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Draft Buffer Zone Sampling and Analysis Plan



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EXECUTIVE SUMMARY

The Buffer Zone (BZ) Sampling and Analysis Plan (SAP) (BZSAP) describes surface and subsurface soil characterization and remediation confirmation sampling activities for Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), and Under Building Contamination (UBC) Sites, if encountered, at the Rocky Flats Environmental Technology Site (RFETS). It is the Rocky Flats Cleanup Agreement (RFCA) decision document for accelerated action sampling in the BZ.

The objective of the BZSAP is to establish a sampling strategy that includes sampling, data analysis, and analytical methods, and accelerates laboratory and data analysis schedules.

The BZSAP incorporates sampling and analysis methods with a data management approach that enables (1) determination of new sampling locations, (2) generation of near real-time analytical results, (3) verification and validation of field and analytical data, (4) evaluation of analytical results, and (5) integration of analytical results with Geographic Information System (GIS) technology to produce representations of action level (AL) exceedances, hot spots, potential remediation targets, and post-remedial sampling locations.

Methods for determining statistical, geostatistical, and biased characterization and post-remediation sampling location techniques are described. Use of field instrumentation, including high purity germanium detectors and field x-ray diffraction, along with onsite or offsite analytical laboratory support, will result in high quality, near real-time analytical results. These data will be immediately verified and validated so that data analysis and data interpretation will occur within a few days. Data analysis methods, used in accordance with project data quality objectives, provide a consistent and reproducible method for determining AL exceedances and hot spots.

Routine surface and subsurface soil sampling methods are also described. In addition, supporting information, such as data management, health and safety, and quality assurance (QA) requirements are included. Several appendices provide additional analytical and QA information, as well as a summary of existing historical and analytical data at IHSSs and PACs.

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VOLUME 2 – BUFFER ZONE SAMPLING AND ANALYSIS PLAN ADDENDA

ACRONYMS

AOC	Area of Concern
AHA	Activity Hazards Analysis
AL	action level
ALF	Action Levels and Standards Framework for Surface Water, Ground Water, and Soils
AME	Actinide Migration Evaluation
ANOVA	Analysis of Variance
AR	Administrative Record
ASD	Analytical Services Division
AST	Analytical Services Toolkit
bgs	below ground surface
BZ	Buffer Zone
BZSAP	Buffer Zone Sampling and Analysis Plan
CA	contamination area
CAD/ROD	Corrective Action Decision/Record of Decision
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
cm/sec	centimeters per second
COC	contaminant of concern
CPB	Closure Project Baseline
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQO	data quality objective
EDD	Electronic Data Deliverable
EDDIE	Environmental Data Dynamic Information Exchange
EMC	Elevated Measurement Comparison
EMWD	environmental-measurement-while-drilling
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ERA	Ecological Risk Assessment
EU	exposure unit
EZ	exclusion zone
FID	flame ionization detector
FIDLER	Field Instrument for the Detection of Low Energy Radiation
ft	foot
ft ²	square foot

ACRONYMS (continued)

FY	fiscal year
GC/MS	gas chromatography/mass spectrometry
GIS	Geographic Information System
GPR	ground-penetrating radar
GPS	Global Positioning System
GRS	gamma ray spectrometer
Ha	alternative hypothesis
Ho	null hypothesis
H&S	health and safety
HASP	Health and Safety Plan
HDD	horizontal directional drilling
HPGe	high purity germanium
HRR	Historical Release Report
IA	Industrial Area
IASAP	Industrial Area Sampling and Analysis Plan
ICP	inductively coupled plasma
IDW	inverse distance weighting
IGD	Implementation Guidance Document
IHSS	Individual Hazardous Substance Site
IMP	Integrated Monitoring Plan
ISEDS	Integrated Sitewide Environmental Data System
IWCP	Integrated Work Control Program
K-H	Kaiser-Hill Company, L.L.C.
LCS	laboratory control sample
LHSU	lower hydrostratigraphic unit
LIBS	laser-induced breakdown spectroscopy
LRA	Lead Regulatory Agency
m	meter
m ²	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDL	method detection limit
MS	matrix spike
MSD	matrix-spike duplicate
NFA	no further action
NLR	no longer representative
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAC	Potential Area of Concern
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
PCOC	potential contaminant of concern
PDF	portable document format

ACRONYMS (continued)

PE	performance evaluation
PID	photoionization detector
PMJM	Preble's meadow jumping mouse
PPE	personal protective equipment
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
R ²	correlation coefficient
RADMS	Remedial Action Decision Management System
RBA	radiological buffer area
RCRA	Resource Conservation and Recovery Act
RESRAD	Residual Radioactivity Computer Code
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RIN	report identification number
RSOP	RFCA Standard Operating Protocol
RSP	Radiological Safety Procedure
RWP	Radiological Work Permit
SAP	Sampling and Analysis Plan
SED	Ecology Database
SEP	Solar Evaporation Ponds
SID	South Interceptor Ditch
Site	Rocky Flats Environmental Technology Site
SME	subject matter expert
SNL	Sandia National Laboratory
SOP	Standard Operating Procedure
SVOC	semivolatile organic compound
SWD	Soil Water Database
UBC	Under Building Contamination
UCL	upper confidence limit
UHSU	upper hydrostratigraphic unit
VOC	volatile organic compound
WEMS	Waste and Environmental Management System
XRF	x-ray fluorescence

1.0 INTRODUCTION

The Buffer Zone (BZ) Sampling and Analysis Plan (SAP) (BZSAP) describes in-process surface and subsurface soil characterization and remediation confirmation sampling and analysis activities for potential contaminant release sites within the Rocky Flats Environmental Technology Site (RFETS or Site) BZ. Numerous Operable Units (OUs) are located within the RFETS BZ including OU 1 881 Hillside Area, OU 5 Woman Creek Priority Drainage, OU 6 Walnut Creek Priority Drainage, OU 7 Present Landfill, OU 11 West Spray Fields, and the BZ Operable Unit. The RFETS BZ contains 66 Individual Hazardous Substance Sites (IHSSs) (all located within the six previously referenced OUs), 29 Potential Areas of Concern (PACs), as well as White Space Areas (areas existing outside current IHSS and PAC boundaries). The Colorado Department of Public Health and Environment (CDPHE) and U.S. Environmental Protection Agency (EPA) have accepted twenty-one of these IHSSs and fifteen of these PACs as requiring no further action (NFA). Fifty-nine (59) of the IHSSs and PACs, as well as new sites that may be identified during closure activities, remain to be dispositioned. Currently, no under-building contamination (UBC) sites have been identified within the RFETS BZ. However, the BZSAP includes UBC scope in the event that sites with UBC are identified in the future.

The BZSAP is the decision document used to guide sampling in the RFETS BZ and streamline the decision process by providing one document for routine soil sampling and analysis activities throughout the BZ. Annual Addenda will supplement the BZSAP, but may be prepared more frequently if circumstances present additional characterization opportunities.

The BZSAP includes innovative sampling, analysis, data evaluation, and data management methods. A key component of the BZSAP is the “in-process” sampling approach that will accelerate characterization and remediation schedules. The in-process approach combines statistical methodologies with field analytical instruments and provides a way to determine, in the field, where and at what levels contamination is present. This results in being able to accomplish the following:

- Define contamination within an IHSS and PAC (or UBC site, if encountered);
- Determine the spatial boundaries of the Area of Concern (AOC) which is defined as the area where an action may be required. The AOC is the area that is evaluated for action through characterization and data aggregation;
- Determine areas that exceed Rocky Flats Cleanup Agreement (RFCA) Action Levels and Standards Framework for Surface Water, Ground Water, and Soil (ALF) action levels (ALs);
- Determine the extent of hot spots; and
- Determine when cleanup objectives are achieved.

The "in-process" sampling approach combines a statistical approach to determine characterization and remediation confirmation sampling locations with the use of field analytical equipment. As samples are taken, they are analyzed with field instrumentation, and a remedial decision is made. If remediation is necessary, soil is excavated. Samples of the remaining soil are taken and analyzed with field instrumentation. Excavation and confirmation sampling continue until remedial objectives are met.

While standard statistical methods will be used to determine sampling locations at many IHSSs and PACs, a geostatistical tool will also be used as appropriate to determine sample locations. Statistical methods incorporate a hot spot identification and analysis methodology, and post-remediation confirmation sampling location methodology based on the size of the remediated area.

Data management methods will ensure that quality data are available to project personnel on an almost real-time basis, while also ensuring that Site data management protocols and requirements are met.

1.1 REGULATORY FRAMEWORK

RFCA, signed by the U.S. Department of Energy (DOE), CDPHE, and EPA (the RFCA Parties), on July 19, 1996, provides the regulatory framework for the cleanup of RFETS (DOE 1996). RFCA streamlines remediation of the Site through accelerated actions that include characterization, remediation, and closure of IHSSs and PACs in the RFETS BZ.

RFCA provides the regulatory framework for DOE response obligations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and corrective action obligations under the Resource Conservation and Recovery Act (RCRA). The RFCA accelerated action process incorporates the requirements of both CERCLA and RCRA characterization, remediation, and closure. The accelerated action process includes development of a SAP, characterization, remediation (if necessary), and development of a Closeout Report. This process also serves to provide the documentation for the closure of IHSSs and PACs in the BZ that are also RCRA units.

Environmental Restoration (ER) will accelerate all BZ remedial activities to meet the Site goal of 2006 closure. To streamline schedules, using the in-process approach and by reducing document preparation and review cycles, the BZSAP combines the sampling and analysis requirements for the entire RFETS BZ into one document. After accelerated actions are complete, DOE will develop a RCRA Facility Investigation/Remedial Investigation (RFI/RI) to describe the accelerated actions and a Comprehensive Risk Assessment (CRA) to verify that potential contamination remaining at RFETS is within acceptable risk levels as defined by CERCLA and implemented through RFCA. The final Corrective Action Decision/Record of Decision (CAD/ROD) will include, as necessary, post-closure monitoring and operation requirements, including 5-year requirements for Site reviews to evaluate whether the remedies, including any institutional controls, are effective.

1.2 PURPOSE AND OBJECTIVES

The purpose of the BZSAP is to provide sampling and analysis methods and protocols for surface and subsurface soil characterization and post-remediation confirmation sampling and analysis within the RFETS BZ. The BZSAP addresses the following:

1. Characterization sampling for IHSSs and PACs in the RFETS BZ;
2. Post-remediation confirmation sampling at IHSSs and PACs within the RFETS BZ; and
3. Characterization sampling in White Space (areas outside of IHSSs and PACs) in the RFETS BZ for the CRA.

The BZSAP approaches characterization of the RFETS BZ as a single sampling project implemented over the period required to complete remediation of the BZ. It includes grouping of the remaining 59 IHSSs and PACs requiring disposition and is based on similar disposal methods, common contaminants of concern, and mutual proximity.

Table 1 provides a list of IHSS and PACs as BZ Characterization Groups.

Table 1 Buffer Zone Characterization Groups

Group	OU	ID	Description
000-5		NW-1502	Disposal of diesel contaminated material at Landfill (formerly NW-177)
		NW-1503	Disposal of Fuel Contaminated Material at Landfill
		NW-1504	Disposal of Thorosilane Contaminated Material at Landfill
	6	166.1	Landfill Trench A
	6	166.2	Landfill Trench B
	6	166.3	Landfill Trench C
	6	167.2	Landfill Pond Spray Area
	6	167.3	Landfill Pond Spray Area
	7	114	Present Landfill
	900-11		900-1316
		SE-1602	East Firing Range
BZ		109	Ryan's Pit (Trench 2)
BZ		112	903 Pad
BZ		140	Hazardous Disposal Area
BZ		155	903 Lip Area
BZ		183	Gas Detoxification Area
900-12	BZ	108	Trench T-1
	BZ	110	Trench T-3
	BZ	111.2	Trench T-5
	BZ	111.3	Trench T-6
	BZ	111.5	Trench T-8
	BZ	111.6	Trench T-9
	BZ	111.7	Trench T-10

Group	OU	ID	Description	
900-2	BZ	111.8	Trench T-11	
	BZ	153	Oil Burn Pit No. 2	
	BZ	154	Pallet Burn Site	
	BZ	216.2	East Spray Field-Center Area	
	BZ	216.3	East Spray Field-South Area	
NE-1	6	216.1	East Spray Field-North Area	
	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	
			NE-1404	Diesel Spill at Pond B-2 Spillway
	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	
NE/NW		NE-1407	OU2 Treatment Facility	
		NE-1409	Modular Tanks and 910 Treatment Sys Spill (formerly 000-503)	
		NE-1410	Diesel fuel Spill at field Treatability Unit	
		NE-1411	Diesel Fuel Overflowed from Tanker @ OU2	
		NE-1412	Trench T-12 Located @ OU2 East Trenches	
		NE-1413	Trench T-13 Located @ OU2 East Trenches	
		BZ	170	PU&D Storage Yard
SW-1	BZ	174a	PU&D Yard - Drum Storage	
		SW-1701	Recently Identified Ash Pit	
		SW-1702	Recently Identified Ash Pit	
	5	133.1	Ash Pit 1	
	5	133.2	Ash Pit 2	
	5	133.3	Ash Pit 3	
	5	133.4	Ash Pit 4	
	5	133.5	Incinerator	
	5	133.6	Concrete Wash Pad	

In addition to enhancing efficiency of the characterization and remediation effort, grouping acknowledges that IHSS designations represent the characterization starting points but do not necessarily represent the actual boundaries of areas of contamination. By removing the constraint of the IHSS boundary, it enables characterization and

remediation to proceed unencumbered by issues such as overlapping IHSSs and contaminant depth. Specific objectives of the BZSAP include the following:

- Optimize resources by conducting sampling programs that support all appropriate decisions, including whether remediation is required, remedial objectives have been achieved, or a NFA recommendation can be justified;
- Define data quality objectives (DQOs) for characterization, post-remediation confirmation sampling, and document the decisions and uses for which data are needed;
- Define a sampling strategy that supports DQO criteria for characterization, post-remediation confirmation sampling, and CRA sampling and analysis requirements so that each area will only be sampled once for characterization, as needed for in-process characterization, and once for post-remediation confirmation;
- Define sampling, data analysis and analytical methods;
- Ensure data are of the appropriate quality to support remedial decisions and CRA requirements;
- Define a sampling strategy that accelerates laboratory and data analysis schedules; and
- Define a sampling strategy for IHSSs and PACs coordinated with the Decommissioning schedule.

The BZSAP will be the current and complete decision document guiding characterization, confirmation sampling, and sampling for the CRA. Modifications to sampling methodologies, DQOs, and other elements that effect sampling strategies will be proposed to CDPHE and EPA for their approval. Modifications to the initial BZSAP will be designated sequentially beginning with "Modification 1" and will be documented in Appendix A.

The BZSAP is designed to promote maximum sampling efficiency and quality at all suspected contaminant release sites, some of which have little or no starting-point data. Guided by the DQOs (Section 3), and the data acquisition and analysis process (Section 5), the sampling approach will adapt to changing conditions as new information is acquired. The anticipated frequent adjustments to the sampling approach will be implemented using the field modification process described in RFCA (§ 130) (DOE 1996). Points of contact for implementing the field modification process will be the Lead Regulatory Agency (LRA) Project Manager and the DOE Contractor Project Manager assigned to the sampling project.

1.3 BZSAP ADDENDUM

While the BZSAP approaches characterization of the RFETS BZ as a single project, all IHSSs and PACs must be administratively dispositioned to achieve Site closure. The

BZSAP Addendum enables the BZSAP to accommodate this obligation over the period required to complete remediation of the BZ. The Addendum identifies the specific sites that will be characterized during a given interval such as a fiscal year (FY) and serves as the beginning reference point to track all IHSSs and PACs from characterization through remediation and ultimately to Site closure.

Addenda will be developed prior to the beginning of each FY and may be prepared more frequently if additional remediation opportunities arise. The Addendum scope will include:

- Project organization;
- BZ Group-specific potential contaminants of concern (PCOCs);
- BZ Group-specific maps showing existing qualified data points (DOE 2001a);
- Starting-point sampling locations based on approved BZSAP methodologies; and
- Sampling methodology for each IHSS or PAC.

CDPHE and EPA will have 14 calendar days for review and approval of the Addendum. The regulatory agencies can approve all or part of the Addendum. This will allow work to continue if specific issues require resolution. No response from the regulatory agencies during the 14-day period implies approval. Appendix B provides an example of the BZSAP Addendum format. Volume 2 of the BZSAP will contain the addenda. Table 2 lists the planned FY when each BZ Group Addendum will be prepared based on the current Closure Project Baseline (CPB). Changes to the baseline schedule or circumstances that provide accelerated characterization opportunities will result in changes to the schedule.

**Table 2
Buffer Zone - Addendum Preparation Schedule**

FY01		FY04	
BZ Group	Description	BZ Group	Description
900-2	Oil Burn Pit, Pallet Burn Pit, East Spray Fields – North, -Center, -South	900-12	Trench 5,6,8,9,10
NE/NW	Trenches T-12 and T-13	NE-1	Ponds B-1, B-2, B-3
SW-1	Incinerator, Concrete Wash Pad		
FY02		FY05	
BZ Group	Description	BZ Group	Description
900-11	903 Pad, 903 Lip Area, Hazardous Waste Disposal Area, East Firing Range and Target Area		To Be Determined
NE-2	Trench T-7		
FY03		FY06	
BZ Group	Description	BZ Group	Description
	To Be Determined		To Be Determined, if required

Table 2 presents descriptions of IHSS and PACs baselined for characterization activities. Table 1 provides a complete list of IHSS and PACs not accepted as NFA (potential requiring characterization) as of the 2000 Annual Update to the Historical Release Report (DOE 2000a).

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2.0 SITE DESCRIPTION

2.1 PHYSICAL SETTING

RFETS is located approximately 16 miles northwest of Denver, Colorado, in northern Jefferson County. The site occupies approximately 10 square miles. Boundaries and major features are illustrated on Figure 1. Most of the buildings are located within an industrial complex of approximately 350 acres (the IA) surrounded by a BZ of approximately 6,150 acres. RFETS is a government-owned, contractor-operated facility that has been in operation since 1952.

The BZ surrounds the IA where the bulk of RFETS mission activities took place between 1951 and 1989 (DOE 1996). Most of the buildings and associated structures were used for historic processing activities associated with weapons production.

Materials defined as hazardous substances by CERCLA, and materials defined as hazardous constituents by RCRA and/or the Colorado Hazardous Waste Act (CHWA) may have been released to the environment at various locations at RFETS. In the BZ, releases were identified at 96 IHSSs and PACs as illustrated on Figure 1. Of these 96 IHSS and PACs, 36 have been approved for no further action. Fifty-nine IHSS and PACs in the Buffer Zone have not been approved as NFAs and may require additional characterization under this SAP.

2.2 CONCEPTUAL MODEL

2.2.1 Geology and Hydrogeology

In the pediment area of the BZ, relatively flat-lying Quaternary surficial deposits overlie Cretaceous bedrock. The surficial deposits consist primarily of the Rocky Flats Alluvium and artificial fill materials (EG&G 1992). The alluvium ranges from over 100 feet thick at the western edge of the BZ (OU11) to 10 feet thick at the eastern edge of the IA. The Rocky Flats Alluvium is truncated by erosion immediately east of the IA. The Rocky Flats Alluvium consists of unconsolidated, poorly sorted coarse gravels, coarse sands, and gravelly clays with discontinuous lenses of clay, silt, and sand.

The alluvium unconformably overlies weathered claystone bedrock consisting of the Upper Cretaceous Arapahoe and Laramie Formations. The Arapahoe Formation is less than 50 feet thick in the central portion of the BZ and consists of siltstones and claystones with sandstone lenses. In some areas, such as near the Solar Evaporation Ponds (SEP), well sorted and coarser grained sandstone is present. This sandstone may provide a preferential pathway; however, it is interrupted by erosion and does not provide an offsite pathway for groundwater and contaminant migration. The Laramie Formation unconformably underlies the Arapahoe Formation. Beneath the BZ, the Laramie Formation is 600 to 800 feet thick and consists primarily of claystone with siltstone; fine-grained sandstone and coal lenses are also present (EG&G 1995a).

2.2.2 Surface Water Hydrology

Three intermittent streams drain RFETS: Rock Creek, Walnut Creek, and Woman Creek. The northwestern corner of RFETS is drained by Rock Creek, which flows northeast

through the BZ to its offsite confluence with Coal Creek. Rock Creek, North and South Walnut Creeks, and an unnamed tributary drain the northern part of the BZ. The confluence of North and South Walnut Creeks is below Ponds A-4 and B-5. The South Interceptor Ditch (SID), located between the BZ and Woman Creek, collects runoff from the southern part of RFETS and ultimately diverts the water to Pond C-2. Water from Pond C-2 is monitored and discharged. Woman Creek is diverted under the SID, flows around Pond C-2, and then flows offsite into the Woman Creek Reservoir.

2.2.3 Hydrogeologic Setting

Two hydrostratigraphic units are present within the BZ: the upper hydrostratigraphic unit (UHSU), and the lower hydrostratigraphic unit (LHSU). The UHSU consists of the unconfined saturated Rocky Flats Alluvium and weathered Arapahoe and Laramie Formation bedrock, including sandstone lenses. This hydrostratigraphic unit contains most of the groundwater impacted by Site activities. The LHSU consists of the unweathered Arapahoe and Laramie Formations. These claystones and silty claystones act as an aquitard, inhibiting downward groundwater movement. The geometric mean of measured hydraulic conductivity values in the Rocky Flats Alluvium is approximately 10^{-4} centimeters per second (cm/sec). The LHSU hydraulic conductivity is generally lower than those of the overlying UHSU because of the higher percentage of fine-grained material (EG&G 1995b).

Groundwater within the UHSU primarily flows from west to east along the bedrock contact with the underlying Arapahoe and Laramie Formation claystones. Groundwater elevations are highest in the spring and early summer when precipitation is highest and evapotranspiration is low. Groundwater elevations decline during the remainder of the year, and some areas of the UHSU in the BZ are seasonally dry. Groundwater from the UHSU discharges at springs and seeps on the hillsides of the BZ at the contact between the alluvium and bedrock, and where sandstone lenses subcrop in drainages (EG&G 1995b).

To the west, where the alluvium is thickest, the average depth to the water table is 70 feet below ground surface. Depth to water generally decreases from west to east as the surficial material thins. Depth to water in the BZ ranges from discharging as springs (Antelope Springs) to greater than 70 feet (OU 11). Engineered structures cause variations in water levels and saturated thickness. The impact of building footing drains, utility corridors, and other structures has not been fully evaluated; however, these structures are believed to impact groundwater flow (EG&G 1995b).

3.0 DATA QUALITY OBJECTIVES

The RFETS quality assurance (QA) staff and risk assessment working group developed preliminary DQOs for the Industrial Area Sampling and Analysis Plan (IASAP)(DOE, 2001b). The working group consisted of DOE, the Kaiser-Hill Company, L.L.C. (K-H) Team, CDPHE, and EPA representatives. These DQOs will also be applied to data collected for decisionmaking purposes within the RFETS BZ. This section details sampling, analytical, and data analysis DQOs for BZ activities. BZ Group-specific DQOs will be presented in the appropriate BZSAP Addenda, if required.

3.1 DATA QUALITY OBJECTIVE PROCESS FOR THE BZSAP

The DQO process is a series of planning steps designed to ensure that the type, quantity, and quality of environmental data used in decisionmaking are appropriate for the intended purpose. EPA has issued guidelines to help data users develop site- and project-specific DQOs (EPA 1994). The DQO process is intended to:

- Clarify the study objective;
- Define the most appropriate types of data to collect;
- Determine the most appropriate conditions under which to collect the data; and
- Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support decisions.

The DQO process specifies project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. The DQO process consists of seven steps. Each step influences choices that will be made later in the process. These steps are as follows:

- Step 1 State the Problem
- Step 2 Identify the Decision
- Step 3 Identify the Inputs to the Decision
- Step 4 Define the Study Boundaries
- Step 5 Develop a Decision Rule
- Step 6 Specify Tolerable Limits on Decision Errors
- Step 7 Optimize the Design

During the first six steps of the DQO process, the planning team develops decision performance criteria (i.e., DQOs) for the data collection design. DQOs for the BZSAP provide key BZ characterization decision rules. All decision rules need to be considered, as appropriate. The final step of the process involves developing the data collection design based on the DQOs. The data collection design is presented in Section 4.0. These DQOs are based on EPA Guidance for the Data Quality Objective Process (EPA 1994). Data developed under these DQOs will be used to:

1. Establish the nature and extent of contamination within IHSS, PACs, UBC Sites (if encountered) and White Space Areas in the BZ, including areas where RFCA ALs are exceeded;
2. Confirm that remediation within IHSSs and PACs was successful;
3. Determine whether selected final remedies are protective, based on the CRA, for post-closure uses; and
4. Support final remedy selection analysis.

The BZSAP DQOs apply to surface and subsurface soil encountered during characterization and post-remediation confirmation sampling. CRA DQOs in the BZSAP are specific to soil sampling; more detailed CRA DQOs are presented in the CRA Methodology (Appendix D).

The BZSAP DQOs complement those used in the RFETS Integrated Monitoring Plan (IMP) (DOE 1999). The IMP and associated DQOs focus on air, surface water, groundwater, and ecology, and will be used to support remediation decisions and the CRA. Project-specific air, surface water, and groundwater performance monitoring data from stations surrounding remediation project locations will be used to identify additional areas that may require evaluation.

3.1.1 Characterization of IHSSs and PACs

The Problem

The nature and extent of contamination must be known with adequate confidence to make remedial decisions. Data of sufficient quality and quantity must be available to conduct an AL comparison, as specified in the RFCA Implementation Guidance Document (IGD), and assess whether an IHSS or PAC requires remediation or management.

Identification of Decisions

The decisions that will be made are as follows:

1. Determine whether the nature and extent of PCOCs in an IHSS or PAC are known with adequate confidence;
2. Characterize an IHSS or PAC to determine whether sampling and analysis results are greater than RFCA Tier I ALs; and
3. Characterize an IHSS or PAC to determine whether sampling and analysis results are greater than RFCA Tier II ALs.

Inputs to the Decisions

Information needed to make the characterization decisions specified above include the following:

1. PCOCs

PCOCs include all analytes detected during previous studies in the BZ and generally include the following analytical suites:

- Target Compound List (Organics)
 - Volatile organic compounds (VOCs)
 - semi-volatile organic compounds (SVOCs)
 - Pesticides

Arochlors (PCBs)
Herbicides

- Target Analyte List
 - Metals
 - Cyanide
- Radionuclides (RFETS-specific)

PCOCs will be evaluated for each BZ Group during preparation of the BZSAP Addenda. At that time, the PCOC list may be expanded or abbreviated depending on site-specific analytical data and process knowledge;

2. Method detection limits (MDLs)

MDLs for BZ PCOCs and analytical methods are presented in Appendix E. Analytical methods are organized in tables by general analytical suite. The tables present the minimum required analytes within each respective suite, as well as the required analytical sensitivity for each analyte. Sensitivities are expressed as MDLs, and are specific to the measurement systems used for BZ sample analysis. The RFCA ALs are the lowest values stipulated in RFCA for any exposure scenario. These conservative values are provided to ensure that method sensitivities, for each and every PCOC, are adequate for making project decisions.

Accuracy and precision tolerances are also provided in each table. Accuracy specifications apply to methods only, whereas precision specifications are presented relative to both laboratory and instrument performance and the overall project, which includes sampling error;

3. Background levels for each inorganic and radionuclide PCOC, included in Appendix F;
4. RFCA Tier I and Tier II ALs for surface and subsurface soil as listed in the ALF (Attachment 5, RFCA). Comparison criteria include the following:
- a) Soil data values for inorganics will be compared to the background mean plus two standard deviations. Soil data values for organics will be compared to detection limits.
 - b) Each soil data value will be compared to the appropriate AL.
 - c) RCFA Tier I exceedance is defined as:
 - Ratio of each soil data value to the Tier I AL is > 1 , or
 - Sum of the ratios for either nonradionuclides or radionuclides is > 1 .
 - d) RCFA Tier II exceedance is defined as:
 - Ratio of each soil data value to the Tier II AL is > 1 , or
 - Sum of the ratios for either nonradionuclides or radionuclides is > 1 .

e) Below Tier II is defined as:

- Ratio of each soil data value to the Tier II AL is < 1 , or
- Sum of the ratios for either nonradionuclides or radionuclides is < 1 .

f) For sites with soil data values exceeding Tier II ALs, the spatial extent of the AOC will be established by delineating PCOC values above the background mean plus two standard deviations for inorganics and radionuclides, and PCOC values above detection limits for organics. PCOC values above Tier I ALs and PCOC values above Tier II ALs will be delineated. There is no lower limit on the size of an AOC; however, no single AOC will exceed 10 acres or an approved exposure unit (EU).

The process for determining the extent of the AOC is shown on Figure 2 and described below:

- Compare data for inorganics and radionuclides to the background mean plus two standard deviations; compare data for organics to detection limits.
 - Establish AOCs based on the spatial distribution of data.
 - Aggregate data over the AOC, according to decision rules.
 - Compare the 95% upper confidence limit (UCL) of the mean for each PCOC to the Tier I and Tier II ALs.
 - When evaluation of a Tier I exceedance indicates an area of very limited extent (i.e., a hot spot), data aggregation may not be appropriate. The methodology for determining potential hot spots is described in Section 4.3.
5. Process knowledge and historical data, including information and data contained in technical memoranda, RFI/RI reports, remedial action reports, IMP reports, the Historical Release Report (HRR) (DOE 1992), and other relevant documents; and
6. Existing and BZSAP-generated characterization data, which meet usability criteria and pass the Data Quality Filter (DOE 2001a) (Figure 3) will be used to assess the variability of PCOC and contaminant of concern (COC) concentrations.

Study Boundaries

Characterization decision boundaries that define when and where data will be collected are listed below.

1. IHSSs and PACs are listed in Table 2 and shown on Figure 1. The actual boundary of an AOC will be determined from the spatial distribution of the sampling data. White Space Areas will be addressed after IHSS and PAC remediation.
2. The decisions will be applied to each IHSS and PAC located in the BZ.

3. Soil will be considered from the land surface to the top of the saturated zone or top of bedrock, as appropriate.
4. Temporal boundaries will be consistent with BZ project schedules. These boundaries will be refined in the BZSAP Addenda.

Decision Rules

The characterization decision rules that describe how the data will be aggregated and evaluated are listed below. Decision rules are complex and must be applied in a systematic way. Figure 4 illustrates the decision sequence and Figure 5 illustrates how PCOCs become COCs. The decision rules are as follows:

1. If each PCOC has been adequately documented with respect to concentrations and three-dimensional locations for IHSSs and PACs, the nature and extent are adequately defined. Otherwise, PCOCs have not been adequately characterized, and additional sampling and analysis are necessary.
2. If all analytical results are nondetections, a PCOC will be disqualified from further consideration; otherwise, the PCOC will be retained. AOCs will be determined based on PCOC concentrations above detection limits.
3. If all data values are below the background mean plus two standard deviations, the PCOC will be disqualified from further consideration. Some inorganic and radionuclide concentrations may be below background levels but above Tier II ALs. Data values below background will not be carried over for further evaluation. AOCs will be determined based on PCOC concentrations detected above background.
4. If a single maximum PCOC data point is below the Tier II AL, and the sum of the maximum ratios of the concentrations of each PCOC across the AOC to their respective Tier II AL for both nonradionuclides and radionuclides, considered separately, is below 1, then no evaluation, management, or remediation of the AOC is necessary in accordance with RFCA requirements.
5. If a single maximum PCOC data point is equal to or above the Tier II AL, aggregation and evaluation as described in decision rules 7, 8, and 9 are necessary in accordance with RFCA requirements. If the sum of the ratios of the maximum concentrations for each PCOC across the AOC to its respective Tier II AL for either nonradionuclides or radionuclides is greater than or equal to 1, aggregation and evaluation as described in decision rules 7, 8, and 9 are necessary in accordance with RFCA requirements.
6. If a single maximum PCOC data point is above the Tier I AL, or the sum of the ratios of the maximum concentrations for each PCOC to its respective Tier I AL for either nonradionuclides or radionuclides is greater than or equal to 1, additional data evaluation as a potential hot spot may be necessary and the data will be aggregated as described in decision rules 7, 8, and 9.

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7. If the ratio of the 95% UCL of the mean concentration for a single PCOC to its Tier I AL across the AOC is greater than or equal to 1, the PCOC is then considered a COC and a remedial action decision will be made in accordance with RFCA requirements. If the sum of the ratios of the 95% UCL of the mean concentrations for all PCOCs to their respective Tier I ALs for both radionuclides and nonradionuclides across the AOC is greater than or equal to 1, the PCOCs are then considered COCs and a remedial action decision will be made in accordance with RFCA requirements.
8. If the ratio of the 95% UCL of the mean concentration for a single PCOC to its respective AL, or the sum of the ratios of the 95% UCL of the mean concentrations for all PCOCs across the AOC to their respective ALs for either radionuclides or nonradionuclides is greater than or equal to 1 for Tier II ALs and below 1 for Tier I ALs, the PCOCs are considered COCs and further evaluation of the site is required in accordance with RFCA requirements.
9. If the ratio of the 95% UCL of the mean concentration for a single COC to its Tier II AL, and the sum of the ratios of the 95% UCL of the mean concentrations for all PCOCs across the AOC to their respective Tier II ALs for either radionuclides or nonradionuclides are below 1, then the soil does not need to be further evaluated or managed in accordance with RFCA requirements.

Tolerable Limits on Decision Errors

Sample data requirements will be based on uncertainties of 10 percent or less for alpha (false positive) errors and 20 percent or less for beta (false negative) errors. The null hypothesis (Ho) is that the AOC is contaminated. The null and alternative hypotheses (Ha) are stated as follows:

Ho = AOC concentrations \geq ALs

Ha = AOC concentrations $<$ ALs

Characterization of data, including the minimum detectable relative differences and data variability, will be evaluated for each AOC.

Optimization of Plan Design

The BZSAP sampling design will be optimized through the BZSAP Addenda. Sampling locations, sampling depth, and PCOCs will be described in the BZSAP Addenda for each IHSS and PAC. Optimization will be conducted in consultation with CDPHE and EPA through a shared access data and mapping system (Section 6.2). This will allow RFETS and regulatory agency staffs to communicate and view data and maps concurrently so that potential sampling design issues are resolved.

Existing data and process knowledge will be reviewed and analyzed to determine:

- Type of statistical sampling methods (geostatistical, standard, biased, or a combination of methods) appropriate for each site;

- Specific PCOC lists for each IHSS and PAC through comparison to background for metals and radionuclides, and detection limits for organics; and
- Sampling depth.

Consistent with the iterative approach of the DQO process, decisions without adequate confidence will be revisited until enough data are gathered to make a decision. Existing data sets may be checked for sampling adequacy based on comparison with the EPA G-4 model (EPA 1994) or Gilbert's methods (Gilbert 1987). Sampling requirements and densities will be based on the AOC. The following documents will be used as guidance in optimizing sampling and analysis requirements:

- EPA, 1989, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December.
- EPA, 1992, Guidance for Data Usability in Risk Assessment (Parts A&B), EPA Publication 9285.7-09A&B, April/May.
- EPA, 1994, Guidance for the Data Quality Objective Process, QA/G-4 EPA/600/R-96/055, September.
- EPA, 1996, Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, May.
- EPA, 1997, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016, December.
- EPA, 1998, Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis, QA/G-9 EPA/600/R-96/084, January.
- EPA, 1999, Guidance on Environmental Data Verification and Validation, Peer Review Draft, QA/G-8, August.
- EPA, 2000, Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4HW, EPA/600/R-00/007, January.

3.1.2 Confirmation Sampling and Analysis

The Problem

Following remediation of any contaminated area, the concentrations of remaining contaminants, if any, are not known with adequate confidence to conclude that remediation was complete and successful.

Due to the nature of some remediation technologies, such as soil excavation and hauling with heavy equipment, the possibility exists that limited contaminated media could be released outside the remediation boundaries during field activities.

Identification of Decisions

The confirmation sampling and analysis questions that will be resolved include the following:

1. Has contamination within an AOC been successfully remediated based on RFCA ALs and other mutually agreed-upon cleanup criteria?
2. Did any releases of contamination occur outside the remediation activity boundaries during the remediation activity (based on compliance and project-specific performance monitoring)?

Inputs to the Decisions

Information needed to resolve the confirmation sampling and analysis questions are as follows:

1. COCs as determined by the AL screen;
2. Post-remediation sampling locations based on RFCA and CRA requirements;
3. Compliance monitoring results concurrent with remediation;
4. MDLs

MDLs for BZ COCs and field analytical equipment are presented in Appendix E. Analytical methods are organized in tables by general analytical suite. The tables present the minimum required analytes within each respective suite, as well as the required sensitivity for each analyte. Sensitivities are expressed as MDLs, and are specific to the measurement systems used for BZ sample analysis. The RFCA ALs are the lowest values stipulated in RFCA for any exposure scenario. These conservative values are provided to ensure that method sensitivities, for each and every COC, are adequate for making project decisions.

Accuracy and precision tolerances are also provided in each table. Accuracy specifications apply to methods only, whereas precision specifications are presented relative to both laboratory and instrument performance and the overall project, which includes sampling error.

MDLs for offsite analytical laboratories are those established by Analytical Services Division (ASD) and are listed in Appendix E;

5. Confirmation sample results (post-remediation concentrations);
6. RFCA Tier I and Tier II ALs for surface and subsurface soil as listed in the ALF (Attachment 5, RFCA). Comparison criteria include the following:
 - a) Each soil data value will be compared to the background mean plus two standard deviations.
 - b) Each soil data value will be compared to the appropriate AL.

- c) RFCA Tier I exceedance is defined as:
 - Ratio of each soil data value to the Tier I AL is > 1 , or
 - Sum of the ratios for either nonradionuclides or radionuclides is > 1 .
 - d) RFCA Tier II exceedance is defined as:
 - Ratio of each soil data value to the Tier II AL is > 1 , or
 - Sum of the ratios for either nonradionuclides or radionuclides is > 1 .
 - e) Below RFCA Tier II is defined as:
 - Ratio of each soil data value to the Tier II AL is < 1 , or
 - Sum of the ratios for either nonradionuclides or radionuclides is < 1 .
7. Other mutually agreed-upon cleanup criteria.

Data will be reviewed and evaluated against usability criteria and must pass the Data Quality Filter (DOE 2001a).

Study Boundaries

Decision boundaries that determine when and where data will be collected are listed below.

1. Identified IHSS and PAC are listed in Table 2 and shown on Figure 1. The actual boundary of an AOC will be determined from the spatial distribution of the sampling data, as specified in the IGD. The AOCs determined will be used as areas for confirmation sampling and analysis immediately after remediation.
2. White Space Areas will be sampled and addressed when monitoring data indicate contamination was spread during remediation of adjacent sites. Otherwise, White Space Areas will be addressed as part of the CRA.
3. COCs determined for each AOC in accordance with Section 3.1.1 will be compared to ALs or other mutually agreed-upon cleanup criteria.
4. Confirmation sampling will cover the area remediated.
5. Soil will be considered from the land surface to the top of the saturated zone or top of bedrock, as appropriate.
6. Temporal boundaries will be consistent with BZ project schedules. These boundaries will be refined as the BZSAP is developed and BZ remediation proceeds. Confirmation sampling will be conducted after remediation. Data from confirmation sampling will be used to support the CRA.

Decision Rules

The confirmation sampling and analysis decision rules that describe how the data will be aggregated and evaluated are illustrated on Figure 6 and listed below.

1. The concentration and distribution of each COC, after the remedial action has been performed, must be adequately documented within the AOC boundaries of interest to evaluate the remediation using the following decision rules. Otherwise, post-remediation COCs have not been adequately characterized, and additional sampling and analysis are necessary.
2. If all COC data values are below the background mean plus two standard deviations, the COC will be disqualified from further consideration. Some inorganic and radionuclide concentrations may be below background but above Tier II ALs. Data values that are below background will not be carried over for further evaluation.
3. If a single maximum COC data point is below the Tier II AL, and the sum of the ratios of the maximum concentrations for each COC across the AOC to its respective Tier II AL for both nonradionuclides and radionuclides is below 1, no action is necessary in accordance with RFCA requirements.
4. If a single maximum COC data point is above the Tier II AL, or the sum of the ratios of the maximum concentrations for each COC across the AOC to its respective Tier II AL for either nonradionuclides or radionuclides is greater than or equal to 1, then aggregation and evaluation as described in decision rules 6, 7, and 8 are necessary in accordance with RFCA requirements.
5. If a single maximum COC data point is above the Tier I AL, or the sum of the ratios of the concentrations for each COC across the AOC to its respective Tier I AL for either nonradionuclides or radionuclides is greater than or equal to 1, then additional evaluation as a potential hot spot may be necessary and the data will be aggregated as described in decision rules 6, 7, and 8.
6. If the ratio of the 95% UCL of the mean concentration for a single COC to its Tier I AL, and the sum of ratios of the 95% UCL of the mean concentrations for all COCs to their respective Tier I ALs for both nonradionuclides and radionuclides across the AOC are greater than or equal to 1, then a remedial decision will be made in accordance with RFCA requirements.
7. If the ratio of the 95% UCL of the mean concentration for a single COC to its respective AL, or the sum of the ratios of the 95% UCL of the mean concentration for all COCs across the AOC to their respective ALs is greater than or equal to 1 for Tier II ALs and below 1 for Tier I ALs, a remedial decision will be made in accordance with RFCA requirements.
8. If the ratio of the 95% UCL of the mean concentration for a single COC to its respective Tier II AL, and the sum of the ratios of the 95% UCL of the mean concentration for all COCs across the AOC to their respective Tier II ALs are below 1, then no further action is required in accordance with RFCA requirements.
9. If compliance or project-specific performance monitoring (e.g., air or surface water monitoring) corresponding with the BZ remediation activity produces results that exceed ALs stated in RFCA, then the potential release of contaminants resulting from the respective remediation activity will be evaluated. Otherwise, the

remediation activity was adequately controlled to prevent release of contaminants outside the immediate remediation boundaries.

Tolerable Limits on Decision Errors

Areas and associated COCs disqualified from further characterization or remediation based on process knowledge have no associated quantifiable decision error. Sample data requirements will be based on uncertainties of 10 percent or less for alpha errors and 20 percent or less for beta errors. The null hypothesis is that the AOC is contaminated. Characterization of data, including the minimum detectable relative differences and data variability, will be evaluated for each AOC.

Optimization of Plan Design

Optimization of the post-remediation data collection process will be based on statistical or geostatistical analysis where possible. Consistent with the iterative approach of the DQO process, decisions without adequate confidence will be revisited until enough data are gathered to make a decision. Existing data sets may be checked for sampling adequacy by comparison with the EPA G-4 model, Gilbert's methods (Gilbert 1987), or MARSSIM (EPA 1997). Sampling requirements and densities will be based on the remediation area considerations.

The following documents will be used as guidance to optimize sampling and analysis requirements in support of remediation activities:

- EPA, 1989, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December.
- EPA, 1992, Guidance for Data Usability in Risk Assessment (Parts A&B), EPA Publication 9285.7-09A&B, April/May.
- EPA, 1994, Guidance for the Data Quality Objective Process, QA/G-4 EPA/600/R-96/055, September.
- EPA, 1996, Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, May.
- EPA, 1997, MARSSIM, NUREG-1575, EPA 402-R-97-016, December.
- EPA, 1998, Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis, QA/G-9 EPA/600/R-96/084, January.
- EPA, 1999, Guidance on Environmental Data Verification and Validation, Peer Review Draft, QA/G-8, August.
- EPA, 2000, Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4-HW, EPA/600/R-00/007, January.

3.1.3 Final Characterization of the Buffer Zone for the Comprehensive Risk Assessment

The BZ must be assessed to ensure that the post-remediation state is protective of human health and the environment based on post-closure uses. Data will be collected to ensure that the nature and extent of any remaining contamination are known, so that a CRA can be performed to ensure post-closure uses are protective. The CRA will address direct surface soil, surface water, and air exposure pathways and offsite exposures; however, the BZSAP DQOs only address soil. Other media will be sampled and evaluated as part of the compliance monitoring or other RFETS programs.

The nature and extent of soil characterization and remediation within the BZ AOCs will have been determined; however, nature and extent of soil contamination in most White Space Areas will be unknown. The concentrations of COCs in soil in all areas within the BZ must be determined with adequate confidence to be protective of post-closure uses.

Data used in the CRA will be evaluated based on EUs. The extent of the EUs will be determined in the CRA Methodology (Appendix D), and will not depend on the size of the AOCs. CRA DQOs for the BZSAP provide information for data collection. Detailed CRA DQOs are presented in the CRA Methodology (Appendix D).

The Problem

Human and ecological receptors can be expected to randomly contact soil from any or all parts of the BZ. The previous DQOs address select areas of known contamination; however, there are areas within the BZ for which no data are available. The post-remediation state of the BZ must be assessed to determine whether it is adequately protective of the post-closure uses.

Identification of Decisions

The CRA questions that will be resolved are listed below:

1. Has each COC and its nature and extent within IHSSs, PACs, AOCs, and White Space Areas been identified with adequate confidence, based on process knowledge and analytical data?
2. Are long-term risks to receptors in an EU acceptable, based on post-closure uses?
3. Are long-term risks to onsite and offsite receptors via the air and surface water pathways acceptable, based on post-closure uses?
4. Does residual contamination within an Ecological Risk Assessment (ERA) EU represent an acceptable ecological risk due to direct contact with abiotic media?

Inputs to the Decisions

The information needed to resolve the CRA questions above are listed below.

