deficiencies that will likely need to be addressed more fully in the RI/FS, CRA, or SCP to be completed by DOE/KH. Other comments concerned unstated or unclear reasoning regarding DOE/KH sampling and analytical protocols, which also will likely need to be addressed more fully in the RI/FS, CRA, or SCP. It is the recommendation of the principal investigator that these comments be used by the public and others concerned with evaluating the site characterization and cleanup confirmation conducted by DOE/KH in the portion of the BZ that will eventually become the Refuge.

Based on this independent review and technical evaluation, and the comments contained within this report, the following is a list of items or issues that warrant inclusion and detailed evaluation in the RI/FS, CRA, or SCP:

(1) Post-closure institutional controls and long-term monitoring plans, including the notifications and actions required for future releases of contamination into the Refuge and existing contamination that may be identified within the Refuge in the future as the result of routine Refuge operation. (See Sections 2.1 and 2.2).

(2) Reevaluation of all accelerated remedial actions and comprehensive evaluation of all IHSSs/PACs and White Space Areas in the BZ, regardless of whether they have undergone accelerated remedial action and regardless of their NFA/NFAA designation. (See Section 2.3).

(3) Description and evaluation of how data obtained using a variety of sample collection methods and sample supports were compiled for site characterization and cleanup confirmation purposes. (See Section 2.4).

(4) Documentation of the expected size of hot spots based on historical information versus the actual size of hot spots based on site characterization results. (See Section 2.6.2).

(5) Discussion and definition of the difference in sampling depths relative to the RSALs and the subsurface remedial criteria, especially in terms of data compilation and accelerated remedial action. (See Section 2.7).

(6) Provision and evaluation of the necessary calibration and verification data with which to assess the HPGe method relative to the established DQOs. (See Sections 2.7 and 3.2).

(7) Review and discussion of the sampling approaches employed for cleanup confirmation, including detailed description of the sampling data and evaluation of the uncertainty of the confirmation data. (See Section 3.2).

(8) Description and evaluation of how the field analytical HPGe data were adjusted to account for measured bias in the method. (See Section 3.3).

(9) Assessment of the differences, if any, in data quality requirements (DQOs) for the accelerated remedial actions versus those required to support the RI/FS and CRA. (See Section 3.4).

(10) Justification for the EMC approach, especially with regard to the method of censorship employed in its calculation, and provision and evaluation of the AF in the EMC calculation. (See Section 3.5).

(11) Justification and evaluation of the usability of the data generated from the Final Status Survey for purposes of the RI/FS and CRA. (See Section 3.6).

(12) Clarification of the reasons for modification of the MARSSIM guidelines with respect to the statistical sampling comparison and the verification sampling. (See Section 3.6).

(13) Discussion and evaluation of the mathematical model used to convert aerial survey measurements from a per area to a per mass basis. (See Section 3.6).

(14) Clarification and justification for calculating the post-closure reasonable maximum exposure level for $^{239/240}Pu$, including the basis for the currently anticipated (by DOE/KH) level of 7 pCi/g in surface soils in the BZ/Refuge. (See Section 3.6).

Section 5
References

References for this technical evaluation were obtained from document archives available to the public. Unless indicated otherwise, documents were reviewed at the Rocky Flats Reading Room of Front Range Community College, Westminster, Colorado. Documents in electronic format were obtained primarily from the DOE Environmental Data Dynamic Information Exchange (EDDIE) and are provided on the enclosed disk (**Appendix A**). Available electronic files are indicated in brackets, i.e., [*filename.zip*], following the reference.

[1] Site Background

DOE (2003) paper authored by P. Buffer, “Beyond the Buildings at a place called Rocky Flats, A timeline of more than 50 years of Rocky Flats history.”

DOE (1998) aerial photograph of the RFETS showing the Industrial Area and the surrounding Buffer Zone.

DOE (1998) aerial photograph of Rocky Flats enhanced to show the 2006 conceptual vision of the RFETS following site cleanup.

DOE/KH (undated) fact sheet summarizing the activities being conducted to clean up and close the RFETS.

DOE/KH (undated) diagram showing timelines of pertinent cleanup and transition activities beginning in 1995.

DOE (2004) Fact Sheet addressing issues related to the Rocky Flats Cleanup.

[*RFETS.zip*]

[2] Rocky Flats Cleanup Agreement

DOE, EPA, and CDPHE (1996) Final Rocky Flats Cleanup Agreement.

DOE, EPA, and CDPHE (2003) Approved Final Modifications to Rocky Flats Cleanup Agreement Attachments.

DOE (1998) strategic plan for achieving accelerated cleanup while meeting the requirements of the RFCA.

[*RFCA.zip*]

[3] Comprehensive Conservation Plan/Environmental Impact Statement

FWS (2005) Final Comprehensive Conservation Plan/Environmental Impact

Statement (CCP/EIS) for the Refuge.