1. Characterization data from RIs, RFI/RI reports, CMSs/FSs, remedial action reports, IMP reports, predemolition survey reports, and other projects and data sets, including BZSAP-generated, historical, and compliance monitoring data (e.g., concentrations of COCs in surface and subsurface soil, surface water, groundwater, air, and biota), as described in the CRA Methodology (Appendix D), will be used as inputs to the decisions. BZSAP data will include data collected for pre- and post-remediation AL comparisons. Data used in the CRA will be screened through the Data Quality Filter (DOE 2001a);
2. All available historical information, sampling data, and risk assessment requirements, as documented in the CRA Methodology (Appendix D), will be used to determine sampling locations and densities for White Space Areas to support CRA decisions. Data used in the CRA will be screened through the Data Quality Filter (DOE 2001a).
3. These data will be processed using one or more numerical methods to provide a decision context. These methods may include:
 - PCOC filter (algorithm);
 - Monte Carlo methods;
 - Air dispersion modeling;
 - Surface water, groundwater, or erosion modeling;
 - CRA modeling; and
 - ALF comparisons on an EU basis;
4. COCs as determined from sampling and remediation efforts;
5. Pre- and post-remediation sampling locations;
6. MDLs

MDLs for BZ COCs and field analytical equipment are presented in Appendix E. Analytical methods are organized in tables by general analytical suite. The tables present the minimum required analytes within each respective suite, as well as the required sensitivity for each analyte. Sensitivities are expressed as MDLs, and are specific to the measurement systems used for BZ sample analysis. The RFCA ALs are the lowest values stipulated in RFCA for any exposure scenario. These conservative values are provided to ensure that method sensitivities, for each and every COC, are adequate for making project decisions.

Accuracy and precision tolerances are also presented in each table. Accuracy specifications apply to methods only, whereas precision specifications are presented

relative to both laboratory and instrument performance and the overall project, which includes sampling error.

MDLs for offsite analytical laboratories are established by ASD and are listed in Appendix E; and

7. Acceptable human health and ecological risk levels for post-closure uses

All characterization (unless remediated) and confirmation data for environmental media in the BZ that pass the Data Quality Filter (DOE 2001a) will be used in the CRA. This will include data from historical investigations and actions, BZ characterization, remediation confirmation, compliance monitoring, and additional samples to complete the nature and extent determination. All appropriate modeling results will be used in the assessment.

CRA data will meet at least one of the following criteria:

- Data must pass the Data Quality Filter (DOE 2001a).
- Data must meet compliance monitoring DQO requirements.
- Data used for CRA modeling must meet Actinide Migration Evaluation (AME) DQO modeling criteria.

Data will be stratified using appropriate statistical methods to account for possible higher density sampling and higher levels of contamination in AOCs than in White Space Areas.

Study Boundaries

Decision boundaries to determine when and where data will be collected are listed below.

1. The data associated with IHSSs, PACs, AOCs, and White Space Areas will be incorporated into EUs as designated in the CRA Methodology (Appendix D).
2. EU sizes and factors will be documented in the CRA Methodology (Appendix D). The size of the EUs will be based on the potential land uses identified on Figure 1 of RFCA Attachment 5. The EUs will contain IHSSs, PACs, AOCs, and White Space Areas, as appropriate.
3. For ecological characterization, the minimum grid spacing for selecting random samples within an ERA EU will be based on the average home range of the Prebles meadow jumping mouse (PMJM) (3.5 hectares in a linear-ovate configuration). Other grid spacing will be used in habitats not frequented by the PMJM.
4. AL comparisons will be performed on aggregated data for COCs contained in an EU to account for direct exposure, including contact with multiple contaminants.

5. Aggregate human health risks and doses, and ecological risks, will be assessed for projected land uses in accordance with RFCA, and for adjacent areas including those downwind and downstream, as specified in the CRA Methodology (Appendix D).
6. Soil will be considered from the land surface to the top of the saturated zone or top of bedrock, as appropriate.
7. Temporal boundaries will be consistent with BZ project schedules. These boundaries will be refined as the BZSAP is developed and BZ remediation proceeds (e.g., to consider the optimal season for various sample types).
8. The CRA modeling effort will include several out-year land use scenarios as defined in the CRA Methodology (Appendix D).
9. The CRA will use characterization and confirmation data as appropriate from IHSSs, PACs, AOCs, and White Space Areas.

Decision Rules

The decision rules that describe how the data will be evaluated are illustrated on Figure 7 and listed below.

1. If the nature and extent of chemicals, metals, and radionuclides are known for an EU with sufficient certainty so that human health risks and doses and ecological risks can be adequately quantified, then additional sampling and analysis will not be performed. Otherwise, additional sampling and analysis will be performed.

Tolerable Limits on Decision Errors

Sample data requirements will be based on uncertainties of 10 percent or less for alpha errors and 20 percent or less for beta errors. Characterization of data, including the minimum detectable relative differences and data variability, will be evaluated for each EU. Sources of uncertainties in the risk assessments will be identified and minimized.

Optimization of Plan Design

Optimization of the post-remediation data collection and sampling requirements will be based on the EU for the appropriate land use, in consultation with CDPHE and EPA during development of the CRA Methodology (Appendix D).

The following documents will be used as guidance in defining the sampling and analysis requirements for the CRA:

- EPA, 1989, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December.
- EPA, 1992, Guidance for Data Usability in Risk Assessment (Parts A&B), 9285.7-09A&B, April/May.

- EPA, 1996, Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, May.
- EPA, 1997, MARSSIM, NUREG-1575, EPA 402-R-97-016, December.

4.0 SAMPLING STRATEGY

The BZ sampling strategy specifies surface and subsurface soil sampling and analysis methodologies that will streamline characterization and remediation processes and maintain appropriate QA. The sampling strategy will:

- Provide a consistent process for characterizing IHSSs and PACs;
- Provide characterization focused on identifying areas that require remediation;
- Diminish reliance on offsite analytical laboratories to reduce cost and accelerate schedules; and
- Provide defensible quality data for the CRA.

The BZ sampling strategy includes the following key elements:

- In-process characterization and remediation sampling at IHSSs and PACs;
- Post-remediation confirmation sampling at IHSSs and PACs; and
- Sampling in White Space Areas for the CRA.

4.1 IN-PROCESS SAMPLING

The K-H characterization team will implement an in-process sampling approach that combines a statistical approach to determine sampling locations and remediation areas with the use of field analytical equipment. Existing data and historical process information will be used to determine the statistical approach needed to determine characterization sampling locations in IHSSs, PACs, and White Space Areas. After the sampling locations have been identified, samples will be collected and analyzed using field analytical instrumentation. The data will be evaluated using a geostatistical or standard statistical approach to delineate the AOC and areas that require remediation.

After the areas have been remediated, samples will be collected and analyzed using field analytical instrumentation to immediately determine whether remediation goals have been achieved. Soil will be removed in "lifts." After a lift is removed, the remaining soil will be analyzed with field instrumentation. This process will continue until remedial objectives have been achieved. When field analytical results indicate remediation has been achieved, post-remediation confirmation samples will be collected and analyzed on site, if appropriate data quality can be demonstrated, or sent to an offsite laboratory for analysis. Offsite laboratory results will be validated according to ASD requirements.

If remediation is not required at specific IHSSs or PACs based on the results of field analysis, confirmation samples will be collected to support an NFA recommendation and the CRA. An offsite or onsite laboratory will perform the confirmation sample analysis. Field analytical instrument data will be used for the CRA if appropriate data quality can be demonstrated. Offsite laboratory results will be validated according to DQO requirements. Figure 8 illustrates the overall in-process sampling technique for IHSSs and PACs.

4.2 STATISTICAL APPROACHES

Characterization sampling locations will be determined for each IHSS, and PAC using geostatistical, standard statistical, or biased sample selection methods. Table 3 generally describes when each method will be used. Using existing data, a decision as to whether the data define a contaminant distribution (apply geostatistical approach) or a localized hot spot (apply standard or biased approach) will be made. The method for determining sampling locations will be specified in the appropriate BZSAP Addenda. In some cases, a combination of techniques may be used. For example, if process knowledge or existing data indicate discrete spill areas in a large IHSS, both standard statistical and biased sampling may be appropriate.

Table 3
Sampling Decision Matrix for IHSSs and PACs

Method	Condition
Geostatistical	<ul style="list-style-type: none"> • Existing analytical data • Existing data indicate a contaminant distribution
Standard Statistical	<ul style="list-style-type: none"> • No existing analytical data • Limited analytical data • Process knowledge
Biased Sampling	<ul style="list-style-type: none"> • Process knowledge • Limited analytical data • Analytical data indicate localized contamination or point sources

In-process sampling will use a variety of statistical error management approaches to meet the decision error limits specified in the DQOs. The specific approach will be customized to meet the uncertainty, time, and health and safety (H&S) constraints of each IHSS and PAC characterization.

Each component of the sampling design is based on the project DQOs presented in Section 3.0. The sampling strategies described in this section are the basis for IHSS and PAC characterization. However, these strategies are flexible and will be modified, as needed, to fit actual field conditions. Statistical methods are described in the following sections.

4.2.1 Geostatistical Approach

SmartSampling, a geostatistical approach developed at Sandia National Laboratory (SNL) and used at several DOE sites is the basis for the geostatistical approach that will

be used to determine the optimum number and location of samples needed to characterize IHSSs and PACs for remediation.

The geostatistical approach will be used to:

- Optimize the number and locations of characterization samples;
- Develop maps of the areas with concentrations or activities exceeding RFCA ALs at a given level of probability;
- Optimize the number and location of post-remediation confirmation samples;
- Achieve DQO-specified limits on decision errors; and
- Link onsite analysis with sampling to allow near real-time remediation decisions.

Geostatistics uses an iterative process based on remediating a site to required ALs at a specified level of confidence. Geostatistics will be applied using existing data to generate maps showing the probability of exceeding RFCA ALs in IHSSs, PACs, and White Space Areas. Based on the probability of exceedance maps, two types of maps can be developed:

1. Maps showing areas requiring additional sampling; and
2. Maps showing both Tier I and Tier II AL exceedances at a specified level of reliability.

Existing data will be analyzed, and a decision to collect more samples will be based on an analysis of sampling locations, analytical results, and the chosen reliability level. After characterization of individual IHSSs and PACs, geostatistical or standard statistical techniques will be used to define AOCs and areas above RFCA ALs. Sampling necessary to define the extent of contamination will be iterative: as sample data are received, they will be evaluated using geostatistics. The results will be used to determine the optimal number and locations of samples to be collected in the next iteration, if necessary. This iterative updating will be conducted in near real-time (on the order of several hours turnaround for incorporating the new sample information).

Geostatistics are not designed for developing a characterization plan around a single hot spot. Sampling to identify hot spots will generally be more focused on defining contaminants in a single location, and may not provide the necessary areal coverage to define the extent of contamination across an entire IHSS. However, depending on the size of the IHSS, the same sampling grid spacing used for finding a hot spot may provide the necessary information for the geostatistical approach.

Figure 9 illustrates how geostatistics will be used at the IHSSs and PACs. A more detailed description of geostatistical procedures is provided in Section 5.2.4.

4.2.2 Standard Statistical Approach

The geostatistical approach is not suitable for IHSSs or PACs that have relatively few or no observations. Therefore, a separate sampling methodology is necessary to adequately characterize soil contamination in these areas. An efficient sampling strategy for delineating the spatial distribution and total amount of contamination encompassing “poorly” defined areas is a statistical grid design. This type of design is best suited for detecting potential hot spots of unknown spatial distribution(s).

Appropriate grid designs will be developed based on project DQOs and may include, but not be limited to, triangular and random stratified grids. Sampling IHSSs and PACs on a triangular grid will result in a spatial configuration of data that can be used for geostatistical analysis. This approach is conducive to determining the spatial correlation structure of the data set, which can be used in the geostatistical analysis to define areas above Tier I and Tier II ALs.

A systematic sampling scheme will be used to identify and delineate hot spots within the areas of interest following procedures outlined in Gilbert (1987). Sampling locations will be positioned into equilateral grids, such as triangular grids, following the methods presented in Gilbert (1987), Gilbert and Simpson (1992), and Section 4.3. Triangular grid sampling provides uniform coverage of a sampling area and increases the chances of identifying an elliptical or circular hot spot (Gilbert 1987). The following assumptions apply to the proposed sampling design:

- Samples will be collected on a statistical grid.
- The sampled area is much smaller than the grid spacing.
- Hot spots are circular or elliptical.

Hot spots will be defined.

After the grid interval is calculated for the specified area, a random-start grid overlay will be superimposed on a map of the IHSS or PAC. In some cases, biased sampling will supplement the grid interval. This methodology provides grid coverage with a 90% confidence of finding a radionuclide hot spot, as well as provides statistical confidence for other constituents consistent with DQO error rates of 10% (alpha) and 20% (beta) for both radionuclides and nonradionuclides. Confidence limits are also consistent with EPA specifications (EPA 1992).

Soil samples will be collected at the intersection of each grid according to the sample collection methods described in Section 4.8. Additional samples will be collected, as needed, to determine the size of the AOC. Sampling methods for each IHSS and PAC will be specified in the appropriate BZSAP Addendum.

In summary, standard statistical techniques, outlined in Gilbert (1987) (and incorporated in a number of available software programs [e.g., Visual Sampling Plan]) will be used to determine sampling locations in areas where:

- No existing analytical data are available;
- Limited analytical data are available;
- Process knowledge does not indicate biased sampling is appropriate; and
- Uniform contamination is indicated.

A hot spot methodology (Section 4.3) augments the standard statistical approach used to define grid spacing in IHSSs and PACs.

Figures 10 and 11 illustrate how standard statistical techniques, and standard statistical techniques combined with a biased sampling approach, respectively, will be used at IHSSs and PACs.

4.2.3 Biased Sampling Approach

In addition to the systematic sampling design, some areas may require judgment or biased sampling where process knowledge or analytical data suggest there is a high probability of contamination in a limited area. This approach will provide targeted sampling of potential problem areas and result in the following:

- Additional sampling between the standard grid, if necessary; and
- Limited sampling of some IHSSs and PACs.

Biased sampling locations might include areas of deposition where contaminants have a tendency to accumulate. Other physical features that may warrant biased sampling include confluences, outfall points, and apparent discoloration of the soil, sediment, or vegetation. These features and the applicability of biased locations will be assessed during characterization planning. Figure 12 illustrates how biased sampling will be used at IHSSs and PACs.

In summary, a biased sampling approach will be used when:

- Process knowledge indicates discrete spills or releases; or
- Limited analytical data indicate hot spots or other discrete areas of interest.

4.3 HOT SPOT METHODOLOGY

Hot spot is a relative term used to denote an area that has a significantly higher contaminant concentration than the surrounding area. Hot spots are quantified by their size and contaminant concentration. A method for measuring hot spots is needed to:

- Determine areas of limited extent that require remediation;
- Statistically evaluate the extent of contamination in localized areas; and

- Determine the size of the sampling grid.

Hot spot size drives the grid density and number of samples for a given area of interest. To determine grid density for BZ and CRA sampling, the Site has been divided into three areas based on the following criteria:

- Potentially Contaminated Areas - IHSSs, PACS, and UBC Sites in the IA and BZ are areas of known contamination or have a potential for contamination (based on process knowledge or analytical data).
- Areas Not Expected To Exceed Action Levels - White Space Areas in the IA and inner BZ are considered areas that have a potential for contamination or known contamination but the contamination is not expected to exceed RFCA ALs.
- Outer Buffer Zone – Areas outside of IHSSs and PACs within the outer BZ are not expected to contain significantly higher contamination than the surrounding area. The outer BZ White Space will not require sampling activities for hot spots.

4.3.1 Potentially Contaminated Areas

IHSSs and PACs will be sampled based on the requirements of standard statistics and/or geostatistics depending on site-specific circumstances. These statistical approaches are used to assess the concentration/activity of an analyte across an IHSSs and PACs for comparison with RFCA Tier I and Tier II ALs. This AL comparison must also include a hot spot analysis to ensure that small, localized areas with elevated sample results comply with health-based requirements.

A two-step process will be used to define hot spots in potentially contaminated areas.

1. The first step is to evaluate existing analytical data to determine whether there are data to constrain the size of a potential hot spot in an IHSS or PAC. If data exist that provide information on potential hot spot size (or sizes), these data will be used. For example, knowledge of the size of hazardous waste storage units such as drum pallets, storage tanks, and crates, or the size of spills, will dictate the likely hot spot dimension(s) in a given area. If there is more than one potential hot spot in a given area, an average hot spot size will be determined. The grid size used for sampling and number of samples required will be based on the defined hot spot size and level of probability (90 percent) of finding a hot spot (Gilbert 1987). Biased sampling may also be used to augment the grid design.
2. If there are no data available that can constrain the size of a hot spot, two options will be considered.
 - a) The hot spot size in IHSSs and PACs will be based on the sampling grid used to characterize radiologically contaminated surface soil within the 903 Pad Area. The 903 Pad Area was characterized using high-purity germanium (HPGe) instrumentation on an 11-meter (m) (36-foot[ft]) triangular grid. Based on this grid dimension, there is a 90 percent probability of detecting a hot spot using Gilbert's (1987) methodology. The hot spot size is assumed to be circular with a

diameter of 36 ft. (The field of view of the HPGe was 10 meters [m] [or 33 ft], which was based on the instrumentation, not a specified hot spot size.) The 36-ft triangular grid spacing is conservative for characterizing nonradionuclides, and provides a consistent approach for both radionuclides and nonradionuclides.

This methodology will provide a consistent sample density for most IHSSs and PACs in the BZ, and is small enough to detect most hot spots. Additionally, sampling at this grid size will provide data for subsequent geostatistical analysis, if needed.

- (b) There are IHSSs and PACs that are smaller than the proposed grid size of 10 m across. If there are no data available to constrain a hot spot size in these IHSSs and PACs, a minimum of five samples will be collected in a triangular, square, or random stratified grid pattern. This methodology will provide the minimum number of samples that can be used for statistical analysis. Additional samples will be collected as needed based on the in-process sampling results.

Areas with concentrations above RFCA Tier I and Tier II ALs will be evaluated, according to BZSAP DQOs and methods described in Section 5.0, to determine whether a hot spot is present. Hot spot size, along with grid spacing and number of samples required for individual IHSSs and PACs in the BZ, will be described in the BZSAP Addenda.

4.3.2 Areas Not Expected To Exceed Action Levels

White Space and inner BZ is not expected to have contamination above ALs and will be sampled to support CRA analyses. Surface soil in the inner BZ White Space and inner BZ will be sampled at grid points located based on Gilbert's methods and the probability of finding an area of elevated contamination. The area of the IA White Space and inner BZ is approximately 1,027 acres and a grid size of 2.5 acres has been chosen for the following reasons:

- There is very little precedence in existing literature for determining grid size at DOE Superfund sites. However, provides guidance on the evaluation of land areas at radionuclide sites. MARSSIM defines land areas that have a potential for contamination as not greater than 10,000 square meters (m^2) in size. The IA White Space Areas and inner BZ are considerably larger (approximately 1,027 acres, 45 million ft^2 , or 4 million m^2) than a MARSSIM area of 10,000 m^2 (2.5 acres or 107,639 ft^2). A grid size of 2.5 acres in the IA White Space and inner BZ would be approximately 0.2 percent of the area and provides a conservative method for determining contaminant distribution.
- The grid design based on the 2.5-acre grid will augment geostatistical analysis by filling in data gaps between IHSSs and PACs..
- The grid size of 2.5 acres will provide appropriate sampling frequency and information for geostatistical analysis of White Space Areas in the IA and inner BZ.

Areas with concentrations above RFCA Tier I and Tier II ALs will be evaluated, according to BZSAP DQOs and methods described in Section 5.0, to determine whether contamination is present. Figure 13 illustrates the extent of the inner and outer BZ areas at RFETS.

4.3.3 Elevated Measurement Comparison

In AOCs that contain RFCA Tier I and Tier II AL exceedances, remedial and management decisions can be based on the Elevated Measurement Comparison (EMC) (MYAPC 1999). The EMC defines significantly high measurements relative to the size of a hot spot, magnitude of the AL, and mean of the surrounding measurements. The EMC depends on several variables: AL, measured value, size of the hot spot, and size of the AOC. The EMC is applicable to all sample results or hot spots with concentrations above RFCA Tier I or Tier II ALs. In AOCs where all sample results are less than ALs, the EMC is not required.

The decision whether a hot spot requires remediation is not part of the BZ characterization or post-remedial sampling effort. The EMC is presented in the BZSAP because the EMC is consistent with BZSAP DQOs for data aggregation and evaluation.

Results of the EMC equation (Section 5.3) greater than 1 indicate action is necessary, and results less than 1 indicate action is not necessary. Because the EMC includes an area-weighting component, results for very small hot spots may indicate action is not necessary for very high contaminant concentrations. To reduce this effect, when the concentration of a contaminant at a hot spot is three times the Tier I AL, action is indicated. The “three times the AL” concept will not apply to ALs that are based on acute toxicity. Using a value of three times the AL as an upper limit for reevaluation is consistent with the Residual Radioactivity Computer Code (RESRAD) release criteria. If the hot spot is remediated, the confirmation sample values will be used in the equation.

The EMC equation is discussed in Section 5.3 and several examples of how the equation works are presented in Appendix G.

4.4 CHARACTERIZATION SAMPLING STRATEGY FOR IHSSS AND PACS

Existing analytical and historical information will be evaluated for each IHSS and PAC to establish the appropriate statistical method (Section 4.2) for determining characterization sampling locations, PCOCs, and sampling methods for the site. A list of IHSSs and PACs, and a preliminary assessment of the statistical method that will be used, is provided in Table 4. PCOCs for the BZ are listed in Section 3.0. Sampling locations for IHSSs and PACs will be detailed in the appropriate BZSAP Addendum.

4.4.1 Surface and Subsurface Soil Sampling

The characterization team will sample surface soil in accordance with Standard Operating Procedure (SOP)-OPS-GT-08 and as described in Section 4.8. Surface soil samples will be analyzed with field instruments for radionuclides, metals, SVOCs, and, if existing historical or analytical data suggest, other analytes (pesticides, PCBs, etc.). In some

cases where existing data suggest a restricted COC list, soil samples will be analyzed for the specific COCs only. A list of PCOCs will be included in the BZSAP Addenda.

Subsurface soil will be sampled where historical information and analytical data suggest contamination may be present below a depth of 6 inches. The characterization team will collect subsurface soil samples with a Geoprobe® (or other appropriate method) to the top of the saturated zone or top of bedrock. The characterization team will use concrete drills,drills (for concrete slabs, and other foundation areas) where necessary. The types of Geoprobe® and other sampling methods that may be used are described in Section 4.8. Sample Collection and COCs for each IHSS and PAC will be specified in the appropriate BZSAP Addendum.

**Table 4
Preliminary Sample Location Statistical Technique**

IHSS Group	Description	IID	NFA Status	Number of Existing Sample Locations						Historical Notes	Preliminary Sampling Methodology	
				Area (ft ²)	Rads	Metals	PCBs	Pesticides	SVOCs			VOCs
000-5	Disposal of Diesel Contaminated Material at Landfill (formerly NW-177)	NW-1502	P	356							Disposal of 50 lbs of soil and oil absorbent contaminated with diesel fuel.	Biased/Stratified Statistical Grid
	Disposal of Fuel Contaminated Material at Landfill	NW-1503	P	356							Empty motor oil containers, used oil filters and oil stained debris were removed.	Biased/Stratified Statistical Grid
	Disposal of Thorosilane Contaminated Material at Landfill	NW-1504	P	356							Release of thorosilane and disposal of contaminated absorbent.	Biased/Stratified Statistical Grid
	Landfill Trench A	166.1	P	13,959	8	7	7	7	7		Disposal of sanitary sewage sludge and liquids. Potential radiological contamination.	Biased/Stratified Statistical Grid
	Landfill Trench B	166.2	P	17,208	6	6	6	6	6		Disposal of sanitary sewage sludge and liquids. Potential radiological contamination.	Biased/Stratified Statistical Grid
	Landfill Trench C	166.3	P	15,820	6	6	6	6	6		Disposal of sanitary sewage sludge and liquids. Potential radiological contamination.	Biased/Stratified Statistical Grid
	Landfill Pond Spray Area	167.2	P	10,875	4	4					Spray evaporation of landfill leachate	Biased/Stratified Statistical Grid
900-11	Landfill Pond Spray Area	167.3	P	10,875	3	3					Spray evaporation of landfill leachate	Biased/Stratified Statistical Grid
	Present Landfill	114	P	1,644,510	188	196	41	19	34	28	Disposal of uncontaminated solid waste	Geostatistical/Biased
	Elevated Chromium Identified During Geotechnical Drilling	900-1316	P	4,586							Potential chromium release	Biased/Stratified Statistical Grid

Dr. Buffer Zone Sampling and Analysis Plan

IHSS Group	Description	ID	NPA Status	Area (ft ²)	Number of Existing Sample Locations						Historical Notes	Preliminary Sampling Methodology	
					Rads	Metals	PCBs	Pesticides	SVOCs	VOCs			
	East Firing Range & Target Area	SE-1602		465,173							Lead bullets in Firing Range berm. Armor piercing bullet fragments made of depleted uranium in Target Area	Biased/Stratified Statistical Grid	
	Ryan's Pit (Trench 2)	109		261	2	2		2			Disposal of VOCs and drum carcasses.	Biased/Stratified Statistical Grid	
	903 Pad	112		146,727	52	12	7	17	22	27	Leaks and spills from Drum Storage	Geostatistical/Biased	
	Haz Disposal Area	140	R	65,498	14	12	6	16	10	16	Reactive metal destruction and disposal site.	Biased/Stratified Statistical Grid	
	903 Lip Area	155		1,009,572	1173	16	11	25	12	25	Wind dispersal contamination from the 903 Pad.	Geostatistical/Biased	
	Gas Detox Area	183	S	354							Toxic gas storage and gas detoxification/neutralization area.	Biased/Stratified Statistical Grid	
900-12	Trench T-1	108	S	6,286	1	1	1	1	1	1	Disposal of sanitary waste sludge and debris.	Biased/Stratified Statistical Grid	
	Trench T-3	110	S	7,823	12	12	1	15	11	15	Disposal of sanitary waste sludge and debris.	Geostatistical/Biased	
	Trench T-5	111.2		19,235	5	5	2	6	5	6	Disposal of sanitary waste sludge	Biased/Stratified Statistical Grid	
	Trench T-6	111.3		4,089	2	2	1	2	2	2	Disposal of sanitary waste sludge	Biased/Stratified Statistical Grid	
	Trench T-8	111.5		7,297	1	1	1	1	1	1	Disposal of sanitary waste sludge	Biased/Stratified Statistical Grid	
	Trench T-9	111.6		14,705	4	4	1	4	4	4	Disposal of sanitary waste sludge, scrap metal, and junk	Biased/Stratified Statistical Grid	
	Trench T-10	111.7		4,271	4	4	1	4	4	4	Disposal of sanitary waste sludge	Biased/Stratified Statistical Grid	
	Trench T-11	111.8		5,776	4	4		4	2	4	Disposal of sanitary waste sludge and asphalt planking	Biased/Stratified Statistical Grid	
		Oil Bum Pit No. 2	153		6,403							Disposal and burning of uranium contaminated coolant and waste oils	Biased/Stratified Statistical Grid
		Pallet Burn Site	154		3,152							Burning of wooden pallets	Biased/Stratified Statistical Grid
	900-2	East Spray Field-North Area	216.1	P	149,481	12	12		6		6	Spray evaporation of B-Series	Biased/Stratified Statistical Grid

D. Buffer Zone Sampling and Analysis Plan

IHSS Group	Description	ID	NFA Status	Area (ft ²)	Number of Existing Sample Locations							Historical Notes	Preliminary Sampling Methodology
					Rads	Metals	PGBs	Pesticides	SVOCs	VOCs			
NE-1	East Spray Field-Center Area	216.2	D	73,458	1	1	1	3	1	3	pond water	Biased/Stratified Statistical Grid	
	East Spray Field-South Area	216.3	D	651,580	10	13	3	13	4	13	Spray irrigation from Pond B-3	Biased/Stratified Statistical Grid	
	Pond C-1	142.10	R	33,975	2	2	1	1	2	2	Retention and monitoring pond. Received sanitary sewage discharge and runoff from the 903 Pad Area.	Biased/Stratified Statistical Grid	
	Pond C-2	142.11	R	168,524	3	4	3	3	3	4	Received discharge from the South Interceptor Ditch.	Biased/Stratified Statistical Grid	
	Pond A-1	142.1	R	39,294	4	4	4	4	4	4	Received wastewater effluent from the Industrial Area. Spill control.	Biased/Stratified Statistical Grid	
	Pond A-5	142.12	R	12,256	5	5	5	5	5	5	Received wastewater effluent from the Industrial Area.	Biased/Stratified Statistical Grid	
	Pond A-2	142.2	R	61,373	1	4	4	4	4	4	Received wastewater effluent from the Industrial Area. Spill control.	Biased/Stratified Statistical Grid	
	Pond A-3	142.3	R	122,909	4	5	4	4	4	4	Received wastewater effluent from the Industrial Area.	Biased/Stratified Statistical Grid	
	Pond A-4	142.4	R	254,102	4	4	4	4	4	4	Received wastewater effluent from the Industrial Area.	Biased/Stratified Statistical Grid	
	Pond B-1	142.5		11,396	5	4	5	5	5	5	Flow-through retention pond. Received treated sanitary effluent and process waste.	Biased/Stratified Statistical Grid	
	Pond B-2	142.6		33,761	5	5	5	5	5	5	Flow-through retention pond. Received treated sanitary effluent and process waste.	Biased/Stratified Statistical Grid	
	Pond B-3	142.7		18,422	4	4	4	4	4	4	Flow-through retention pond. Received treated sanitary wastewater effluent discharge.	Biased/Stratified Statistical Grid	
	Pond B-4	142.8	R	11,731	5	5	5	5	5	5	Flow-through retention pond. Received treated sanitary effluent and process waste.	Biased/Stratified Statistical Grid	
	Pond B-5	142.9	R	129,515	5	5	5	7	5	7	Flow-through retention pond. Received treated sanitary effluent and process waste. 18 gallons of diesel released	Biased/Stratified Statistical Grid	
		Diesel Spill at Pond B-2 Spillway	NE-1404	D	356								Biased/Stratified Statistical Grid

Buffer Zone Sampling and Analysis Plan

IHSS Group	Description	ID	NPA Status	Area (ft ²)	Number of Existing Sample Locations						Historical Notes	Preliminary Sampling Methodology
					Rads	Metals	PCBs	Pesticides	SVOCs	VOCs		
NE-2	Trench T-7	111.4		15,565	9	9	1	9	8	9	on the shore	Biased/Stratified Statistical Grid
NE/NW	OU2 Treatment Facility	NE-1407		356							Leaks and spills from process operations.	Biased/Stratified Statistical Grid
	Modular Tanks and 910 Treatment Sys Spill (formerly 000-503)	NE-1409 S		68							Release of 4,700 gallons of RCRA F-listed water.	Biased/Stratified Statistical Grid
	Diesel fuel Spill at field Treatability Unit	NE-1410 P		356							Release of 2-4 gallons of diesel fuel followed by removal action.	Biased/Stratified Statistical Grid
	Diesel Fuel Overflowed from Tanker @ OU2	NE-1411 P		356							Release of 20 gallons of diesel fuel followed by removal action.	Biased/Stratified Statistical Grid
	PU&D Storage Yard	170	D	221,304	37	37	37	39	39	39	Drum and dumpster storage	Geostatistical/Biased
	Trench T-12 Located @ OU2 East Trenches	NE-1412		7,449							Disposal of sanitary waste sludge and flattened drums.	Biased/Stratified Statistical Grid
	Trench T-13 Located @ OU2 East Trenches	NE-1413		5,090							Disposal of sanitary waste sludge and flattened drums.	Biased/Stratified Statistical Grid
	PU&D Yard - Drum Storage	174a		4,342	21	21	21	24	24	24	Leaks and spills from RCRA drum storage.	Geostatistical/Biased
SW-1	Recently Identified Ash Pit	SW-1701	D	11,066							Disposal of combustible waste ash, depleted uranium and metallic debris.	Biased/Stratified Statistical Grid
	Recently Identified Ash Pit	SW-1702		5,588							Disposal of combustible waste ash, depleted uranium and metallic debris.	Biased/Stratified Statistical Grid
	Ash Pit 1	133.1		13,960	4	4					Disposal of combustible waste ash and noncombustible trash.	Biased/Stratified Statistical Grid
	Ash Pit 2	133.2		26,624	7	7					Disposal of combustible waste ash and noncombustible trash.	Biased/Stratified Statistical Grid
	Ash Pit 3	133.3		13,023	3	3					Disposal of combustible waste ash and noncombustible trash.	Biased/Stratified Statistical Grid
	Ash Pit 4	133.4		10,749	3	3					Disposal of combustible waste ash and noncombustible trash.	Biased/Stratified Statistical Grid

D. Buffer Zone Sampling and Analysis Plan

IHSS Group	Description	ID	NFA Status ¹	Area (ft ²)	Number of Existing Sample Locations						Historical Notes	Preliminary Sampling Methodology	
					Rads	Metals	PCBs	Pesticides	SVOCs	VOCs			
	Incinerator	133.5	D	45,495	2	2				1		Area backfilled with ash potentially contaminated with depleted uranium	Biased/Stratified Statistical Grid
	Concrete Wash Pad	133.6	D	35,274	1	1	1	1		1		Deposition of potentially contaminated ash	Biased/Stratified Statistical Grid

¹ No Further Action Status based on Annual Update for the Historical Release Report (DOE 2000a) IHSS and PACs with NFA status identified as Proposed (P) or Resubmitted (S) or Request Additional Data (D) approved by regulators. If approved as NFAs these IHSSs and PACs are excluded from the BZSAP scope.

Surface and subsurface soil sample analytical results will be compared to RFCA Tier I and Tier II ALs. Data from each IHSS and PAC will be evaluated according to DQOs (Section 3.0).

4.5 POST-REMEDATION CONFIRMATION SAMPLING

Post-remediation confirmation sampling will be conducted at AOCs associated with IHSSs and PACs in the BZ. In-process confirmation soil samples will be collected and analyzed during remediation to verify cleanup below remediation goals. In-process samples will be analyzed with field analytical instruments. Post-remediation confirmation samples will also be collected and analyzed. The combination of in-process and confirmation samples will ensure that residual contamination levels are below remediation goals.

4.5.1 Confirmation Sampling and Analysis

Confirmation samples are defined as those samples acquired following a remedial action. The characterization team will conduct confirmation sampling and analysis on remediated areas to verify that the site has met remedial objectives. The confirmation sampling and analysis will provide a representative assessment of the magnitude and spatial configuration of the COC(s) after remediation. The number and distribution of confirmation samples will be based on the probability of detecting residual contamination (90 percent) and the size and spatial variability of the remediated site. Statistical sampling strategies will ensure that the appropriate numbers of samples are collected from unbiased locations.

The characterization team will collect soil from the remediated areas before the areas are covered with clean fill. Confirmation sampling locations will be determined using geostatistical methods or the approach described in Section 4.5.2. Soil samples will be analyzed onsite if appropriate data quality is achieved, or sent to offsite analytical laboratories for analysis, and analytical data will be validated in accordance with ASD requirements. If adequate correlation is demonstrated between field analytical and laboratory analysis data, field instrumentation may also be used for confirmation analysis.

The characterization team will conduct confirmation sampling at all BZ Group remediations during FY02. They will compile and evaluate confirmation sampling data generated during that time to determine whether field analytical data are of sufficient quality to be used for CRA analyses. If the regulatory agencies concur that the field analytical data are of sufficient quality, remediation confirmation samples will be analyzed with field analytical instruments rather than sent to offsite laboratories.

4.5.2 Sampling Locations

A triangular sampling grid, based on the size of an excavation, will be used for the selection of confirmation sampling points. Three grid densities will be used to verify remediation. The origin of the grid will be determined using a randomizing technique to minimize sampling bias.

1. For remediated areas that were contaminated with radionuclides, 90 percent of the area will be scanned using in-situ HPGe techniques within a triangular grid system. Considering an HPGe 11-m diameter field of view with the detector placed 1 m above the soil surface, a grid interval of 11 m (36 ft) will be used to achieve 90 percent coverage. This grid spacing is consistent with the characterization sampling approach.
2. The second approach for defining a grid density will be applicable to areas where nonradiological-contaminated soil was remediated. The grid density for confirmation sampling in nonradiological-contaminated areas will be based on the size of the remediated area (Michigan DNR 1994). This approach is based on a 95% confidence level of determining any hot spot concentrations on a site. Incorporating confirmation sampling will allow for a reduction in the Type I error rate from 0.1 to 0.05, which will reduce the probability of residual contamination after remediation. This approach is designed to delineate nonuniform areas of residual contamination, and is therefore appropriate for reliable characterization of the entire remedial area. Grid density is proportional to the size of the area and can be determined using one of the following equations (Michigan DNR 1994):

Small Remediation Site (0.06 to 0.25 acre): $GI = \frac{\sqrt{A/\pi}}{2}$ (Equation 4-1)

Medium Remediation Site (0.25 to 3.0 acres): $GI = \frac{\sqrt{A/\pi}}{4}$ (Equation 4-2)

Large Remediation Site (> 3.0 acres): $GI = \sqrt{(A * \pi) / SF}$ (Equation 4-3)

Where

GI = grid size

A = size of area of interest

SF = site factor, length of grid area [dimensionless]

As shown above, the grid equations apply to three different size areas. The grid densities vary according to the size of the area of interest.

Table 5 presents several examples of the calculations.

Table 5
Calculation of Confirmation Sampling Location Grids

Equation 4-1	Area (ft²)	A/π	Sq Root	Grid Size (ft²)
Small Site - 0.06 to 0.25 acre (2,614 to 10,890 ft ²)	2,614	832	28	14
	5,000	1,592	39	20
	10,890	3,468	58	29
Equation 4-2				
Medium Site - 0.25 to 3.0 acres (10,890 to 130,680 ft ²)	10,890	3,468	58	15
	50,000	15,923	126	32
	100,000	31,847	178	45
	130,680	41,617	204	51
Equation 4-3	Area (ft²)	A*π	SF	Grid Size (ft²)
Large Site - >3.0 acres (130,680 ft ²)	1,000,000	3,140,000	1,000	56

After the grid size is calculated for a specified area, a randomly located grid overlay will be superimposed on a map of the remediated area. Some grid adjustment may be necessary for unusually shaped areas. For excavations, both the sidewalls and bottom areas will be included in the determination of the area size. A minimum of one sample for each sidewall is required. Sidewall samples will be located in biased areas, if possible.

The systematic grid sampling will be augmented with biased sampling as necessary. Exact locations of biased sampling points will be based on site-specific information (e.g., location of leaks in an underground storage tank or its piping) and physical characteristics of the soil. Some characteristics that may require biased sampling may include, but are not limited to, the following:

- Preferential migration pathways (e.g., burrows, fractures, bedding planes, and sandstone lenses);
 - Source areas (e.g., outfalls, storage areas, and historical spill sites);
 - Stained soil;
 - Changes in soil characteristics (e.g., sand/clay interfaces); and
 - Depressions and ditches.
3. At remediated areas smaller than 0.06 acre (2,614 ft²), a minimum of five locations will be sampled. Locations will include the walls and floor of the remediated area.

4.6 CHARACTERIZATION SAMPLING STRATEGY FOR SURFACE SOIL IN THE OUTER BUFFER ZONE WHITE SPACE AREAS

Surface soil in outer BZ White Space Areas will be sampled and analyzed to provide data for the CRA. The sum of ratio data for COCs from existing and BZ characterization data will be compared to RFCA Tier I and Tier II ALs.

Sampling grid spacing and the number of required samples will be on the EU defined in the CRA Methodology. Specific sampling locations will be described in the appropriate BZSAP Addendum.

Surface soil samples will be collected at the specified locations and depths according to the sample collection methods described in Section 4.8. These samples will be analyzed at an offsite analytical laboratory or with field instruments for radionuclides, metals, and SVOCs. Areas with concentrations above RFCA Tier I and Tier II ALs will be evaluated, according to DQOs (Section 3.0) and methods described in Section 5.0, to determine whether contamination is present.

4.7 FIELD ANALYTICAL APPROACH

The characterization team will use field analytical instruments to detect COCs above RFCA Tier I and Tier II ALs in surface and subsurface soil samples. All analytical instruments will have detection limits below RFCA ALs. Field analytical instruments will be coupled with computer software so that analytical results can be uploaded into statistical and geostatistical programs and the Site database. Field analytical instruments will be field portable where possible or available in an onsite mobile laboratory. For compounds that cannot be analyzed for using field analytical instruments, samples may be sent to offsite laboratories.

All field analytical instruments will be calibrated to determine their relationship with standard laboratory procedures. The sample size (support) investigated with field analytical techniques will be made as close as possible to the support investigated by the laboratory analytical techniques. This calibration and consistency in sample supports will ensure a valid relationship between the concentration/activity values determined by the field analytical techniques and the concentration/activity values determined in the final confirmation sample analyses (Myers 1997, Pitard 1993).

Field analytical instruments, either portable or in a mobile laboratory, may include, but are not limited to, the following:

- Multielement x-ray fluorescence (XRF) spectrum analyzer, laser-induced breakdown spectroscopy (LIBS), and inductively coupled plasma (ICP) spectrometer analysis for metals;
- HPGe for radionuclides; and
- Gas chromatography/mass spectrometry (GC/MS) for VOCs, SVOCs, pesticides, herbicides, and PCBs.

Other field screening analytical instruments, including organic vapor analyzers, Field Instruments for the Detection of Low Energy Radiation (FIDLERs), flame ionization detectors (FIDs), or photoionization detectors (PIDs) may be chosen based on analytical requirements. Additionally, offsite analytical laboratories will be used as necessary for specific analytes or groups of analytes.

4.7.1 Radionuclides

Gamma spectroscopy using an HPGe is the primary means by which the type and quantity of radionuclides in soil will be determined. In general, gamma spectroscopy will be used in lieu of alpha spectroscopy, because gamma spectroscopy provides data of comparable quality and sensitivity in a shorter time. Limited alpha spectroscopy analyses may be performed for verification and validation of gamma spectroscopy methods.

Soil samples will be screened with HPGe to detect areas with radionuclides elevated above Tier II ALs. Gamma spectroscopy methods may be used in at least two ways: in situ and field laboratory. In-situ methods provide field data for two-dimensional measurements (areal), or three-dimensional measurements with very limited depth. Field-of-view depths are typically limited to several centimeters within the soil. Use of in-situ gamma spectrometry to investigate “soils at depth” for confirmation sampling will be based on remediation lifts (i.e., exposed soil surfaces as the lift moves downward or laterally). The exposed soil surfaces will have relatively flat surface geometries that can be accommodated by the gamma-spectrometry measurement system. Where counting times for radionuclides are long and for subsurface samples, samples may be analyzed in the field laboratory. Quality control (QC) specifications for both techniques are presented in the Quality Assurance Project Plan (QAPjP), which is included in Appendix H. These controls will be contractually required of the gamma spectrometry vendor. Detection limits and counting times for radionuclides are specified in the DQOs and Appendices E and H.

4.7.2 Metals

Soil samples will be analyzed to detect the presence of metals using EPA Method 6200, *Field Portable XRF Spectrometry*, or SW 7090 or 7091 or equivalent. Quality controls required for this method are summarized in the QAPjP. Field analytical equipment may include field-portable XRF or LIBS. Specific manufacturers and models will be chosen by the analytical subcontractor, but will be approved by K-H QA personnel. The selected instruments will have detection limits below RFCA ALs as specified in the DQOs. Mobile laboratory and offsite laboratory analyses will use standard fixed-laboratory methods (e.g., SW846).

4.7.3 Organic Compounds

Concentrations of VOCs, SVOCs, pesticides, herbicides, PCBs, and other organics will be measured using a mobile GC or GC/MS in a field or offsite analytical laboratory. Organic analyses will be preceded by an appropriate extraction/digestion method. Preparation and analysis will consist of SW846 methodologies, and will be consistent with existing ASD contractual requirements, with variances listed in the QAPjP. Examples of variances might include abbreviated analytical suites based on the final BZ

PCOC list, as well as abbreviated reporting requirements, where data packages and Electronic Data Deliverables (EDDs) will be streamlined to accelerate decisionmaking in the field. Instrumentation will have detection limits below RFCA ALs as specified in the DQOs.

4.8 SAMPLE COLLECTION

Sample collection requirements and procedures are described in this section. If conditions are encountered during sampling activities that may result in unsafe or inappropriate use of the sampling technique, procedures may be modified or replaced. Modifications or replacements will be justified and detailed in the sampling records, and the resulting data will be comparable and adequate to meet the project DQOs.

4.8.1 Presampling Activities

In preparation for sampling and associated field activities, contamination area (CA), radiological buffer area (RBA), and exclusion zone (EZ) support zones, and all related radiological and H&S postings will be established and identified at each work site in accordance with project-specific H&S protocols and Radiological Safety Procedures (RSPs), as required.

All H&S protocols will be followed in accordance with the requirements specified in the Health and Safety Plan (HASP) for each BZ Group. Drilling and sampling subcontractors will provide a HASP specific to their scope. Each HASP will be developed under the guidance of, and in accordance with, applicable federal, state, local, and Site policies and procedures. Each HASP will identify all personal protective equipment (PPE), training, and air monitoring requirements, as well as all other hazard assessments and controls specific to the work scope and the Site.

Nonintrusive Surveys

Nonintrusive surveys will be conducted to detect structures and debris beneath the soil and building surfaces. These surveys may include ground-penetrating radar (GPR). RFETS Excavation Specialists routinely use GPR and other survey instruments to locate subsurface utilities and structures prior to drilling and in preparation for an Activity Hazards Analysis (AHA).

4.8.2 Surface Soil Sampling

The characterization team will collect surface soil samples in accordance with DQOs and at locations specified in the BZSAP Addenda. Modifications to sampling procedures will be made as field conditions warrant. All modifications will be documented and justified in the final report.

Where required, pre-work radiological surveys will be conducted. Sampling locations will be marked in accordance with OPS-PRO.947, *Location/Surveying*. Location numbers will correspond with sample numbers assigned by ASD (Section 6.0).

The characterization team will collect soil samples from the 0- to 6-inch horizon using grab or hand auger methods. Each sample will be collected using a clean, stainless steel or disposable scoop/trowel or hand auger depending on the sampling location and soil types present. If surface vegetation is present, it will be removed from the sampling location with a decontaminated, stainless steel shovel or appropriate hand tool prior to soil collection. All sample material recovered will be placed into individual sample jars according to OPS-PRO.069, *Containerizing, Preserving, Handling and Shipping of Soil and Water Samples*. The samples will be analyzed, in the field, with field analytical instruments for characterization or in-process post-remediation sampling, or sent to an offsite laboratory for confirmation sampling. Duplicate and equipment rinse QC samples will represent 5 percent of the samples to provide adequate information on sample variability, as defined in Guidance for Data Quality Objective Process (EPA 1994).

All reusable sampling equipment will be decontaminated prior to and between each sampling location with a Liquinox (or Alconox) solution, and rinsed with deionized or distilled water in accordance with 4-S01-ENV-OPS-FO.03, *Field Decontamination Operations* and the project-specific HASP. Other sampling equipment and materials will include standard items such as chain-of-custody seals, forms, and logbooks. Soil descriptions will be recorded in the field, as appropriate.

In areas where the ground surface is covered with pavement or concrete, the characterization team will collect soil samples using grab sampling or hand augering methods. The characterization team will access the soil by removing surface obstructions using a concrete corer, rotary hammer, or other appropriate equipment. Samples will be collected from the soil substrate underlying whatever base materials are beneath the pavement. Samples will then be collected to a depth of 6 inches from the top of the collection zone.

Asphalt and concrete samples will also be collected. These samples will consist of one or more small-diameter (approximately 1- to 2-inch) core plugs. The cores will be collected in sufficient quantities with respect to the required field and/or laboratory analyses. The characterization team will collect core plugs using a rotary-type, concrete coring drill. Wet coring techniques will be used where radiological contamination is suspected to prevent airborne contamination. Residual concrete and drilling water will be handled in accordance with 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging*. Wastes will be managed in accordance with the Draft RFCA Standard Operating Protocol (RSOP) for Asphalt and Soil Management (DOE 2001c), whichever is current.

4.8.3 Subsurface Soil Sampling

The characterization team may use several types of Geoprobess® (Table 7) to collect vertical profile soil samples in areas of interest. Geoprobess® will be used in accordance with Site procedure OPS-PRO.124, *Push Subsurface Soil Sampling*. Soil cores will be recovered continuously to the desired depth in 2-ft increments using a core barrel as specified in this procedure. If the characterization team encounters probe refusal before reaching the target borehole depth, they will abandon the boring using procedure

OPS-PRO.117, *Plugging and Abandonment of Boreholes*, and attempt an offset boring within 3 ft of the original boring. If probe refusal occurs repeatedly, or a much greater depth is required, a truck-mounted, hollow-stem auger drill may be used to complete the boring. Detailed hollow-stem auger drilling and sampling procedures are presented in OPS-PRO.114, *Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques*.

Before advancing boreholes, all locations will be cleared in accordance with OPS-PRO.102, *Borehole Clearing*, and marked in accordance with OPS-PRO.124, *Push Subsurface Soil Sampling*. A prework radiological survey will be conducted.

Soil cores will be recovered continuously (when possible) in 2-ft increments using a 2-inch-diameter (or 2.125-inch-diameter for the dual-wall system) by 24- to 48-inch-long

Table 7
Potential Geoprobe® Models for BZ Characterization

5400

- Standard Geoprobe® unit
- Attaches to the back of most vehicles (vans, pickup trucks, etc.)
- Hydraulics powered by hooking up to vehicle engine

54LT

- Track-mounted, compact, and designed to maneuver within building structures
- 34.5 inches wide, fits through standard 3-foot doorway
- Slightly more powerful than the 5400 model: 20,000 lbs down-force, 27,000 lbs up-force
- Diesel engine

54DT

- Track-mounted
- Designed to maneuver over rough terrain, mud, and tight congested areas; 48 inches wide
- Can maneuver through 10 to 12 inches of standing water
- Angle probing capabilities
- Diesel engine

66DT

- Track-mounted, most powerful model: 34,000 lbs down-force, 46,000 lbs up-force
- 48 inches wide
- Sufficiently powered to probe to deeper depths or through denser materials
- Can also be used to concrete drill and soil auger
- Able to use larger downhole tooling for increased sample volume recoveries
- Diesel engine

All units can collect groundwater samples and use Geoprobe® instrumentation if desired (e.g., soil conductivity and membrane interface probes for logging VOCs in subsurface).

stainless steel- or lexon-lined core barrel. Cores will be monitored following recovery for H&S purposes with a FID or PID, as appropriate, in accordance with OPS-PRO.121, *Soil Gas Sampling and Field Analysis*, and with a FIDLER, in accordance with 3-PRO-112-RSP-02.01.

Samples will be collected from the core in 2-ft increments. The characterization team will analyze the lowest 6 inches of a 2-ft increment using field instrumentation. VOC grab samples from the same interval will be containerized to minimize the amount of headspace within the sample container as actual field and sample recovery conditions permit. Due to the unconsolidated nature of the local soil, gravel recovered with the core may be removed prior to sampling.

For sampling locations beneath building slabs, a rotary-type, wet coring system will be used to initiate boreholes through the slabs. This type of system is useful in containing contamination that may be present within the paint and/or concrete. The corer is held to the floor surface by vacuum pressure supplied by a vacuum pump. The slurry produced by coring will be contained by a slurry collection system used in conjunction with a wet/dry vacuum. Little or no airborne emissions will be produced during coring activities.

Upon the completion of each boring, the characterization team will abandon the borehole in accordance with OPS-PRO.117, *Plugging and Abandonment of Boreholes*.

Equipment will be monitored for radiological contamination during and after sampling activities. All sampling equipment will be decontaminated with a Liquinox (or Alconox) solution, and rinsed with deionized or distilled water, in accordance with 4-S01-ENV-OPS-FO.03, *Field Decontamination Operations*. All other sampling equipment will include standard items such as chain-of-custody seals, forms, and logbooks. Field duplicates will represent 5 percent of the samples to provide adequate information on sample variability, as defined in Guidance for Data Quality Objective Process (EPA 1994), and in accordance with Appendix H.

4.8.4 Horizontal Drilling

The characterization team may elect to use horizontal directional drilling (HDD) and environmental-measurement-while-drilling (EMWD) for characterization of soil beneath buildings. They may use HDD instead of, or with, Geoprobe® drilling to sample soil beneath buildings and building slabs, if UBC is encountered. Drilling and sampling will be conducted in accordance with operating procedures, if the techniques are demonstrated at UBC 123 and Building 886.

HDD sample intervals will be reached using an appropriately sized and equipped horizontal drilling rig in accordance with the subcontractor drilling procedure. The characterization team will collect soil samples at the depths and intervals specified in the appropriate BZSAP Addenda. Every effort will be made to collect an undisturbed sample from the borehole to obtain accurate and representative data from each sampling event.

If EMWD is successfully demonstrated at Building 886 and UBC 123, the levels of gamma-emitting radionuclides within subsurface soil will be continuously monitored and

recorded every 20 seconds with a gamma ray spectrometer (GRS) providing real-time data to operations at the surface. Additional samples may be collected if the downhole GRS indicates elevated radiological conditions, or if visible evidence (staining, odors, etc.) of contamination is present in drill cuttings.

4.8.5 Surveying

The locations of all surface soil sampling and boreholes will be surveyed using a Global Positioning System (GPS) or other surveying instruments. Sampling locations will be surveyed for northing and easting in state planar coordinates and elevation, and will be entered into the BZ database and Soil Water Database (SWD). Using GPS is not possible inside buildings; manual measurements will be collected instead. Sampling location surveying will be conducted in accordance with OPS-PRO.947, *Location/Surveying*.

4.8.6 Equipment Decontamination and Waste Handling

Reusable sampling equipment will be decontaminated in accordance with OPS-FO.03, *Field Decontamination Operations*. Decontamination water generated during sampling will be managed according to OPS-PRO.112, *Handling of Field Decontamination Water*. Horizontal drilling and Geoprobe® rigs and equipment will be decontaminated between locations, and following project completion at the Decontamination Pad in accordance with OPS-PRO.070, *Equipment Decontamination at Decontamination Facilities*.

PPE will be disposed of in accordance with 1-PRO-573-SWODP, *Sanitary Waste Offsite Disposal Procedure*. Residual soil will be handled in accordance with 1-PRO-079-WGI-001, *Wastes Characterization, Generation, and Packaging*. Returned sample media will be managed in accordance with 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging*. In the event that hazardous, low-level, or mixed wastes are generated, project waste generators will package and manage the waste containers in accordance with Site procedures OPS-FO.23, *Management of Soil and Sediment Investigative Derived Materials* or the Asphalt and Soil Management RSOP, whichever is current.

4.9 GROUNDWATER AND INCIDENTAL WATER SAMPLING

4.9.1 Groundwater

Several groundwater contaminant plumes were identified during previous RFI/RIs and Sitewide programs. Groundwater wells, installed to monitor plume extent, are being sampled as part of the compliance monitoring program. When active groundwater wells are located in IHSSs, PACs, or areas being characterized, compliance staff may direct or perform groundwater sampling.

4.9.2 Incidental Water

Incidental water is defined in the IMP as “precipitation, surface water, groundwater, utility water, process water, or wastewater collected in one or more of the following areas:

- Excavation sites, pits, or trenches;

- Secondary containments or berms;
- Valve vaults;
- Electrical vaults;
- Steam pits and other utility pits;
- Utility manholes;
- Other natural or manmade depressions that must be dewatered; or
- Discharges from a fire suppression system that has been breached within a radiological buffer area or a contamination area” (DOE 1999).

If incidental water is encountered during characterization, dewatering of the area may be necessary to maintain a safe working environment. If dewatering of the area is necessary, a temporary sump will be installed to transfer the water into a temporary storage container(s). The water will then be sampled and managed in accordance with the Site’s Incidental Water Program, 1-C91-EPR-SW.01, *Control and Disposition of Incidental Water*.

Incidental water is sampled to determine whether it may be discharged to the environment, or treatment is required. Process knowledge, field pH, appearance, field nitrate, and field conductivity are the initial screening criteria. Compliance staff may direct or perform additional sampling and analysis, when known or suspected contamination is present.

5.0 DATA ANALYSIS PROCEDURES

The characterization team will aggregate and evaluate data generated as part of BZSAP activities in accordance with the BZSAP DQOs. This will include the following:

- Aggregation according to BZSAP DQOs for comparison to RFCA Tier I and Tier II ALs;
- Use of geostatistical or standard statistical techniques to determine whether additional sampling is required to reach specified confidence levels that an IHSS and PAC has been adequately characterized;
- Use of verification sampling techniques to ensure the accuracy of data generated from field instrumentation;
- Use of geostatistical or standard statistical techniques to determine whether RFCA ALs have been exceeded;

- Aggregation of remediation confirmation data according to BZSAP DQOs for comparison to RFCA Tier I and Tier II ALs to determine whether remediation was successful; and
- Aggregation and evaluation according to BZSAP DQOs for use in the CRA.

5.1 VERIFICATION OF FIELD ANALYTICAL DATA

Data generated from field instrumentation will be correlated with analytical laboratory data. The following techniques will verify the accuracy of field analytical data:

1. Evaluation of linear regression based on data developed during the 903 Pad characterization for HPGe correlation (Appendix I);
2. Initial verification study to compare new field analytical instruments to laboratory analytical data;
3. Ongoing verification sampling of field analytical results at a rate of 5 to 10 percent (i.e., 5 to 10 laboratory analytical samples for every 100 field analytical samples); and
4. Confirmation sampling.

5.1.1 Linear Regression Analysis

The QA staff will evaluate the accuracy of HPGe, and other field instrument methods, not only through standard, periodic QC specifications (such as daily source checks and annual full-scale calibrations), but also by regressing field measurements against associated laboratory measurements. Regression analysis provides a means of "normalizing," or standardizing, field measurements to laboratory measurements. The general linear model that relates a response to a set of indefinite variables will be used.

Successful regression analyses of HPGe data have been performed at RFETS, and other DOE sites (DOE 2000b). Regression analysis has also been successfully used in the quantification of metals (Sackett and Martin 1998), and is recommended by EPA to correct for low biases inherent in the field methods.

Optimization of sample homogeneity is a key factor in producing usable field/laboratory correlations (Sackett and Martin 1998), where relatively large and variable grain sizes are thought to cause a low bias (in field methods). Samples will be homogenized and sieved, and each sample will be split for field and laboratory analysis.

A general linear model (Equation 5-1) that relates a response to a set of indefinite variables may be used.

$$y = B_0 + B_1x_1 + B_2x_2 + \dots B_kx_k + E \quad (\text{Equation 5-1})$$

Where:

x_1, x_2, \dots, x_k = independent variables

$B_1, B_2 \dots B_k$ = unknown parameters
 E = random error term

Consistent with calibration curves constructed for laboratory analytical methodologies (EPA SW846), where full-range curves are constituted by four (e.g., metals, SW6010) to five (e.g., VOCs, SW8260) sequentially increasing values, regression analyses will be initiated with a minimum of five values through the measurement range of interest. Additional values will be added to the curves as the project progresses.

Based on previous experience and related publications (Sackett and Martin 1998), a linear relationship is expected between field and laboratory results. Acceptability of a linear regression will be based on a correlation coefficient (R^2) of greater than 0.90, and use of an Analysis of Variance (ANOVA) and corresponding F Test to determine both “goodness-of-fit” and appropriateness of the model. The regression will be rejected if the measurements are too variable or the model is incorrect. If a linear model is inappropriate, a curvilinear regression may be evaluated (including confidence intervals or limits), and if used, will be evaluated using an ANOVA to determine the significance of adding terms to the regression. Polynomial expansion beyond a quadratic is not anticipated for correlating field results with laboratory results.

5.1.2 Initial Verification Study

An initial verification study will be conducted to confirm the accuracy of field analytical equipment. Soil samples will be collocated with field analytical readings and sent to an offsite analytical laboratory for analysis.

The underlying assumption for the verification study is that a linear relationship exists between the laboratory analytical data and field analytical data. The field analytical data may be standardized using the following equation (Gilbert 1987):

$$\bar{x}_{lr} = \bar{x}_A + b(\bar{x}_n - \bar{x}_F) \quad \text{(Equation 5-2)}$$

Where

\bar{x}_{lr} = standardized estimate of μ
 \bar{x}_A = mean of the n laboratory measurements
 b = slope of the estimated linear regression
 \bar{x}_n = mean of the n' field measurements
 \bar{x}_F = mean of the n field measurements

5.1.3 Ongoing Verification

As stated previously, accuracy of several field methods will be evaluated, not only through standard, periodic QC specifications (such as daily source checks and annual full-scale calibrations), but also by regressing field measurements against associated

laboratory measurements. Regression analysis provides a means of normalizing, or standardizing, field measurements to laboratory measurements.

Verification of field analytical methods will continue throughout BZ characterization and remediation activities. The frequency of split samples for the ongoing field analytical equipment verification sampling will be based on the following:

- Initial verification study;
- Results of previous verification; and
- Field duplicate frequency (5 to 10 percent) as discussed in Section 5.1.4.

5.1.4 Verification Sampling

Environmental projects may use a variety of QC samples, depending on the needs and goals of the project. The QC samples could include blanks (e.g., preparation blanks and trip blanks), duplicates, splits, blind performance evaluation (PE) samples, etc. Typically, each type of QC sample has only one use; for example, field duplicates are used to evaluate sampling precision. The QC samples required for the BZ sampling and analysis effort are presented in Appendix H.

To increase efficiency and reliability of the project, one type of QC sample, the duplicate, will serve several purposes:

1. To evaluate sampling precision (its typical use);
2. To confirm that methods are sufficiently comparable with laboratory methods; and
3. As “confirmation samples” to confirm the results in the AOC.

This approach will eliminate the time and cost of performing a separate phase of verification sampling and will be performed in parallel with field sampling and analysis. This approach will be implemented by sending a duplicate sample, after it is analyzed for its first purpose, to the laboratory for verification analysis. The duplicate sample, initially used for field precision purposes, effectively becomes a replicate when used for verification purposes. Acceptable verification will be determined through use of a percent difference value; specifically, this is the laboratory value compared with the normalized field value (i.e., field value based on the regression analysis).

In certain cases where field analytical methods (or onsite laboratories) do not provide adequate quality, such as unacceptable detection limits or field/laboratory correlations, verification sampling must be more aggressive than described above. More rigor could include the original grid spacing and number of samples used for characterization purposes, which consider hot spot size and contaminant boundaries. The term “verification sample,” in the context of the BZSAP, is reserved for those specific samples whose sole purpose is to confirm (or contradict) results of samples already collected. Because of this narrow purpose, the number of samples needed is much less than the previous number of samples required to characterize the site of interest. If an aggressive

design for verification sampling is required, it indicates that characterization sampling (and field analysis), relative to a specific COC and applicable ALs, was inadequate for cleanup decisions.

5.2 TIER I AND TIER II ACTION LEVELS AND DATA EVALUATION

In accordance with the BZSAP DQOs, the extent of contamination must be delineated to RFCA Tier I and Tier II ALs. Designation of hot spots and subsequent remediation and/or closure decisions will be based on comparisons to RFCA Tier I and Tier II ALs. A phased statistical evaluation will be conducted that consists of the following steps:

1. Data aggregation;
2. Comparison of data to Tier I and Tier II ALs;
3. Geostatistical analyses, if appropriate data are available; and
4. EMC (if necessary).

The flow chart presented on Figure 14 displays the steps and decision points used for this phased statistical evaluation. The null (H_0) and alternative (H_a) hypotheses used during the statistical analyses are as follows:

H_0 : Analyte concentrations/activities within the AOC are significantly greater than the Tier I and Tier II ALs.

H_a : Analyte concentrations/activities within the AOC are not significantly greater than the Tier I and Tier II ALs.

5.2.1 Data Aggregation

Data aggregation will be based on media type (e.g., surface or subsurface soil), AOC, and purpose of evaluation (e.g., characterization, confirmation, or CRA). To perform a valid statistical evaluation, data must meet the criteria that all observations are independent but comparable (i.e., collected and analyzed using similar methods). Furthermore, data from various soil horizons need to be aggregated by subgroups before conducting statistical comparisons. These aggregated subgroups must represent a single population characterized by a fixed population mean and variance. Table 8 summarizes the data aggregation and appropriate subdivisions of each group.

**Table 8
Data Aggregation Framework**

Soil Horizon	Depth Interval ¹ (ft)	Subgroups		
		Characterization ²	Confirmation (Excavation Remedy)	CRA
Surface Soil	0.0 to 0.5	Area of Concern	Floor and Sidewalls	Exposure Unit
Subsurface Soil	0.5 to 2.5	Area of Concern		
	2.5 to 4.5	Area of Concern		
	4.5 to 6.5	Area of Concern		
	6.5 to 8.5	Area of Concern		
	8.5 to Bedrock	Area of Concern		

¹ Actual depth intervals will be based on the depth to bedrock contact or depth to water.

² The AOC is based on IHSS, PAC, UBC Site, and White Space Area boundaries as defined by the project team.

The first step in the data evaluation process is to group the data by soil horizons. For example, surface soil samples collected from 0 to 6 inches below ground surface (bgs) will be grouped as a single soil horizon, and subsurface soil samples from 6 to 30 and 30 to 54 inches bgs will be grouped into second and third horizons, respectively, so that each depth interval is grouped as a unique sample population. Although different subsurface soil horizons may have similar geologic and physical properties, the aggregation of distinct soil horizons will conform to remediation excavation techniques. Subsurface soil samples with similar geologic properties may be aggregated into a single group for the CRA.

Data aggregation for remediation confirmation will be based on samples collected within the excavated or remediated area. For excavations, samples from the floor and sidewalls of the excavation will be consolidated into a single subgroup. Data aggregation for the CRA will be based on the size of the EUs (DOE 2000c).

5.2.2 Elevated Measurement Test

Individual measurement values will be compared to corresponding Tier I and Tier II ALs for delineating hot spot areas and making remediation decisions. This elevated measurement test identifies measurements that may normally be overlooked using more robust inferential statistical test procedures. Measurements of a given analyte that are greater than or equal to the elevated measurement value (Tier I or Tier II AL) may indicate potential contamination. However, some Tier I and Tier II ALs may be less than mean background concentrations or activities. Therefore, data will be prescreened to filter out those that are below background levels (mean plus two standard deviations) and MDLs.

5.2.3 Confirmation Samples

The characterization team will evaluate confirmation sampling measurements to determine whether residual soil is clean with respect to remediation goals. Measurements of a given analyte that exceed remediation goals may require additional evaluation.

Flexibility in the decision process includes statistically comparing means of populations to the corresponding ALs.

5.2.4 Spatial Evaluation – Geostatistics

In addition to defining optimal sampling locations for characterization purposes, the characterization team will also use geostatistical analysis to define areas above RFCA ALs. The geostatistical approach incorporates probabilistic and risk-based outcomes relative to the AL thresholds and decision error rates. The geostatistical methodology is an unbiased geostatistical tool that will be used to optimize characterization and remediation within the BZ. Specifically, geostatistical analysis will be used to:

- Optimize the number and locations of characterization samples;
- Develop maps of the areas with concentrations above RFCA ALs at a given level of probability;
- Optimize the number and locations of confirmation samples; and
- Link onsite analysis with sampling to allow near real-time remedial decisions.

Geostatistical Procedures

Geostatistical analysis is a spatial correlation modeling approach that uses several evaluative steps. Descriptions and applications of the SmartSampling geostatistical technique are presented in reports published by SNL (1998), Rautman (1996), and McKenna (1997). The following describes the ordered process of the geostatistical approach:

1. *Exploratory Analysis* - The first step in the geostatistical evaluation is to determine the distribution of the data set by evaluating descriptive statistics and plotting the data on a histogram. Data found to depart from the normal distribution function should be normalized prior to performing the geostatistical evaluation.
2. *Structural Analysis* - Variograms (Myers 1997), which describe the geostatistical spatial correlation between samples, are generated. This procedure defines the spatial variance between data points. Three important parameters defined by the variogram include (1) the range (distance at which samples are spatially correlated), (2) sill (similar to the variance of the data set), and (3) nugget effect (departure from the origin, which indicates microscale sampling variability or imprecision of the data set).
3. *Kriging* - The spatial correlation model derived from the variogram analysis is used in the kriging simulation. Kriging is the process of simulating predicted values in unsampled areas by calculating a weighted least-squares mean of the surrounding data points. The weighted values account for not only the distance between known observations and points of predicted values, but also the correlation of clustered observations. For example, clustered data may provide redundancy and are weighted less than a single observation at an equal distance in a different direction. The kriging

simulations are processed to produce maps defining the spatial distribution of the contaminants and uncertainty in the spatial distribution.

4. *Probability Kriging* - Probability maps that describe the likelihood a contaminant value at any unsampled location exceeds the AL are generated. Probability kriging is based on multiple simulations of the contaminant concentration. The outcome of each simulation reflects the actual observations within the area. The multiple simulations of the concentrations provide the basis for determining the relative uncertainty so that the probability of exceeding a specified threshold value (e.g., RCFA ALs) at any point within the area can be estimated. The simulations are processed to produce maps defining the spatial distribution of the contaminants and the inherent uncertainty in spatial distribution.
5. *Probability Calculation* - The probabilities are calculated from the estimated value from each realization and a cumulative distribution function at each point of estimation is developed. For example, assume 100 realizations are performed for the area of interest. If the threshold value is 10 picocuries per gram (pCi/g) and 20 of the 100 realizations exceed the threshold value at a given point, the probability of exceedance is 20 percent at that point.
6. *Uncertainty Mapping* - A map with optimal locations for additional sampling is developed. These locations are optimized to produce the greatest decrease in the spatial uncertainty of the contaminant distribution with respect to ALs. That is, areas with the greatest uncertainty of exceeding the ALs are identified and targeted for additional sampling and analysis.
7. *Sample Optimization* - Data are collected and added to the geostatistical program.
8. Steps 2 through 5 are repeated as necessary.
9. *Excavation Mapping* - Excavation maps are developed from the probability kriging. These maps are based on the probability of exceeding a specified AL as described in Step 4. An excavation map requires that an acceptable reliability of remediation is determined. This is similar to the process of specifying an acceptable level of false positive errors in the traditional DQO procedure. For example, if the Type I error rate is specified at 10 percent, then all remediation units exceeding 10 percent would be targeted for remediation.

5.3 ELEVATED MEASUREMENT COMPARISON

The EMC (MYAPC 1999) comparison, illustrated on Figure 15, includes an equation that depends on several variables: AL, measured value, size of the hot spot, and size of the AOC. The EMC is applicable to all sample results or hot spots that are above RFCA Tier I or Tier II ALs. In AOCs where all sample results are less than ALs, the EMC is not required. The EMC for nonradionuclides is shown in Equation 5-3. If the EMC is greater than or equal to 1, action is indicated.

(Equation 5-3)

$$\text{If : } \sum_{i=1}^n \left[\frac{95\%UCL_{AOC}}{AL} \right]_i + \sum_{j=1}^n \left[\frac{(\text{SampleResult}_{hs} - 95\%UCL_{AOC})}{\left(\frac{AL * Area_{AOC}}{Area_{hs}} \right)} \right]_j \geq 1 \text{ Then : Action is Indicated}$$

Where

$(95\%UCL)_{AOC}$	=	95% UCL of the mean concentration in the AOC
AL	=	Tier I or Tier II soil AL
$(\text{Sample Result})_{hs}$	=	hot spot sample result
$(Area)_{AOC}$	=	area of the AOC
$(Area)_{hs}$	=	hot spot area (based on the area surrounding the elevated sample result)
i	=	number of COCs
j	=	number of hot spots for a particular COC

The first term “i” of Equation 5-3 will be applied to each COC separately. This term will be used for all observations less than Tier I or Tier II ALs within the AOC. As shown in Equation 5-3, the first term is defined as the ratio of the 95% UCL of the mean to the RFCA Tier I or Tier II AL for the AOC. Observations greater than the ALs will be excluded from the 95% UCL calculations, because this type of censorship will ensure the data set complies with normality assumptions required for calculating the 95% UCL.

The second term “j” of Equation 5-3 will be applied to each sample result that exceeds the RFCA Tier I or Tier II AL separately, so that these results can be evaluated as a function of the hot spot size relative to the AOC and magnitude of the AL. Because human health risks are based on an individual’s exposure across an area, the incremental risk due to a small, elevated COC sample result (hot spot) needs to be determined. The second term of Equation 5-3 is defined as the difference between the 95% UCL of the mean concentration and the sample result divided by the RFCA Tier I or Tier II AL for a given COC. The AL is area-weighted, which is appropriate because exposure to contamination is random across an area.

For radionuclides, an area factor consistent with MARSSIM (EPA 1997) guidance is applied to the AL as shown in Equation 5-4. Radionuclide-specific area factors are based on exposure pathway models, which can be estimated from RESRAD simulations.

(Equation 5-4)

$$\text{If : } \sum_{i=1}^n \left[\frac{95\%UCL_{AOC}}{AL} \right]_i + \sum_{j=1}^n \left[\frac{(\text{SampleResult}_{hs} - 95\%UCL_{AOC})}{(AL * AF)} \right]_j \geq 1 \text{ Then : Action is Indicated}$$

Where

$(95\%UCL)_{AOC}$	=	95% UCL of the mean concentration in the AOC
AL	=	Tier I or Tier II soil AL
$(\text{Sample Result})_{hs}$	=	hot spot sample result
AF	=	area factor (for radionuclides)

i = number of COCs
 j = number of hot spots for a particular COC

The product of Equations 5-3 and 5-4 is the summation of EMCs for all COCs and each hot spot within a given AOC. Results of the equation greater than 1 indicate action may be necessary and results less than 1 indicate action is not necessary. Because the EMC includes an area-weighting component, results for very small hot spots may indicate action is not necessary for very high contaminant concentrations. To reduce this effect, when the concentration of the contaminant at a hot spot is three times the Tier I AL, action is indicated. If the hot spot is remediated, the confirmation sample values will be used in the equation. Using a value of three times the AL as an upper limit for re-evaluation is consistent with RESRAD's release criteria. An example data set (Appendix J) shows how the EMC is applied.

6.0 DATA MANAGEMENT

A variety of data types will be generated during BZ characterization and remediation to support data analysis and reporting requirements. ER will manage in-process field analytical data so that the characterization staff can evaluate these data on a daily basis. All field analytical data will be transferred to ASD for long-term data management. All offsite analytical data will be managed by ASD.

Data generated during BZ characterization and remediation will include, but not be limited to, the following:

- Sampling location data;
- Field parameters (depth, sample interval, field instrument readings, etc);
- Surface and subsurface soil analytical data; and
- Investigative-derived materials data (e.g., stockpiles and drill cuttings).

All data collected during these activities will meet RFETS data quality requirements and project DQOs. BZ investigation data will be used for the following purposes:

- Document BZ investigation activities and decisions;
- Provide final characterization of all residuals left in the BZ;
- Provide data for the CRA; and
- Support the CAD/ROD and post-closure monitoring.

A generalized overview of the BZ investigation environmental data management process is shown on Figure 16. This diagram also identifies where electronic and hard copy data may be located. The majority of data collected will be available electronically and stored in shared data systems accessible to all project team members. Current environmental

data systems are summarized in Table 9. The data systems used to support the BZ investigation are in common RFETS standard platforms to facilitate integration of data and information among media and make data easily available to users.

Table 9
Current Environmental Data Systems at RFETS

Environmental Data System	Software Platform in FY00	Typical Data
Air Database (AIR)	Oracle V8.0	Effluent air, ambient air, meteorology
Soil Water Database (SWD)	Oracle V8.0	Laboratory analytical data for soil, groundwater, surface water, non-WIPP waste, sediment, and miscellaneous media; field parameters for environmental sampling; sampling locations (x/y)
Flow	Oracle V8.0	Surface water flow measurements
Ecology Database (SED)	Access	Ecological species, ecological sampling locations
Administrative Record (AR)	Oracle V8.0	Index of AR documents
Industrial Area Data Analysis Database	Access	Database for IA characterization and remediation data
Waste Environmental Management System	Oracle V.8	Waste drum tracking
Analytical Services Toolkit (AST)/EDDProPlus(BIG EDD)	Access/Oracle V8.0	Laboratory analyses tracking, electronic laboratory analyses (EDD) processing
Geographic Information System (GIS)	ArcInfo V.8	Spatial data coverages for base features (topography, roads, buildings, etc.) and interpreted spatial data for extent of chemical contamination
Integrated Sitewide Environmental Data System (ISEDS)	Internet (regulatory agency access only)	Uninterpreted analytical data (all media), electronic field measurements, interpreted data sets, "residual" data sets
Environmental Data Dynamic Information Exchange (EDDIE)	Internet	Final environmental reports, photos, data summaries, and update information on environmental programs

6.1 DATA MANAGEMENT REQUIREMENTS

Surface and subsurface soil data collected as part of the BZ investigations will be stored in the applicable database listed in Table 9. All data collected and/or information generated as part of the BZ investigation will be managed in accordance with the requirements presented below.

6.1.1 Sample Tracking Information

Laboratory Analytical Sample Tracking

All offsite laboratory analytical samples will be tracked using the Analytical Services Toolkit (AST) or equivalent system, which tracks the entire lifecycle of a sample request and provides a chain-of-custody. Samples will be numbered in accordance with ASD-003, *Identification System for Reports and Samples*.

Field Analytical Sample Tracking

All field analytical samples will be given an AST tracking number that will be used for the entire life cycle of the sample request. The AST tracking number will ensure that data generated during BZ characterization activities will be consistent with AST requirements and formats for transfer to SWD. Samples will be numbered in accordance with ASD-003, *Identification System for Reports and Samples*. Field analytical data will be tracked in the BZ data analysis system and transferred to SWD.

6.1.2 Sampling Locations

Sampling Location Codes and Names

Sampling location codes and names used to support data analysis and Geographic Information System (GIS) analysis will be created following requirements specified in PRO-1058-ASD-005, *Environmental Data Management Procedure*.

Location Spatial Coordinates

Spatial coordinates will be collected at all sampling locations in accordance with OPS-PRO-947, *Location/Surveying*. Final approved coordinates will be stored in the SWD Master Location Table.

6.1.3 Analytical Laboratory Data

Electronic Analytical Data

Offsite laboratory analytical data collected during BZ sampling activities will be processed, subjected to QC review and tracked through EDDPRo Plus, and entered into SWD. Electronic analytical data packages in a portable document format (PDF) file will be managed by K-H ASD according to PRO-1058-ASD-005, *Environmental Data Management Procedure*.

Field Analytical Data

Field analytical data generated from instrument-specific software will be controlled, and data will be backed up daily on an RFETS server to ensure no loss of data occurs prior to transfer to ASD.

Hard Copy Analytical Data

Hard copy laboratory analytical data will be managed according to PRO-1058-ASD-005, *Environmental Data Management Procedure*.

6.1.4 Nonanalytical Field Data

Field Parameter Data

Field parameter data will be entered into the AST Field Event Data Module and stored in SWD in accordance with PRO-1058-ASD-005, *Environmental Data Management Procedure*.

6.1.5 Maps

Geographic Information System Maps

GIS maps will be created using the RFETS GIS. All GIS files will be labeled and stored in the GIS tracking system following GIS Department SOPs. Map presentation will adhere to PRO-1130-ASD-006, *Spatial Data Map Control*.

6.1.6 Samples/Data of Special Significance

Confirmation Soil Sampling/Excavation Boundary Samples

Confirmation/excavation boundary soil samples collected to demonstrate performance will be labeled in SWD in accordance with PRO-1058-ASD-005, *Environmental Data Management Procedure*. Any excavation boundary samples representing material removed from the site will be labeled as no longer representative (NLR) in SWD within 10 days of determination.

No Longer Representative Data

If during BZ activities, data are determined to be NLR of site conditions (i.e., source material has been removed and shipped from the site, or otherwise made not representative), they will be coded NLR in SWD within 10 days of determination in accordance with PRO-1058-ASD-005, *Environmental Data Management Procedure*.

Stockpile Sampling

Where treated or untreated soil has been stockpiled and sampled prior to returning it to an excavated location (put back), any sample results representative of the stockpile and thus the returned soil, will be labeled with the appropriate final location in SWD.

Waste

All waste sample analyses and waste drums are tracked through the Waste and Environmental Management System (WEMS).

6.1.7 Final Decision Documents, Reports, and Data Sets

Final Reports – Electronic Version

All final reports and/or decision documents will be provided in electronic format to the RFETS Environmental Data Dynamic Information Exchange (EDDIE) Web site for dissemination to the public.

Final Reports – Hard Copy

All final reports and/or decision documents will be provided in hard copy to the CERCLA Administrative Record (AR) staff for inclusion into the RFETS AR.

Interpreted Report Data

The BZ investigation will generate sets of subject matter expert (SME)-interpreted data to document decisions. These data sets will be created using RFETS standard software (such as Microsoft Excel, ArcInfo, or Microsoft Access) and will be stored electronically on the Integrated Sitewide Environmental Data System (ISEDS) Web site. Files will be clearly labeled to identify project and data set, and a text file describing the data set will be created and stored on the ISEDS site. Interpreted data sets will be provided to ISEDS within 10 days of submission of final approved report or decision document.

6.1.8 Field Analytical Data Management

Field analytical data generated during BZ sampling activities will be managed so that data are easily configured and transferred to the appropriate Site databases. Field analytical data will be generated by several field instruments (Section 4.7). All field instrumentation will be equipped with instrument-specific software that will record and report all relevant environmental and QC data generated. Field measurements will be downloaded daily, or at the end of the sampling event if it is less than 1 day. Data will be configured for the following uses:

- ER data evaluation according to DQOs;
- Geostatistical analysis;
- AST; and
- SWD.

6.1.9 Environmental Restoration Data Evaluation

The ER data evaluation will include the following information for samples collected in each IHSS and PAC:

- Location code;
- Project identification;

- Sample date;
- X-coordinate (latitude);
- Y-coordinate (longitude);
- Elevation;
- Depth interval;
- Soil horizon;
- Sample type;
- Analyte;
- Results;
- Result units;
- Detection limit;
- Dilution factor (if applicable); and
- QC partners.

Geostatistical Evaluation

Geostatistical evaluation will include the following information:

- Location code;
- X-coordinate (latitude);
- Y-coordinate (longitude);
- Elevation;
- Depth interval;
- Soil horizon;
- Sample type; and
- Sum of ratios per location code for radionuclides and nonradionuclides relative to Tier I and Tier II ALs.

6.1.10 Field Instrument Data Definition

EDDs will be produced for all field sampling events through the Remedial Action Decision Management System (RADMS). EDDs will be consistent with ASD EDDs, but may include additional fields relevant only to the BZSAP DQOs. If these additional fields are of archival value for future Site needs, SWD will be modified to accommodate the additional information.

Files will be in space delimited text format that is easily portable to Microsoft Access or Microsoft Excel. The format may vary from the template displayed below; however, all records will include, at a minimum, the fields specified in Table 10.

6.1.11 Sample Handling and Documentation

Soil samples will be handled and containerized according to OPS-PRO.069, *Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples*. Transferring and shipping samples will be performed according to PRO-908-ASD-004, *On-Site Transfer and Off-Site Shipment of Samples*.

Samples sent offsite for analysis will require evaluation under 49 Code of Federal Regulations (CFR) 173, the U.S. Department of Transportation (DOT) radioactive materials criteria of 2,000 pCi/g total radioactivity. If radiological screening indicates levels above this threshold, samples may be analyzed onsite or transported to offsite laboratories in accordance with hazardous materials transportation shipping requirements. DOT radiological screening samples will be collected and assigned a unique sample designation as described in Section 6.1.12. In addition, radiological screening samples collected under the BZSAP will be sufficient to support DOT shipping and offsite laboratory license requirements.

6.1.12 Sample Numbering

Unique sample numbers will be generated for each BZ Group sampling effort. A report identification number (RIN) will be generated through the AST system. The unique sample number consists of the RIN, event number, and, if necessary, a bottle number. The event number is the sampling event at a given location and time. The bottle number is the numbers for bottles for multiple analyses from the same event.

**Table 10
Electronic Digital Data Format**

Field Type	Field Name	Description	Definition
	LAB_CODE	Laboratory Code	Coded value identifying the analytical laboratory
project-specific	PROJECT_ID	Project Name	Project description/unique identification
project-specific	CUST_SAMP_NUM	Customer Sample Number	Text field used by the sample team that identifies the sample
	LAB_SAMPLE_NUM	Laboratory Sample Number	Laboratory's unique sample identifier, assigned by the laboratory
	LAB_SAMPLE_RECEIPT_DATE	Laboratory Sample Receipt Date	Date laboratory received the sample
	LAB_BATCH_ID	Laboratory Batch ID	Laboratory's unique numerical identifier relating a group of samples to a given laboratory batch
	SAMPLE_VOLUME	Sample Volume	Volumetric amount of sample for analysis
	SAMPLE_VOLUME_UNIT_CODE	Sample Volume Unit Code	Coded value representing the volumetric units
	ALIQUOT	Aliquot Size	Volume or mass of aliquot analyzed
	ALIQUOT_UNITS	Units of Measure for the Aliquot	Units of measure for the volume or mass of the aliquot
	EXTR_METH_CODE	Code Denoting an Approved Sample preparation/extraction method	Specific laboratory preparation or extraction procedure used to digest the sample prior to analysis
	ANAL_METH_NAME	Name of the approved test method	Specific laboratory test methods used to analyze the sample
	% MOISTURE	Percent moisture	Mass percentage of moisture in the sample; allows correction of result to dry weight basis
	LAB_EXTRACTION_DATE	Laboratory Extraction Date	Date the sample was extracted
	LAB_EXTRACTION_TIME	Laboratory Extraction Time	Time the sample was extracted
	LAB_ANALYSIS_DATE	Laboratory Analysis Date	Date of analysis
	LAB_ANALYSIS_TIME	Laboratory Analysis Time	Time of analysis
	INSTRUMENT_ID	Identification of Instrument	Unique ID number of the measurement system used to measure the sample
	CAS_NO	CAS Number	Code that identifies the analyte tested
	ANALYTE_NAME	Analyte Name	Name of the analyte
	RESULT	The measured numerical analytical result	Analytical numeric result
	SIG_FIGS	Significant Figures	Number of significant figures for the result
	UNIT_CODE	Unit Code	Units used at the laboratory
	RESULT_TYPE_CODE	Result Type	Coded value identifying the type of sample, including all QC types (target, matrix spike, etc.)

Best Available Copy

Differential Buffer Zone Sampling and Analysis Plan

Field Type	Field Name	Description	Definition
	DETECTION_LIMIT	Detection Limit	Numeric value representing the MDL or minimum detectable activity with same units as result
	DETECTION_LIMIT_TYPE_CODE	Detection Limit Type Code	Coded value indicating which detection limit was used (MDL, instrument detection, etc.)
	BASIS	Wet or Dry Basis	Mass basis for reported concentration of a solid sample; typically, results are reported on a dry basis
	DILUTION_FACTOR	Serial Dilution Factor	Numeric factor when a sample was diluted prior to analysis
	RESULT_SEQUENCE_ID	Result Sequence Identifier	Unique record-level sequential identifier for the datum
	COMMENTS	Comment	Any comment that relates to the record
	SPIKE_AMOUNT	Amount of spike concentration or reference standard value	Spike concentration of analyte or activity value for radioactive standards
	%_RECOVERY	Percent recovery	Measured recovery, expressed as percentage, of a spike or reference standard value
	LCL	Lower Control Limit	Lower control limit on a measurement relative to a spike or reference standard amount
	UCL	Upper Control Limit	Upper control limit on a measurement relative to a spike or reference standard amount
	RPD	Relative Percent Difference	Relative percent difference between an original sample and its corresponding duplicate or replicate sample
	LAB_RESULT_QUALIFIER_CODES	Laboratory Result Qualifier Codes	Coded value indicating a laboratory qualifier or flag
	VALIDATION_QUALIFIER_CODE	Validation Qualifier Code	Coded value representing the validation qualifier or flag
	VALIDATION_REASON_CODES	Validation Reason Codes	Numeric value describing the reason for the validation qualifier
	VALIDATION_DATE	Validation Date	Date validation was performed on the laboratory batch
	COUNT_TIME	Counting time for radioactivity	Amount of time, in minutes, that sample was counted; for radiological measurements only
	DETECTOR_EFF	Detector Efficiency	Efficiency of the detector used for radiological measurement of the sample; unitless
	BACKGROUND	Radiological Background	Numerical background value
	CHEM_YIELD	Chemical Yield	Chemical yield of the tracer (radiometric) or carrier (gravimetric)
	BKGRD_UNITS	Background Units of Measure	Unit of measure for radiological background values, typically in pCi/g
	DUPLICATE_EQUIVALENCY	Duplicate Equivalency	Measure of precision using duplicate samples
	COUNT_ERROR	Counting Error	Measure of random error in the measurement based on the stochastic nature of radioactive decay
	TOTAL_ERROR	Total Error	Total error of the measurement, which includes random (e.g., counting) and systematic error

Note: All parameter fields are left-justified and padded to the right with blanks. File Name field may be omitted if all records are provided as one file.

The unique sample number format is presented below.

Format: YYNXXXX-EVT.BOT
RIN, seven digits, three parts YYNXXXX
YY= FY
N= use code
XXXX = sequential number

Each sample will be assigned a unique number in accordance with procedure, ASD-003, *Identification System for Reports and Samples*. The RIN is used by ASD to track and file analytical data and will be designated by ASD prior to sampling activities. The unique sample number is broken down into the following three parts:

- RIN;
- Event number; and
- Bottle number.

As presented above, the RIN is a seven-digit alphanumeric code starting with the FY (e.g., "00" for the year 2000). The RIN is followed by a dash, and then by the event number. The event number is a three-digit code, starting with "001" under the RIN, and is sequential. Each typical sampling location will have a unique event number under the RIN. QC samples will have unique event numbers to support a "blind" submittal to the analytical laboratories. The event number will be followed by a period, and then by the sequential bottle number. The bottle number is a three-digit sequential code, starting with "001," and is used to identify individual sample containers collected at the same location and same event number.

In addition to the sample numbering scheme above, additional information will be collected with respect to each sample and recorded on the project logsheets. This includes:

- Sample type; and
- QC code.

QC codes will include the following, as appropriate:

- REAL: regular sample; and
- DUP: duplicate sample.

A sample number will also be assigned to each sample collected for internal sample tracking. The block of sample numbers will be of sufficient size to include the entire number of possible samples (including QA samples) and location codes. In preparation for the final report, the ASD and project sample numbers will be cross-referenced with location codes.

6.2 REMEDIAL ACTION DECISION MANAGEMENT SYSTEM

The ER RADMS is a system that generates, verifies, validates, and delivers environmental data products to ER staff in complete and timely maps and reports in conformance with requirements described in Section 6.1. The ER RADMS is a tool for accessing and evaluating environmental data produced within 24 to 48 hours of sample analysis (coupled with historical data as needed), during both characterization and remediation activities. Figure 17 illustrates the general data flow and system configuration.

Detailed specifications of the ER RADMS are described in the data management plan, which describes data generation, aggregation, QC, archival, and access policies. Field and analytical data is organized in Microsoft Access and linked with a GIS, specifically ArcView, to provide users with contaminant data by geographic location and the ability to perform spatial analyses as needed. The ER RADMS will interface with existing site databases, including ASD and SWD, to ensure data consistency and retrievability.