[*CCPEIS.zip*]

[4] Historical Release Report

DOE (1992) Rocky Flats Historical Release Report. Not available electronically. The report, which includes annual updates, is a detailed compilation of historical site information and historical data.

[5] Characterization Data Summary Reports

DOE (2002) Characterization Data Summary Report – IHSS Group 900-2.

DOE (2003) Characterization Data Summary Report – IHSS Group NE/NW.

[*CDSR.zip*]

[6] Environmental Restoration Standard Operating Protocols

DOE (2001) Draft Environmental Restoration RFCA Standard Operating Protocol for Routine Soil Remediation.

DOE (2002) Environmental Restoration Standard Operating Protocol for Routine Soil Remediation Notification 03-01. Protocols for the accelerated remedial actions at BZ Group NE-2, IHSS/PAC 111.4.

DOE (2002) Environmental Restoration Standard Operating Protocol for Routine Soil Remediation Notification 03-02. Protocols for the accelerated remedial actions at BZ Group SW-1, IHSS/PAC 133.1, 133.2, 133.4, and SW-1702.

DOE (2003) Environmental Restoration Standard Operating Protocol for Routine Soil Remediation Notification 03-07. Protocols for the accelerated remedial actions at BZ Group 900-11, IHSS/PAC 155.

DOE (2003) Environmental Restoration Standard Operating Protocol for Routine Soil Remediation Notification 03-09. Protocols for the accelerated remedial actions at BZ Group SW-1, IHSS/PAC 133.5.

DOE (2004) Environmental Restoration Standard Operating Protocol for Routine Soil Remediation Notification 04-11. Protocols for the accelerated remedial actions at BZ Group NE-1, IHSSs/PACs 142.5, 142.6 and 142.7.

DOE (2004) Interim Measure/Interim Remedial Action for Group 900-11, IHSS/PAC 903 – Lip Area and Vicinity, the Windblown Area, and Surface Soil in Operable Unit 1 (881 Hillside).

[*ERRSOP.zip*]

[7] Interim Measure/Interim Remedial Action

DOE (2004) Interim Measure/Interim Remedial Action for IHSS Group 900-11 (903 Lip Area and Vicinity, the Windblown Area, and Surface Soil in Operable Unit 1 [881 Hillside]).

[*IMIRA.zip*]

[8] Closeout Reports

DOE (2003) Closeout Report – IHSS Group SW-1.

DOE (2005) Closeout Report – IHSS Group 900-11 – IHSS 900-155, 903 Lip Area; IHSS 900-140, Hazardous Disposal Area. Not available electronically.

[*CR.zip*]

[9] Buffer Zone Sampling and Analysis Plans

DOE (2001) Draft Buffer Zone Sampling and Analysis Plan (BZSAP).

DOE (2001) Draft Buffer Zone Data Summary Report. Summarizes the historical (pre-characterization) sample/analytical data available in the Buffer Zone. Not available electronically.

DOE (2002) Final Buffer Zone Sampling and Analysis Plan. Not available electronically.

DOE (2002) Buffer Zone Sampling and Analysis Plan Addendum BZ-02. Specifies characterization and confirmation sampling actions for BZ Group 900-2, IHSSs/PACs 153 and 154, and BZ Group NE/NW, IHSSs/PACs 216.2, 216.3, NE-1412, NE-1413, NE-1407 and 174a.

DOE (2003) Buffer Zone Sampling and Analysis Plan Addendum BZ-04-02. Specifies characterization and confirmation sampling actions for BZ Group 900-12, IHSSs/PACs NE-111.3, 111.5, 111.6a and 111.6b.

DOE (2004) Buffer Zone Sampling and Analysis Plan Addendum BZ-04-01. Specifies characterization and confirmation sampling actions for BZ Group 900-11, IHSS/PAC 155.

DOE (2004) Buffer Zone Sampling and Analysis Plan Addendum BZ-04-11. Specifies characterization and confirmation sampling actions for BZ Group 900-11, IHSS/PAC SE-1602.

[*BZSAP.zip*]

[10] Comprehensive Risk Assessment

DOE (2004) Comprehensive Risk Assessment Sampling and Analysis Plan. Not available electronically.

[11] Buffer Zone Data Summary Report

DOE (2001) Draft Buffer Zone Data Summary Report, Rocky Flats Environmental Technology Site, Golden, Colorado. Not available electronically.

[12] Actinide Migration Studies

AME (2002) Pathway Analysis Report.

[*AME.zip*]

[13] MARSSIM

EPA, DOE, DOD and NRC (2000) Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

[*MARSSIM.zip*]

[14] Final Status Survey

DOE (2005) Final Survey Plan for Rocky Flats Sitewide Surface Radiological Characterization.

ORISE (2005) Project-Specific Plan for the Independent Verification of Soils in the Buffer Zone and Industrial Area, Rocky Flats Environmental Technology Site.

[*FSS.zip*]