The ER staff will use RADMS to:

- Evaluate analytical data;
- Track environmental samples and maintain chain-of-custody;
- Assess the quality of analytical results;
- Determine characterization sampling locations;
- Determine remediation areas;
- Determine confirmation sampling locations;
- Estimate risk from residual contamination;
- Track closure of RCRA units;
- Track waste volumes and composition; and,
- Produce reports.

Additionally, RADMS will be available to CDPHE and EPA. ER staff will work interactively with the regulatory agencies to:

- View existing data;
- Determine proposed characterization sampling locations;
- Determine remediation areas;
- Determine confirmation sampling locations; and,

- Accelerate the review and approval process by working with virtual data and graphics prior to submittal of Closeout Reports.

The RADMS includes several modules customized for ER program requirements. The modules include the following:

- Sample tracking;
- Data analysis
 - Data verification and validation
 - Spatial analysis (contaminant-concentration isopleths)
 - Risk screen;
- RCRA closure;
- Waste management; and
- Reporting.

6.2.1 Sample Tracking

All characterization and remediation samples will be tracked through the RADMS field data collection management module. Sample tracking will be keyed to the ASD sample numbering system, and will include a variety of field parameters (e.g., those currently required by ASD, as well as sample depth, test method, collection time, and field QC information). Chain-of-custody forms and sample labels may also be printed from this module.

6.2.2 Data Analysis

Data will be analyzed through several different modules as described below. Routine statistical, verification and validation, and spatial analysis will be automated. The algorithms and data analysis sequences are consistent with project DQOs (Section 3.1.1 and data evaluation (Section 5.0). Data analysis will be performed with verified and validated data after characterization sampling is complete, and again after remediation confirmation sampling.

6.2.3 Verification and Validation

All data collected during ER characterization and remediation sampling will be verified and validated according to QA requirements. Verification will consist of ensuring that all data received from the analytical vendor(s) are complete and correctly formatted. Validation will consist of a systematic comparison of all QC requirements with results reported by the vendor (e.g., relative to laboratory control samples [LCSs], matrix spikes [MSs], matrix-spike duplicates [MSDs], and blanks). The verification and validation

process will establish usability of the data by determining, reporting, and archiving the following criteria relative to each measurement set or batch:

- Precision;
- Accuracy;
- Bias;
- Sensitivity; and,
- Completeness.

6.2.4 Spatial Analysis

Several data aggregation and evaluation options will be available in the spatial analysis module, including inverse distance weighting (IDW), kriging, Monte Carlo simulations, and other geostatistical techniques. Spatial analysis will allow determination of contaminant-concentration boundaries as defined by RFCA Tier I, Tier II, and background values. This analysis will also be used to determine additional sampling locations, remediation areas, and associated confidences in the values/decisions.

6.2.5 Risk Screen

The risk screening module is used to determine whether human health risks are acceptable in remediated areas. Algorithms in the risk screening module are consistent with DQOs in the Draft CRA (DOE 2000c) and the BZSAP. The risk screening module includes estimation of external and internal exposures on an BZ Group basis

6.2.6 RCRA Closure

The RCRA closure module allows a user to archive all pertinent location, analytical, and remediation information about RCRA units. This will be used to track closure of sections of the OPWL and NPWL.

6.2.7 Waste Management

Location, volume, characteristics, classification, and container type will be tracked for all ER remediation waste, and will allow links with other RFETS waste management databases.

6.2.8 Reporting

RADMS is configured to produce reports from all of the customized modules. Hardcopy reports will typically consist of data tables (queries), isopleth maps (e.g., Tier I, Tier II, and background concentration boundaries, and risk), and combinations of tables and maps tailored to specific needs. Hardcopy reports will be minimized through the routine use of desktop "workstations" dedicated to specific locations and/or personnel within the project, DOE, EPA, and CDPHE.

7.0 PROJECT ORGANIZATION

The overall BZ project organization is shown on Figure 18 and the general BZ Group characterization project organization is shown on Figure 19.

The overall BZ project organization is designed to provide support to the project manager by ensuring the various support functions are consistent across the BZ characterization program and available to the project. These support functions will include, but not necessarily be limited to, the following:

- H&S;
- QA;
- Field instrumentation and mobile laboratory services;
- Data configuration;
- Data analysis procedures;
- Interactions with ASD and SWD;
- Data management; and
- Reporting procedures.

The BZ Group characterization organization shown on Figure 19 illustrates the characterization team functions. Individuals assigned to each specific BZ Group characterization will be identified in the appropriate BZSAP Addenda.

8.0 QUALITY ASSURANCE AND QUALITY CONTROL

QA requirements defined in this BZSAP are consistent with quality requirements as defined in DOE (Order 414.1A, *Quality Assurance*) and EPA (QA/R-5, EPA *Requirements for Quality Assurance Project Plans*) (EPA 1999b). These requirements are also consistent with RFETS-specific quality requirements as described in the Kaiser-Hill Team *Quality Assurance Program*, PADC-1996-00051 (K-H 1999).

The applicable QC categories include the following:

Management

- Quality Program;
- Training;
- Quality Improvement;
- Documents/Records;

Performance

- Work Processes;
- Design;
- Procurement;
- Inspection/Acceptance Testing;

Assessments

- Management Assessments; and
- Independent Assessments.

The QAPJP (Appendix H) discusses in detail how these criteria will be implemented. The project manager will be in direct contact with the QA manager to identify and correct potential quality-affecting issues. Oversight of field sampling and analysis will be conducted to ensure data comply with quality requirements. The confidence levels of the data will be maintained by the collection of QC samples and implementation of the DQO process.

Data verification and validation will be performed according to ASD procedures. Analytical laboratories supporting this task undergo annual technical and QA audits performed by ASD.

Data quality will be measured in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. Data collected during BZ sampling activities will be evaluated using the PARCC parameters (Appendix H). Measurement sensitivity and bias will also be addressed.

9.0 HEALTH AND SAFETY

All necessary H&S protocols will be followed in accordance with the specifications in the BZSAP Addenda and Integrated Work Control Program (IWCP), as appropriate. In addition, work will be conducted under Radiological Work Permits (RWPs), as applicable. A readiness review will be conducted before the start of fieldwork for all BZ Groups. The BZSAP Addenda will include H&S requirements for the specific PCOCs, hazards, and emergency response protocols associated with the BZ activities.

The Occupational Safety and Health Administration (OSHA) construction standard for Hazardous Waste Operations and Emergency Response, 29 CFR 1926.65, is followed at RFETS. Under this standard, a H&S plan that addresses the safety and health hazards of each phase of the project and specifies the requirements and procedures for employee protection will be developed. In addition, the DOE Order for Construction Project Safety and Health Management, 5480.9A, applies to this project. This order requires the preparation of AHAs to identify each task, hazards associated with each task, and

cautions necessary to mitigate the hazards. These requirements will be integrated wherever appropriate.

BZSAP activities could expose workers to physical, chemical, and low levels of radiological hazards. Physical hazards include those associated with excavation activities, drilling, use of heavy equipment, noise, heat stress, cold stress, and work on uneven surfaces. Physical hazards will be mitigated by appropriate use of PPE, engineering, and administrative controls. Chemical hazards will be mitigated by use of PPE and administrative controls. Appropriate skin and respiratory PPE will be worn throughout the project.

VOC monitoring will be conducted with an organic vapor monitor for any employees who must work near suspected VOC-contaminated soil (e.g., soil sampling or excavation personnel). Based on employee exposure evaluations, the Site H&S officer may downgrade PPE requirements, if appropriate.

H&S data and controls will be continually evaluated. Field radiological screening will be conducted using radiological instruments appropriate to detect surface contamination and airborne radioactivity. As stated in 10 CFR 835, Radiation Protection of Occupational Workers, all applicable implementing procedures will be followed to ensure protection of workers. Dust minimization techniques will be used to minimize suspension of contaminated soil.

10.0 SCHEDULE

The schedule for characterization of the BZ Groups is shown on Figure 20. This figure illustrates the 2005 Working Schedule for RFETS Closure, but may change based on the decommissioning schedule and characterization acceleration opportunities.

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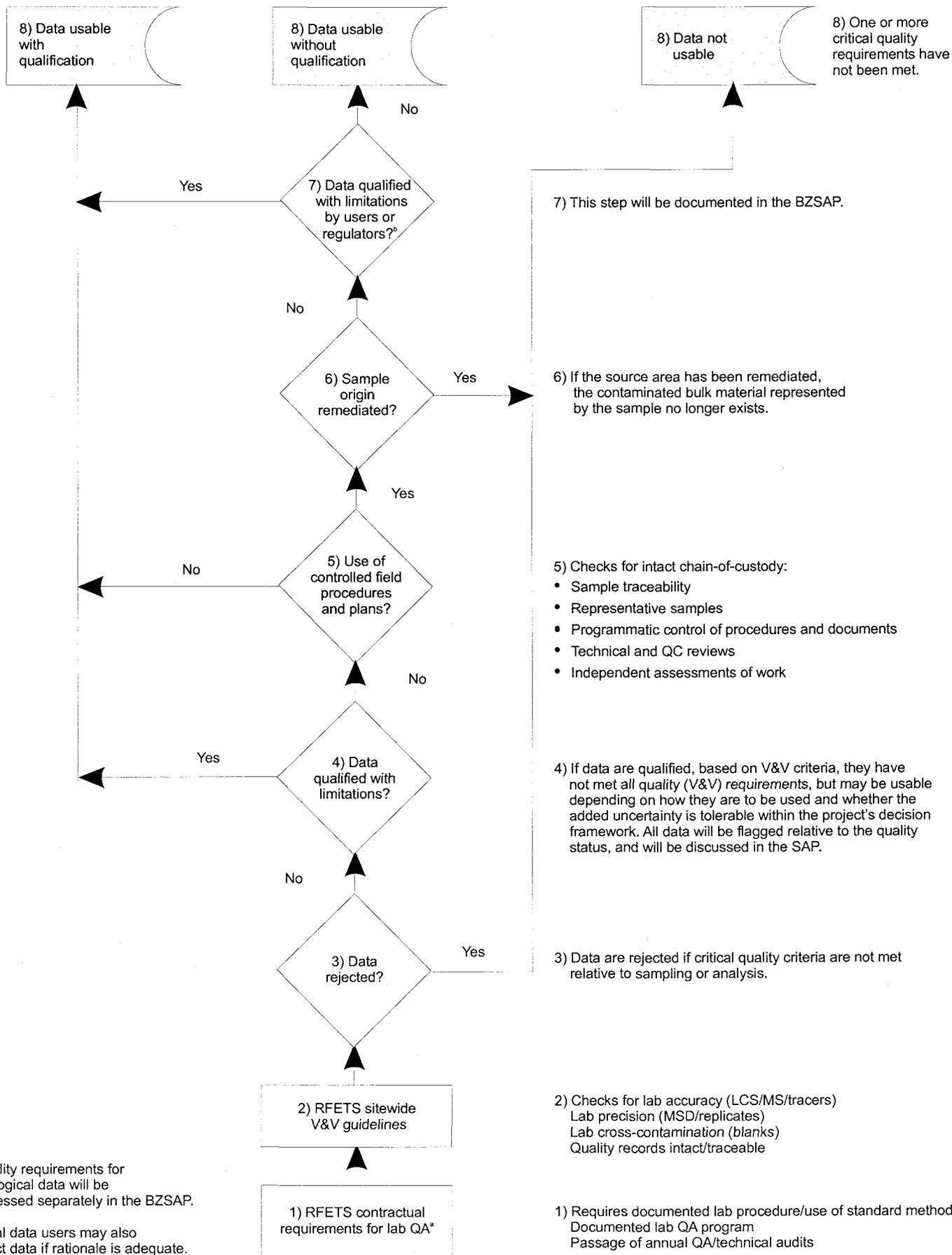
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LIST OF APPLICABLE STANDARD OPERATING PROCEDURES

<u>Identification Number</u>	<u>Procedure Title</u>
1-C91-EPR-SW.01	<i>Control and Disposition of Incidental Waters</i>
1-PRO-079-WGI-001	<i>Waste Characterization, Generation, and Packaging</i>
1-PRO-573-SWODP	<i>Sanitary Waste Offsite Disposal Procedure</i>
3-PRO-112-RSP-02.01	<i>Radiological Instrumentation</i>
4-S01-ENV-OPS-FO.03	<i>Field Decontamination Operations</i>
ASD-003	<i>Identification System for Reports and Samples</i>
OPS-PRO.069	<i>Containerizing, Preserving, Handling and Shipping of Soil and Water Samples</i>
OPS-PRO.070	<i>Equipment Decontamination at Decontamination Facilities</i>
OPS-PRO.102	<i>Borehole Clearing</i>
OPS-PRO.112	<i>Handling of Field Decontamination Water</i>
OPS-PRO.114	<i>Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques</i>
OPS-PRO.117	<i>Plugging and Abandonment of Boreholes</i>
OPS-PRO.121	<i>Soil Gas Sampling and Field Analysis</i>
OPS-PRO.124	<i>Push Subsurface Soil Sampling</i>
OPS-PRO-947	<i>Location/Surveying</i>
PRO-1058-ASD-005	<i>Environmental Data Management Procedure</i>
PRO-1130-ASD-006	<i>Spatial Data Map Control</i>
PRO-908-ASD-004	<i>On-Site Transfer and Off-Site Shipment of Samples</i>
RF/RMRS-98-200	<i>Evaluation of Data for Usability in Final Reports</i>

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**Figure 3
Data Quality Filter for the Buffer Zone Sampling
and Analysis Plan**



* Quality requirements for ecological data will be addressed separately in the BZSAP.

* Final data users may also reject data if rationale is adequate.

Figure 7

Comprehensive Risk Assessment Sampling Data Quality Assessment Logic Flow Diagram

Decision: Determine Whether Each COC and its Nature and Extent within IHSSs and PACs and associated AOCs and White Space Areas Have Been Identified With Adequate Confidence?

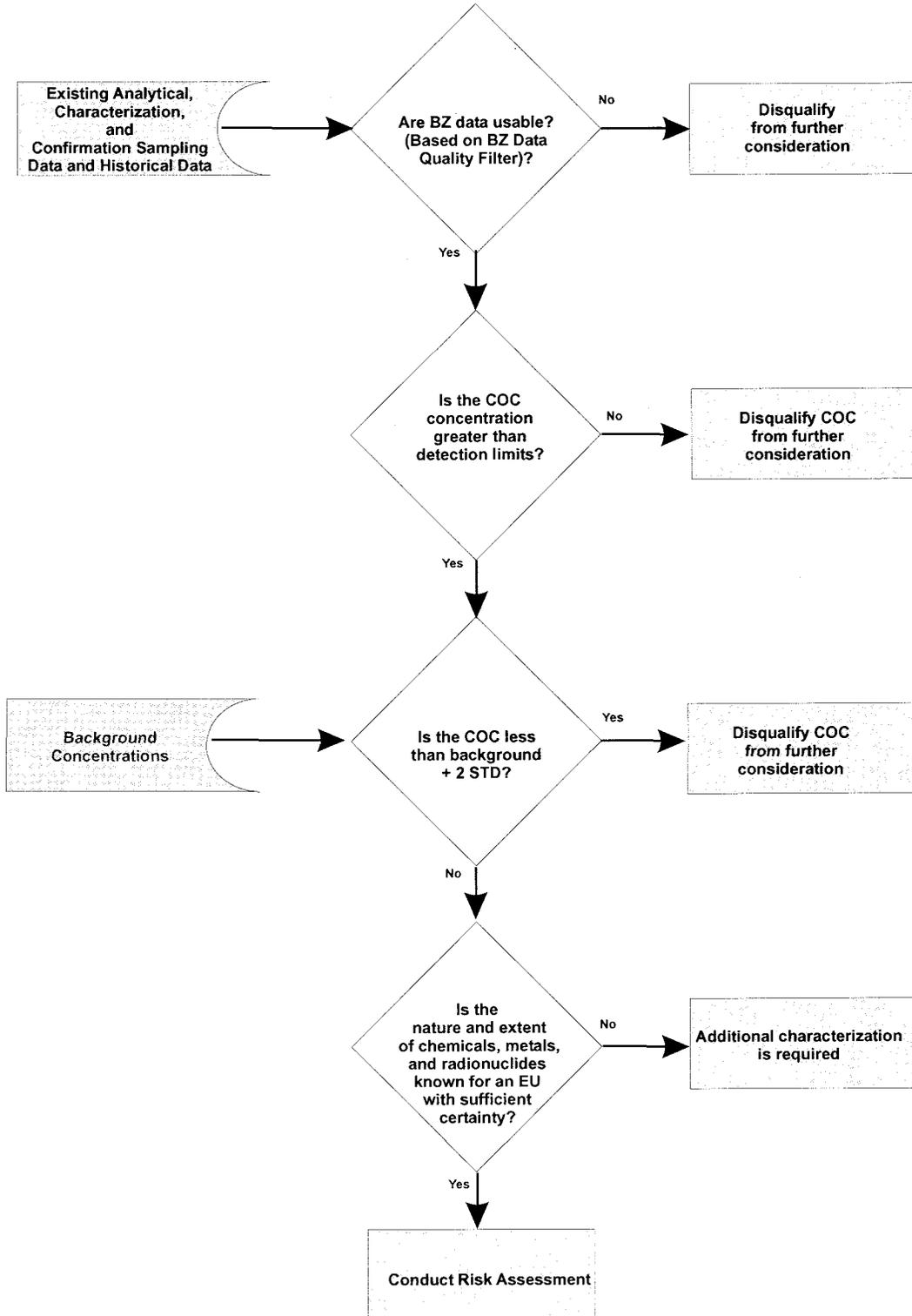


Figure 9
Buffer Zone Sampling and Analysis Plan
Geostatistical Process for IHSSs and PACs

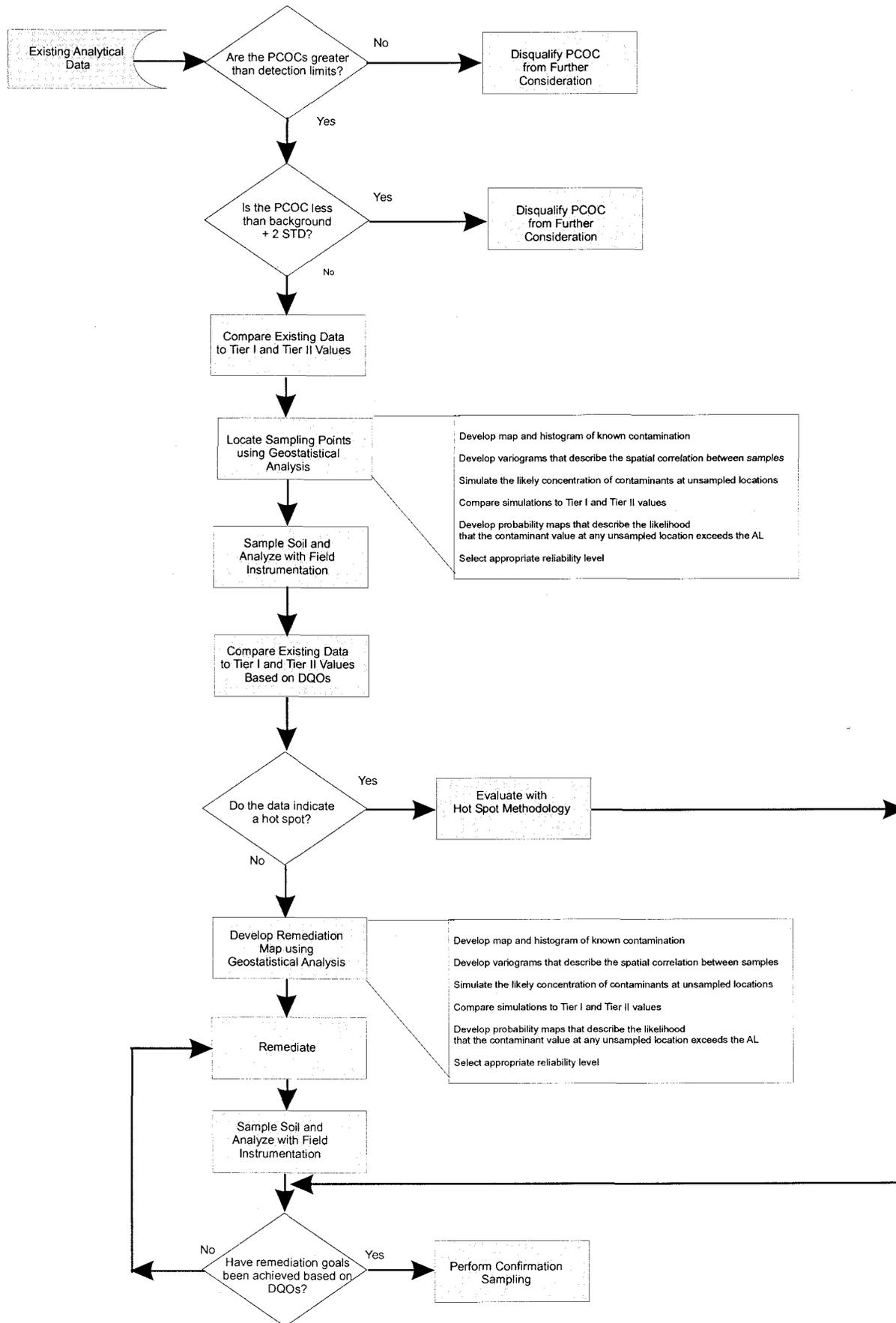


Figure 10
Buffer Zone Sampling and Analysis Plan
Standard Statistical Sampling Process
for IHSSs and PACs

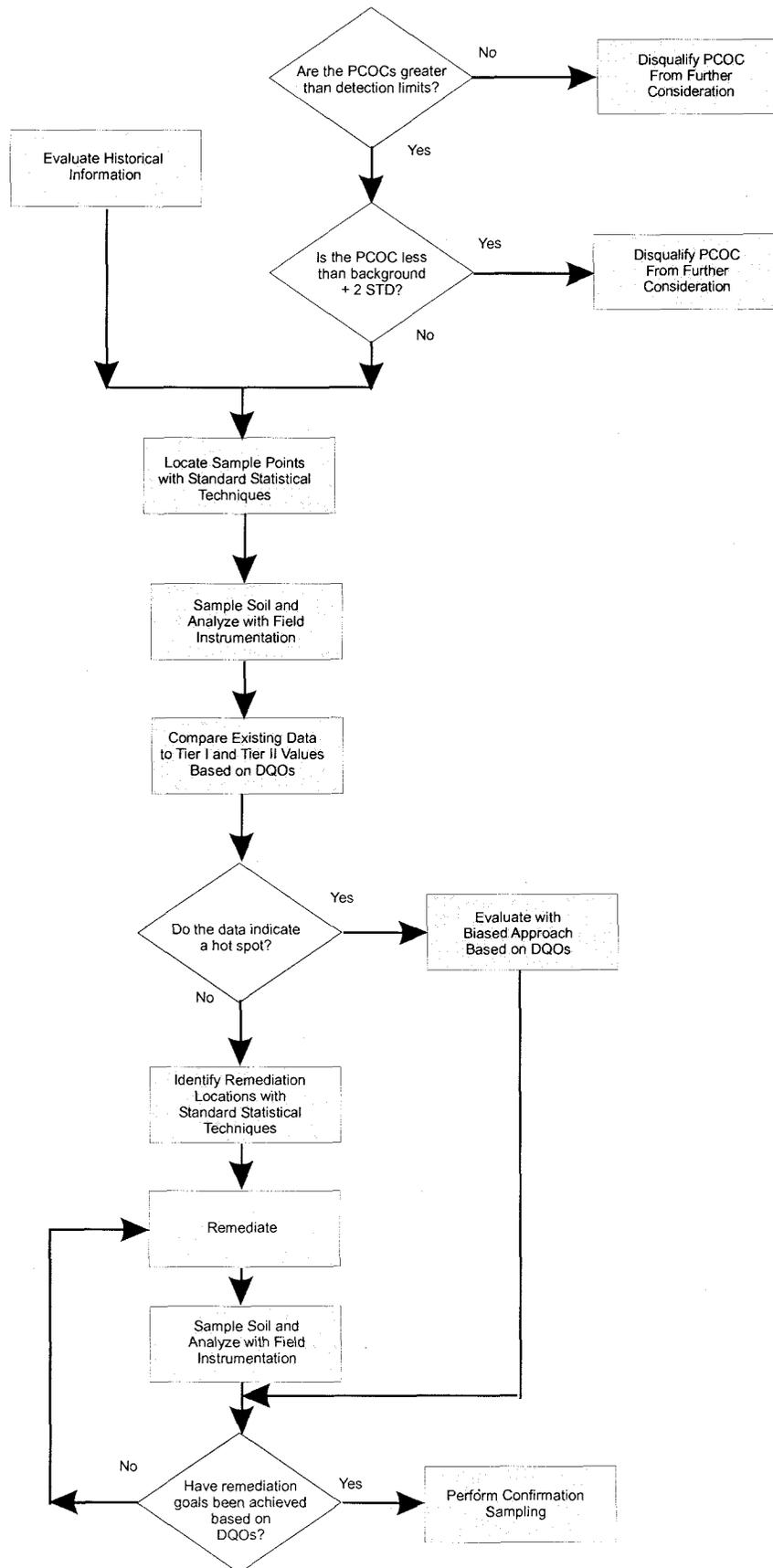


Figure 12
Buffer Zone Sampling and Analysis Plan
Biased Sampling Process
for IHSSs and PACs

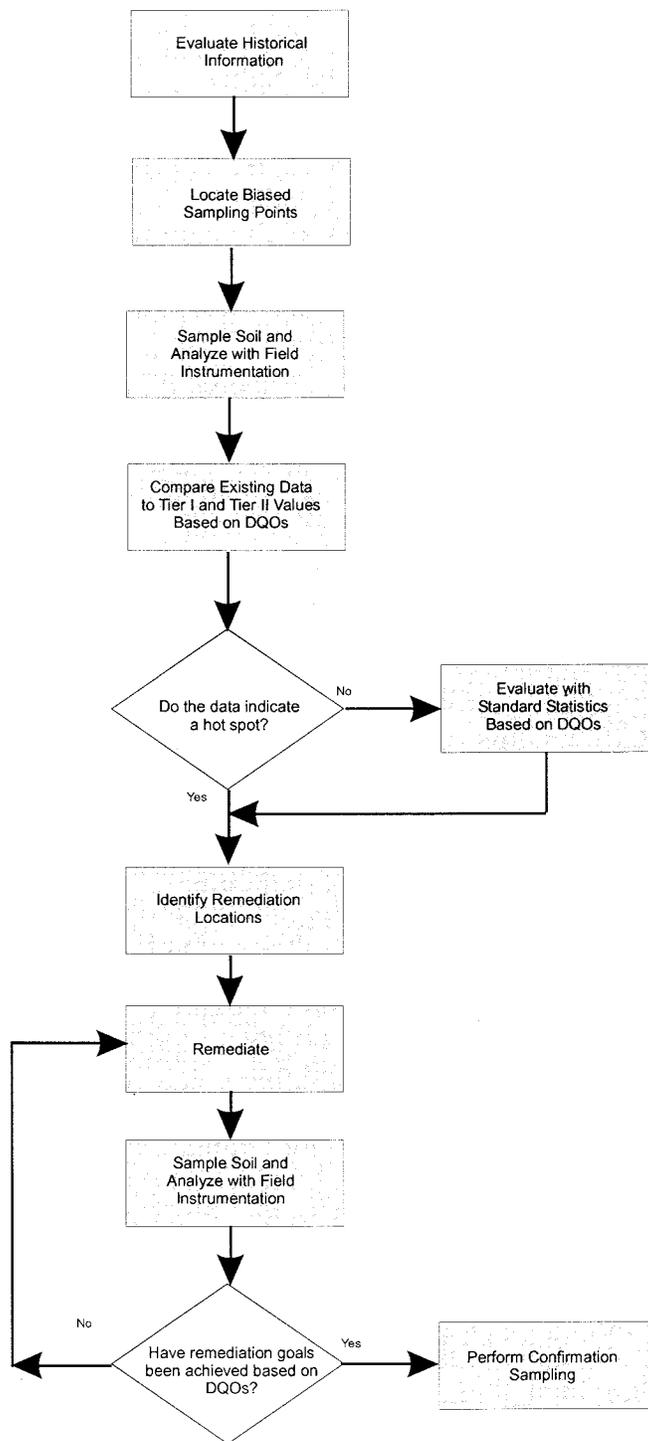


Figure 16

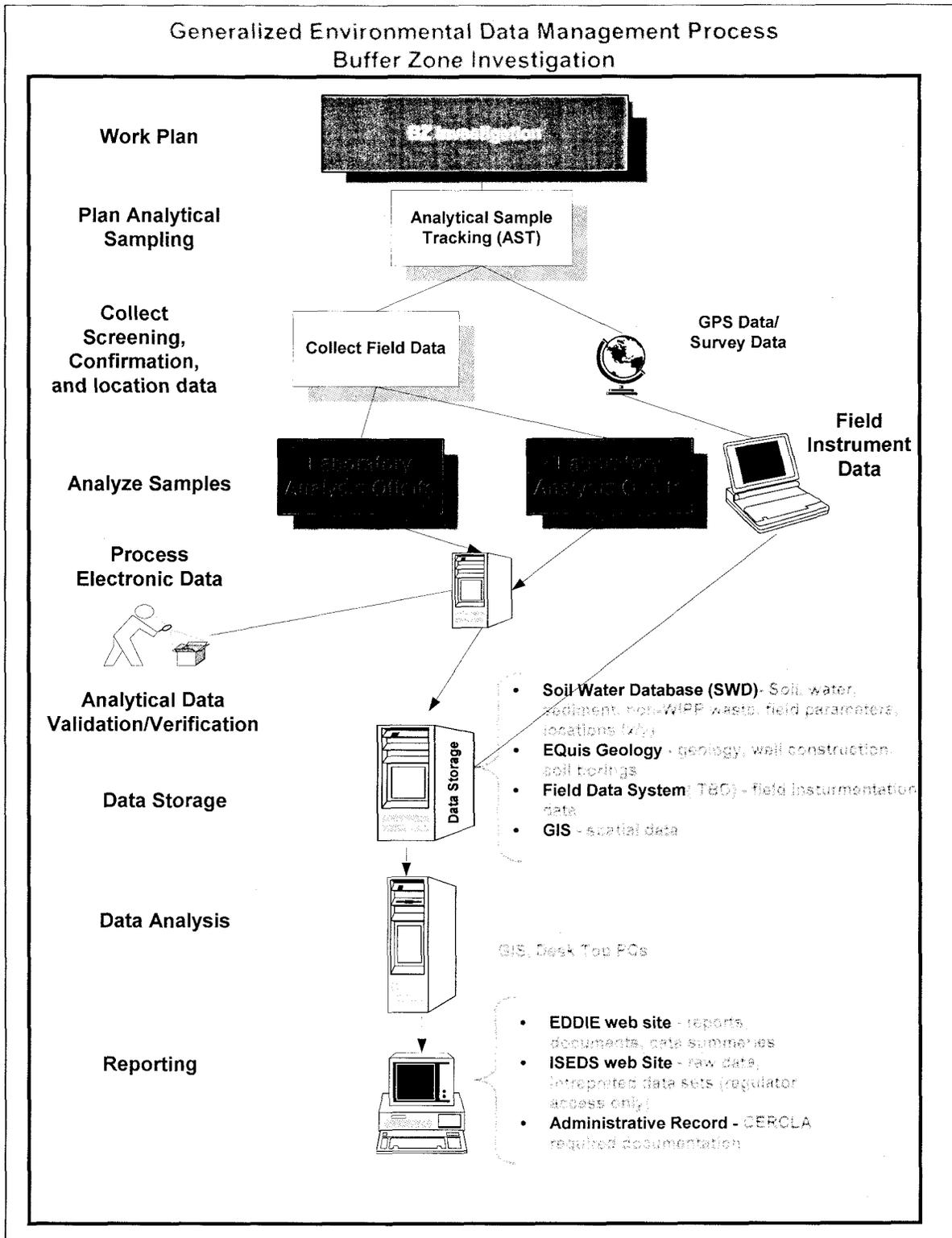


Figure 18
Buffer Zone Characterization Project Organization

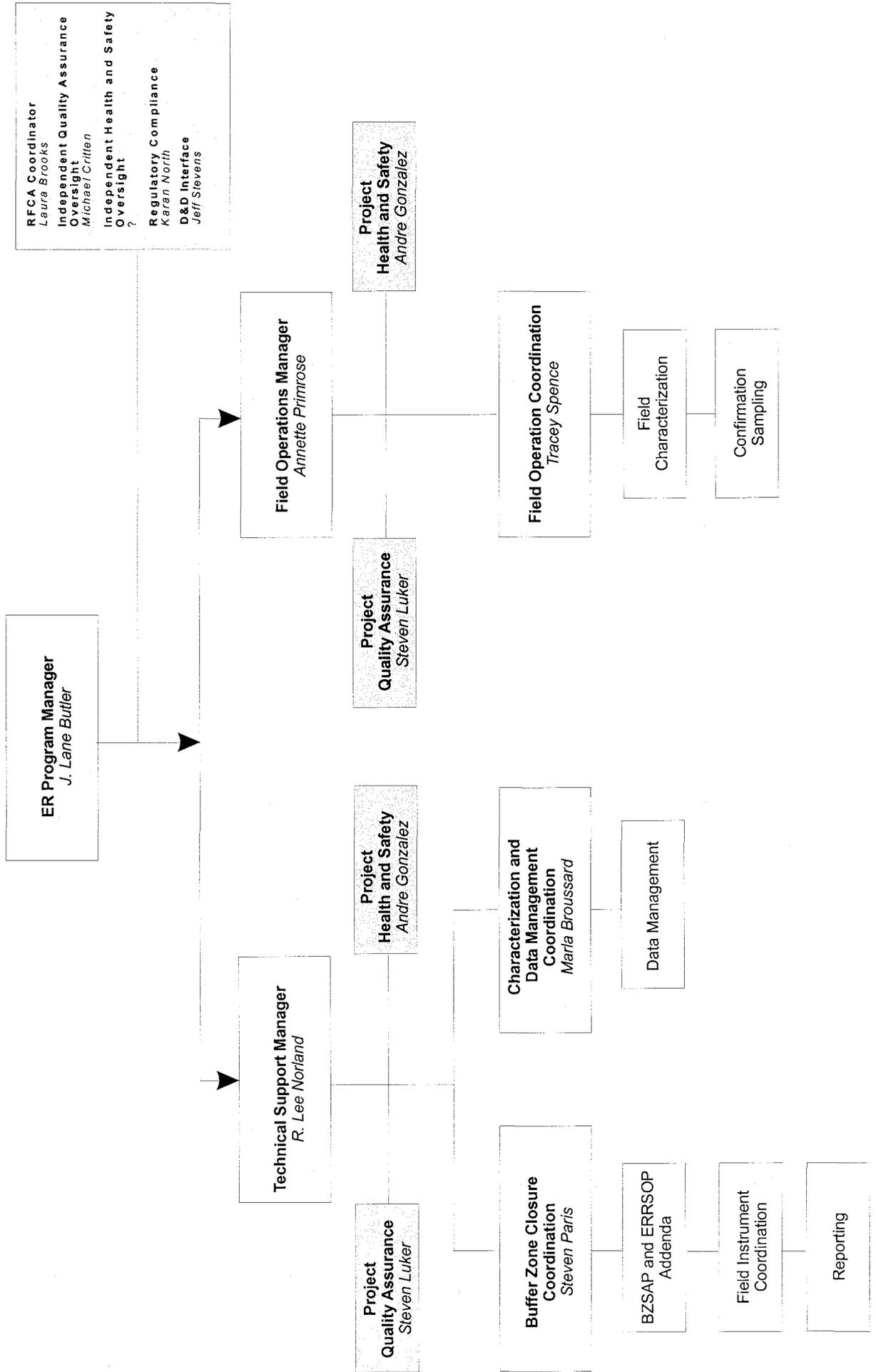
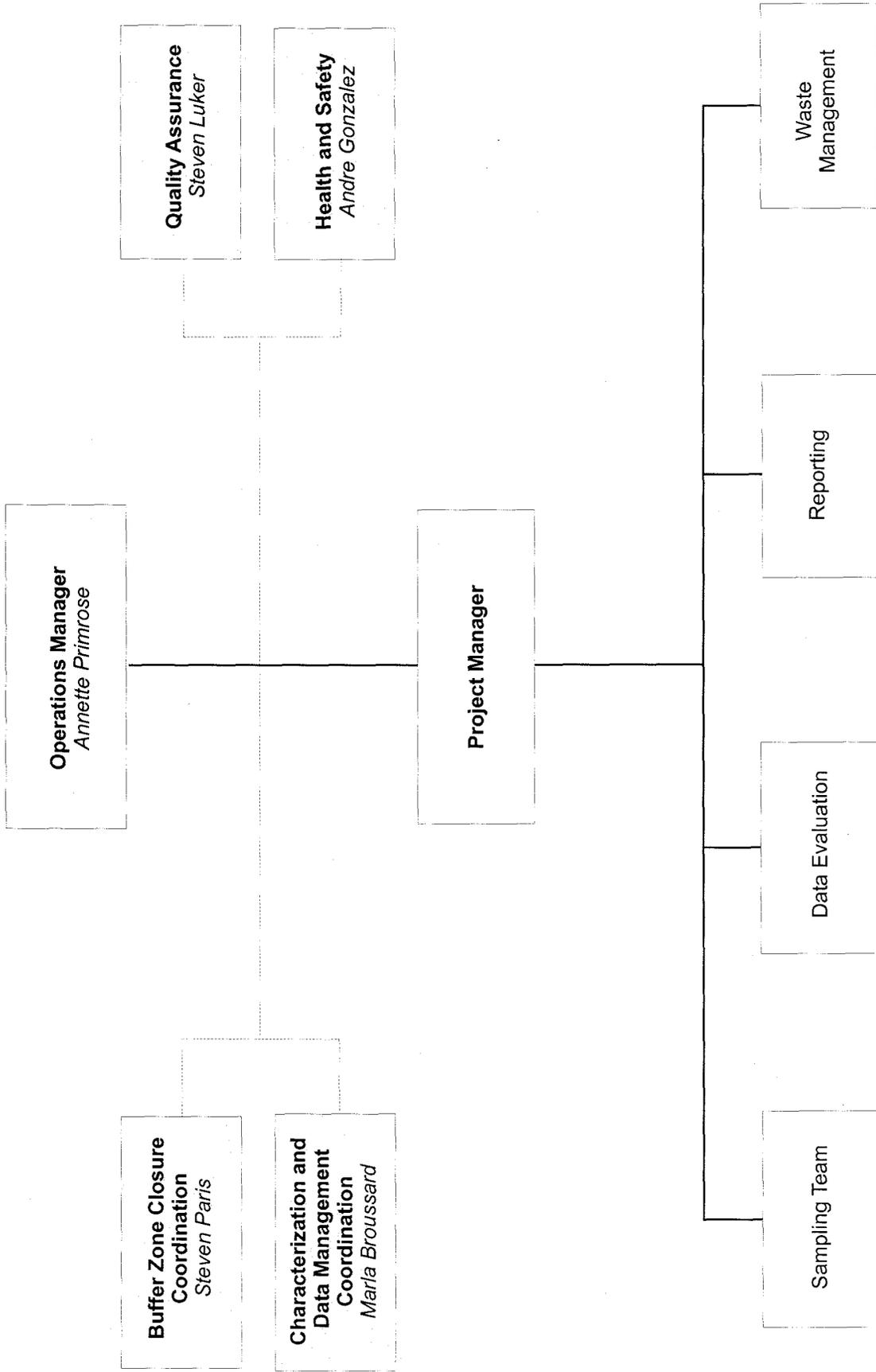


Figure 19
Buffer Zone General BZ Group
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APPENDIX A

Buffer Zone Sampling and Analysis Plan Modifications

APPENDIX B

**Buffer Zone Sampling and Analysis Plan
Example Addendum Format
Buffer Zone Characterization Group XXX-X**

APPENDIX B

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1.0 INTRODUCTION

This Buffer Zone (BZ) Sampling and Analysis Plan (SAP) (BZSAP) Addendum for BZ Group XXX-X includes BZ Group-specific information, sampling locations, and potential contaminants of concern (PCOCs) for all Individual Hazardous Substance Sites (IHSSs) and Potential Areas of Concern (PACs). The location of BZ Group XXX-X and all IHSSs and PACs in this Characterization Group are shown on Figure 1.

2.0 EXISTING INFORMATION

Existing information for the IHSSs and PACs in BZ Characterization Group XXX-X are available in Appendix C of the BZSAP. Existing data may be found in the Buffer Zone Data Evaluation Report (K-H 2001).

2.1 POTENTIAL CONTAMINANTS OF CONCERN

PCOCs in BZ Group XXX-X are presented by IHSS and PACs in Table 1.

2.2 EXISTING DATA MAPS

Existing analytical data for BZ Group XXX-X are shown on Figure 2. All analytical results, greater than background plus two standard deviations for metals and radionuclides and those above detection limits for organics, are shown in accordance with BZSAP data quality objectives (DQOs [Section 3.0 of the BZSAP]).

3.0 SAMPLING LOCATIONS

The number and locations of additional sampling requirements needed to meet DQOs will be evaluated based on existing data. These additional sampling locations will be determined using geostatistical techniques (Figure 3) as outlined in Section 4 of the BASAP. In the event that the existing data does not support a geostatistical evaluation, a standard statistical (Figure 4) or biased sampling approach (Figure 5) will be implemented.

4.0 PROJECT ORGANIZATION

The project organization is shown on Figure 6.

Figure 1
BZ Group XXX-X Location Map

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**Table 1
BZ Group XXX-X Potential Contaminants of Concern (Example)**

IHSS/PAC	Potential Contaminants of Concern	Data Source	Analytes	Sample Type	Sampling Location Method
IHSS XXX	Trichloroethylene Americium Plutonium	Process Knowledge Or Analytical Data	Radionuclides VOCs SVOCs Metals	Surface and subsurface soil to 6 feet	Biased towards know leaks, spills, and OPWL and Statistical Grid

Figure 2
BZ Group XXX-X Existing Data (above background or detection limit)

Figure 3
BZ Group XXX-X IHSS XXX Sampling Locations Based on Geostatistical
Evaluation of Existing Data

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Figure 4
BZ Group XXX-X Biased Sampling Locations

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Figure 5
BZ Group XXX-X Statistical Grid Sampling Locations

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Figure 6
BZ Group XXX-X Project Organization

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5.0 BZ GROUP XXX-X - SPECIFIC DATA QUALITY OBJECTIVES

BZ Group XXX-X-specific DQOs will be presented here.

6.0 BZ GROUP XXX-X - SPECIFIC SAMPLING AND ANALYTICAL METHODS

The section shall present IHSS-specific sampling and analyses methods.

7.0 A GROUP XXX-X - SPECIFIC HEALTH AND SAFETY REQUIREMENTS

Health and safety requirements are contained in the Integrated Work Control Permits (IWCPs), as appropriate. In addition, work in soil contamination areas will be conducted under Radiological Work Permits (RWPs), as applicable. A readiness review will be conducted before the start of fieldwork for all BZ Groups.

IHSS and PAC characterization may result in hazards not normally encountered during routine field activities. Specific additional hazards that will be addressed include the following:

- Ventilation – Carbon monoxide emissions from combustible engines (e.g., Geoprobe rig) may result in respiratory distress when activities are conducted in weather shelters. All combustible engine emissions will be diverted to an outside ventilation duct.
- Heavy Equipment Access – Maneuvering heavy equipment in weather shelters will require appropriate transportation and restraining devices.
- Radiological Hazards – Radiological hazards are expected to be much higher within specific BZ IHSSs. Characterization activities will be performed in accordance with IHSS-specific Health and Safety Plans.

8.0 BZ GROUP XXX-X - SPECIFIC QUALITY ASSURANCE PROTOCOLS

BZ Group XXX-X-specific quality assurance requirements for this project will be presented here.

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1.0 INTRODUCTION

This appendix describes potential contaminant sources within the RFETS Buffer Zone. Descriptions are provided for IHSSs and PACs that have not been approved as NFA based on the Agencies June 23, 2000 correspondence regarding responses to NFAs proposed in the 1999 Annual Update to the HRR. These descriptions are derived primarily from the Historical Release Report (HRR [DOE, 1992]), and Quarterly and Annual Updates for the HRR (DOE, 1993; RMRS, 1997a; RMRS, 1999a; and Kaiser-Hill, 2000a), which provide information on hazardous releases for all IHSSs and PACs. Other sources of information include the Closeout Report for the Source Removal at the Trench 1 Site IHSS 108 (RMRS, 1999b), Closeout Report for the Remediation of Individual Hazardous Substance Site 109, Ryan's Pit (RMRS, 1997b), Completion Report for the Source Removal at Trenches T-3 and T-4 (RMRS, 1996), and the Characterization Report for the 903 Drum Storage Area, 903 Lip Area, and Americium Zone (Kaiser-Hill, 2000b).

2.0 CHARACTERIZATION GROUP 000-5

Characterization Group 000-5 is comprised of the IHSS and PACs located within or adjacent to the Present Landfill. These include the Present Landfill (IHSS 114), Landfill Trenches A, B, and C (IHSSs 166.1, 166.2, and 166.3), the Landfill Pond Spray Areas (IHSSs 167.2 and 167.3), the Disposal of Diesel Contaminated Materials at Landfill (PAC-1502), Disposal of Fuel Contaminated Materials at Landfill (PAC-1503), and Disposal of Thorosilane Contaminated Materials at Landfill (PAC-1504).

2.1 IHSS 114 Present Landfill

The Present Landfill is located in a natural drainage tributary to North Walnut Creek, approximately 560 feet north of the 700 Area (Figure 1). The landfill was constructed in August 1968 for the disposal of uncontaminated solid. The landfill was used for the disposal of general RFP refuse collected from various locations throughout the plant. Wastes include paper, rags, floor sweepings, cartons, demolition material, and miscellaneous items. Routine operation of the landfill included the disposal of sanitary wastewater treatment plant sludge, asbestos, and polychlorinated biphenyls (PCBs).

Radioactively contaminated sludge from the sanitary wastewater treatment plant (Building 995) was routinely disposed of at the landfill from August 1968 through May 1970. The contamination consisted of uranium and plutonium, which had entered the sanitary sewage system with laundry water. Approximately 2,200 pounds of sludge containing an estimated 8 milligrams of plutonium were buried in the landfill. This sludge also contained depleted uranium. This practice was discontinued in May 1970 when offsite shipment of sludge as low-level waste began. Other sources include nonradioactive sludge from the Reverse Osmosis Plant, sludge from the Building 373 cooling tower, and dried sludge from the Sewage Treatment Plant (DOE, 1992).

In 1985, asbestos was disposed of in a designated area, which consisted of a 10-foot deep pit. Warning signs were displayed at the entrance to the disposal area and at a distance of 100 feet around the asbestos disposal pit. By December 1988, asbestos was disposed of

in several pits in specified areas near the center of the landfill. The approximate locations of these areas were marked with asbestos warning signs to comply with appropriate regulations (DOE, 1992).

Small quantities of PCB containing materials (e.g., used fluorescent light ballasts) were routinely disposed of in the landfill. A cargo container located in the currently inactive hazardous waste storage area (PAC NW-203), west of the landfill, was used for PCB storage prior to offsite disposal (DOE, 1992).

Other non-routine incidents of waste disposal in the landfill include disposition of mercaptan (odor additive to natural gas) tank, tear gas powder, a drum of solidified polystyrene resin used in fiberglassing, soil contaminated from a release of approximately 700 gallons of No. 6 fuel oil in the 600 area (PAC 600-152), burning of chromium-contaminated wood (from the Building 444 cooling tower) near the landfill in May 1975, dumping of unknown chemicals, unknown reactive chemical residue, and aluminum oxide (DOE, 1992).

Hazardous waste that routinely went to the landfill are grouped into four categories: 1) containers partially filled with paint, solvents, and foam polymers; 2) wipes and rags contaminated with listed hazardous wastes; 3) filters, typically including silicone oil filters, paint filters, and other miscellaneous filters that may have contained hazardous constituents; and 4) metal cuttings and shavings, including mineral and asbestos dust and metal chips coated with hydraulic oil and organic solvents. Disposal of hazardous constituents ceased in the fall of 1986 (DOE, 1992).

Characterization activities at the Present Landfill confirm contamination above Tier II soil action levels (SALs) in subsurface soil, surface soil, and sediment. Several subsurface soil samples were detected above the Tier II Subsurface SALs for benzo(a)pyrene, methylene chloride, and TCE..

2.2 IHSS 166.1 Present Landfill Trench A, IHSS 166.2 Trench B, and IHSS 166.3 Trench C

As stated in the Historical Release Report for the Rocky Flats Plant, conflicting information has been found regarding the description of the operation or occurrence. Listed below are four explanations for the existence of these trenches.

1. According to one reference, these trenches received a few hundred gallons of liquid from the RFP sanitary wastewater treatment plant (Building 995) in 1970. A map with that reference indicates only one trench in the area.
2. A RCRA 3004(u) waste management report stated that sludge from Building 995 was disposed of in two trenches and possibly in a third trench near the landfill. This sludge was generated during a period of high sewage sludge output from Building 995, but no other time frame for these activities is given.
3. A brief discussion of possible sludge disposal "out north of the plant" is found. This document also discusses sludge disposal by Austin (a

construction firm) to the north of the plant. The source of this waste was the number 1 digester at Building 995.

4. Another reference states that the sanitary sewage sludge that was disposed of in this area was simply pumped on the ground and the area never actually trenched.

Photographs of the RFP do not indicate any disturbances in the location of these trenches in 1955, but in 1964, disturbed areas corresponding to these three trenches were visible. The disturbed areas do not show significant change in 1971 or in any other photographs taken after 1964.

The material reported to be placed in this unit consisted of sanitary wastewater treatment plant sludge. Older sludge (prior to 1957) would have had primarily uranium contamination with newer sludge having an increasing amount of plutonium contamination during and after 1957. Total long-lived alpha activity present in the sludge has been reported between a minimum of 382 pCi/g in August 1964 to a maximum of 3,591 pCi/g in June 1960. Analysis of soil samples collected during exploratory drilling did not indicate the presence of any radioactivity.

Prior to the issuance of the HRR, a number of documents were located that make reference to analytical data indicating that uranium, 2-butanol, 1,1,1-TCA, TCE, and toluene were detected in Trench A soil. A search for the data was made, but nothing found.

Soil sampling at these trenches in the late 1970s or early 1980s did not reveal any radioactivity. In 1991, Trenches A, B, and C were included in the IAG as IHSSs 166.1, 166.2, and 166.3, respectively, and slated for further study as part of the OU 6 RFI/RI. During the OU 6 field investigation (1992-1993) 26 soil borings were drilled to a depth of 5 feet below the bottom of each trench. Eight borings were drilled in Trench A, seven in Trench B, six in Trench C west, and five in Trench C east. Soil samples were analyzed for VOCs, metals, and radionuclides. In addition, five existing monitoring wells, located in the vicinity of these trenches, were sampled. Groundwater samples were analyzed for VOCs, semi-VOCs, pesticides/PCBs, metals, and gross alpha and beta. NFAs were recommend for IHSSs 166.1, 166.2, and 166.3, (Trenches A, B, and C) in the 1996 Annual Update to the HRR (RMRS, 1996).

2.3 IHSS 167.2 Landfill Pond Spray Area (North) and IHSS 167.3 Landfill Pond Spray Area (South)

Spray evaporation of water from the East Landfill Pond began in September 1975 and was discontinued in 1994. During that time, approximately 5,500,000 gallons of water was stored to maintain a 75% capacity for the pond. Two discrete spray areas have been identified adjacent to the landfill pond; IHSS 167.2 on the north bank and IHSS 167.3 on the south bank. These IHSSs were originally part of Operable Unit 6 but were transferred to Operable Unit 7 in 1994 (DOE, 1994). Dimensions of the spray fields are approximately 100 x 460 ft. for IHSS 167.2 and 120 x 440 ft. for IHSS 167.3. The landfill pond water potentially contaminated surface soils in the spray evaporation areas.

Surface soils down-gradient of the East Landfill Pond dam are considered downwind and also potentially contaminated by spray activities.

The water sprayed onto the North and South Area Spray Fields may have been contaminated with varying amounts of low-level radioactivity derived from tritium, strontium, plutonium, and americium. Low concentrations of phenol and nitrate were also detected in the spray water. Surface soil samples were collected on a grid from the landfill eastward across the spray evaporation areas and surrounding slopes downwind below the dam. Soil samples were collected at 133 locations from the 0 - 2 in. soil horizon during the OU-7 Phase I RFI/RI and 12 additional samples were collected from the 0 - 2 in. soil horizon during the supplemental Phase I field investigation. All samples were analyzed for metals, radionuclides, and indicator parameters.

Background comparisons were performed to identify PCOCs. Analytes that were detected at concentrations or activities above background concentrations include metals, radionuclides, and indicator parameters. Additional information is provided in the OU 7 Final Work Plan. Arsenic was detected in all samples and was frequently detected above background. The maximum concentration of arsenic is 16 ppm at one location southwest of IHSS 167.3. The maximum activity of americium-241 is 1 picocurie per gram (pCi/g) at a location on the hill-slope south of the pond. This area was regraded during routine maintenance at the landfill in September 1993, and falls under the proposed footprint of the landfill cap. The maximum activity of radium-226 is 2 pCi/g at a location downwind of the spray evaporation areas below the dam. Radium was not detected in confirmation samples collected during the supplemental Phase I fieldwork.

The 1996 Annual Update to the HRR (RMRS, 1996) stated that these results indicate that there is negligible risk to human health from exposure to surface soils down-gradient of the landfill for an open space receptor and that the requirements to support a No Action or No Further Action (as defined by CERCLA) remedy have been met.

2.4 PAC NW-1502 Improper Disposal of Diesel-Contaminated Material at Landfill

Approximately one gallon of diesel fuel spilled onto the asphalt surface while patching Building 850's parking lot. The release was cleaned up with 50 pounds of soil and Oil-Dri™ absorbent and inadvertently taken to the Present Landfill (IHSS 114) for disposal. Following notification of the regulatory agencies, an estimated 100 pounds of material suspected to be contaminated were recovered from the landfill release location and disposed of properly. (EG&G, 1994). Additional actions that may be required based on material not recovered in 1994 were addressed in the OU 7 RI/RFI.

2.5 PAC NW-1503 Improper Disposal of Fuel Contaminated Material at Landfill

On February 26, 1992 empty motor oil containers, used oil filters and oil-stained debris were inadvertently disposed of in the Present Landfill. The materials of concern were immediately recovered and disposed in drums by landfill personnel. The RCRA Contingency Plan was implemented and a determination was made that due to the prompt recovery of the material, no actual or potential treat to the environment or human health

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was posed. A NFA was recommended for this PAC in the Seventh Quarterly Update to the HRR (EG&G, 1994).

2.6 PAC NW-1504 Improper Disposal Thorosilane Material at Landfill

On January 28, 1994 materials potentially contaminated with Thorosilane were disposed of in the Present Landfill. This incident occurred as a result of a January 27, 1994 spill in Building 551 when approximately 5 gallons of Thorosilane product leaked into the double bags surrounding the can. Thorosilane is an ignitable liquid that was stored in Building 551 Warehouse Flammable Storage Vault #4. A warehouse employee cleaned up the material released into the surrounding bags. The employee had been given proper disposal instructions by the Environmental Coordinator to dispose of the spilled material, but misunderstood the cleanup procedure. As a result, the spill was cleaned up by placing the bucket containing the Thorosilane and the bags containing the released Thorosilane in a 20-gallon poly-pack drum and adding 75-pounds of Oil-Dri™ to the top without properly agitating the drum contents. The drum was then sealed and placed in a dumpster. The contents of the dumpster were transferred to the trash truck and subsequently placed in the Present Landfill.

On the afternoon of January 28, two Environmental Coordinators went to the Warehouse to follow-up the incident in Building 551 and to discuss the usability of the contents remaining in the five-gallon bucket. Upon arrival, they discovered that improper procedures had been followed and that both the spilled material and the bucket of the residual unspilled Thorosilane had been sent to the landfill.

Upon further investigation on January 31, it was determined that because of the addition of Oil-Dri™ to the drum without proper agitation. It was possible that free liquids could have leaked from the drum into the trash in the truck. The RCRA Contingency Plan was implemented as a precautionary measure because Thorosilane, when disposed of in liquid form, is considered a hazardous waste.

On February 1, 1994, the poly-pack was located in the landfill; however, the lids and approximately half of the water were not found. It was presumed that the hydraulic compaction system in the trash truck crushed both the overpack and metal bucket and that the lids from both containers were dislodged as a result of being crushed. Thus, the contents of the overpack could have been commingled with the trash in the truck prior to placement in the landfill. The crushed poly-pack and product bucket contain part of the Oil-Dri™ were packaged in a 55-gallon drum and returned to the warehouse for proper handling and disposition. A determination was made that the drummed material no longer constituted hazardous waste. The drums remained in the warehouse until they were disposed of. The HRR Update did not identify the final disposal location of the drums.

Based on the recovery of the crushed poly-pack, product bucket and approximately 50 pounds of Oil-Dri™ and absorbent liquid, approximately one-half of the contaminated material was recovered from the landfill. Upon observations of the recovered containers, no free liquids were found to be present. Based on these observations, no evidence of RCRA-regulated ignitable hazardous water material was present, however, approximately

50% of the material was not recovered. The RCRA Contingency Plan Implementation Report indicated that the incident had not contributed any measurable quantities to deteriorate the landfill condition.

A NFA was recommended for this PAC in Seventh Quarterly Update to the HRR (EG&G, 1994). The possible presence of Thorosilane-contaminated materials in the Present Landfill was to be noted by the OU 7 Project Manager for future evaluation.

3.0 CHARACTERIZATION GROUP 900-2

Characterization Group 900-2 is comprised of the Oil Burn Pit No.2 (IHSS 153) and the Pallet Burn Site (IHSS 154). Characterization Group 900-2 is located approximately 800 feet northwest of the inner east guard entrance, south of Central Avenue (Figure 2-1). These areas are within the boundaries of the Protected Area security fence.

3.1 IHSS 153 Oil Burn Pit No.2

Activities at the Oil Burn Pit No.2 included burning of uranium-contaminated coolant and waste oils from Building 444 and Building 881 in two open pits between March 1957 and May 1965. Unknown organic liquids were also stored at the site. Records indicate that the pits were actually two parallel trenches. The second pit was excavated in November 1961. The trenches, which were adjacent to the Mound (IHSS 113), were located north of Central Avenue and southeast of Building 991. On the average, the contents of approximately 80 drums were dumped monthly into the pits and ignited. It is estimated that the contents of 1,354 drums were emptied into the pits and burned (DOE, 1992).

Liquid residues in the pits ranged from 300,000 dpm/l to 12,000 dpm/l uranium activity. In 1978, approximately 240 boxes of soil were excavated from Oil Burn Pit No. 2 and shipped offsite for treatment and disposal. However, clean-up criteria were based on radioactivity measurements and not measurements of solvent residuum. Approximately 10,000 cubic feet of depleted uranium residue were estimated to be present in the area (DOE, 1992).

3.2 IHSS 154 Pallet Burn Site

At the Pallet Burn Site (IHSS 154), wooden pallets were burned in the area southwest of Oil Burn Pit No. 2 (IHSS 153). Activities occurred in 1965 and the site was later removed at an unspecified date during the 1970s. The site was identified as being located in the area now occupied by fencing surrounding the Protect Area. Records do not specify any hazardous constituents that were stored or disposed at this site (DOE, 1992).

4.0 CHARACTERIZATION GROUP 900-11

Characterization Group 900-11 encompasses approximately 39 acres and is comprised of Trench 2 (Ryan's Pit [IHSS 109]), the 903 Pad (IHSS 112), Hazardous Disposal Area (IHSS 140), 903 Lip Area (IHSS 155), the Gas Detoxification Area (IHSS 183), the Elevated Chromium Identified During Geotechnical Drilling site (PAC-1316), and East Firing Range (PAC SE-1602). This group is located east-southeast of the Industrial Area

and south of Central Avenue (Figure 1). Much of the surface soil in the area is contaminated above Tier I Radiological Soil Action Levels (RSALs) for plutonium-239/240 and americium-241. Contaminants of concern other than radionuclides include chlorinated solvents, and metals.

4.1 IHSS 109 Trench 2 (Ryan's Pit)

Ryan's Pit is located approximately 250 feet south of the 903 Pad (IHSS 112) and north of the South Interceptor Ditch. The dimensions of Ryan's Pit are approximately 20 feet long, 10 feet wide, and 5 feet deep. Historical records indicate that Ryan's Pit was used for the disposal of liquid waste and small quantities of debris (e.g., drum carcasses) between 1966 and 1971. Solvents that were disposed in Ryan's Pit included PCE and TCE. Other disposed chemicals included paint thinner and small quantities of construction-related chemicals.

In 1995, a source removal action was performed at Ryan's Pit. This action included the excavation and treatment of approximately 180 cubic yards of soil and debris contaminated with VOCs. The excavated soil was treated with a low temperature thermal desorption unit (TDU) and returned to the pit as "clean" backfill (RMRS, 1997b).

A total of 36 batches of excavated soil and drum carcasses were treated by the low temperature thermal desorption unit. An additional twelve batches were processed due to batches not meeting the treatment performance standards. On September 16 and 17, 1996 the treated soils were returned to the Trench 2 excavation and covered with the original untreated topsoil. The area was revegetated on September 30, 1996.

The IHSS was proposed as an NFA in the 1997 update to the HRR. The CDPHE responded by stating that the thermal desorption unit performance standards referenced in the NFA recommendation are not NFA criterion. The CDPHE stated that neither are the PPRGs for a construction worker, which are referenced in the Closeout Report for the IHSS. Analytical results of confirmation samples along the south wall of the trench exceeded current Tier II action levels for several VOCs (PCE, TCE, Toluene, and ethylbenzene). These Tier II exceedances requires an evaluation of the impacts of these residual contaminants on surface water and ecological resources. The south wall confirmation samples also exceed the Tier I action levels for PCE and TCE. The CDPHE concluded that the IHSS could not, therefore, be considered for a NFA.

4.2 IHSS 112 903 Pad

Waste releases at the 903 Pad (IHSS 112) are considered the primary source of radiological contamination in the surficial soil in this part of the RFETS. Drums that contained hydraulic fluids and lathe coolant contaminated with plutonium and uranium were stored at this location from the summer of 1958 to January 1967. Approximately three fourths of the drums contained liquids contaminated with plutonium while most of the remaining drums contained liquids contaminated with uranium. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were vacuum pump oils, trichloroethene (TCE), tetrachloroethene (PCE), silicone oils, and acetone still bottoms (DOE, 1995).

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Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium (DOE, 1995). Characterization activities indicate approximately 2.5 acres and 2,575 cubic yards of soil and artificial fill beneath the 903 Pad is contaminated above Tier II RSALs. Approximately 1.5 acres and 1,268 cubic yards of this soil material exceeds Tier I RSALs. An additional 10,876 cubic yards of soil is contaminated with chlorinated solvents above the Tier II Subsurface Soil Action Levels (SSALs), of which 4,063 cubic yards exceeds the Tier I SSAL (Kaiser-Hill, 2000).

4.3 IHSS 140 Hazardous Disposal Area

The Hazardous Disposal Area (IHSS 140) was used for the destruction and disposal of reactive metals and other chemicals. Destruction of metallic lithium occurred in the 1950s and 1960s. The destructive reaction process included the disposition of metallic lithium in a trench and subsequent moistening with water to initiate the reaction. After the reaction, the residues (non-toxic lithium carbonate) were covered with fill and buried at the southeast corner of the site. It is estimated that approximately 400 to 500 pounds of lithium were destroyed at the site. Unknown quantities of other reactive metals (sodium, calcium, and magnesium) and some solvents were also destroyed at this location. In addition, nine bottles of nickel carbonyl and one can of iron carbonyl were disposed of in this area (DOE, 1992).

Surface soils in the Hazardous Disposal Area (PAC 900-140), located south of the Lip Area, also exhibit elevated Pu-239/240 and Am-241 activities. This contamination is primarily attributed to wind dispersion from the 903 Pad with potential contributions from historical fires, stack effluent, and stormwater related surface soil erosion. It is estimated that approximately 60% of IHSS 140 surface soils exceed Tier II RSALs (i.e., 2000 cubic yards of soil). One “hot spot” in surface soil above Tier I RSALs is also present.

4.4 IHSS 155 Lip Area

From 1968 through 1970, radiologically contaminated material was removed from the 903 Pad and Lip Area. Some of the surrounding Lip Area was regraded, and much of the area was covered by an imported base coarse material. An asphalt cap was placed over the most contaminated area resulting in the 903 Pad. However, during drum removal and cleanup activities, wind and rain (stormwater erosion) spread plutonium-contaminated soils to the east and southeast from the 903 Pad area resulting in contamination of the 903 Lip Area. Several limited excavations have removed some of the plutonium-contaminated soils from the Lip Area (DOE, 1995; Barker, 1982; and RMRS, 1997a). Approximately 15.5 acres and 4,811 cubic yards of soil is contaminated above the Tier II RSAL, of which 1.8 acres and 1,580 cubic yards of soil exceeds the Tier I RSAL (Kaiser-Hill, 2000b).

4.5 IHHS 183 Gas Detoxification Area

Building 952 was constructed in 1963 as a Toxic Gas Storage Building and managed by the Industrial Hygiene Group. Beginning in January 1967, bottles containing hazardous gases were transported by the Rocky Flats Fire Department from various buildings to Building 952 for storage. Typically, shipments consisted of one or two lecture-size gas bottles. Gases were stored for up to five years prior to disposal. Selected gases were detoxified at the site. The method of detoxification was selected based on the characteristics of the material. Others were packed and shipped to off-site vendors for disposal. There are no reports of a release to the surrounding soils having occurred from the storage of this material.

Selected gases were detoxified using various commercial neutralization processes available at the time. Neutralization processes included reaction with water, acid, caustic, carbon, or air. Byproducts were disposed of as process wastes. Upon completion of the neutralization process for each type of gas, the glassware used in the process was triple rinsed, crushed, and deposited in the Present Landfill.

No documentation was found which detailed any release from IHSS 183. This IHSS was initially investigated as part of Operable Unit 2 (DOE, 1995). As presented in the HRR and supporting reference material, past releases from Toxic Gas Storage Building are not known to have occurred. The reference material, which included records on the movement, storage and disposal of toxic gases, Industrial Hygiene status reports, and the RCRA 3004(u) waste management report, were re-evaluated to support the assertion that a release at Toxic Gas Storage Building has not occurred. IHSS 183 was grouped with the Hazardous Disposal Area (IHSS 140) during the OU2 RI/RFI due to the geographic proximity of these two IHSSs. Of the nine boreholes located within the Hazardous Disposal Area, one borehole (12791) was located near the Toxic Gas Storage Building. Samples were collected and analyzed for VOCs, SVOCs, pesticides/PCBs, metals and radionuclides. Only methylene chloride (2 ppb) and acetone (15 ppb) were detected in borehole 12791. These chemicals were not retained in the OU2 RFI/RI or the associated human health risk assessment as chemicals of concern (DOE 1995). In regard to ecological receptors, IHSS 183 was not identified as a source area in the Ecological Risk Assessment for the Woman Creek Watershed (DOE, 1996).

IHSS 183 was proposed for NFA in the 1999 Annual Update to the HRR (RMRS, 1999) for the following reasons: 1) there is no evidence or knowledge of a release to the surrounding soils at this location; 2) no current source of contamination can be identified; 3) the DOE submitted RCRA clean closure certification for RCRA Unit 23 in March 1996 (see attached); and 4) recommendation for NFA at this site is consistent with the criteria for recommending No Further Action decisions presented in RFCA, Attachment 6, RCRA Guidance (DOE, 1996).

4.6 900-1316 Elevated Chromium (Total) Identified During Geotechnical Drilling

On August 24, 1994 while conducting geotechnical drilling prior to construction for a storage facility (Investigative Derived Material Storage Facility) at the Field Operations Yard located south and west of the 904 Pad, chromium (total) was detected in the

drummed cuttings at levels above allowable RCRA limits (106 ppm and 120 ppm). Additional sampling was conducted on September 28, 1994 from six study pits excavated to a depth of 6 feet along the eastern perimeter of the proposed building foundation to provide additional information. Analytical data received October 5, 1994 confirm chromium levels below background concentrations. On October 19, 1994 one additional borehole was drilled approximately 18 feet northwest of the southwest corner of the proposed building. Analytical data received October 26, 1994 concluded that chromium (total) was detected at 138 ppm and 347 ppm from two depth integrated composited sample intervals taken between 6 and 8 feet and 10.5 and 14 feet, respectively. Volatile organics were not detected in any of the samples.

The initial construction phase which, included excavation to a depth of 6 feet for the building foundation was put on hold pending a Risk Assessment Screen using all available data. The risk assessment was completed on January 17, 1995. Interviews with plant employees familiar with past uses of the Field Operations Yard were conducted on January 18, and January 27, 1995. Historically, the Field Operations Yard was used to store miscellaneous equipment, discard scrap metal, stockpile gravel for construction use, and deposit spoil from excavation projects. One employee stated that from approximately 1971 to 1980, chromium shavings from a chrome-plating laboratory in Building 444 and a plating/testing laboratory in Building 779 were frequently swept using an industrial sweeper truck. The sweepings were emptied from the sweeper in the contractor yard. The employee's recollection of their practices was collaborated with two other employees.

Findings from the comprehensive Risk Assessment Screen completed January 17, 1995 and negative chromium results from the TCLP analysis warrant no further action for this PAC (RMRS, 1997c).

4.7 PAC SE -1602 East Firing Range

The East Firing Range (PAC SE-1602) was used for target practice and security officer qualification from 1951 through 1986. The firing range is divided into north and south target areas. The north target area consists of a firing range and berm (approximately 300 feet by 200 feet). Bullets have been found in the berm and may also be present up to 20 feet behind the berm. Handgun and shotgun bullets of various calibers were used in this area. The south target area is located on the hillside south of Woman Creek. Bullets have been found in a broad area between the range and road above the hillside. Handgun, shotgun, and rifle bullets of various caliber (up to 50 caliber), as well as depleted uranium armor-piercing bullets were used in this area. (RMRS, 1999).

5.0 CHARACTERIZATION GROUP 900-12

Characterization Group 900-12 is comprised of Trench T-5 (IHSS 111.2), Trench T-6 (IHSS 111.3), Trench T-8 (IHSS 111.5), Trench T-9 (IHSS 111.6), Trench T-10 (IHSS 111.7), and Trench T-11. This characterization group includes Trench T-1 (IHSS 108) and Trench T-3 (IHSS 111.1) which were remediated under an accelerated actions in 1998 and 1996, respectively. Characterization Group 900-112 encompasses less than 1.3 acres and is located approximately 1,600 to 2,000 feet northeast of the 903 Pad (PAC

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900-112 [Figure 2-1]). Contaminants of concern include SVOCs and chlorinated solvents.

The trenches in Group 900-12 were used primarily for the disposal of sanitary wastewater treatment plant sludge. It is also reported that 2,400 gallons of water and lathe coolant generated in Building 444 was disposed in one of the trenches. These liquids had a total alpha activity of 150,000 dpm/l. Asphalt planking was also disposed of in Trenches T-9 and T-11. In addition, unspecified amounts of scrap metal and junk were disposed in Trench T-9. It is believed that approximately 1.3 kilograms (kg) of depleted uranium may be present in the trenches (DOE, 1992).

The exact dates of operation are unknown, except for the period of July 29, 1954, through August 14, 1968. The disposal trenches are reported to be approximately 10 feet deep and are covered with approximately two feet of "clean" fill. The trenches are variable in length, with the average length being approximately 250 feet (DOE, 1992).

Some uranium and plutonium is present in this sludge. Gross alpha activity of the sludge ranged from 382 pCi/g to 3,591 pCi/l. Uranium contamination may also be present in the form of flattened drums (from activities associated with Oil Burn Pit No.2 [PAC 900-153]) that may have been disposed in any one of the trenches. It is estimated that up to 300 flattened drums may have been buried in the trenches. Records indicate that 16.2 grams of uranium-235 are buried in Trench T-11 (DOE, 1992).

Despite the presence of actinides, previous characterization studies indicate that only chlorinated solvents and semi-volatile organic compounds exceed Tier II Subsurface SALs. PCE, TCE, methylene chloride and n-nitrosodiphenylamine exceed corresponding Tier II Subsurface SALs in Trench T-5. Methylene chloride exceeds the corresponding Tier II Subsurface SALs in T-5, T-6, T-8, T-9, and T-10. PCE, TCE, benzo(a)anthracene and benzo(a)pyrene exceed the corresponding Tier II subsurface SALs in Trench T-10.

5.1 IHSS 111.4 Trench 7

Trench T-7 (IHSS 111.4), is located approximately 1400 feet east of the inner east guard gate and south of the East Access Road (Figure 2-1). Trench T-7 is approximately 400 feet long and encompasses an area of approximately 0.36 acres. The trench is believed to be approximately 10 feet thick and is covered with several feet of fill. Contaminants of concern include actinides, metals, and chlorinated solvents (DOE, 1992).

Trench T-7 was primarily used for the disposal of sanitary wastewater treatment plant sludge. The disposal history and potential contaminants are thought to be similar to those trenches in Characterization Group 900-12 (refer to Section 2.1.3). Recent characterization activities resulted in subsurface soil samples that exceeded Tier I SALs (plutonium and PCE) and Tier II SALs (americium, methylene chloride and 1,1,2,2-tetrachloroethane). To date no remedial responses have been taken.

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5.2 IHSS 108 Trench 1 Accelerated Remedial Action

The Trench 1 excavation was conducted between June 10 and August 20, 1998 and is documented in the Closeout Report for the Source Removal at the Trench 1 Site IHSS 108 (DOE, 1999).

A proposed action memorandum (PAM) decision document presenting the proposed remedial alternative for Trench 1 as part of a CERCLA Accelerated Source Removal Action was approved by the Regulatory Agencies in April 1998. The excavation phase of the source removal action was initiated on June 10, 1998 and completed on August 20, 1998. The action included the excavation of materials buried in the trench, segregation of material during excavation and packaging of the waste streams based on waste type. The 230 foot long trench contained 160 drums of depleted uranium and 10 drums of cemented cyanide that were removed from the excavation. Most of the Trench 1 waste was stored in RCRA Unit 15 after being stored in a Temporary Unit on the north side of the Trench 1 project site. A field modification to the PAM allowed for the storage of T-1 remediation wastes in RCRA Unit 15 (Kaiser-Hill, 1999).

VOC and PCB concentrations detected at or above RCRA and TSCA regulatory thresholds (i.e., RCRA, TSCA) were mixed with depleted uranium in drums stored at the site. This prevented the shipment of this material for offsite treatment and disposal. The Trench 1 mixed waste will remain in interim storage at Rocky Flats until an off-site treatment process or disposal site can be identified (Kaiser-Hill, 1999).

The removal action was completed and verification samples were collected from the excavation bottom and side-walls. Sampling was performed in accordance with the Sampling and Analysis Plan to Support the Source Removal at the Trench T-1 Site, IHSS 108 (RMRS, 1998b). Samples were collected and analyzed for radionuclides, VOCs, PCBs (as appropriate?), and cyanide (as appropriate?). The analytical results confirmed that the trench had been successfully remediated relative to cleanup levels specified in the PAM (RMRS, 1999).

Sampling of the clean soil stockpile (segregated using a FIDLER and organic vapor analyzers during excavation) was performed in accordance with the Project's SAP. The 95% Upper Confidence Levels calculated for each COC were less than the corresponding action levels specified in the PAM. This stockpiled soil was therefore returned to the excavation.

In addition, soil from 1,434 drums of Investigation Derived Material (IDM) was returned to T-1 as part of the trench back-filling operations. Approval for placement of this material was given by the EPA with concurrence by the CDPHE (RMRS, 1999). Criteria for using IDM as backfill included using soils with radionuclide activities less than Tier I action levels and with VOC concentrations less than Tier I action levels. Secondary waste streams were stored on Site or disposed of at off-site facilities. A NFA was proposed for Trench 1 in the 2000 Update to the HRR.

5.3 IHSS 110 Trench 3 Accelerated Remedial Action

Trench T-3 was used primarily for the disposal of sanitary wastewater treatment plant sludge from 1955 until February 1970. The sewage sludge reportedly contained low levels of uranium and plutonium. Other wastes such as miscellaneous debris and crushed drums were also disposed in the trench. The operational and disposal history of Trench T-3 is similar to trenches described in Characterization Group 900-12.

Trench T-3 is located approximately 400 feet northeast of the inner east guard gate and north of the East Access Road (Figure 2-1). Trench T-3 is approximately 136 feet long, 18 to 24 feet wide and approximately 15 feet deep. The total area of this Characterization Group encompasses approximately 0.61 acres.

The source removal of Trench 3 was performed concurrently with the source removal of Trench 4 but will be discussed as a separate action. The Proposed Action Memorandum (PAM) for the Source Removal at Trenches T-3 and T-4, Revision 2 was approved March 28, 1996. The Completion Report for the Source Removal at Trenches T-3 and T-4 (IHSSs 110 and 111.1) (RMRS, 1996g) provides details on remedial activities conducted at these sites. Approximately 3,796 cubic yards of contaminated soils and debris were removed for the trenches and processed using thermal desorption to remove VOCs (primarily carbon tetrachloride, trichloroethene [TCE], and tetrachloroethene [PCE]). The excavation of Trench 3 was approximately 136 feet long, 18 to 24 feet wide and approximately 15 feet deep. Approximately 1,706 cubic yards of material was excavated by August 19, 1996. The excavation of Trench 4 was 148 feet long, 19 to 22 feet wide and approximately 12 feet deep in most places. An isolated portion of trench required excavation down to 26 feet to the bedrock contact. A total of 2,090 cubic yards of material was excavated by August 14th, 1996.

Confirmation samples were collected from both Trench 3 and 4 excavation sidewalls and bottoms. Each trench was subdivided into sixteen grids and samples were collected from each grid to confirm attainment of cleanup levels. The confirmation sample results from Trench 3 met cleanup criteria. Three samples from grids in Trench 4 failed to meet cleanup levels, which subsequently required additional excavation down to the bedrock contact at 26 feet bgs. However, confirmation samples collected in these three grids also exceeded cleanup levels. The excavation was terminated at this depth in accordance with PAM specifications.

A total of 1,706 cubic yards of soil from Trench 3 and 2,090 cubic yards of soil from Trench 4 were treated by the low temperature thermal desorption unit. Of this material 500 cubic yards were segregated and stockpiled as potentially containing radiological material. Following sampling and analysis of this material it was confirmed that radionuclides were present below Tier I but above Tier II soil action levels in 250 cubic yards of stockpiled soil. This portion of the soil was returned to Trench 4 but was segregated in geotextile materials buried at approximately 4 to 8 feet bgs at the west end of Trench 4. The remainder of the trench was backfilled with treated soils below Tier II action levels and clean topsoil.

Trenches 3 and 4 were proposed as NFAs in the 1997 Annual Update to the HRR. The NFA for Trench T-4 was approved in 1999. The regulators requested additional data from Trench 3. Trench 3 was proposed for an NFA in the 2000 Annual Update to the HRR because the source removal and treatment goals specified in the PAM were achieved and were consistent with the action levels agreed upon in RFCA. In accordance with the PAM, the source removal would be considered complete if analysis from confirmation samples were below cleanup levels or if the depth of contamination reached the water table or bedrock. Residual contamination below these boundaries would be subject to groundwater remediation.

6.0 CHARACTERIZATION GROUP NE/NW

Characterization Group NE/NW encompasses approximately 0.4 acres and is comprised of the PU&D Yard – Drum Storage (IHSS 174a), OU2 Treatment Facility (PAC NE-1407), Trench T-12 (PAC NE-1412), and Trench T-13 (PAC NE-1413). IHSS 174 is located north of the 300 area (Figure 1). Trenches T-12 and T-13 are located approximately 900 to 1,000 feet east of the inner east guard gate east of the current East Access Road (Figure 2-1). The OU2 Treatment Facility is located approximately 950 feet northeast of the inner east guard gate. Contaminants of concern include actinides, chlorinated solvents, and metals.

6.1 IHSS 170 – Property Utilization and Disposal Yard

Historically, the Property Utilization and Disposal (PU&D) storage yard was used for storing empty drums and dumpsters, cargo boxes, cable spools and similar materials. The yard was divided into three storage areas, which were separated by wire fencing. The eastern-most storage area was used for storage of scrap metal and contains IHSS 174A and IHSS 174B.

The middle storage area was used for the storage of equipment such as stainless steel tanks. The western-most storage area was used for the storage of excess property. The greatest potential for contamination occurs in IHSS 174A and 174B because scrap metal may have been stored without prior decontamination and hazardous material in drums and dumpsters were transferred in this area of the yard. These areas have been investigated and results are presented in the Data Summary Report for IHSSs 170, 174A, and 174B, Property Utilization & Disposal Yard, (RMRS, 1999). IHSS 170 was proposed as an NFA in the 1999 Annual Update to the HRR, which also includes IHSS 174B. However, IHSS 174A has not been proposed for a NFA

6.2 IHSS 174a – Property Utilization and Disposal Yard – Drum Storage Area

IHSS 174a was used as a drum storage area since 1974. The area was used to store RCRA regulated waste until August 1985. Since then, it has been used for the storage of empty drums. The drums held waste oils which contained hazardous constituents, waste paints, and spent paint thinner. Waste oils were typically derived from equipment and vehicle maintenance activities. Records indicate that mixed radioactive waste was not stored in this area. Other unspecified material was stored in these areas prior to shipment for off-site recycling.

Periodic reconnaissance monitoring of the drum storage area indicated visible staining on the ground surface in the drum storage area. A release to the environment likely occurred in May 1982 when it was reported that two drums storing liquid waste were bulging and a third drum had ruptured. Records do not specify the hazardous constituents released to the environment but a release to the ground surface was likely since there was no secondary containment around the drums. The damaged drums were subsequently removed and stored in the Hazardous Waste Storage Area (IHSS 203) west of the Present Landfill. An Interim Status Closure Plan for IHSS 174a was prepared in 1986 and revised in 1988 but was superseded by the RFI/RI process outlined in the IAG (DOE, 1992).

Characterization of IHSS 174a indicate the presence of metals, PCBs, SVOCs, and chlorinated solvents in surface and subsurface soil. In surface soil, Aroclor-1254 was detected above the corresponding Tier II SALs. Vanadium was detected in one surface soil sample above the Tier I SAL. In subsurface soil, methylene chloride and PCE were detected above the corresponding SALs.

6.3 IHSS 216.1 East Spray Field - North Area, IHSS 216.2 East Spray Field–Center Area and IHSS 216.3 2 East Spray Field–South Area

The East Spray Field – North Area (IHSS 216.1) is located on the top of a hill between the A-Series and B-Series drainages, east of the protected area fence. The North Area began operating in 1989 because of excessive runoff from the existing east spray field irrigation. However, the area was closed shortly thereafter due to excessive runoff. IHSS 216.2 is located immediately north of the East Access Road and was only operated for a few years (1979 to the early 1980's) until it was closed due to erosion and soil slumping problems on hillsides near the spray field. The East Spray Field-South Area (IHSS 216.3) operated from the early 1980s to 1990, was considerably larger and operated for 10 years. This spray field was located between the B-series drainage and the C-series drainage, on top of a hillside to the south of the East Access Road. Spray field operation ceased in the spring of 1990 due to concerns over the validity of spray irrigation as a water control technique (DOE, 1992).

Spray irrigation of Pond B-3 water was initiated in 1979 as an action to achieve zero off-site discharge of sanitary effluent from the Rocky Flats Plant. Water from Pond B-3, which receives treated sanitary wastewater flows, was applied to the East Spray Fields. This activity was allowed in the NPDES Permit of May 1981 (DOE, 1992).

It is estimated that during spray irrigation activities, up to 20 million gallons per year of water was disposed in this manner. The spray irrigation often saturated the soils near the spray fields, leading to overland flow of the sprayed effluent into the detention ponds. Direct runoff of spray-irrigated water from the south portion of the East Spray Field into Woman Creek was observed on March 2, 1987. In response to this NPDES violation, a ditch was constructed to divert runoff waters from the south portion of the East Spray Field into Pond C-2 (DOE, 1992).

A second incident occurred following a spill of chromic acid in Building 444 on February 22, 1989. This chromic acid was inadvertently pumped to the sanitary sewer system.

Eventually it was estimated that 4.7 pounds of chromium was discharged to Pond B-3. The water from this pond was then spray irrigated on the North and South portions of the East Spray Fields. In response, 34 soil samples were collected from the North and South Areas of the spray fields. The EP Toxicity chromium analyses of these soil samples confirmed leachable chromium concentrations that ranged from non detect to 0.082 mg/l, which was higher than the range of concentrations reported from background samples (up to 0.023 mg/l [DOE, 1992]).

It should be noted that the treated sanitary effluent would mix with Pond B-3 waters prior to spray irrigation, introducing the possibility that other chemical constituents already in the pond might have been included in the irrigation water. Based on the wastes and discharges known to have been made to the B-Series Drainage, the types of contaminants that have been detected include plutonium, americium, arsenic, beryllium, gamma-bhc, and methylene chloride.

IHSS 216.1 was slated for further study as part of the OU 6 RFI/RI. During the OU 6 field investigation (1992-1993) six surface soil samples were collected and analyzed for metals, radionuclides, and TOC. In addition, six soil borings were drilled to a depth of 4 feet and sampled in 2-foot intervals. Samples were analyzed for VOCs, metals, radionuclides, and TOC. IHSS 216.1 lies in an unsaturated zone between the two drainages; therefore, no groundwater was available for sampling. The IHSS was recommended as an NFA in the 1996 Annual Update to the HRR (RMRS, 1999).

6.4 PAC NE-1404 Diesel Spill at Pond B-2 Spillway

A release of approximately 18 gallons of diesel fuel resulted from a leak in the fuel tank of a portable pump used to transfer water from Pond B-2 to Pond A-2. The release occurred October 27, 1992 in the spillway area of Pond B-2, approximately 15 feet from the shore of the pond. A containment dike was built around the pump to prevent residual fuel from entering the pond. Absorbent booms were pulled across Pond B-2 from west to east to absorb the fuel released. An estimated 200 pounds of material (soil and absorbent booms) were recovered from the spill area. Approximately 1.5 cubic yards of fuel-contaminated soil was removed from the spill site and containerized in half-crate plywood boxes (Kaiser-Hill, 2000).

6.5 PAC NE-1407 OU2 Treatment Facility (PAC NE-1407)

The OU 2 Treatment Facility (PAC NE-1407) is located in the 900 Area on the hillside north of Woman Creek. The treatment facility has been in operation since May, 1991 and is used primarily to treat contaminated groundwater using chemical precipitation/microfiltration/granular activated carbon system. On March 9, 1993, approximately 50 gallons of untreated seepage/spring water leaked from a ruptured elbow in a secondary containment line as the water was being pumped from to the treatment facility. Routine sampling of the influent indicated concentrations of carbon tetrachloride, trichloroethane, PCE, chromium, and 1,2 DCE were detected slightly above the SWDA drinking water standards (DOE, 1993).

In response to the leak, the pump was turned off and a berm was constructed to contain the spill area within 150 square feet. Soil samples of the affected area did not pose an unacceptable risk to human health and the environment. Therefore immediate removal of the affected soil was not performed.

6.6 PAC NE-1409 Modular Tanks And 910 Treatment System Spill

A spill related to the pumping operation of surface and ground water collected by the Solar Evaporation Ponds Interceptor Trench System (ITS) and subsequent transfer to the Modular Storage Tanks (MSTs) occurred on July 20, 1993. Approximately 4,700 gallons of RCRA F-listed water in the primary containment piping that connected the Modular Storage Tanks to the ITS sump began leaking into the secondary containment. The water overflowed back into the ITPH as designed and was fully contained in the pump house secondary containment. When the water level in the pump house secondary containment rose, the local alarm activated and the pumps automatically shut down. This alerted the Building 910 operators to the spill. When the building operators found that liquid was still siphoning out through the pump, they closed the manual valves. Some of the water drained back into the ITS sump through a failed hose connection on the secondary containment piping located within the ITS sump. This water was then pumped back into the MSTs.

The released material was considered RCRA F-listed hazardous waste based on 6 CCR 1007-3 because it passed through the ITS sump (which is considered a waste generation point). Applicable EPA waste codes for the released material includes F001, F002, F003, F005, F006, F007 and F009. Samples were taken in 1991-1992 at the ITPH sump (SW095). Based on the results of samples collected, some of the constituents appear to have exceeded current RFCA surface water action levels and standards (RFCA Attachment 5, March 21, 2000) at the point of release. However, the spill occurred prior to RFCA and was not released to surface water (i.e. North Walnut Creek) or the environment. The water that overflowed into the MST pump house was pumped into a portable tanker and trucked to Building 374 for treatment.

The following actions were performed to operate the system in accordance with RCRA requirements as summarized in the spill notification report (DOE, 1994):

1. Repaired the primary transfer pipeline;
2. Modified the secondary containment portion of the line within the ITS sump to prevent leakage of water into the sump. Although the portion of the line can be visually inspected, it was preferable to modify the secondary containment in this manner;
3. Re-tested the line following repair;
4. Completed or repaired leak-detectors in the secondary containment portion of the line that were not operational at the time of the incident;

5. Confirmed that the process control logic supported positive shutdown of the pumps when a leak is detected in the secondary containment system of the transfer lines from the ITPH to the MSTs;
6. Repaired the remote alarm that was not operable when the liquid was released into the pump house;
7. Analyzed pressure conditions in the Building 910 feed system to determine if components had experienced an over-pressurization; and
8. Incorporated pressure-surge control to ensure "hammer-free" operation when the liquid discharge is intermittently secured by automatically operating feed valves in Building 910.

It is believed that no hazardous releases to the environment occurred from this incident; however, because the concrete sump was unlined, the RCRA Contingency Plan was implemented as a precautionary measure. PAC NE-1409 had not been subject to immediate investigation until construction activities related to the MST Freeze Protection project were initiated in November 1998. Four soil samples were collected in December 1998 and January 1999 in support of the Site Survey Determination for Environmental and Worker Exposure, the supporting Soil Disturbance Evaluation and hazardous waste determination requirements. The sample locations were placed at each corner of the ITS sump and selected based on professional judgement (i.e., if a release actually had occurred from the sump the soil surrounding the sump would likely be contaminated). Based on the characteristics of the waste that accumulated in the sump, the soil samples were analyzed for metals and VOCs. Analysis for cyanide was not performed because the waste concentrations were below background concentrations. Additionally, because groundwater in the surrounding area is contaminated with nitrate and uranium, samples were also analyzed for nitrate and isotopic radionuclides. Sampling for semivolatile organic compounds (SVOCs) was requested by the qualified hazardous waste generator and performed at two of the four locations. All of the analytical results were below RFCA action levels

Based upon the results of the soil samples collected, no current or potential contaminant source was identified. The release in 1993 was a single incident and not a continuous release to the environment. Potential Contaminants of Concern (PCOCs) for PAC NE-1409 were not detected; therefore PAC NE-1409 was proposed for NFA in the 1999 Annual Update to the HRR (DOE, 1999). The regulators requested additional data to support the NFA recommendation. The PAC narrative was updated with additional analytical data and recommended as an NFA in the 2000 Annual Update to the HRR (DOE, 2000).

6.7 PAC 1410 Diesel Spill at Field Treatability Unit, OU2

On October 10, 1993 Garage personnel were refueling an emergency generator unit with diesel fuel at OU 2. The operator turned his back on the operation to shield himself from the wind, and when he turned back around, the automatic nozzle valve had not automatically turned off as expected, resulting in approximately 0.5 to 1 gallon of fuel

spilling inside the generator unit. The spill was cleaned up using the absorbent, Oil-Dri™.

On October 11, 1993 at 9:30 am, a second spill occurred during refueling of the generator. The OU 2 Project manager was conducting a shift inspection at this time and noticed a shiny pool of 2- 3 gallons of a substance on the ground on the north side of the generator. The Hazardous Material Team responded by applying Oil-Dri™ to the standing liquid. The soil around the affected area was compact but was loosened with a backhoe. The affected soil was removed and placed in six 55-gallon gray drums and stored in the garage prior to being moved to the 90-Day RCRA accumulation storage area in the PU&D Yard. Final disposition for this type of waste is typically incineration in an off-site RCRA permitted incinerator. Soil samples were taken from the soil and the bermed area. The Waste Identification and Characteristic Organization determined the samples to be non-hazardous and below regulatory limits for compounds such as benzene. A NFA was recommended for this PAC in the Seventh Quarterly Update to the HRR (EG&G, 1994).

6.8 PAC NE-1411 Diesel Spill at Field Treatability Unit, OU2

As garage employees were refueling a diesel generator located near OU 2, approximately 20 gallons of diesel fuel was released to the ground. The incident occurred during the transfer of fuel from the storage tanks (Tank B to Tank A) to the generator). The multi-tank fueling process is necessary due to limited space near the generator. The generator is first refueled from Tank A and then from Tank B. Due to extreme cold, personnel performing the refueling operation were sitting in the truck cab and were not able to hear a problem due to the generator noise. When they smelled diesel fumes, they immediately cut the master switch from inside the cab and notified the Shift Supervisor of the spill. It was determined that the backfeed preventer tube on the pump nozzle froze, causing the automatic shut-off to malfunction, releasing approximately 20 gallons of diesel fuel to the ground. Although the generator itself is located within secondary containment, the spill area was not within the containment and diesel was released to the soil.

Personnel immediately notified the Shift Superintendent who then notified the EG&G Fire Department Hazardous Material team, which responded by containing the leak. The EG&G Waste Regulatory Program was notified and determined that the spill was non-hazardous based on recent soil characterization. Labor and Hazardous Materials personnel removed the soil and placed it in barrels per Waste Regulatory Programs and Operations requirements identified in Rocky Flats Plant directives and procedures. A NFA was recommended for this PAC in the Seventh Quarterly Update to the HRR (EG&G, 1994).

6.9 PACs NE 1412 Trenches T-12 and NE 1413 T-13

Similar to the trenches in PAC NE-1412, Trenches T-12 and PAC NE-1413 T-13 were used primarily for the disposal of sanitary wastewater treatment plant sludge. These trenches were identified during a 1993 evaluation of aerial photographs taken on April 15, 1966 and April 29, 1967. The trenches are believed to be approximately 10 feet deep

and covered with several feet of fill. The waste streams and potential contaminants are similar to those reported for the trenches in Characterization Group 900-112.

7.0 CHARACTERIZATION GROUP NE-1

Characterization Group NE-1 is comprised of the A-, B-, and C-series retention ponds (Figure 2-1). The A-series ponds are located in the North Walnut Creek drainage downstream of the 900 Area and includes Pond A-1 (IHSS 142.1), Pond A-2 (IHSS 142.2), Pond A-3 (IHSS 142.3), and Pond A-4 (IHSS 142.4). The B-series Ponds are located in the South Walnut Creek Drainage, downstream of the 900 Area, and includes Pond B-1 (IHSS 142.5), Pond B-2 (IHSS 142.6), Pond B-3 (IHSS 142.7), Pond B-5 (IHSS 142.8), and Pond B-5 (IHSS 142.9). The C-series ponds are located in the Woman Creek Drainage southeast of the 900 Area and includes Pond C-1 (IHSS 142.10) and Pond C-2 (IHSS 142.11). The total combined surface area of the Ponds encompasses approximately 20.5 acres. However, it should be noted that the Characterization Group NE-1 boundaries actually extend in the upstream and downstream directions from the ponds to either the RFP boundaries or closest PAC boundary.

The RFP began use of the drainages immediately upon opening of the plant. The A-, B-, and C-series ponds were designed and constructed to provide residence time and holding capacity for spills and sedimentation of suspended material. However, some of the stream and pond sediments have become contaminated due to releases from industrial processes. Potential contaminants of concern include radionuclides, metals, pesticides, PCBs, and nitrates.

7.1 A-Series Ponds

The general types of materials that have been directly or indirectly released to the A-Series drainage (these are non-emergency and non-spill related) during the history of the RFP include: untreated wastewater from Building 771, cooling tower and roof drain water from Building 774, Building 774 evaporator condensate water, and footing drain flows. The Building 771 wastewater was primarily composed of decontamination laundry wastewater, but it also contained water from the analytical laboratory, radiography operations, personnel decontamination room, and runoff. Building 771 waste discharged to a storm drain north (PAC 700-143) and west of Building 771 which flowed to the A-Series drainage. In 1971, it was reported that the Building 774 evaporator condensate drain typically released 20,000 gallons per day of water at 100 dpm/l, with 5 parts per million (milligrams per liter) of nitrate.

A known problem in the A-series drainage for some time has been the presence of nitrate and radioactive contamination in the stream and pond sediments. In 1973, it was estimated that 14 microcuries (mCi) of plutonium was present in Pond A-1 sediment. In response to this problem, a series of trenches and pumps to collect contaminated groundwater and seepage was constructed between the solar ponds (PAC 000-101) and the A-Series Drainage. Other response actions to contamination in the A-Series drainage included the removal of contamination near the Building 771 outfall (PAC 700-143), the re-routing of discharges to other facilities, and the elimination of flows from Building 774.

7.2 B-Series Ponds

A sediment study conducted by Colorado State University (CSU) resulted in data that indicated radioactive contamination of sediments in the B-Series drainage. Pond reconstruction activities in 1971 to 1973 were found to cause resuspension and downstream migration of contaminated sediment. This caused the inventory of plutonium in Pond B-1 sediment to increase from 0.085 curies in 1971 to 2.9 curies in 1973. Plutonium activity in Pond B-1 sediment in June 1973 varied from 10 to 502 picocuries per gram (pCi/g) of dry sediment based on the CSU sampling (DOE, 1992).

An RFP study completed in June 1973 indicated radioactive contamination of sediments upstream from the drainage ponds. This study found an average activity concentration of 40 dpm/g from the "west culvert" (the culvert west of the Building 995 outfall) to the "east culvert" (the culvert immediately east of the Building 995 outfall). The area of contaminated soil/sediment was estimated to cover approximately 3900 square feet (DOE, 1992).

Releases to the B-Series drainage include: a sodium hydroxide discharge from a bulk caustic storage tank that was diverted to Pond B-1 for temporary holding; a steam condensate line break in the Building 707 area that discharged to Pond B-4 and South Walnut Creek downgradient of Pond B-4; release of approximately 155 gallons of a 25% solution of ethylene glycol (antifreeze); and a release of chromic acid to Pond B-3 from the sewage treatment plant (Building 995) occurred on February 22 and 23, 1989. It is believed that approximately 4.7 pounds of chromium were released to Pond B-3. The water from Pond B-3 was then sprayed on the East Spray Fields (PAC NE-216.1 - NE-216.3 [refer to Section 2.1.10.1]).

In response to the identification of plutonium contamination in the sediments of the drainages in 1973, a study was conducted to ascertain the source of the plutonium contamination present in the B-Series drainage. This study indicated that approximately 88% of the total activity released by Building 995 was due to the release of laundry decontamination water to the sanitary sewer. After December 21, 1973, laundry water was only discharged to Pond B-2 where some of the water may have been diverted to Pond A-2. In the fall and winter of 1973, removal operations for contaminated soil were being conducted in the stream bed below the Building 995 outfall. Analysis of soil samples indicated that the concentrations of leachable chromium were far below the RCRA Extraction Procedure Toxicity limits.

In the early 1980s, actions were taken at Pond B-5 to reduce the potential for off-site movement of contaminated sediments. The discharge structure for this pond was modified by adding a vertical standpipe and a perforated pipe along the bottom of the pond surrounded by granular material. Some sediments present in Pond B-5 were also removed from the drainage and deposited in the Soil Dump Area in the northeast buffer zone (PAC NE-156.2). These activities helped to minimize off-site transport of contaminated sediments (DOE, 1992).

In summary, based on the wastes and discharges known to have been made to the B-Series Drainage, the types of contaminants that have been detected include plutonium,

americium, arsenic, beryllium, gamma-bhc, and methylene chloride. Pond B-1 appears to have the greatest amount of contamination with a number of sediment samples that exceed the corresponding Tier II SALs for plutonium and americium, including one sample that exceed the Tier I SAL for americium. Several sediment samples in Pond B-2 exceed the corresponding Tier II SALs for plutonium, americium, and PCBs, including one sample exceedance above the Tier I SAL for plutonium. In Pond B-3, several sediment samples exceed the corresponding Tier II SALs for americium. Historical sample results from Pond B-4 and Pond B-5 are below Tier II SALs.

7.3 C-Series Ponds

Pond C-1 was built in 1955 to provide temporary holding and provide for monitoring of Woman Creek waters and waters discharged from RFP Ponds 6, 7, and 8 (which are no longer in existence). Pond C-2 and the South Interceptor Ditch were built in 1979. The South Interceptor Ditch was built in order to re-route runoff from the southern portions of the RFP main manufacturing area to Pond C-2. Water from the South Interceptor Ditch is the only input to Pond C-2, allowing Pond C-2 to serve as a surface water retention and spill control pond. Discharges from Pond C-1 are routed around Pond C-2 and back into the natural Woman Creek channel.

Potential hazardous releases into the Women Creek drainage include: water treatment plant backwash; 2,700 gallons of steam condensate from the Building 881 cooling towers; sanitary sewer overflow and discharge of untreated sanitary sewage; Building 881 cooling tower overflow/blowdown; ashes from the plant incinerator; dumping of graphite, used caustic drums, and general trash; resuspended soils and runoff from the 903 Pad area (Characterization Group 900-11); fuel/oil discharge from an overturned armored vehicle; leakage from the South Interceptor Ditch to Woman Creek; direct runoff from the East Spray Field (PAC NE-216.1 - NE-216.3); spill of waste acid into the South Interceptor Ditch; and measurable quantities of Atrazine in Pond C-2.

Since the 903 Pad potentially impacted the C-Series drainage, response actions to the 903 Pad also apply to the C-Series drainage. These response actions include soil removal, soil capping, grass seeding, restriction of traffic in areas contaminated by the wind-blown contamination, and restriction of access to the impacted buffer zone. To date, no sediment samples collected from Pond C-1 and Pond C-2 exceed Tier II SALs .

8.0 CHARACTERIZATION GROUP SW-1

Characterization Group SW-1 is comprised of Ash Pit 1 (IHSS 133.1), Ash Pit 2 (IHSS 133.2), Ash Pit 3 (IHSS 133.3), Ash Pit 4 (IHSS 133.4), Incinerator (IHSS 133.5), the Concrete Wash Pad (IHSS 133.6), Ash Pit TDEM-1 (PAC SW-1701), and Ash Pit TDEM-2 (PAC SW-1702). Ash Pits TDEM –1 and TDEM-2 were identified during a 1993 geophysical survey of the area. The Ash Pits belonging to this Group are located south of the 900 Area between the West Access Road and Woman Creek (Figure 1). Contaminants of concern include depleted uranium and metals.

The Ash Pits were in operation from 1952 to 1968 and were used for disposal of combustible ash from the incinerator. Dimensions of the pits are approximately 150 to

200 feet long by 12 feet wide by 10 feet deep, and are covered with 3 feet of fill. It was estimated that approximately 30,000 cubic feet of soil and ash are contained in the pits. Other material reportedly disposed in the pits include noncombustible trash such as counting discs, broken glassware, and metal (DOE, 1992).

Measured activities of the ash ranged up to 4,000 counts per minute (cpm) alpha and 30 millirems per hour (mr/hr) beta. In September 1954, five samples of ash resulting from the burning of Building 991 wastes were sampled, which resulted in an average value of 4.5×10^7 dpm/kg of dry ash. In 1956, special monitoring was performed during and after burning contaminated waste in the plant incinerator. Ash samples showed 1.9 grams of material (depleted uranium) per kilogram of ash. Small quantities of depleted uranium-contaminated combustibles were burned along with the general combustible plant refuse. It was estimated that less than 100 grams of depleted uranium were involved. Assays of the ash indicated approximately one to eight kilograms of depleted uranium per ton of ash (DOE, 1992). Radiological surveys of the soil and metallic debris around Ash Pits TDEM 1 and TDEM 2 confirmed radioactivity up to 2,500 counts per minute beta/gamma (RMRS, 1997a).

Characterization activities of the Ash Pits conducted in 1993 resulted in the following subsurface soil samples that exceeded Tier I and Tier II Subsurface SALs:

In Ash Pit 1, several samples of uranium-238 were detected above the corresponding Tier II Subsurface SALs including one sample above the Tier I Subsurface SAL. Uranium-235, and uranium-238 exceeded the corresponding Tier II Subsurface SALs in Ash Pit 2. Two samples also collected from Ash Pit 2 exceeded the Tier I Subsurface SALs for uranium-238. No samples collected from Ash Pits 3 and 4 exceeded Tier II Subsurface SALs.

8.1 IHSS 133.5 Incinerator

The incinerator (IHSS 133.5) was located south of the west access road near the plant's original west boundary (Figure 1). The incinerator was in operation from 1952 through August 1968 and was used to burn office wastes. Incinerator operations ceased in 1968 due to deterioration of the fire box and stack, and was dismantled in 1971. Records indicate that the surrounding area around the incinerator may have been backfilled with ash.

An estimated 100 grams of depleted uranium were burned with the general combustible wastes. Until 1959, the ashes and noncombustible material were placed around the incinerator and to the south near the concrete wash pad area. After 1959, ash was placed in trenches to the south and southwest of the incinerator (Characterization Group SW-1). An "ash dump" south of the plant was monitored in May 1959 and found to contain up to 4,000 counts per minute (cpm) alpha activity and 20 millirems per hour (mr/hr) beta activity (DOE, 1992).

8.2 IHSS 133.6 Concrete Wash Pad

The Concrete Wash Pad is adjacent to the former plant incinerator (Figure 2-1). Excess concrete from construction activities on plant site was routinely washed from concrete trucks from 1953 through March 1979. Potentially contaminated ash generated from the incinerator may have been deposited southwest of the incinerator (PAC SW-133.5) in the area of the concrete wash pad (DOE, 1992).

9.0 REFERENCES

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APPENDIX D

Comprehensive Risk Assessment Methodology

The Final Comprehensive Risk Assessment will be included when it is approved by the regulatory agencies.

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APPENDIX E

**Buffer Zone Potential Contaminants of Concern, Contaminants of
Concern, and Method Detection Limits**

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ACRONYM LIST

%R	percent recovery
AOC	Area of Concern
AL	action level
ALF	Action Levels and Standards Framework for Surface Water, Ground Water, and Soils
ASTM	American Society for Testing and Materials
BHC	lindane
BZ	Buffer Zone
BZSAP	Buffer Zone Sampling and Analysis Plan
CAS No.	Chemical Abstract Society number
COC	contaminant of concern
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DNT	dinitrotoluene
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ICP-MS	Inductively Coupled Plasma-Mass Spectroscopy
IHSS	Individual Hazardous Substance Site
LCS	laboratory control sample
LIBS	laser-induced breakdown spectroscopy
m	metastable
MDL	method detection limit
mg/kg	milligrams per kilogram
MS	matrix-spike
MSD	matrix-spike duplicate
PCB	polychlorinated biphenyl
PCOC	potential contaminant of concern
ppm	parts per million
QC	quality control
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RPD	relative percent difference
s	standard deviation
S ²	variance
SAP	Sampling and Analysis Plan
SOW	Statement of Work
SVOC	semivolatile organic compound
TCA	trichloroethane
U	undetected
UWQ4	usable with qualification, Result no longer representative, source area remediated
UWQ5	usable with qualification, QC Data; do not use for statistics or contaminant characterization
VOC	volatile organic compound
XRF	X-ray fluorescence

1.0 ANALYTICAL METHODS

Analytical methods, method detection limits (MDLs), and contaminants of concern (COCs) for the Buffer Zone (BZ) Sampling and Analysis Plan (SAP) (BZSAP) are shown in Tables E1 through E12. The tables present the minimum required analytes within each respective suite, as well as the required sensitivity for each analyte. Sensitivities are expressed as MDLs, and are specific to the measurement systems used for BZ samples. The action levels (ALs) provided represent the lowest values stipulated in the Rocky Flats Cleanup Agreement (RFCA), based on the various exposure scenarios. These (conservative) values are provided to ensure that method sensitivities, for each and every COC, are adequate for making project decisions that depend on sampling and analytical data.

General accuracy and precision tolerances for the methods are also given at the bottom of each table. Actual upper and lower control limits will be evaluated on a laboratory-by-laboratory basis. All MDLs will be less than or equal to RFCA action levels, where possible. The MDLs listed in the following tables represent values generally attainable by commercial laboratories and field mobile labs. The laboratory MDLs will be established through the following three steps.

1. Seven Replicates

Prepare (extract, digest, etc.) and analyze seven samples of a matrix spike (American Society for Testing and Materials [ASTM] Type II water for aqueous methods, Ottawa sand for soil methods, and glass beads of 1 millimeter [mm] diameter or smaller for metals) containing the analyte of interest at a concentration three to five times the estimated MDL.

2. Variance and Standard Deviation

Determine the variance (S^2) for each analyte as follows:

$$S^2 = \frac{1}{n-1} \left[\sum_{i=1}^n (x_i - \bar{x})^2 \right]$$

where x_i = the i th measurement of the variable x and \bar{x} = the average value of x

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n x_i$$

Determine the standard deviation (s) for each analyte as follows:

$$s = (S^2)^{1/2}$$

3. MDL

Determine the MDL for each analyte as follows:

$$MDL = 3.14(s)$$

(Note: 3.14 is the one-sided t-statistic at the 99 percent confidence level appropriate for determining the MDL using seven samples).

MDLs are greater than the existing RFCA Tier I and Tier II ALs for some organics, as shown in Tables E1 and E2.

Table E1
Method Detection Limits Greater than Tier I and Tier II Action Levels

Analyte (Base-Neutral Extractables)	Soil (mg/kg) Mobile Lab (SW8270C)	Action Levels (mg/kg)	
		RFCA Tier I	RFCA Tier II
2,4-DNT	6.60E-01	5.01E-02	5.01E-04
2,6-DNT	6.60E-01	3.88E-02	3.88E-04
Bis (2-chlorethyl)ether	6.60E-01	9.73E-03	9.73E-05
n-Nitrosodi-n-propylamine	7E-01	1.89E-03	1.89E-05

MDLs for the following analytes are greater than RFCA Tier II ALs.

Table E2
Method Detection Limits Greater than Tier II Action Levels

Analyte	Soil (mg/kg) Mobile Lab	Action Levels (mg/kg)	
		RFCA Tier I	RFCA Tier II
VOCs			
1,1,2-2-Tetrachloroethane	5E-03	1.68E-01	1.68E-03
Trans-1,3-Dichloropropene	5E-03	1.20E-01	1.20E-03
Vinyl chloride	5E-03	3.46E-01	3.46E-03
SVOCs			
Nitrobenzene	7E-01	5.39E+00	5.39E-02
Isophorone	6.60E-01	2.09E+01	2.09E-01
2,4,6-Trichlorophenol	6.60E-01	1.07E+01	1.07E-01
2,4-Dichlorophenol	6.60E-01	6.35E+01	6.35E-01
Pentachlorophenol	3.30E+00	2.11E+00	2.11E-02
Pesticides			
α-BHC	2E-02	5.80E-02	5.80E-04
β-BHC	4E-02	2.08E-01	2.08E-03
γ-BHC	2.7E-02	7.50E-01	7.50E-03
Dieldrin	1.4E-02	3.92E-01	3.92E-03

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**Table E3
Analytical Procedures**

Analytical Method	Parameter	Preparatory Methods
8081A	Organochlorine pesticides (water and soil)	3510C, 3520C, 3540C, 3541, 3545, 3550B
8082	PCBs (water and soil)	3510C, 3520C, 3540C, 3541
8260B	Volatile organics (water and soil)	3585, 5021, 5030B, 5031, 5032, 5035
8270C	Semivolatile organics (water and soil)	3510C, 3520C, 3540C, 3541, 3545, 3550B
6020 6200/LIBS	Trace metals by ICP-MS (water and soil)	3005A, 3010A, 3015, 3050B, 3051 NA
7471A	Mercury (soil)	1311
9056	Common anions	NA
KH Module RC01 (alpha spec); Gamma Spectroscopy RC03-A.1 ^A In situ ^B	Radionuclides (RFETS standard suite of five isotopes)	NA

^A Containerized samples for field-laboratory analysis

^B In situ measurements; see Appendix H for measurement specifications

NA Not applicable

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**Table E4
Method Detection Limits for Metals**

Analyte	Soil (mg/kg)		Action Levels (mg/kg)		Background (ppm)	
	Fixed lab (SW6010B)	Portable/ Field Lab (LIBS/XRF) ^B	RCFA Tier I	RFCA Tier II	Surface Mean Plus 2 σ	Subsurface Mean Plus 2 σ
Aluminum	3.E+00	TBD	>1.E+06	>1.E+06	1.69E+04	3.54E+04
Antimony ^A	4E+0	5E+02	7.68E+02	7.68E+2	NA	1.70E+01
Arsenic ^A	6E+01	2E+02	2.99E+02	2.99E+00	NA	1.31E+01
Barium	2.E+01	3.E+02	1.33E+05	1.33E+05	1.41E+02	2.89E+03
Beryllium	2.E-01	<1	1.04E+02	1.04E+00	9.66E-01	1.42E+01
Cadmium	1.E-01	3.E+01	1.92E+03	1.92E+03	1.612E+00	1.7E+00
Calcium ^C	NA	NA	NA	NA	4.47E+03	NA
Chromium	≥2E+00	2E+00	8.72E+03	1.02E+03	1.7E+01	6.83E+01
Cobalt	1.E+01	1.3E+02	1.15E+05	1.15E+05	1.1E+01	2.90E+01
Copper	6.E-01	3.E+00	7.11E+04	7.11E+04	1.8E+01	3.82E+01
Iron ^C	NA	NA	NA	NA	1.8E+04	4.10E+04
Lead	4.E-01	3.E+01	1.00E+03	1.00E+03	5.5E+01	2.5E+01
Lithium	2.E+01	2.E+02	3.84E+04	3.84E+04	1.2E+01	3.47E+01
Manganese	3.E+00	1.3E+02	6.68E+04	8.36E+04	3.65E+02	9.02E+02
Mercury	2.E-01	6.E+00	5.76E+02	5.76E+02	1.34E-01	1.52E+00
Molybdenum ^A	8E+00	1E+01	9.61E+03	9.61E+03	NA	2.56E+01
Nickel	5.E+00	.9E+02	3.84E+04	3.84E+04	1.5E+01	6.22E+01
Selenium	3.E+00	1.5E+02	9.61E+03	9.61E+03	1.2E+00	4.8E+00
Silver ^A	7E+00	1.3E+01	9.61E+03	9.61E+03	NA	2.45E+01
Sodium ^C	NA	NA	NA	NA	9.2+01	NA
Strontium	4.E+01	1.3E+02	>1E+6	>1E+6	4.9E+01	2.11E+02
Vanadium	8.E+00	1.3E+02	1.34E+04	1.34E+04	4.6E+01	8.85E+01
Zinc	4.E+00	2.E+01	5.76E+05	5.76E+05	7.4E+01	1.39E+02
ACCURACY	±20% recovery (of reference standards) SOW reqs	±20% calibration standard; acceptable regression w/ lab results				
PRECISION	±25% RPD (MSD)	±35% RPD				

^A Subsurface soils only

^B Laser-induced breakdown spectroscopy (LIBS)/x-ray fluorescence (XRF). Measurements may require extended analysis times to meet MDL (e.g., 2 minutes vs. 1 minute).

^C Constituents may be eliminated for the risk assessment if they are essential human nutrients (EPA 1989a). Commonly detected chemicals considered to be an essential part of a daily human diet (EPA 1994b) include calcium, iron, magnesium, potassium, and sodium.

TBD to be determined

NA Not applicable

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Table E5
Method Detection Limits for Volatile Organic Compounds

Analyte	Soil (mg/kg) Mobile Lab (SW8260B)	Action Levels (mg/kg)	
		RFCA Tier I	RFCA Tier II
1,1,1-TCA	5E-03	9.48E+01	9.48E-01
1,1,2,2-Tetrachloroethane	5E-03	1.68E-01	1.68E-03
1,1,2-TCA	5E-03	1.23E+00	1.23E-02
1,1-DCA	5E-03	6.89E+02	6.89E+00
1,1-DCE	5E-03	2.19E+00	2.19E-02
1,2-DCA	5E-03	6.68E-01	6.68E-03
1,2-DCB	2E-03	1.32E+03	1.32E+01
1,2-Dibromo-3-chloropropane	5E-03	1.40E+01	1.40E-01
1,2-Dichloropropane	5E-03	1.13E+00	1.13E-02
1,4-DCB	6.60E-01	1.65E+02	1.65E+00
2-Butanone	1.0E-01	NV	1E+06
Acetone	1.0E-01	2.72E+04	2.72E+02
Benzene	5E-03	1.41E+00	1.41E-02
Bromodichloromethane	5E-03	2.64E+01	2.64E-01
Bromoform	5E-03	3.72E+01	3.72E-01
Bromomethane	5E-03	5.98E+00	5.98E-02
Carbon tetrachloride	5E-03	3.56E+00	3.56E-02
Chlorobenzene	5E-03	8.30E+01	8.30E-01
Chloroethane	5E-03	1.55E+05	1.55E+03
Chloroform	5E-03	2.14E+01	2.14E-01
Chloromethane	5E-03	3.45E+04	3.45E+02
Cis-1,3-Dichloropropene	5E-03	1.20E-01	1.20E-03
Dibromochloromethane	5E-03	5.34E+03	5.34E+01
Ethylbenzene	5E-03	9.32E+02	9.32E+00
Methylene chloride	5E-03	5.78E-01	5.78E-03
Styrene	5E-03	2.74E+02	2.74E+00
TCE	5E-03	3.28E+00	3.25E-02
Tetrachloroethene	5E-03	3.15E-02	7.07E+00
Toluene	5E-03	7.07E+00	4.07E+00
Trans-1,3-Dichloropropene	5E-03	1.20E-01	1.20E-03
Vinyl acetate		3.33E+03	3.33E+01
Vinyl chloride	5E-03	3.46E-01	3.46E-03
Xylenes (total)	5E-03	9.74E+03	9.74E+01
ACCURACY	±30% R for LCS; lab-specific for MS (per analyte) SOW reqs		
PRECISION	RPD ≤30% (MSD)		

NV No value

Table E6
Method Detection Limits for Semivolatile Organic Compounds

Analyte (Base-Neutral Extractables)	Soil (mg/kg)	Action Levels (mg/kg)	
	Mobile Lab (SW8270C)	RFCA Tier I	RFCA Tier II
1,2,4-Trichlorobenzene	6.60E-01	4.33E+02	4.33E+00
1,2-DCB	6.60E-01	1.32E+03	1.32E+01
1,4-DCB	6.60E-01	1.65E+02	1.65E+00
2,4-DNT	6.60E-01	5.01E-02	5.01E-04
2,6-DNT	6.60E-01	3.88E-02	3.88E-04
2-Chloronaphthalene	6.60E-01	1.54E+05	1.54E+05
2-Methylnaphthalene	6.60E-01	7.68E+04	7.68E+04
2-Nitroaniline	3.30E+00	1.15E+02	1.15E+02
3,3'-Dichlorobenzidine	1.30E+00	9.96E+02	4.84E-03
4-Chloroaniline	1.30E+00	7.68E+03	4.37E-01
Acenaphthene	6.60E-01	5.34E+04	5.34E+02
Anthracene	6.60E-01	5.76E+05	1.12E+04
Benzo (a) anthracene	6.60E-01	1.60E+02	1.60E+00
Benzo (a) pyrene	6.60E-01	1.60E+02	6.14E+00
Benzo (b) fluoranthene	6.60E-01	4.95E+02	4.95E+00
Benzyl alcohol	1.30E+00	5.76E+05	5.76E+05
Bis (2-chlorethyl) ether	6.60E-01	9.73E-03	9.73E-05
Bis (2-chloroisopropyl) ether	6.60E-01	6.40E+03	6.40E+01
Bis (2-ethylhexyl) phthalate	6.60E-01	3.20E+04	3.20E+02
Butyl benzylphthalate	6.60E-01	3.84E+05	1.44E+04
Chrysene	6.60E-01	1.60E+04	1.6E+02
Di-n-octylphthalate	6.60E-01	>1E+06	3.84E+04
Dibenz (a,h) anthracene	6.60E-01	6.14E+01	6.14E-01
Dibenzofuran	6.60E-01	7.68E+03	7.68E+03
Diethyl phthalate	6.60E-01	3.10E+04	3.10E+02
Dimethyl phthalate	6.60E-01	>1E+06	>1E+06
Fluoranthene	6.60E-01	7.68E+04	5.37E+03
Fluorene	6.60E-01	6.94E+04	6.94E+02
Hexachlorobenzene	6.60E-01	1.89E+02	1.89E+00
Hexachlorobutadiene	6.60E-01	2.01E+02	2.01E+00
Hexachlorocyclopentadiene	6.60E-01	1.33E+04	3.44E+02
Hexachloroethane	6.60E-01	3.77E+01	3.77E-01
Indeno (1,2,3-cd) pyrene	6.60E-01	6.14E+02	6.14E+00
n-Nitrosodiphenylamine	7.E-01	7.84E+01	7.84E-01
n-Nitrosodi-n-propylamine	7.E-01	1.89E-03	1.89E-05
Naphthalene	6.60E-01	1.01E+04	1.01E+02
Nitrobenzene	7.E-01	5.39E+00	5.39E-02
Pyrene	6.60E-01	5.76E+04	3.97E+03
Isophorone	6.60E-01	2.09E+01	2.09E-01

Table E6
Method Detection Limits for Semivolatile Organic Compounds (continued)

Analyte (Acid Extractables)	Soil (mg/kg)	Action Levels (mg/kg)	
	Mobile Lab (SW8270C)	RFCA Tier I	RFCA Tier II
2,4,5-Trichlorophenol	6.60E-01	2.79E+02	2.79E+00
2,4,6-Trichlorophenol	6.60E-01	1.07E+01	1.07E-01
2,4-Dichlorophenol	6.60E-01	6.35E+01	6.35E-01
2,4-Dimethylphenol	6.60E-01	5.77E+02	5.77E+00
2,4-Dinitrophenol	3.30E+00	5.29E+00	5.29E-02
2-Chlorophenol	6.60E-01	2.57E+02	2.57E+00
2-Methylphenol	6.60E-01	7.06E+02	7.06E+00
4,6-Dinitro-2-methylphenol	3.30E+00	1.92E+02	1.92E+02
4-Methylphenol	6.60E-01	9.61E+03	9.61E+03
4-Nitrophenol	3.30E+00	1.54E+04	1.54E+04
Benzoic acid	3.30E+00	1.09E+04	1.09E+02
Pentachlorophenol	3.30E+00	2.11E+00	2.11E-02
Phenol	6.60E-01	3.25E+03	3.75E+01
ACCURACY	±30% Recovery (R) for LCS; lab-specific for MS (per analyte) SOW reqs		
PRECISION	RPD ≤30% (MSD)		

Table E7
Method Detection Limits for Pesticides

Analyte	Soil (mg/kg)	Action Levels (mg/kg)	
	Mobile Lab (SW8081A)	RFCA Tier I	RFCA Tier II
α-BHC	2.E-02	5.80E-02	5.80E-04
β-BHC	4.E-02	2.08E-01	2.08E-03
α-Chlordane	1E+00	8.25E+02	8.25E+00
β-Chlordane	1E+00	8.25E+02	8.25E+00
γ-Chlordane	1E+00	8.25E+02	8.25E+00
Aldrin	2.7E-02	2.64E+01	2.64E-01
Dieldrin	1.4E-02	3.92E-01	3.92E-03
Heptachlor	2.E-02	9.96E+01	9.96E-01
Heptachlor Epoxide	5.4E-02	4.93E+01	4.92E-01
Methoxychlor	1.2E+00	9.61E+03	1.34E+02
Toxaphene	1.7E+00	4.07E+02	4.07E+00
ACCURACY	±30% R for LCS; lab-specific for MS (per analyte) SOW reqs		
PRECISION	RPD ≤50% (MSD)		

**Table E8
Method Detection Limits for PCBs**

Analyte	Soil (mg/kg)	Action Levels (mg/kg)	
	Mobile Lab (SW8082)	RFCA Tier I	RFCA Tier II
PCB-1016	3.50E-01	2.24E+02	2.24E+00
PCB-1221	3.50E-01	2.24E+02	2.24E+00
PCB-1232	3.50E-01	2.24E+02	2.24E+00
PCB-1242	3.50E-01	2.24E+02	2.24E+00
PCB-1248	3.50E-01	2.24E+02	2.24E+00
PCB-1254	3.50E-01	2.24E+02	2.24E+00
PCB-1260	3.50E-01	2.24E+02	2.24E+00
ACCURACY	±30% R for LCS; lab-specific for MS (per analyte) SOW reqs		
PRECISION	RPD ≤50% (MSD)		

**Table E9
Minimum Detectable Activities for Radionuclides**

Analyte	Soil (pCi/g)		Action Levels (pCi/g)	
	Onsite Gamma Spec	Offsite Alpha Spec (Module GR01)	RFCA Tier I	RFCA Tier II
Americium-241	1.0	0.3	209	38
Plutonium-239/240	8 ^A	0.3	1088	252
Uranium-233/234	EST	1.0	1627	307
Uranium-235	0.5	1.0	113	24
Uranium-238	5.0 ^B	1.0	506	103
ACCURACY	±20% recovery (of reference standards) SOW reqs.			
PRECISION	±40% RPD (duplicates)			

^A Plutonium-239/240 is estimated based on site-specific decay ratios between americium-241 and plutonium-239/240.

^B Uranium-238 is estimated based on equilibrium with thorium-234 and protactinium-234 m.

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**Table E10
Method Detection Limits for Method SW9056**

Analyte	Soil (mg/kg)	RFCA Action Levels (mg/kg)	
		Tier I	Tier II
Nitrate	1.0	>1E+6	>1E+6
Nitrite	1.0	1.92E+05	1.92E+05
ACCURACY	±30% R for LCS; lab-specific for MS (per analyte) SOW reqs		
PRECISION	RPD ≤50% (MSD)		

**Table E11
Method Detection Limits for Method SW9010B**

Analyte	Soil (mg/kg)	RFCA Action Levels (mg/kg)	
		Tier I	Tier II
Total cyanide	0.25	3.84E+04	3.84E+04
ACCURACY	±30% R for LCS; lab-specific for MS (per analyte) SOW reqs		
PRECISION	RPD ≤50% (MSD)		

2.0 CONTAMINANTS DISQUALIFIED FROM FURTHER CONSIDERATION

The contaminants disqualified from further sampling and analysis in the BZ are based on the (data) filter criteria listed below. All data related to these contaminants were passed through the prerequisite “Data Quality Filter” as referenced in Section 3.1 of the BZSAP.

The data comparisons described below were performed for two (2) separate subsets of data, specifically the two matrix types of interest: surface soils and subsurface soils.

2.1 DETECTION LIMIT/BACKGROUND COMPARISON

Results are disqualified from further consideration based on the following criteria:

- a. The analyte was not detected (specifically, the result was flagged with lab qualifier “U”), not remediated after detection (“UWQ4”) or was not a lab quality control (QC) sample (“UWQ5”);
- b. The analyte does not exceed published background values (Appendix F) plus two standard deviations;
- c. The analyte exists as a tentatively identified compound only;

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- d. The analyte was rejected through formal data validation process (“R”), or
- e. The analyte did not have a published Tier I or Tier II AL (RFCA Attachment 5), as noted in Table E12.

Note that background values are not established for most organic analytical suites of interest (esp. VOCs, SVOCs, pesticides, and PCBs).

Potential contaminants of concern (PCOCs) will be re-evaluated on an area of concern (AOC)-by-AOC basis to ensure that potential contaminants without RFCA ALs are not overlooked during sampling and analysis.

2.2 COMPARISON WITH RFCA ACTION LEVELS

If a RFCA AL is not published for the analyte of interest (RFCA Attachment 5), the analyte is disqualified from further consideration as a potential contaminant, consistent with the RFCA Action Level Framework (ALF).

Those analytes exceeding detection limits, but without associated RFCA ALs, will be addressed on an individual hazardous substance site (IHSS)-by-IHSS basis.

Table E12
Disqualified Analytes

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
0,0,0-Triethyl Phosphorothioat	126-68-1	4	17	8.1	µg/kg
1,1,2,2-Tetrachloroethane	630-20-6	226	96000	96000	µg/kg
1,1,2-Trichlorotrifluoroethane	76-13-1	223	96000	96000	µg/kg
1,1-Dichloropropene	563-58-6	221	96000	96000	µg/kg
1,2,3-Trichlorobenzene	87-61-6	221	96000	96000	µg/kg
1,2,3-Trichloropropane	96-18-4	227	96000	96000	µg/kg
1,2,4,5-Tetrachlorobenzene	95-94-3	98	16000	790	µg/kg
1,2,4-Trimethylbenzene	95-63-6	223	96000	96000	µg/kg
1,2,3,4 Dibenzoanthracene	130498-29-2	1	2300	0	µg/kg
1,2-Benzenedicarboxylic Acid	17851-53-5	2	1100	0	µg/kg
1,2-Benzenedicarboxylic Acid	27554-26-3	1	280	0	µg/kg
1,2-Benzenedicarboxylic Acid	88-99-3	5	2700	0	µg/kg
1,2-Cis-Dichloroethylene	156-59-2	231	96000	96000	µg/kg
1,2-Cyclohexanediol	931-17-9	1	500	0	µg/kg
1,2-Dibromo-3-Chloropropane	96-12-8	227	96000	96000	µg/kg
1,2-Dibromoethane	106-93-4	227	48	48	µg/kg
1,2-Dichlorobenzene	541-73-1	5545	96000	96000	µg/kg
1,2-Dichloroethane-D4 (Surr)	17070-07-0	1	100	0	µg/kg
1,2-Dichloroethane-D4 (SURR)	17060-07-0	1	101	0	µg/kg
1,2-Dichloroethene (Total)	156-60-5	707	96000	0	µg/kg
1,2-Dichloroethylene	540-59-0	3093	880000	1500	µg/kg
1,2-Xylene	95-47-6	235	140	8	µg/kg
1,3- And 1,4-Xylene	108-38-3	4	6	6	µg/kg
1,3,5-Trimethylbenzene	108-67-8	222	96000	96000	µg/kg
1,3-Dichloropropane	142-28-9	221	96000	96000	µg/kg
1,4-Benzenedicarboxylic Acid	100-21-0	1	1200	0	µg/kg
1,4-Naphthoquinone	130-15-4	7	3900	3900	µg/kg
1,4-Naphthoquinone, 6-Ethyl-	13378-87-5	1	510	0	µg/kg
1-Dotriacontanol	6624-79-9	2	420	0	µg/kg
1-Eicosanol	629-96-9	1	530	0	µg/kg
1-Hexanol, 2-Ethyl-	104-76-7	2	1900	0	µg/kg
1-Hexanol, 2-Ethyl-	TIC	1	6	0	µg/kg
1h-Indene, 2,3-Dihydro-1,2-D	17057-82-8	1	99	0	µg/kg
1h-Indene, Octahydro-2,2,4,4	54832-83-6	1	1200	0	µg/kg
1-Methylnaphthalene	90-12-0	6	490	0	µg/kg
1-Methyl-Pyrene	2381-21-7	1	740	0	µg/kg
1-Naphthylamine	134-32-7	7	790	790	µg/kg
1-Pentadecanol	629-76-5	1	530	0	µg/kg
1-Pentanol	71-41-0	1	120	0	µg/kg
1-Phenylnaphthalene	605-02-7	2	320	0	µg/kg
2,2-Dichloropropane	594-20-7	212	96000	96000	µg/kg
2,3,4,6-Tetrachlorophenol	58-90-2	7	790	790	µg/kg
2,4,5-T	93-76-5	19	240	40	µg/kg
2,4,5-Tp (Silvex)	93-72-1	19	240	240	µg/kg

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
2,4-D	94-75-7	19	270	240	µg/kg
2,4'-DDE	3424-86-6	3	20	20	µg/kg
2,4'-DDT	789-02-6	3	20	20	µg/kg
2,4-Decadienal, (E,E)-	25152-84-5	4	470	0	µg/kg
2,6-Dichlorophenol	87-65-0	7	790	790	µg/kg
2-Acetylaminofluorene	53-96-3	7	1600	830	µg/kg
2-Chloro-1,3-Butadiene	126-99-8	5	240	240	µg/kg
2-Chloroethylvinylether	110-75-8	701	73000	290	µg/kg
2-Chlorotoluene	95-49-8	222	96000	96000	µg/kg
2-Cyclohexen-1-One	930-68-7	1	97	0	µg/kg
2-Hexanone	591-78-6	3864	1800000	99	µg/kg
2-Methylnaphthalene	91-57-6	2229	26000	990	µg/kg
2-Naphthylamine	91-59-8	7	790	790	µg/kg
2-Nitroaniline	88-74-4	2230	110000	9900	µg/kg
2-Nitrophenol	88-75-5	2213	22000	990	µg/kg
2-Pentanone, 3,3,4,4-Tetrame	865-66-7	1	180	0	µg/kg
2-Pentanone, 4-Hydroxy-4-Met	123-42-2	36	190000	0	µg/kg
2-Pentanone, 4-Methoxy-4-Met	107-70-0	1	240	0	µg/kg
2-Propenoic Acid,2-Methyl-	80-62-6	8	48	48	µg/kg
2-Pyrrolidinone, 1-Methyl-	872-50-4	39	12000	0	µg/kg
2-Sec-Butyl-4,6-Dinitrophenol	88-85-7	7	1600	830	µg/kg
3,3'-Dimethylbenzidine	119-93-7	7	1600	830	µg/kg
3-Hexen-2-One,5-Methyl	5166-53-0	5	480	0	µg/kg
3-Hexene-2,5-Dione	4436-75-3	7	1200	0	µg/kg
3hydroxy-3methyl-2-Butanone	115-22-0	1	14	0	µg/kg
3-Methoxy-2-Butanol	53778-72-6	5	210	0	µg/kg
3-Methylcholanthrene	56-49-5	7	790	790	µg/kg
3-Methylphenol	108-39-4	7	790	790	µg/kg
3-Nitroaniline	99-09-2	2230	110000	9900	µg/kg
3-Pyrrolidinol	40499-83-0	15	1200	0	µg/kg
4,6-Dinitro-2-Methylphenol	534-52-1	2212	160000	9900	µg/kg
4-Aminobiphenyl	92-67-1	7	790	790	µg/kg
4-Bromophenyl Phenyl Ether	101-55-3	2230	22000	990	µg/kg
4-Chloro-3-Methylphenol	59-50-7	2069	32000	990	µg/kg
4-Chlorophenylphenyl Ether	7005-72-3	2230	22000	990	µg/kg
4-Chlorotoluene	106-43-4	222	96000	96000	µg/kg
4H-Cyclopenta(Def)Phenanthrene	203-64-5	24	75000	0	µg/kg
4-Isopropyltoluene	99-87-6	224	96000	96000	µg/kg
4-Methylphenol	65794-96-9	22	790	790	µg/kg
4-Nitroaniline	100-01-6	2230	160000	9900	µg/kg
4-Nitrophenol	100-02-7	2068	110000	9900	µg/kg
4-Nitroquinoline-1-Oxide	56-57-5	7	3900	3900	µg/kg
5-NITRO-O-TOLUIDINE	99-55-8	7	1600	830	µg/kg
7,12-DIMETHYLBENZ(A)ANTHRACENE	57-97-6	7	1600	830	µg/kg
7H-Benz[De]Anthracen-7-One	82-05-3	1	810	0	µg/kg
7-Hexadecene, (Z)-	35507-09-6	2	46000	0	µg/kg

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
9,10-Anthracenedione	84-65-1	21	38000	0	µg/kg
9H-Fluoren-9-One	486-25-9	8	33000	0	µg/kg
A,A-Dimethylphenethylamine	122-09-8	7	3900	3900	µg/kg
Acenaphthylene	208-96-8	2250	22000	990	µg/kg
Acetonitrile	75-05-8	5	240	240	µg/kg
Acetophenone	98-86-2	7	790	790	µg/kg
Acetylacetone	123-54-6	2	180000	0	µg/kg
Acrolein	107-02-8	5	1200	620	µg/kg
Acrylonitrile	107-13-1	5	240	240	µg/kg
Aldol Condensation	TIC	26	4700	330	µg/kg
Aldol Condensation	TIC-4	1	220	0	µg/kg
Allyl Chloride	107-05-1	5	24	24	µg/kg
Alpha Particle Radioactivity	12587-46-1	3819	39900	23.5	µg/kg
Alpha.-Amyrin	638-95-9	1	680	0	µg/kg
Ametryn	834-12-8	1	0	0.06	µg/kg
Aniline	62-53-3	127	4400	4400	µg/kg
Arachidonic Acid	506-30-9	1	200	0	µg/kg
Aramite	140-57-8	7	1600	830	µg/kg
Atraton	1610-17-9	1	0	0.06	µg/kg
Atrazine	1912-24-9	1	0	0.05	µg/kg
Azinphos Methyl	86-50-0	2	43	43	µg/kg
Azobenzene	103-33-3	91	16000	330	µg/kg
Behenic Acid	112-85-6	1	470	0	µg/kg
Benzenamine, 4-Methyl-2-Nitro	89-62-3	1	110	0	µg/kg
Benzene, 1-Ethyl-2,3-Diethyl	933-98-2	1	16	0	µg/kg
Benzene, 1-Ethyl-3,5-Dimethyl	934-74-7	1	21000	0	µg/kg
Benzene, 1-Methyl-4-Propyl-	1074-55-1	1	10	0	µg/kg
Benzene, 2-Ethyl-1,3-Dimethyl	2870-04-4	1	12	0	µg/kg
Benzene, 4-Ethyl-1,2-Dimethyl	934-80-5	1	17	0	µg/kg
Benzenesulfonamide, 4-Methyl	70-55-3	4	460	0	µg/kg
Benzidine	92-87-5	120	4400	4400	µg/kg
Benzo(G,H,I)Perylene	191-24-2	2251	22000	990	µg/kg
Benzo[B]Naphtho[1,2-D]Thioph	205-43-6	1	360	0	µg/kg
Benzoic Acid, 3-Methyl-	99-04-7	5	3900	0	µg/kg
Beta Particle Radioactivity	12587-47-2	3816	1580	9.99	µg/kg
Beta.-Amyrin	559-70-6	1	340	0	µg/kg
Bis(2Chloroethoxy)Methane	111-91-1	2231	22000	990	µg/kg
Bis(2-Chloroisopropyl) Ether	108-60-1	2228	22000	990	µg/kg
Bromobenzene	108-86-1	223	96000	96000	µg/kg
Bromochloromethane	74-97-5	221	96000	96000	µg/kg
Bromofluorobenzene (SURR)	460-00-4	60	2720	0	µg/kg
Butyric Acid, Thio-, S-Decyl	2432-55-5	1	170	0	µg/kg
Carbonic Acid, Dipentyl Este	2050-94-4	1	420	0	µg/kg
Carbozole	86-74-8	83	12500	940	µg/kg
Chlordane	57-74-9	279	20	20	µg/kg
Chlorobenzilate	510-15-6	7	790	790	µg/kg

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
Chlorophene	120-32-1	1	6600	0	µg/kg
Chlorpyrifos	2921-88-2	4	17	8.1	µg/kg
Cholesterol	57-88-5	3	2000	0	µg/kg
Coumaphos	56-72-4	4	87	87	µg/kg
Cyclohexane (DOT)	110-82-7	1	6	0	µg/kg
Cyclohexane, 1-Methyl-3-(1-M	16580-24-8	1	5000	0	µg/kg
Cyclopenta[Def]Phenanthrene	5737-13-3	2	350	0	µg/kg
Cyclotetrasiloxane	TIC	1	7	0	µg/kg
Cyclotrisiloxane	TIC	1	7	0	µg/kg
Decane	124-18-5	2	11000	0	µg/kg
Delta-BHC	319-86-8	1672	720	99	µg/kg
Demeton,S	126-75-0	1	8	8.1	µg/kg
Demeton,S	8065-48-3	1	17	17	µg/kg
Diallate	2303-16-4	7	790	790	µg/kg
Diazanon	333-41-5	4	17	8.1	µg/kg
Dibenzofuran	132-64-9	2230	22000	990	µg/kg
Dibromofluoromethane	1868-53-7	58	2330	0	µg/kg
Dibromomethane	74-95-3	226	96000	96000	µg/kg
Dichlorodifluoromethane	75-71-8	227	96000	96000	µg/kg
Dichlorvos	62-73-7	2	17	8.1	µg/kg
Diesel	68334-30-5	20	6000	25	µg/kg
Dimethoate	60-51-5	4	17	8.1	µg/kg
Dimethyl Disulfide	624-92-0	2	16	0	µg/kg
Dioxane	123-91-1	7	3200	3200	µg/kg
Diphenylamine	122-39-4	7	790	790	µg/kg
Disolfoton	298-04-4	4	17	8.1	µg/kg
Dodecanamide, N,N-Bis(2-Hydr	120-40-1	1	250	0	µg/kg
Dodecane	112-40-3	8	5300	0	µg/kg
Eicosane	112-95-8	3	1200	0	µg/kg
Endosulfan Sulfate	1031-07-8	1669	1400	98	µg/kg
Endrin Aldehyde	7421-93-4	94	410	41	µg/kg
Endrin Ketone	53494-70-5	1646	1400	98	µg/kg
EPN	2104-64-5	4	17	8.1	µg/kg
Ergost-5-En-3-Ol, (3.Beta.)-	4651-51-8	1	460	0	µg/kg
Ethanol, 2-Phenoxy-	122-99-6	2	110	0	µg/kg
Ethoprop	13194-48-4	4	17	8.1	µg/kg
Ethyl Hexanol	TIC	6	10	0	µg/kg
Ethyl Methanesulfonate	62-50-0	7	790	790	µg/kg
Ethyl Parathion	14265-44-2	4	17	8.1	µg/kg
Ethylmethacrylate	97-63-2	5	48	48	µg/kg
Famphur (Famophos)	52-85-7	4	43	43	µg/kg
Fensulfotion	115-90-2	2	17	8.1	µg/kg
Fenthion	55-38-9	2	17	8.1	µg/kg
Gamma.-Sitosterol	83-47-6	8	4500	0	µg/kg
Gasoline	8006-61-9	34	200000	100	µg/kg
Hentriacontane	630-04-6	1	1200	0	µg/kg

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
Heptacosane	593-49-7	4	570	0	µg/kg
Heptadecane	629-78-7	5	45000	0	µg/kg
Heptane, 3,4-Dimethyl-	922-28-1	1	200	0	µg/kg
Hexachloroethane	TIC	1	9	0	µg/kg
Hexachlorophene	70-30-4	7	7900	7900	µg/kg
Hexachloropropene	1888-71-7	7	1600	830	µg/kg
Hexadecane	544-76-3	4	12000	0	µg/kg
Hexadecane, 2,6,10,14-Tetramet	638-36-8	4	8700	0	µg/kg
Hexadecanoic Acid	57-10-3	99	5000	0	µg/kg
Hexadecenoic Acid	2091-29-4	1	600	0	µg/kg
Hexanal	TIC	4	98	0	µg/kg
Hexanal C6H12O	66-25-1	42	1500	0	µg/kg
Hexane	TIC	1	870	0	µg/kg
Hexanedioic Acid, Dicyclohex	849-99-0	1	140	0	µg/kg
Hexanedioic Acid, Dioctyl Es	123-79-5	26	36000	0	µg/kg
Hexanedioic Acid, Mono(2-Eth	4337-65-9	1	490	0	µg/kg
Hexanoic Acid, 2-Ethyl-	149-57-5	3	280	0	µg/kg
Hexatriacontane	630-06-8	2	650	0	µg/kg
Hydrocarbon C6h14	TIC	2	30	0	µg/kg
Isobutanol	78-83-1	6	4800	4800	µg/kg
Isodrin	465-73-6	9	19	9.9	µg/kg
Isopropanol	67-63-0	6	810	0	µg/kg
Isopropylbenzene	98-82-8	221	96000	96000	µg/kg
Isosafrole	120-58-1	7	790	790	µg/kg
Kepone	143-50-0	9	37	37	µg/kg
Lupeol	545-47-1	1	460	0	µg/kg
Malathion	121-75-5	4	17	8.1	µg/kg
Merphos	150-50-5	4	17	8.1	µg/kg
Meta-Dinitrobenzene	99-65-0	7	1600	1600	µg/kg
Methacrylonitrile	126-98-7	5	48	48	µg/kg
Methapyrilene	91-80-5	7	2000	950	µg/kg
Methyl Iodide	74-88-4	5	24	24	µg/kg
Methyl Methanesulfonate	66-27-3	7	790	790	µg/kg
Methyl Parathion	298-00-0	2	17	8.1	µg/kg
Methyl Propyl Ketone	107-87-9	1	850	0	µg/kg
Methyl Sulfide	75-18-3	3	73	0	µg/kg
Mevinphos	7786-34-7	4	17	8.1	µg/kg
Mitotane	53-19-0	3	20	20	µg/kg
Molecular Sulfur	10544-50-0	7	9900	0	µg/kg
Monochrotophos	6923-22-4	2	1500	87	µg/kg
Naled	300-76-5	4	43	43	µg/kg
Naphthalene, 6,7-Diethyl-1,2	55741-10-1	4	900	0	µg/kg
Naphthalene, Decahydro-2-Methy	2958-76-1	1	75	0	µg/kg
N-Butybenzene	104-51-8	222	96000	96000	µg/kg
N-Caproic Acid	142-62-1	7	340	0	µg/kg
N-Nitrosodiethylamine	55-18-5	98	32000	790	µg/kg

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
N-Nitroso-Di-Methylamine	62-75-9	218	32000	950	µg/kg
N-Nitroso-Di-N-Butylamine	924-16-3	98	16000	790	µg/kg
N-Nitrosomethylethylamine	10595-95-6	7	790	790	µg/kg
N-Nitrosomorpholine	59-89-2	7	1600	830	µg/kg
N-Nitrosopiperidine	100-75-4	7	790	790	µg/kg
N-Nitrosopyrrolidine	930-55-2	7	3900	3900	µg/kg
Nonacosane	630-03-5	4	1700	0	µg/kg
Nonadecane	629-92-5	4	5500	0	µg/kg
Nonanal	124-19-6	3	11	0	µg/kg
N-Propylbenzene	103-65-1	222	96000	96000	µg/kg
N-Valeraldehyde	110-62-3	10	2000	0	µg/kg
Octacosane	630-02-4	3	2600	0	µg/kg
Octadecane	593-45-3	4	4200	0	µg/kg
Octadecanoic Acid	57-11-4	6	400	0	µg/kg
Oil & Grease	10-30-0	106	68000	17	µg/kg
Olean-12-Ene	471-68-1	2	550	0	µg/kg
Oleic Acid	112-80-1	2	640	0	µg/kg
O-Toluidine	95-53-4	7	790	790	µg/kg
P-Dimethylaminoazobenzene	60-11-7	7	1600	0	µg/kg
Pentachlorobenzene	608-93-5	98	16000	790	µg/kg
Pentachloroethane	76-01-7	5	48	0	µg/kg
Pentadecane	629-62-9	5	9100	0	µg/kg
Pentadecane, 2,6,10,14-Tetrame	1921-70-6	1	7300	0	µg/kg
Pentane, 1,1 -Oxybis-	693-65-2	1	10	0	µg/kg
Pentanoic Acid	109-52-4	4	260	0	µg/kg
Pentanol,2,4-Dimethyl	TIC	1	5	0	µg/kg
-Pentene, -Dimethyl-	10574-37-5	1	600	0	µg/kg
Petroleum Hydrocarbons	10-90-2	255	3500	0	µg/kg
Phenacetin	62-44-2	7	790	0	µg/kg
Phenanthrene	85-01-8	2249	25000	990	µg/kg
Phenanthrene, 2,3,5-Trimethyl	3674-73-5	1	3200	0	µg/kg
Phenanthrene, 2,3,5-Trimethyl-	3674-73-5A	1	6500	0	µg/kg
Phenanthrene, 2,3,5-Trimethyl-	3674-73-5B	1	10000	0	µg/kg
Phenol, 2,6-Bis(1,1-Dimethylet	128-37-0	2	240	0	µg/kg
Phenol, 4,4'-Butylidenebis[2	85-60-9	7	1300	0	µg/kg
Phenol, Bis(1,1-Dimethylethy	26746-38-3	1	150	0	µg/kg
Phenylenediamine	106-50-3	7	1600	830	µg/kg
Phorate	298-02-2	4	17	8.1	µg/kg
Phosphonic Acid, Dioctadecyl	19047-85-9	1	470	0	µg/kg
Phosphoric Acid, Tributyl Esth	126-73-8	1	11000	0	µg/kg
Phthalate Ester	TIC	1	230	0	µg/kg
Phthalic Anhydride	85-44-9	2	330	0	µg/kg
Phytol	150-86-7	2	600	0	µg/kg
Picoline	109-06-8	7	790	790	µg/kg
Prometon	1610-18-0	1	0	0.03	µg/kg
Prometryn	7287-19-6	1	0	0.06	µg/kg

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
Pronamide	23950-58-5	7	790	0	µg/kg
Propanoic Acid, 2-Methyl-, 1	74381-40-1	13	3000	0	µg/kg
Propazine	139-40-2	1	0	0.03	µg/kg
Propionaldehyde	123-38-6	1	500	0	µg/kg
Propionitrile (Ethyl Cyanide)	107-12-0	5	120	0	µg/kg
Pyridine	110-86-1	7	1600	830	µg/kg
Quintozine	82-68-8	7	790	790	µg/kg
Ronnel	299-84-3	4	17	8.1	µg/kg
Safrole	94-59-7	7	790	790	µg/kg
Sec-Butylbenzene	135-98-8	222	96000	0	µg/kg
Simazine	122-34-9	1	0	0.06	µg/kg
Simetryne	1014-70-6	1	0	0.07	µg/kg
Sr90	10098-97-2	208	15		µg/kg
Stigmasta-5,22-Dien-3-Ol, (3	83-48-7	1	530	0	µg/kg
Stirofos	22248-79-9	4	43	43	µg/kg
Subst. Benzene	TIC-5	1	50	0	µg/kg
Subst. Propenoic Acid	TIC	2	30	0	µg/kg
Substituted Benzene	TIC	2	20	0	µg/kg
Sulfide (Rep)	18496-25-8	804	498	20	µg/kg
Sulfotep	3689-24-5	2	17	8.1	µg/kg
Sulprofos	35400-43-2	2	17	8.1	µg/kg
Sym-Trinitrobenzene	99-35-4	7	7900	3800	µg/kg
Taraxerol Methyl Ether	14021-23-9	7	4600	0	µg/kg
Taraxerol Methyl Ether	TIC	2	3800	0	µg/kg
TCDD	1746-01-6	2	0	0.2	µg/kg
Terbutylazine	5915-41-3	1	0	0.03	µg/kg
Terbutryn	886-50-0	1	0	0.05	µg/kg
Tert-Butyl Hydroperoxide	75-91-2	2	160	0	µg/kg
Tert-Butylbenzene	98-06-6	223	96000	0	µg/kg
Tetradecane	629-59-4	4	13000	0	µg/kg
Tetradecanoic Acid	544-63-8	7	1600	0	µg/kg
Tetraethyldithiopyrophosphate	107-49-3	1	17	0	µg/kg
Tetrahydrofuran	109-99-9	1	100	0	µg/kg
Tetratetracontane	7098-22-8	1	1700	0	µg/kg
Thionazin (Zinophos)	297-97-2	2	17	0	µg/kg
Tic 2,6-Dichloro-4-Nitroanili	99-30-9	2	7500	0	µg/kg
Tic 3-Penten-2-One, 4-Methyl-	141-79-7	19	28000	0	µg/kg
Tic Decanal	112-31-2	1	7	0	µg/kg
Tic Ethane,1,1'-Oxybis[2-Meth	111-96-6	2	11000	0	µg/kg
Tic Hexane	110-54-3	2	19	0	µg/kg
Tic-Dibenzothiophene	132-65-0	8	43000	0	µg/kg
TOC	10-35-5	1050	59000	697	µg/kg
Tokuthion	34643-46-4	2	17	8.1	µg/kg
Toluene-D8	2037-26-5	84	2560	0	µg/kg
Total Hxcd	34465-46-8	2	0	0	µg/kg
Total Hxcdf	55684-94-1	2	0	0	µg/kg

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
Total Pecdd	36088-22-9	6	0	0	µg/kg
Total Pecdf	30402-15-4	6	0	0	µg/kg
Total TCDD	41903-57-5	2	0	0	µg/kg
Total TCDF	55722-27-5	2	0	0	µg/kg
TOX	59473-04-0	17	180	48.5	µg/kg
Trans-1,2-Dichloroethylene	156-60-5	20	12	0	µg/kg
Trans-1,4-DICHLORO-2-BUTENE	110-57-6	5	48	48	µg/kg
Trichlorofluoromethane	75-69-4	458	96000	24	µg/kg
Trichloronate	327-98-0	4	17	8.1	µg/kg
Trichlorotrifluoroethane	TIC	1	50	0	µg/kg
Tricosane	638-67-5	1	340	0	µg/kg
Tridecane	629-50-5	5	69000	0	µg/kg
Triphenylene	217-59-4	1	360	0	µg/kg
Undecane	1120-21-4	7	1600	0	µg/kg
Unknown	TIC	24	15000	0	µg/kg
Unknown Acid Ester	000-00-0	1	9	0	µg/kg
Unknown Alcohol	000-00-0	2	41	0	µg/kg
Unknown Aldehyde	000-00-0	1	6	0	µg/kg
Unknown Alkane	TIC-40	5	430	0	µg/kg
Unknown Code From RFEDS	1112-39-6	2	10	0	µg/kg
Unknown Code From RFEDS	19047-8-59	1	680	0	µg/kg
Unknown Code From RFEDS	2396-74-9	6	1100	0	µg/kg
Unknown Code From RFEDS	2597-49-1	1	1300	0	µg/kg
Unknown Code From RFEDS	3021-94-1	1	3600	0	µg/kg
Unknown Code From RFEDS	39029-41-9	1	320	0	µg/kg
Unknown Code From RFEDS	515-17-3	1	210	0	µg/kg
Unknown Code From RFEDS	5208-59-3	1	630	0	µg/kg
Unknown Code From RFEDS	54932-78-4	1	1400	0	µg/kg
Unknown Code From RFEDS	591-87-7	2	56	0	µg/kg
Unknown Code From RFEDS	6006-01-5	1	530	0	µg/kg
Unknown Code From RFEDS	619-66-9	2	2800	0	µg/kg
Unknown Code From RFEDS	6245-99-4	1	17	0	µg/kg
Unknown Code From RFEDS	UNKN	9	3300	0	µg/kg
Unknown PAH	TIC	1	410	0	µg/kg
Ac-228	14331-83-0	1167	5	0.82848	pCi/g
Bi-212	14913-49-6	1167	7	3.522	pCi/g
Bi-214	14733-03-0	1167	9	1.8029	pCi/g
Cesium	13-00-0	94	78	1000	pCi/g
Cesium (Cs)	7440-46-2	3584	2830	957	pCi/g
Cesium 134	13967-70-9	745	1	0.9561	pCi/g
Cesium 137	10045-97-3	3783	5	0.7	pCi/g
Co-60	10198-40-0	1167	0	0.14752	pCi/g
Gross Alpha	10-78-6	5	17	2.3	pCi/g
K-40	13966-00-2	1167	54	3.3047	pCi/g
Np-237	13994-20-2	20	0	0.0152	pCi/g
Pb-212	14255-04-0	1167	4	0	pCi/g

Analyte Name	CAS No. ^A	Total No. of Results ^B	Maximum Result ^C	Maximum DL ^D	Unit
Pb-214	15067-28-4	1167	2	0	pCi/g
Plutonium 238	13981-16-3	656	2610	11.5	pCi/g
Plutonium-239	15117-48-3	1	1	0.0055	pCi/g
Pu-239	10-2-8	1	115	0	pCi/g
Pu-239	39733	16	3246	0	pCi/g
Ra-226	13982-63-3	2169	117	0	pCi/g
Radium 228	15262-20-1	2160	8	0	pCi/g
Sr89	14158-27-1	44	0	0	pCi/g
Sr-89,90	11-10-9	2236	17	1.6238	pCi/g
Tl-208	14913-50-9	1167	149060	0	pCi/g
Total Uranium	11-09-6	34	6	0	pCi/g
Tritium	10028-17-8	38	510	420	pCi/g
U238	11-07-4	9	39	0	pCi/g
pH (1:1)	10-29-7	33	9	0	pH
Alkalinity	10-09-3	137	81000	10	mg/kg
Bicarbonate	71-52-3	32	5340	53	mg/kg
Calcium	7440-70-2	4239	254000000	5000	mg/kg
Carbonate	3812-32-6	74	324	53	mg/kg
Chloride	16887-00-6	11	1250	25	mg/kg
Chromium	7440-47-3	4250	15600	10	mg/kg
Exchangeable Cation Ca+	RF00045	2	3100	0.5	mg/kg
Exchangeable Cation K+	RF00056	2	380	0.5	mg/kg
Exchangeable Cation Mg+	RF00046	2	120	0.1	mg/kg
Exchangeable Cation Na+	RF00047	2	10	0.5	mg/kg
Magnesium	7439-95-4	4250	3710000	5000	mg/kg
Nitrate	C-005	70	50	0.5	mg/kg
Nitrate As N	14797-55-8	570	500	2.5	mg/kg
Nitrite, As N	14797-65-0	56	7	2.5	mg/kg
Phosphorus By ICAP	7723-14-0	12	1400	0.5	mg/kg
Potassium	7440-09-7	4240	1635000	5000	mg/kg
Si	7440-21-3	966	7100	200	mg/kg
Sodium	7440-23-5	4240	700000	5000	mg/kg
Sulfate	14808-79-8	13	56	25	mg/kg
Tantalum	7440-25-7	3	20	500	mg/kg
Thallium	7440-28-0	4236	530	10	mg/kg
TKN	7727-37-9	2	3000	0	mg/kg

^A Chemical Abstract Society Identification Number

^B Total number of samples acquired in the BZ

^C Maximum result in mg/kg (pCi/g for radionuclides)

^D Maximum detection limit

3.0 REFERENCES

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APPENDIX F

**Background Levels for Inorganic and Radionuclide
Potential Contaminants of Concern**

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ACRONYMS

BSCP	Background Soils Characterization Plan
DOE	U.S. Department of Energy
g/cm ³	grams per cubic centimeter
IDL	instrument detection limit
mg/kg	milligrams per kilogram
n	number of samples
NC	not calculated
nd	non-detect
pCi/g	picocuries per gram
RFETS	Rocky Flats Environmental Technology Site
U	undetected
UTL	upper tolerance limit

Background levels for inorganic and radionuclide potential contaminants of concern in soil in the Buffer Zone are listed in Tables F1, F2, F3, F4, and F5.

Table F1
Summary Statistics for BSCP Metals (mg/kg) and Naturally Occurring Radionuclides (pCi/g)

Analyte	Distribution	Count (n)	% Non-detection	Minimum mg/kg	Maximum mg/kg	Mean mg/kg	Standard Deviation	M+2SD mg/kg
ALUMINUM	Normal	20	0	4050	17100	10244	3329	16902
ANTIMONY	X	20	96	.19U	0.6255	X	X	X
ARSENIC	Normal	20	0	2.3	9.6	6.09	2	10.09
BARIUM	Normal	20	0	45.7	134	102.4	19.43	141.26
BERYLLIUM	Normal	20	0	0.24	0.9	0.66	0.153	0.966
CADMIUM	Non-parametric	20	39	.295U	2.3	0.714	0.449	1.612
CALCIUM	Normal	20	0	1450	4550	2969	749	4467
CESIUM	X	20	100	6.05U	7U	X	X	X
CHROMIUM	Normal	20	0	5.5	16.9	11.29	2.85	16.99
COBALT	Normal	20	0	3.4	11.2	7.29	1.81	10.91
COPPER	Non-parametric	20	0	5.2	15.68	12.94	2.56	18.06
IRON	Normal	20	0	7390	17503	12549	2744	18037
LEAD	Normal	20	0	8.6	53.3	33.6	10.51	54.62
LITHIUM	Lognormal	20	0	4.8	11.6	7.69	1.93	11.55
MAGNESIUM	Lognormal	20	0	1310	2806	1913.1	468.1	2849.3
MANGANESE	Normal	20	0	129	357	237.3	63.89	365.08
MERCURY	Lognormal	20	65	.04U	0.12	0.072	0.031	0.134
MOLYBDENUM	X	20	91	.29U	0.9515	X	X	X
NICKEL	Normal	20	0	3.8	14	9.63	2.64	14.91
POTASSIUM	Normal	20	0	1110	2830	2061.2	453	2967.2
SELENIUM	Non-parametric	20	39	.29U	1.4	0.634	0.295	1.224
SILICON	Normal	20	0	934	1650	1383.5	179	1741.5
SILVER	X	20	100	.19U	.22U	X	X	X
SODIUM	Lognormal	20	0	43.8	105	62.16	14.84	91.84
STRONTIUM	Lognormal	20	0	9.6	45.2	28.44	10.25	48.94
THALLIUM	X	15*	100	.385U	.445U	X	X	X
TIN	X	20	91	1.35U	4.85	X	X	X
VANADIUM	Normal	20	0	10.8	45.8	27.85	8.87	45.59
ZINC	Normal	20	0	21.1	75.9	49.56	12.1	73.76
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RADIUM-226	Lognormal	20	0	0.1	0.805	0.619	0.153	0.925
RADIUM-228	Normal	20	0	0.2	2.3	1.35	0.48	2.31
URANIUM-233,-234	Lognormal	20	0	0.6	3.1	1.097	0.578	2.253
URANIUM-235	Lognormal	20	0	0.033	0.11	0.0539	0.02	0.0939
URANIUM-238	Lognormal	20	0	0.74	2.6	1.09	0.455	2
<p>X = not applicable because > 80% of data were non-detects % Non-detects (nds) are calculated from all accepted valid data except equipment rinsates Min and Max values: highest/lowest detected value or, if no detected values, 1/2 IDL (notated with "U") IDL = instrument detection limit Uranium-238 had 2 outliers removed for calculation of upper tolerance limit (UTL); outliers retained for summary statistics</p>								
<p>Normal* : Distribution assumed to be normal for summary statistics of supporting data NC = Not calculated</p>								
<p>DOE, 1995. <i>Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program, Table E-1, RFETS, May 1995.</i></p>								

Table F2
Summary Statistics for BSCP Fallout Radionuclides and Supporting Data

Analyte	Distribution	Count (n)	% Non-detection	Minimum	Maximum	Mean	Standard Deviation	Units
AMERICIUM-241	Nonparam	50	0	0.001	0.025	0.0107	0.006	pCi/g
CESIUM-134	Nonparam	50	0	0.05	0.3	0.2	0.056	pCi/g
CESIUM-137	Lognormal	50	0	0.3	1.7	0.941	0.372	pCi/g
PLUTONIUM-239/240	Lognormal	50	0	0.017	0.072	0.038	0.014	pCi/g
STRONTIUM-89,-90	Lognormal	50	0	0.065	0.64	0.254	0.128	pCi/g
% Clay	Normal*	50	0	1	34	11.58	6.37	%
% Sand	Normal*	50	0	24	78	53.29	11.97	%
% Silt	Normal*	50	0	20	51	35.21	7.49	%
Soil density	Normal*	50	0	0.8	1.2	0.944	0.78	g/cm ³
Tot. Org. Carbon	Normal*	50	0	1.4	6.05	3.66	1.24	%

Normal*: Distribution assumed normal for summary statistics of supporting data
 DOE, 1995. *Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program, Table E-3, RFETS, May 1995.*

Table F3
Summary Statistics for Inorganic Compounds (mg/kg)

Analyte	Distribution	Count (n)	% Non-detection	Minimum mg/kg	Maximum mg/kg	Mean mg/kg	Standard Deviation	M+2SD mg/kg
AMMONIA	Normal*	20	39	0.5U	7	2.033333333	1.897674785	5.8
CARBONATE	Normal*	20	100	5U	5.5U	X	X	X
NITRATE/NITRITE	Normal*	20	0	2	7	4	1.685854461	7.4
OIL&GREASE	Normal*	20	0	52	130	94.575	19.32497362	133.2
pH	Normal*	20	0	6	6.8	6.3575	0.242397564	6.8
SPECIFIC COND.	Normal*	20	0	0.1	0.53	0.20825	0.089593747	0.4
T.O.C.	Normal*	20	0	4920	17600	16132.66667	2696.900452	21526.5
% CLAY	Normal*	20	0	7	36	20.45	8.62	37.7
% SAND	Normal*	20	0	22	76	43.93	15.27	74.5
% SILT	Normal*	20	0	18	45.5	35.76	7.52	50.8
SOIL DENSITY	Normal*	20	0	0.9	1.2	0.923	0.07	1.1

Normal* : Distribution assumed to be normal for summary statistics of supporting data
 NC = Not calculated
 DOE, 1995. *Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program, Table E-2, RFETS, May 1995.*

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Table F4
Subsurface Background Soils- Inorganic Compounds

Analyte	Flow System	Sample Size (n)	Percent Detects	Mean	Standard Deviation	Units
ALUMINIUM	UPPER	98	100	12,752.03	11,310.57	mg/kg
ANTIMONY	UPPER	66	3	4.71	6.13	mg/kg
ARSENIC	UPPER	99	75	3.88	4.63	mg/kg
BARIUM	UPPER	99	89	96.46	96.46	mg/kg
BERYLLIUM	UPPER	99	91	4.78	4.71	mg/kg
CADMIUM	UPPER	81	48	0.82	0.44	mg/kg
CALCIUM	UPPER	99	86	6,951.09	16,215.59	mg/kg
CESIUM	UPPER	95	78	230.46	273.51	mg/kg
CHROMIUM	UPPER	99	100	19.61	24.33	mg/kg
COBALT	UPPER	99	30	7.5	10.77	mg/kg
COPPER	UPPER	99	91	12.57	12.82	mg/kg
IRON	UPPER	99	100	14,531.98	13,257.27	mg/kg
LEAD	UPPER	99	100	10.87	7.05	mg/kg
LITHIUM	UPPER	99	45	11.76	11.45	mg/kg
MAGNESIUM	UPPER	99	64	2,584.42	3,365.51	mg/kg
MANGANESE	UPPER	99	100	217.64	341.99	mg/kg
MERCURY	UPPER	86	34	0.24	0.64	mg/kg
MOLYBDENUM	UPPER	99	14	8.93	8.34	mg/kg
NICKEL	UPPER	96	91	20.73	20.74	mg/kg
POTASSIUM	UPPER	98	29	1,311.57	2,442.62	mg/kg
SELENIUM	UPPER	82	26	1.22	1.79	mg/kg
SILVER	UPPER	83	41	5.62	9.46	mg/kg
SODIUM	UPPER	99	9	300.66	475.29	mg/kg
STRONTIUM	UPPER	99	43	65.62	72.88	mg/kg
THALLIUM	UPPER	75	3	0.52	0.66	mg/kg
TIN	UPPER	92	23	61.75	112.28	mg/kg
VANADIUM	UPPER	99	98	31.49	28.50	mg/kg
ZINC	UPPER	98	96	36.86	51.12	mg/kg

DOE, 1993. Background Geochemical Report, Table C-14, RFETS, September 1993.

Table F5
Subsurface Background Soils- Radionuclides

Analyte	Flow System	Sample Size N	Percent Detects	Mean	Standard Deviation	Units
AMERICIUM	UPPER	28	100	0.00	0.01	pCi/g
CESIUM-137	UPPER	99	100	0.01	0.04	pCi/g
GROSS ALPHA	UPPER	99	100	24.91	9.28	pCi/g
GROSS BETA	UPPER	99	100	24.72	6.06	pCi/g
PLUTONIUM-239,240	UPPER	83	100	0.00	0.01	pCi/g
RADIUM-226	UPPER	83	100	0.75	0.23	pCi/g
RADIUM-228	UPPER	99	100	1.40	0.32	pCi/g
STRONTIUM-89,90	UPPER	99	100	0.03	0.36	pCi/g
TRITIUM	UPPER	99	100	141.72	126.75	pCi/g
URANIUM TOTAL	UPPER	99	100	1.46	0.79	pCi/g
URANIUM-244,234	UPPER	99	100	0.78	0.93	pCi/g
URANIUM-235	UPPER	99	100	0.02	0.05	pCi/g
URANIUM-238	UPPER	99	100	0.73	0.38	pCi/g

DOE, 1993. Background Geochemical Report, Table C-15, RFETS, September 1993.

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APPENDIX G

Elevated Measurement Comparison

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Table G2 Hot Spot Equation Analysis Single Sample Exceedance of Tier II Action Level
HCB Soil Data..... 5

ACRONYM LIST

AOC	Area of Concern
AL	Action Level
BZ	Buffer Zone
BZSAP	Buffer Zone Sampling and Analysis Plan
COC	contaminant of concern
EMC	elevated measurement comparison
HS	hot spot
HCB	hexachlorobenzene
IHSS	Individual Hazardous Substance Site
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mg/kg	milligrams per kilogram
MYAPC	Maine Yankee Atomic Power Company
PAC	Potential Area of Concern
RESRAD	Residual Radioactivity Computer Code
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
SAP	Sampling and Analysis Plan
UCL	upper confidence limit

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The Elevated Measurement Comparison (EMC) is discussed in Section 5.3 of the Buffer Zone (BZ) Sampling and Analysis Plan (SAP) (BZSAP). The EMC (MYAPC 1999) defines significantly high measurements relative to the size of a hot spot, magnitude of an action level (AL), and mean of the surrounding measurements. The comparison includes an equation that depends on several variables: AL, measured value, size of the hot spot, and size of the area of concern (AOC). The EMC is applicable to all sample results or hot spots that are above the Rocky Flats Cleanup Agreement (RFCA) Tier I or Tier II ALs. In AOCs where all sample results are less than ALs, the EMC is not required.

The first term (i) of Equation F-1 will be applied to each contaminant of concern (COC) separately. The first term will be used for all observations less than Tier I or Tier II ALs within the AOC. As shown in Equation 1, the first term is defined as the ratio of the 95% upper confidence limit (UCL) of the mean to the RFCA Tier I or Tier II AL for the AOC. Observations greater than the ALs will be excluded from the 95% UCL calculations because this type of censorship will ensure that the data set will comply with normality assumptions required for calculating the 95% UCL.

The second term (j) of the equation will be applied to each sample result that exceeds the RFCA Tier I or Tier II AL separately, so that these results can be evaluated as a function of the hot spot size relative to the AOC and magnitude of the AL. Because human health risks are based on an individual's exposure across an area, the incremental risk due to a small, elevated COC sample result (hot spot) needs to be determined. The second term of Equation G-1 is defined as the difference between the 95% UCL of the mean concentration and the sample result divided by the RFCA Tier I or Tier II AL for the given COC. The AL is area-weighted, which is appropriate weighted exposure to contamination is random across an area.

The area-weighted AL will be applied to nonradionuclides as shown in Equation G-1.

Equation G-1:

$$\text{If: } \sum_{i=1}^n \left[\frac{95\% \text{UCL}_{\text{AOC}}}{\text{AL}} \right]_i + \sum_{j=1}^n \left[\frac{(\text{SampleResult}_{\text{hs}} - 95\% \text{UCL}_{\text{AOC}})}{\left(\frac{\text{AL} * \text{Area}_{\text{AOC}}}{\text{Area}_{\text{hs}}} \right)} \right]_j \geq 1$$

Then: Action is Indicated

Where:

- (95%UCL)_{AOC} = 95% UCL of the mean concentration in IHSS or PAC
- AL = Tier I or Tier II soil action level
- (Sample Result)_{hs} = hot spot sample result
- (Area)_{AOC} = IHSS or PAC
- (Area)_{hs} = hot spot site (based on the area surrounding the elevated sample result)
- i = number of COCs
- j = number of hot spots for a particular COC

For radionuclides, an area factor consistent with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (1997) guidance is applied to the AL as shown in

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Equation G-2. Radionuclide-specific area factors are based on exposure pathway models, which can be estimated from Residual Radioactivity Computer Code (RESRAD) simulations.

Equation G-2:

$$\text{If: } \sum_{i=1}^n \left[\frac{95\% \text{UCL}_{\text{AOC}}}{\text{AL}} \right]_i + \sum_{j=1}^n \left[\frac{(\text{SampleResult}_{\text{hs}} - 95\% \text{UCL}_{\text{AOC}})}{(\text{AL} * \text{AF})} \right]_j \geq 1$$

Then: Action is Indicated

Where

- (95%UCL)_{AOC} = 95% UCL of the mean concentration in IHSS or PAC
- AL = Tier I or Tier II soil action level
- (Sample Result)_{hs} = hot spot sample result
- (Area)_{AOC} = IHSS or PAC
- (Area)_{hs} = hot spot area (based on the area surrounding the elevated sample result)
- AF = area factor (for radionuclides)
- i = number of COCs
- j = number of hot spots for a particular COC

Examples 1, 2, and 3 use the data listed in Table G-1 to illustrate how the equation works for different hot spot sizes and hot spot concentrations. These data were fabricated and are not representative of any area at the Rocky Flats Environmental Technology Site (RFETS).

Example 1:

$$\sum_{i=1}^n \left[\frac{1393.9}{4770.0} \right]_i + \sum_{j=1}^n \left[\frac{(5000_{\text{hs}} - 1393.9_{\text{AOC}})}{\left(\frac{4770 * 16}{1} \right)} \right]_j = .34$$

This value is less than 1, therefore this hot spot does not need to be remediated. This value is low because of the following:

- 1) The concentration of the hot spot is close to the Tier I AL.
- 2) The size of the hot spot is small.

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Table G1
Hot Spot Equation Analysis
Single Sample Exceedance of Tier I Action Level Pentachlorophenol Soil Data

Sampling Location	Pentachlorophenol Soil Concentration (mg/kg)	Pentachlorophenol Hot Spot Concentration (mg/kg)	Part 2 Hot Spot Equation Ratio *	Part 1 + Part 2 Hot Spot Equation Total Ratio **
1	50	5000	0.05	0.34
2	100	6000	0.06	0.35
3	150	7000	0.07	0.37
4	200	8000	0.09	0.38
5	250	9000	0.10	0.39
6	500	10000	0.11	0.40
7	600	20000	0.24	0.54
8	700	30000	0.37	0.67
9	600	40000	0.51	0.80
10	800	50000	0.64	0.93
11	1000	60000	0.77	1.06
12	1500	70000	0.90	1.19
13	2000	80000	1.03	1.32
14	2500	90000	1.16	1.45
15	3000	100000	1.29	1.58
Number of Sample Results	15			
Mean Concentration	930.0			
Standard Deviation	916.7			
95% Confidence Interval	463.9			
95% UCL of Mean	1,393.9			
Tier I Office Worker Soil Action Level	4,770.0			
Tier I Ratio (Part I - Hot Spot Equation ([95%UCL] _{AOC} /AL)	0.2922			

* - $\left(\frac{\text{Sample result}_{hs} - \{95\%UCL\}_{AOC}}{((AL)(Area)_{AOC}) / \{Area\}_{hs}} \right)$

** - Assumes that only one hot spot is present and is 1/16 of the total sample area.

Example 2:

If the size of the hot spot was larger, remediation might be necessary. For this example, remediation will occur when the hot spot size equals the AOC size. Remediation of a hot spot of the same size as in Example 1 would occur when the concentration of the hot spot is 55,413 mg/kg.

$$\sum_{i=1}^n \left[\frac{1393.9}{4770.0} \right]_i + \sum_{j=1}^n \left[\frac{(55413_{hs} - 1393.9_{AOC})}{\left(\frac{4770 * 16}{1} \right)} \right]_j = 1$$

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Example 3:

For an assumed 36 square feet (ft²) hot spot in an 6,000 ft² Individual Hazardous Substance Site (IHSS) with pentachlorophenol, and a hot spot concentration of 10,000 milligrams per kilogram (mg/kg):

$$\sum_{i=1}^n \left[\frac{1393.9}{4770.0} \right]_i + \sum_{j=1}^n \left[\frac{(10000_{hs} - 1393.9_{AOC})}{\left(\frac{4770 * 6000}{36} \right)} \right]_j = .303$$

Example 4:

Example 4 is being used because the AL is lower than the AL for pentachlorophenol. Example 4 is an assumed 36 ft² hot spot in a 6,000 ft² IHSS with HCB as the COC using the data in Table G-2. Table G-2 is a hot spot analysis for HCB in soil assuming a hot spot size 1/16 the size of the AOC. The data listed in Table G-2 are not based on actual information or data from RFETS.

$$\sum_{i=1}^n \left[\frac{2.7}{2.8} \right]_i + \sum_{j=1}^n \left[\frac{(7.5_{hs} - 2.7_{AOC})}{\left(\frac{2.8 * 6000}{36} \right)} \right]_j = .98$$

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**Table G2
Hot Spot Equation Analysis
Single Sample Exceedance of Tier II Action Level
HCB Soil Data**

Sampling Location	HCB Soil Concentration (mg/kg)	HCB Hot Spot Concentration (mg/kg)	Part 2 Hot Spot Equation Ratio *	Part 1 + Part 2 Hot Spot Equation Total Ratio **
1	0.1	3.9	0.00	0.97
2	0.5	5.0	0.00	0.98
3	0.9	6.3	0.01	0.98
4	1.2	7.5	0.01	0.98
5	1.4	9.8	0.02	0.99
6	1.7	10.5	0.02	0.99
7	2.0	12.0	0.02	0.99
8	2.2	15.0	0.03	1.00
9	2.5	16.0	0.03	1.00
10	2.8	21.0	0.04	1.01
11	3.0	25.0	0.05	1.02
12	3.6	88.0	0.18	1.15
13	3.5	104.0	0.22	1.19
14	3.7	200.0	0.42	1.39
15	3.0	251.0	0.53	1.50
Number of Sample Results	15			
Mean Concentration	2.1			
Standard Deviation	1.2			
95% Confidence Interval	0.6			
95% UCL of Mean	2.72			
Tier II Office Worker Soil Action Level	2.80			
Tier II Ratio (Part I - Hot Spot Equation ((95%UCL) _{AOC} /AL))	0.9.715			

* - $[(\text{Sample result})_{\text{hs}} - (95\% \text{UCL})_{\text{AOC}}] / [((\text{AL})(\text{Area})_{\text{AOC}}) / (\text{Area})_{\text{hs}}]$

APPENDIX H

**Buffer Zone Sampling and Analysis Plan
Quality Assurance Project Plan**

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ACRONYM LIST

%	percent
%D	percent difference
%RSD	relative standard deviation
AL	action level
AR	Administrative Record
ASD	Analytical Services Division
ASQC	American Society of Quality Control
BZ	Buffer Zone
BZSAP	Buffer Zone Sampling and Analysis Plan
CAS	Chemical Abstract Society
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
DER	duplicate error ratio
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
DQO	data quality objective
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
ER DMP	Environmental Restoration Data Management Plan
GIS	Geographic Information System
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GPS	global positioning satellite system
H&S	Health and Safety
HASP	Health and Safety Plan
ICP	interference check sample
IMP	Integrated Monitoring Plan
IWCP	Integrated Work Control Package
K-H	Kaiser Hill Company, LLC
LCS	laboratory control sample
LIBS	laser-induced breakdown spectroscopy
M&TE	Measurement and test equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity

ACRONYM LIST, cont.

MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
n	number of observations
NIST	National Institute of Standards Technology
PARCC	precision, accuracy, representativeness, completeness, and comparability
PATS	plant action tracking system
PE	performance evaluation
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RDL	Required detection limit
RFCA	Rocky Flats Cleanup Agreement
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RPD	relative percent difference
RSP	Radiological Safety Procedure
RWP	Radiological Work Permit
SAP	Sampling and Analysis Plan
SDP	standard data package
SOP	Standard Operating Procedure
SOW	Statement of Work
STD	standards
SWD	Soil/Water Database
TBD	to be decided
TCLP	Toxicity Characteristic Leaching Procedure
TIC	tentatively identified compound
TPU	total propagated uncertainty
TSR	training, scheduling, and records
UWQ1	usable with qualification, unable to associate with validated lab batch
UWQ2	usable with qualification, potential low bias may exist per validation qualifier
UWQ3	usable with qualification, samples taken without controlling documents
UWQ4	usable with qualification, source material has been remediated
UWQ5	usable with qualification, QC data
V&V	verification and validation
XRF	X-ray fluorescence

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1.0 QUALITY ASSURANCE CRITERIA

Quality assurance (QA) criteria presented in this Quality Assurance Project Plan (QAPjP) are consistent with quality requirements as defined by both the U.S. Department of Energy (DOE) (Order 414.1A, *Quality Assurance*) and the U.S. Environmental Protection Agency (EPA) (QA/R-5, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, 1997a). Table H1 provides a “crosswalk” between these requirements, illustrating the overlap between them. The application and implementation of these criteria into items and services will be consistent with the graded approach.

The graded approach is a “process of basing the level of application of managerial controls applied to an item or work according to the intended use of the results and the degree of confidence needed in the quality of the results” (E-4, ANSI/ASQC, 1994). The graded approach is also a function of safety (risk) and security required to accomplish program objectives (10 CFR 830.3). In practical terms, the graded approach requires selective application of QA requirements and control to items and services commensurate with their impact on risks posed to workers, the public, and the environment. EPA states that “Environmental data operations encompass diverse and complex activities, and they represent efforts pertaining to rulemaking, compliance with regulations, and research. Consequently, any plan that is developed to represent how QA/quality control (QC) should be applied to environmental activities must contain considerable flexibility...” (EPA 1994a). The content and level of detail in this QAPjP is tailored to the nature of the work and associated risk with the Buffer Zone (BZ) Project.

Hazardous and radiological risks to project personnel are addressed in the project’s Health and Safety Plan (HSP). 10 CFR 830.120 (QA) does not apply to activities controlled by the BZ Sampling and Analysis Plan (SAP) (BZSAP), unless inventories of materials, under direct control of the project, become nuclear facilities as defined in DOE Standard 1027-92.

References cited in this appendix are provided in Section 5.0, *References*, whereas Rocky Flats Environmental Technology Site (RFETS) internal documents are referenced throughout this QAPjP by control numbers maintained at RFETS by Kaiser-Hill Company, LLC (K-H).

QA will also be consistent with the following guidance and regulatory documents:

- ANSI/ASQC E4-1944, American National Standard, Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs;
- DOE Order 414.1, Quality Assurance;
- DOE Order 5400.1, General Environmental Protection Program;
- EPA, 1994a, Guidance for the Data Quality Objectives Process; QA/G-4;

Table H1
Crosswalk Between EPA QA/R-5 and DOE Order 414.1A

EPA QA/R-5 Elements	DOE Order 414.1A Requirements									
	Program	Personnel Training & Qualification	Quality Improvement	Documents & Records	Work Processes	Design	Procurement	Inspection/Acceptance Testing	Management Assessment	Independent Assessment
A1 Title and Approval Sheet										
A2 Table of Contents										
A3 Distribution List										
A4 Project/Task Organization										
A5 Problem Definition & Background										
A6 Project/Task Description										
A7 Quality Objectives & Criteria for Measurement Data										
A8 Special Training Requirements										
A9 Documentation & Records										
B1 Sampling Process and Design										
B2 Sampling Methods Requirements										
B3 Sample Handling and Custody Requirements										
B4 Analytical Methods Requirements										
B5 Quality Control Requirements										
B6 Instrument/Equipment Testing, Inspect. & Maintenance Reqs.										
B7 Instrument Calibration & Frequency										
B8 Inspection/Acceptance Requirements - Supplies/Consumables										
B9 Data Acquisition Requirements										
B10 Data Management										
C1 Assessments & Response Actions										
C2 Reports to Management										
D1 Data Review, Validation, & Verification Requirements										
D2 Validation & Verification Methods										
D3 Reconciliation w/ User Requirements										

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- EPA, 1994b, USEPA Contract Laboratory Program National Function Guidelines for Inorganic Data Review;
- EPA, 1997b, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016, December;
- EPA, 1998, Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis; QA/G-9; and
- EPA, 1999, Guidance on Environmental Data Verification and Validation, QA/G-8.

2.0 MANAGEMENT

2.1 PROGRAM

The BZ quality program implements requirements set forth in Order 414.1A, which is “flowed-down” through the RFETS-specific quality documents of K-H (K-H-QAPD-001, *Quality Assurance Program Description*). Key personnel and organizations for project management are given in the project’s organization charts (Section 7). The organization charts illustrate the infrastructure, functional responsibilities, levels of authority, and organizational interfaces necessary to accomplish the project goals and K-H’s contractual commitments to DOE.

The documents listed in Section 1.0 and the QA Implementation Matrix (Table H2) provide a general perspective of the documents establishing the engineering and administrative controls in place for the BZ Project. Specific document and record control numbers may be obtained through review of the BZ Project Files, K-H Records Center, or K-H Document Control.

2.2 PERSONNEL TRAINING AND QUALIFICATION

Personnel will be qualified to perform their respective tasks based on a combination of education, training, and experience. Education and professional experience will constitute the primary means of qualification for activities that emphasize management and problem-solving strategies. Training will be the primary means of qualification where:

- Consistency and team coordination constitutes a major component of the overall quality (or safety) of the process or item; and
- The process is well established, proven, and perfunctory.

In addition, a project-specific QA briefing will be given during the pre-evolution briefing before project start-up in the field. New personnel will also receive QA briefing prior to their participation on the project. The QA briefing will cover the requirements stated in this QAPjP and will be documented via an attendance roster.

Table H2
QA/QC Implementation Matrix for the BZSAP

DOE Quality Requirement		Implementing Documents and Quality Records
Management	Program	<i>Rocky Flats Cleanup Agreement (RFCA)</i> <i>K-H Team Quality Assurance Program</i> <i>BZ QAPjP (this section of the BZSAP)</i> <i>Stop Work Action (1-V10-ADM-15.02)</i>
	Training/Qualification	<i>Health & Safety Plan (HASP -- lists requirements)</i> <i>K-H Human Resources (Personnel Files)</i> <i>Subcontractor (various) Human Resources (Personnel Files)</i> <i>Readiness Review (verifies personnel training)</i> <i>SOWs/Contracts (for subcontractors)</i>
	Quality Improvement	<i>Plant Action Tracking System (PATS)</i> <i>Corrective Actions Process (3-X31-CAP-001)</i> <i>K-H Assessment Reports (Independent & Management)</i>
	Controlling Documents	<i>Document Control Program Manual (MAN-063-DC)</i> <i>Site Documents Requirements Manual (MAN-001-SDRM)</i> <i>Records Management Guidance for Records Sources (1-V41-RM-001)</i> <i>CERCLA Administrative Record Program (1-F78-ER-ARP.001)</i> <i>SOWs</i>
	Records	Various maps (esp. from GIS/SmartSampling applications) K-H QA Assessment Reports Analytical/radiochemistry data packages, incl. EDDs BZ Final Reports/Technical Memoranda H&S Quality Records, per HASP Radiological Quality Records, incl. routine monitoring Administrative Record (AR) Daily Shift Reports Field Logbooks (controlled) ER GIS Database (ARC/INFO; land surveys/ GPS)
Performance	Work Processes	<i>Control of Processes (1-C20-QAP-09.01)</i> <i>Buffer Zone Sampling & Analysis Plan (BZSAP)</i> <i>Integrated Work Control Manual (MAN-071-IWCP)</i> IWCPs (Integrated Work Control Packages) - TBD <i>(RFETS Radiological Control Manual (Radcon Manual)</i> <i>Radiological Safety Practices (RSPs)</i> <i>Site Design Control Manual (1-W56-COEM-AMN-101)</i> <i>Conduct of Operations Manual (MAN-066-COOP)</i> Subcontractor Statements of Work (incl. Gamma Spec) Gamma Spectroscopy Kaiser-Hill Analytical Services Field Lab - Organics <i>RFETS Integrated Monitoring Plan (IMP)</i> Radiological Work Permits (RWP) SOPs
	Design	IWCPs (listed above) Buffer Zone Sampling & Analysis Plan (BZSAP) BZSAP Addenda Data Management Plans (TBD)
	Procurement	<i>Procurement Quality Assurance Requirements (PRO-572-PQR-001)</i>
	Inspection and Acceptance Testing	Calibration/maintenance records for M&TE <i>Identification and Control of Items (1-A67-QAP-08.01) Inspection and Acceptance Test Program (1-PRO-072-001)</i>
Assessments	Management	<i>K-H Mgmt Assessment Program (3-W24-MA-002)</i>
	Independent	<i>Site Integrated Oversight Manual (MAN-013-SIOM)</i>

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Fundamental education and experience are captured by transcripts and resumes, which are maintained by K-H Human Resources or K-H subcontractors, as applicable. Site-specific and project-specific training records are managed within the BZ Project File and the K-H Training, Scheduling, and Records (TSR) database. Qualification requirements and records may also be maintained through the project manager, individual staff, procurement (within contractual agreements), and/or the centralized training group within K-H.

2.3 QUALITY IMPROVEMENT

Quality improvement will be realized through use of a systematic means of identifying, tracking, and correcting problems (deficiencies, nonconformances, issues, etc.). Problems may be identified by any project personnel, at any time, through formal documentation of issues as stated in 3-X31-CAP-001, Corrective Actions Process. Management and independent assessments will also be used to identify, track, and correct issues (see subsections below). The extent of causal analysis and corrective action will be commensurate with the significance (potential risk) of the failure or problem. “Lessons Learned” will be communicated to staff from management where appropriate.

2.4 DOCUMENTS AND RECORDS

Work-controlling documents, such as work plans (including Integrated Work Control Programs [IWCPs]), standard operating procedures (SOPs), HASPs, etc., will be controlled, where “control” is constituted by the following criteria:

- The documents are uniquely identified for reference purposes.
- The required reviews and approvals are accomplished.
- The personnel who need the documents to perform work use the latest approved versions of the document(s).

The document control process is described in MAN-063-DC-06.01, Document Control Program Manual, and MAN-001-SDRM Site Document Requirements Manual. Essential policies, plans, procedures, decisions, data, and transactions of the project will be documented to an appropriate level of detail. The objective will be to maximize the utility of records and data for accomplishment of performance objectives while minimizing the cost of information management and paperwork for the project (K-H) and its subcontractors. The documents controlling this project are summarized in Table H2.

All documents that constitute contractual deliverables to DOE, such as work plans or final reports, will undergo a minimum of three reviews to ensure that minimum quality requirements are met:

- Management review (level of management higher than originating author[s]);
- Technical/peer review (subject matter experts as determined by management); and,
- QA review.

The project manager may assign other technical reviewers, as applicable, to cover the technical disciplines represented within the document.

Quality records, including digital data stored on computerized media, will be managed to ensure that information is retained, retrievable, and legible. Active records will be maintained by project personnel, including K-H subcontractors, in an organized and retrievable fashion, until such time that the records have served their purpose and become inactive. Quality records are considered active until the final peer reviews are conducted. Thus, quality records are not subject to the 30-day limit on turnover to the Records Center until final peer reviews are conducted. Peer reviews of records must be conducted on records completed by the originator within two weeks of completion. Records at the job-site will be stored and protected in standard filing cabinets, consistent with 1-V41-RM-001, *Records Management Guidance for Records Sources*, and ultimately with 1-F18-ER-ARP.001, *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Administrative Record Program*. Quality records managed by subcontractors will be consistent with K-H requirements.

Quality records resulting from direct measurements or technical sampling activities will be authenticated by the originator and subsequently authenticated by a peer reviewer (“QC checked”). For data uploaded to computer from the quality records described above, final data entry (as portrayed on hardcopy output or the electronic file) must be reviewed by someone other than the data entry person. Errors and changes on completed quality records will be maintained as follows:

1. Hardcopy - By striking through the original entry with a line, and incorporation of the correct data and authentication adjacent to the strikeout; and
2. Electronic files - By incorporating configuration/change control in each applicable document, where all changes and additions (e.g., QC checks) are dated with electronic signatures.

K-H Analytical Services Division (ASD) is responsible for archiving all original hardcopy records produced by offsite laboratories. The K-H Soil/Water Database (SWD) will archive the complete electronic data deliverables (EDDs) provided by the labs via K-H ASD. The BZ Project will manage, in real time, all data critical for decisionmaking in the field, and will be responsible for summarizing the data into usable formats for reporting purposes. Reporting purposes include, primarily, decisions relative to contaminant characterization, remediation, and comprehensive risk assessment. A data-flow/data management diagram will be appended to the BZSAP prior to field work.

3.0 PERFORMANCE

3.1 WORK PROCESSES

3.1.1 Workforce

Management will hire and maintain a workforce capable of performing the project objectives as set forth in the BZSAP. Establishment and maintenance of the workforce for this project will be within budgetary constraints as defined by K-H.

Individual workers are responsible for the quality of their work. Management will provide the workforce with the tools, materials, and resources (including training) necessary for successful accomplishment of their assigned tasks. Performance criteria for personnel are established and

clearly communicated to project personnel through the SAP, associated procedures, and briefings, including “pre-evolution” meetings, readiness reviews, and daily “tool-box” meetings.

3.1.2 Sampling and Analysis

All sampling events will be controlled through documented procedures. These procedures, specific to the type of sampling implemented, are referenced throughout the BZSAP, within the context of sampling discussions, as applicable.

Field methods for metals will be correlated (regressed) with SW-846 methodology, specifically SW6010 and/or 6020. As sampling and analysis in the field progresses, approximately 5 to 10 percent of the samples will be analyzed in a separate laboratory for correlation of results. Such a correlation will provide a basis for overall accuracy and precision.

Inorganic chemical analysis will be correlated to (onsite analysis) or consistent with (offsite analysis) SW-846 methodologies as follows:

- General metals suite -- SW6010/6020;
- Beryllium -- SW7090/7091;
- Mercury -- SW7471A; and
- Inorganic metals -- K-H Module SS05.

Quality controls required for all chemical and radiological services will be further specified in contractual requirements with the applicable vendors (i.e., within Statements of Work, in progress).

Verification samples will be taken on a systematic basis during field measurements to ensure adequate quality control of the field-based sampling and analysis process. Verification samples are necessary to ensure systematic control of quantitative field-based measurements (e.g., those samples analyzed using non-SW846 methods such as X-ray fluorescence [XRF] or laser-induced breakdown spectroscopy [LIBS]) and progression of the characterization/remediation process as a whole. Verification sampling cannot be relegated to only latter stages of the project because of two basic potential liabilities:

1. Problems discovered with repeatability of field measurements (only at the end of the project) would cast ambiguity on the entire field measurement effort (in contrast to correlation of problems with specific segments of field sampling, and thus specific, smaller data sets).
2. Field measurements unassociated with remediation would have no process control, as only the confirmation samples would be analyzed by routine SW-846 methods.

A combination of sampling strategies is planned for the BZ. Both statistical (EPA 1994a QA/G-4, and EPA 1998, QA/G-9) and geostatistical methods will be adopted. Use of these two general approaches is consistent with use of the EPA data quality objectives (DQO) process, which determines the types, quality, and quantity of data needed for environmental decisionmaking, while optimizing time and cost considerations.

3.1.3 Radiological Surveys

Radiological surveys and monitoring will be routinely performed, primarily for purposes of ensuring contamination control and general Health and Safety (H&S) purposes. All surveys for removable and fixed contamination, as well as monitoring for airborne contamination, will be performed and reported consistent with RFETS Radiological Safety Practices (RSPs). Those RSPs planned for implementation in the BZ Project are listed and controlled on the RFETS intranet.

3.1.4 Radiochemistry

Gamma spectroscopy is the primary means by which the type and quantity of radionuclides will be determined. In general, gamma spectroscopy will be used in lieu of alpha spectroscopy, as gamma spectroscopy provides data of comparable quality and sensitivity. Limited alpha spectroscopy analyses may be performed for verification/validation of the gamma spectroscopy methods, consistent with the fielding of this technology in other major projects at RFETS (e.g., Trench-1 and 903 Pad). Alpha spectrometry methods are defined in the following controlling documents:

- K-H Module RC01, Isotopic Determinations by Alpha Spectrometry; and
- K-H Module GR01, General Laboratory Requirements.

Gamma spectroscopy methods for the project may be used in at least two configurations: in situ and field laboratory. In situ methods are measurements acquired in the field for two-dimensional measurements (areal), or three-dimensional measurements with limited thickness. Field laboratory methods will count containerized samples with distinct 3D configurations. An initial draft of QC specifications for the in situ techniques is given in Appendix I. Field laboratory specifications are addressed in K-H Module RC03, Determination of Radionuclides by Gamma Spectrometry. These controls will be contractually required of the gamma spectroscopy vendor. The attachment will be revised before requests for proposals are released to vendors.

3.1.5 Analytical Chemistry

Analytical chemistry generally consists of two types: organic and inorganic, both of which are addressed separately with respect to QC.

Variances to the referenced protocols are summarized below, which allow for mobile methods which will be faster and less expensive than traditional methods, while concurrently providing sufficient quality in the data for making project decisions (including risk assessment). More specific variances will be provided in the final Statement of Work for the vendor ultimately providing analytical services. Generally, the variances reside in the following areas:

- Abbreviated analytical suites, based on BZ contaminants of concern (COCs) only;
- Generalized accuracy specifications, especially percent recoveries;
- Sensitivity specifications, as detailed below; and
- Reporting requirements for abbreviated data packages, with emphasis on EDD specifications designed for use in the field.

Organic chemical analysis will be accomplished through use of a mobile gas chromatography (GC) or gas chromatography/mass spectrometry (GC/MS), preceded by the appropriate extraction/digestion method. Preparation and analytical methods will consist of SW-846 methodology, and will generally be consistent with existing K-H ASD contractual requirements, as referenced below:

- K-H Module SS01, Volatile Organics;
- K-H Module SS02, Semivolatile Organics; and
- K-H Module SS03, PCB/Pesticides.

Inorganic chemistry, primarily metals, will be accomplished through use of both field and laboratory methods. Field methods will implement EPA Method 6200, *Field Portable XRF Spectrometry*, and manufacturer's instructions for a LIBS system. The required analytical suites, sensitivities, and general QC requirements are given in Appendix E of the BZSAP.

The minimum quality requirements specific to use of field/portable metals analysis are summarized below:

1. Standard Operating Procedures - The manufacturer's operating instructions will be used. Any deviations or modifications to the instructions provided with the instrumentation will be documented and dispositioned by both the manufacturer/vendor and the project. Use of standard operating procedures (SOPs) will also include full-range calibrations, periodic performance checks, and maintenance of equipment.
2. Sample Preparation/Measurements - Bulk samples will be composited and homogenized for the purpose of optimizing sample precision. A procedure for sample preparation to homogenize samples before analysis will be produced and controlled as a prerequisite to field analysis, consistent with EPA guidance (EPA 1995). Specific sampling geometries may also be considered, such as compositing samples about a point via a symmetrical, triangular pattern.

3.2 DESIGN

Sound engineering/scientific principles and appropriate technical standards will be incorporated into designs to ensure that they perform as intended, including use of the RFETS Conduct of Engineering Manual.

Final designs, as documents, quality records, or computerized data, will undergo validation through peer review. Peer reviews will be commensurate with the scale, cost, specialty, and hazards of the item or activity in question. Management approval, in addition to peer and quality reviews of designs, will be obtained prior to procurement, manufacture, construction, or field implementation. Peer and quality reviews are corroborated through authentication of the design reviews.

3.2.1 Data Quality Objectives

DQOs are addressed, in detail, in BZSAP Section 3.0.

3.2.2 Computerized Systems (Software/Hardware)

Design control of computerized systems will be commensurate with the hazards associated with the process for which the computer system controls. Systems controlling critical H&S processes will be verified and validated as prescribed in either the BZ HSP or the RSPs, and must simulate working conditions prior to usage in real settings. Such systems will also be tested periodically to ensure functionality as defined in the RFETS Radiation Control Manual or the BZ HSP.

Computerized systems used for data reduction and analysis will be controlled to:

- Ensure traceability of changes made to original data; and
- Allow independent peer reviewers to relate inputs to outputs.

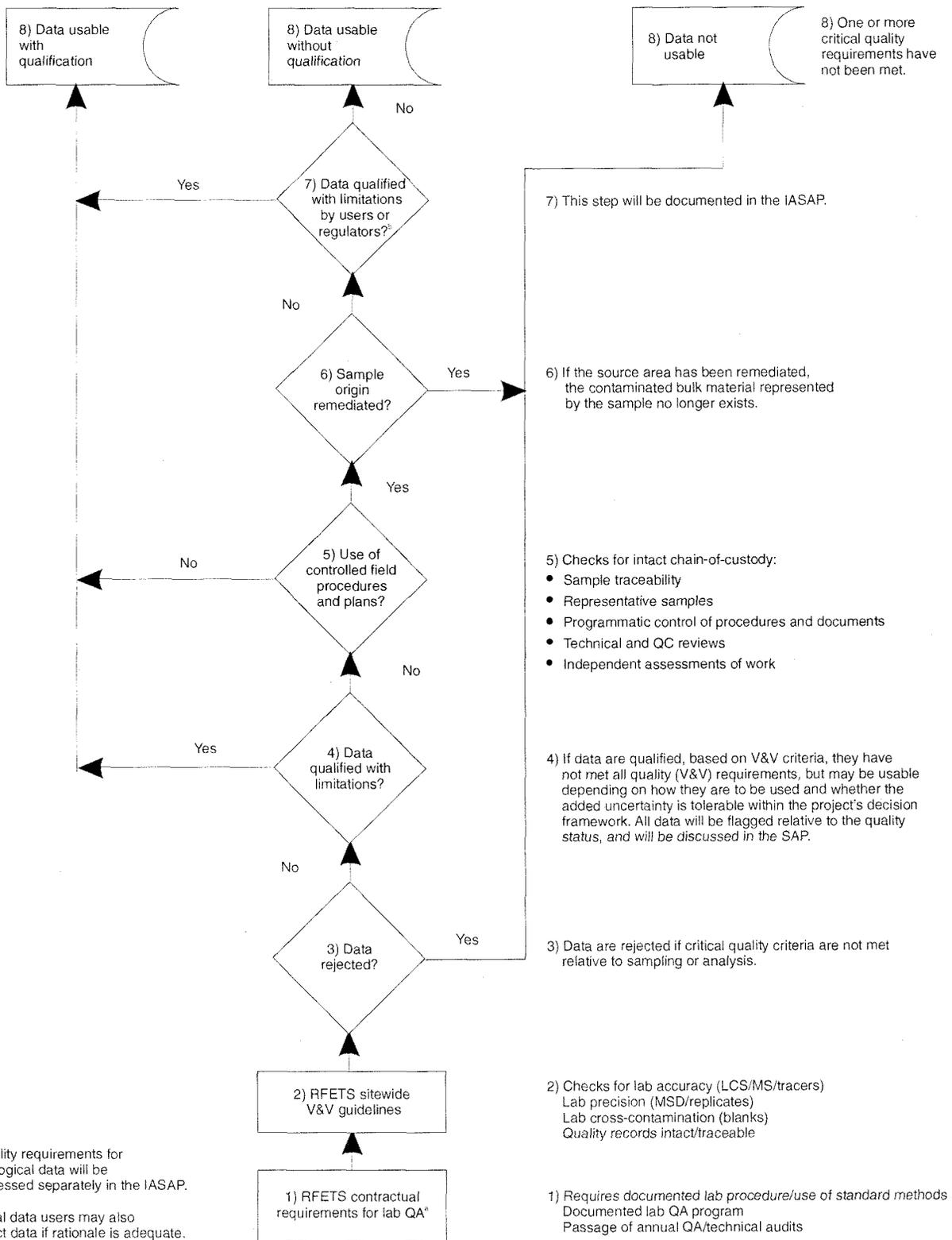
Computerized systems used for measurements will be calibrated via “system calibrations” (i.e., while integrated with all relevant software/hardware configurations, as they are to be operated during routine use). Management of digital data through computerized systems is described in the BZSAP, Section 6.0.

Figures H1, H2, and H3 depict the minimum quality criteria required of the data prior to its use in the BZ project. Tables H3-H7 provide further database filter criteria captured within the flow charts, specifically relative to qualification of data required for its use in characterization and/or risk assessment. Duplicate records from legacy data (i.e., historical analytical data digitally archived within the RFETS SWD) were removed from the BZ data set to improve efficiency and integrity. Criteria for defining duplicate records were as follows:

- location code;
- sample collection date;
- test method;
- lab analysis date;
- Chemical Abstract Society (CAS) number;
- result type code;
- result; and
- dilution factor.

A separate Data Management Plan (ERDMP, in progress) will document all specifications and detailed maintenance and quality requirements for data produced, archived, and reported for the project. These data will be produced from various activities under control of the project, including characterization, remediation, and risk assessment.

Figure H1
Data Quality Filter for the Buffer Zone Sampling and Analysis Plan
and Comprehensive Risk Assessment



^aQuality requirements for ecological data will be addressed separately in the IASAP.

^bFinal data users may also reject data if rationale is adequate.

Figure H2
Buffer Zone Data Quality Filter –Subsurface Soil

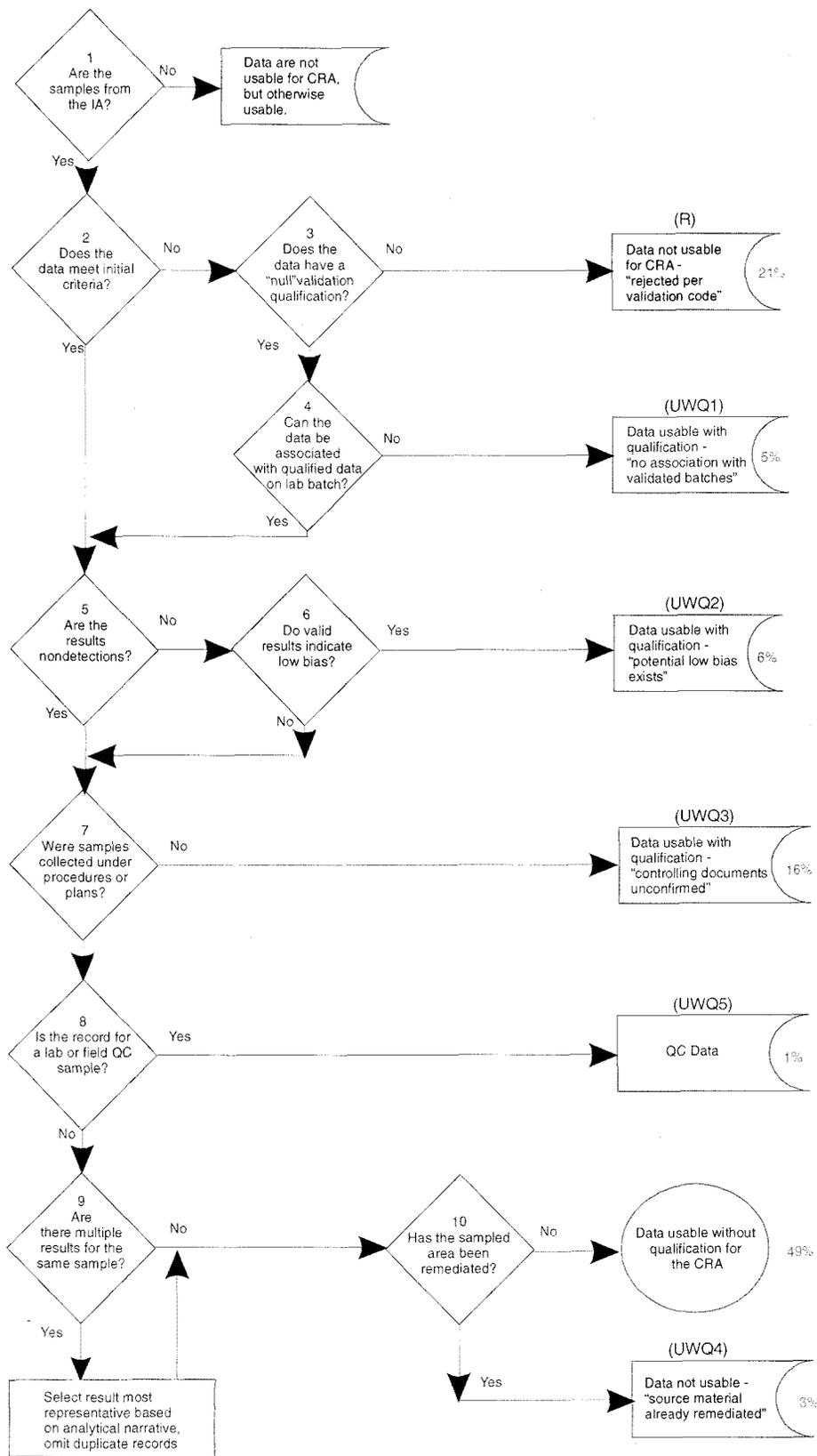


Figure H3
Buffer Zone Data Quality Filter – Surface Soil

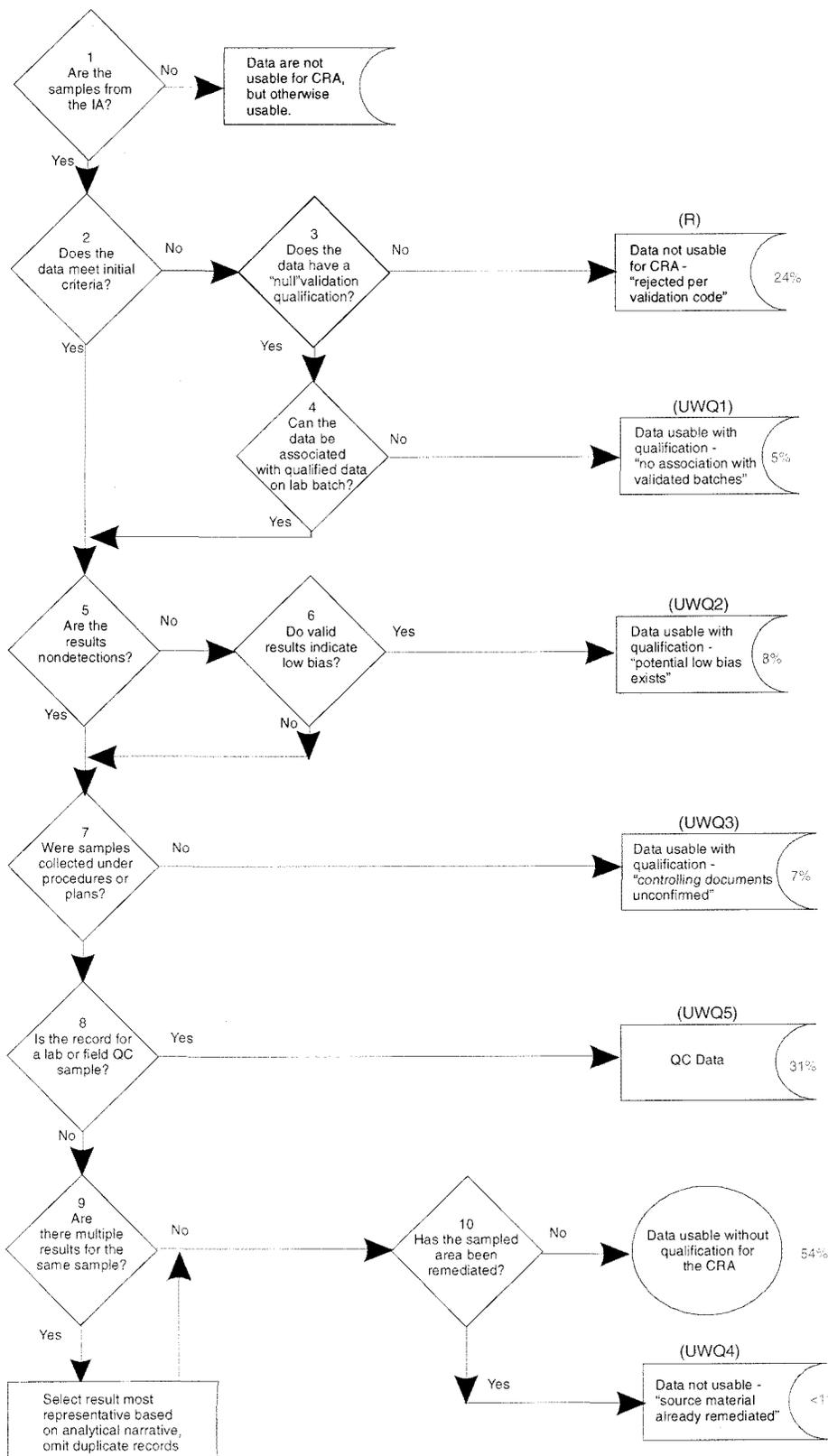


Table H3
Validation Qualifier Codes

Validation Qualifier Code	SWD Definition (sic)	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
1	QC DATA; PACKAGE VERIFICATION (PARTIAL OR COMPLETE)	NA	NA
A	DATA IS ACCEPTABLE, WITH QUALIFICATIONS	NA	NA
A1	DATA IS ACCEPTED W/ QUALIF.; BY ONSITE VALIDATORS	NA	NA
B	INDICATES COMPOUND WAS FOUND IN BLK AND SAMPLE	NA	NA
C	CALIBRATION	NA	NA
E	ASSOC VAL EXCEEDS CALIB RANGE DILUTE AND REANALYZE	NA	NA
J	Estimated quantity - Validation	NA	NA
J1	Estimated quantity - Verification	NA	NA
J2	Estimated quantity - Examination	NA	NA
N	HISTORICAL--VALIDATORS ASKED NOT TO VALIDATE THIS	NA	NA
P	SYSTEMATIC ERROR	NA	NA
R	Data is unusable - Validation	NA	NA
R1	Data is unusable - Verification	Fig 1, Diamond 3, Figs 2 & 3, Diamonds 2 & 3, R (rejected)	QC deficiency results in unquantifiable uncertainty of contaminant concentration
R2	Data is unusable - Examination	Fig 1, Diamond 3, Figs 2 & 3, Diamonds 2 & 3, R (rejected)	QC deficiency results in unquantifiable uncertainty of contaminant concentration
S	MATRIX SPIKE	NA	NA
U	ANALYZED, NOT DETECT AT/ABOVE METHOD DETECT LIMIT	NA	NA
U1	ANALYZED, NOT DETECT AT/ABOVE METH DET LIMIT, VERIFICATION	NA	NA
V	No problems with the data - Validation	NA	NA
V1	No problems with the data - Verification	NA	NA
V2	No problems with the data - Examination	NA	NA
Z	ANALYTICAL RESULTS IN VALIDATION PROCESS	NA	NA
Z	VALIDATION WAS NOT REQUESTED OR PERFORMED	NA	NA
JA	Estimated, acceptable	NA	NA
JB	ORGANIC METHOD BLANK CONTAMINATION - VALIDATION	NA	NA
JB1	ORGANIC METHOD BLANK CONTAMINATION - VERIFICATION	NA	NA
JB2	ORGANIC METHOD BLANK CONTAMINATION - EXAMINATION	NA	NA
NJ	Associated value is presumptively estimated	NA	NA
NJ1	Value presumptively estimated - Verification	NA	NA
NJ2	Value presumptively estimated - Examination	NA	NA
R1	DATA IS UNUSABLE - VERIFICATION	NA	NA
UJ	Assoc value is considered estimated at an elevated detection	NA	NA
UJ1	Estimated at elevated level - Verification	NA	NA
UJ2	Estimated at elevated level - Examination	NA	NA
VA	Data is valid, acceptable with qualifications	NA	NA

NA This validation qualifier code was not used in the data quality filter.

NOTE: dbbZFilterTotalrev2.mdb must be revised so as not to reject subsets of data covered by these qualifiers.

Table H4
Validation Reason Codes

Validation Reason Codes	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
***	Unknown code from RFEDS	NA	NA
	Holding times were exceeded	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
10	Lab control sample recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
101	Holding times were exceeded (attributed to lab problem)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
102	Holding times were grossly exceeded (attributed to lab probl)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
103	Calibration correlation coefficient does not met requirement	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
104	Calibration verification recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
105	Low-level check sample recovery criteria were not met	NA	NA
106	Calibration did not contain minimum number of STDS	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
107	Analyte detected but < RDL in calibration blank verification	NA	NA
109	Interference indicated in the icp interf chk smpl	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
11	Duplicate sample precision criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
110	Lab control sample recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
111	Laboratory duplicate sample precision criteria were not met	NA	NA
112	Predigestion matrix spk crit werent met (+/- 25%)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
113	Predigestion matrix spike recovery is <30%	NA	NA
114	Postdigestion matrix spk crit were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
117	Serial dilution percent d criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
12	Predigestion matrix spk crit werent met (+/- 25%)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
128	Improper aliquot size	NA	NA
129	Verification criteria for frequency or sequence were not met	NA	NA

Validation Reason Codes	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
13	Predigestion matrix spk crit weren't met (<30%)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
136	MDA exceeded the rdl		
139	Tune criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
14	Postdigestion matrix spk recov crit were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
140	Requirements for independent calibration verification were n	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
141	Continuing calibration verification criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
142	Surrogates were outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
143	Internal standards outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
145	Results were not confirmed	NA	NA
147	Percent breakdown exceeded 20 percent	NA	NA
148	Linear range of measurement system was exceeded	NA	NA
149	Method, preparation, or reagent blank contamination > rdl	NA	NA
15	Msa was required but not performed	NA	NA
152	Reported data does not agree with raw data	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
153	Calculation error	NA	NA
155	Original result exceeded range of calibration, result report	NA	NA
159	Magnitude of calibration verification blank result exceeded	NA	NA
16	MSA calibration correlation coefficient <0.995	NA	NA
168	QC sample frequency does not meet requirements	NA	NA
17	Serial dilution criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
175	Blank data not submitted	NA	NA
18	Documentation was not provided	NA	NA
19	Calibration verification criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
199	See hardcopy for further explanation	NA	NA
2	Holding times were grossly exceeded	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration

Validation Reason Codes	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
20	AA dup injection precision crit were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
201	Preservation requirements not met by the laboratory	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
205	Unobtainable omissions or errors on SDP deliverables (required)	NA	NA
206	Analyses were not requested according to sow.	NA	NA
207	Sample pretreatment or sample preparation method is incorrect	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
21	Reagent blanks exceeded MDA	NA	NA
213	Instrument detection limit is greater than the associated rd	NA	NA
214	IDL is older than 3 months from date of analysis	NA	NA
216	Post digestion spike recoveries were outside of 85 -115% cri	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
219	Standards have expired or are not valid	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
22	Tracer contamination	NA	NA
229	Element not analyzed in icp interf check sample	NA	NA
23	Improper aliquot size	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
230	QC sample/analyte (e.g. Spike, dup, lcs) not analyzed	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
231	MS/MSD criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
232	Control limits not assigned correctly	NA	NA
234	QC sample does not meet method requirement	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
235	Duplicate sample control limits do no pass	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
236	LCS control limits do not pass	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
237	Prep blank control limits do not pass	NA	NA
238	Blank correction was not performed	NA	NA
24	Sample aliquot not taken quantitatively	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
242	Tracer requirements were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
243	Std values were not calculated correctly (LCS, tracer, STDS)	NA	NA
246	Background calibration criteria was not met	NA	NA

Validation Reason Codes	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
249	Result qualified due to blank contamination	NA	NA
25	Primary standard had exceeded expiration date	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
250	Incorrect analysis sequence	NA	NA
251	Miss identified target compounds	NA	NA
26	No raw data submitted by the laboratory	NA	NA
27	Recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
28	Duplicate analysis was not performed	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
29	Verification criteria were not met	NA	NA
3	Initial calibration correlation coefficient <0.995	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
30	Replicate precision criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
31	Replicate analysis was not performed	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
32	Lab control samples >+/- 3 sigma	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
33	Lab control samples >+/- 2 sigma and <+/- 3 sigma	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
35	TSIE criteria were not met	NA	NA
36	MDA exceeded the RDL	NA	NA
37	Sample exceeded efficiency curve weight limit	NA	NA
38	Excessive solids on planchet	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
39	Tune criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
4	Calibration verification criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
40	Organics initial calibration crit weren't met	NA	NA
41	Organics cont. Calibration criteria weren't met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
42	Surrogates were outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
43	Internal standards outside criteria	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
44	No mass spectra were provided	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration

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Validation Reason Codes	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
45	Results were not confirmed	NA	NA
47	Percent breakdown exceeded 20 percent	NA	NA
48	Linear range of Instrument was exceeded	NA	NA
49	Method blank contamination	NA	NA
5	CRDL check sample recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
51	Nonverifiable lab results and/or unsubmitted data	NA	NA
52	Transcription error	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
53	Calculation error	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
54	Incorrect reported activity or MDA	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
55	Result exceeds linear range, serial dilution value reported	NA	NA
56	IDL changed due to significant figure discrep.	NA	NA
57	Percent solids < 30 percent	NA	NA
58	Percent solids < 10 percent	NA	NA
59	Blank activity exceeded RDL	NA	NA
6	Incorrect calibration of Instrument	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
60	Blank recovery criteria were not met	NA	NA
61	Replicate recovery criteria were not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
62	LCS relative percent error criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
63	LCS expected value not submitted/verifiable	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
64	Non-traceable/non-certified standard was used	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
67	Sample results not submitted/verifiable	NA	NA
68	Frequency of quality control samples not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
69	Samples not distilled	NA	NA
7	Analyte values > IDL were found in the blanks	NA	NA
70	Resolution criteria not met	NA	NA
701	Holding times were exceeded (not attributed to lab)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration

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Validation Reason Codes	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
702	Holding times were grossly exceeded (not attributed to lab)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
703	Samples were not preserved properly in the field (not attrib)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
71	Unit conversion of results	NA	NA
72	Calibration counting statistics not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
73	IPA not performed	NA	NA
74	LCS data not submitted	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
75	Blank data not submitted	NA	NA
76	Instrument gain and/or efficiency not submitted	NA	NA
77	Detector efficiency criteria not met	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
78	MDAs were calculated by reviewer	NA	NA
79	Result obtained through dilution	NA	NA
8	Negative bias was indicated in the blanks	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
80	Spurious counts of unknown origin	NA	NA
801	Missing deliverables (required for data assessment)	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
802	Missing deliverables (not required for data assessment)	NA	NA
803	Omissions or errors on SDP deliverables (required for data A)	NA	NA
804	Omissions or errors on SDP deliverables (not required for data A)	NA	NA
805	Information missing from narrative	NA	NA
806	Site samples not used for sample matrix QC	NA	NA
807	Original documentation not provided	NA	NA
808	Incorrect or incomplete DRC	NA	NA
81	Repeat count outside of 3 sigma counting error	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
810	EDD does not match hardcopy. May be resubmitted.	NA	NA
82	Sample results were not corrected for decay	NA	NA
83	Sample results weren't included on data sum. Table	NA	NA
84	Key fields wrong	NA	NA
85	Record added by QLI	NA	NA

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Validation Reason Codes	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
86	Results considered Qualitative not quantitative.	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
87	Lab did no analysis for this record	NA	NA
88	Blank corrected results	NA	NA
89	Sample analysis was not requested	NA	NA
9	Interference indicated in the ICP interference check sample	Fig 1, Diamond 4, Figs 2 & 3, Diamonds 5 & 6, UWQ2	QC deficiency results in possible underestimation of analyte concentration
90	Sample result was not validated due to re-analysis	NA	NA
91	Unit conversion, QC sample activity/uncertainty/MDA	NA	NA
99	See hardcopy for further explanation	NA	NA

NA This validation reason code was not used in the data quality filter.

Indicates that query must be modified to include these criteria to yield a UWQ2 qualification.

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**Table H5
Result Type Codes**

Result Type Code	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
BL1	Reagent blank - 1st try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BL2	Reagent blank - 2nd try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BL3	Reagent blank - 3rd try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BL4	Reagent blank - 4th try (rads only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BLK	Blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BS	Blank spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BS1	Blank spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BS2	Blank spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BS3	Blank spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BS4	Blank spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
BSD	Blank spike duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
D	Laboratory duplicates	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
DIL	Dilution	NA	NA
DL	Normal 1st run dilution	NA	NA
DL1	Dilution	NA	NA
DL2	2nd analysis run dilution	NA	NA
DL3	Dilution	NA	NA
DL4	4th analysis run dilution	NA	NA
DL5	5th analysis run dilution	NA	NA
DL6	6th analysis run dilution	NA	NA
DL7	7th analysis run dilution	NA	NA
DL8	8th analysis run dilution	NA	NA
DL9	9th analysis run dilution	NA	NA
DP1	Laboratory duplicate - 1st retry	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
DP2	Laboratory duplicate - 2nd retry	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
DP3	Laboratory duplicate - 3rd retry	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
DUP	Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
FIX	Lab incorrectly used tic or sur, quantalex will fix	NA	NA

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Result Type Code	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
LC1	Lab control sample - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC10	Lab control sample - 10th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC11	Lab control sample - 11th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC12	Lab control sample - 12th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC1B	Lab control blank?	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC2	Lab control sample - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC3	Lab control sample - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC4	Lab control sample - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC5	Lab control sample - 5th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC6	Lab control sample - 6th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC7	Lab control sample - 7th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC8	Lab control sample - 8th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LC9	Lab control sample - 9th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LCS	Laboratory control sample	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD	Laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD1	1st laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD1B	Lab control duplicate?	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD2	2nd laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD3	3rd laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD4	4th laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD5	5th laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD6	6th laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD7	7th laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD8	8th laboratory duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
LD9	9th laboratory duplicate	Figures 2 & 3, Diamond 10, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.

Result Type Code	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
LFB	Lab field blank	Figures 2 & 3, Diamond 8, UWQ5	aggregated for characterization, risk assessment, or statistics. QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB	Method blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB1	Method blank - 1st try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB2	Method blank - 2nd try (non-rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB3	Method blank - 3rd try (non_rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB4	Method blank - 4th try (non_rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB5	Method blank - 5th try (non_rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB6	Method blank - 6th try (non_rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB7	Method blank - 7th try (non_rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB8	Method blank - 8th try (non_rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MB9	Method blank - 9th try (non_rad only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD1	Matrix spike duplicate - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD2	Matrix spike duplicate - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD3	Matrix spike duplicate - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD4	Matrix spike duplicate - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD5	Matrix spike duplicate - 5th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD6	Matrix spike duplicate - 6th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD7	Matrix spike duplicate - 7th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD8	Matrix spike duplicate - 8th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MD9	Matrix spike duplicate - 9th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS	Matrix blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS1	Matrix spike - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS2	Matrix spike - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS3	Matrix spike - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.

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Result Type Code	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
MS4	Matrix spike - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS5	Matrix spike - 5th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS6	Matrix spike - 6th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS7	Matrix spike - 7th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS8	Matrix spike - 8th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MS9	Matrix spike - 9th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
MSD	Matrix blank duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
PB	Prep blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
PB1	Preparation blank - 1st try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
PB2	Preparation blank - 2nd try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
PB3	Preparation blank - 3rd try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
PB4	Preparation blank - 4th try (tritium only)	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
R	Re-analysis	NA	NA
RA1	Re-analysis 1st try	NA	NA
RA2	Re-analysis 2nd try	NA	NA
RA3	Re-analysis 3rd try	NA	NA
RB	Reagent blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
RB1	Reagent blank - 1st analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
RB2	Reagent blank - 2nd analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
RE	Re-extraction	NA	NA
REA	Re-analysis	NA	NA
REP	Replicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
REX	Re-extraction	NA	NA
RP1	Replicate - 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
RP2	Replicate - 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
RP3	Replicate - 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
RP4	Replicate - 4th try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
RS	Historical value - unknown meaning	NA	NA
RX1	Re-extraction 1st try	NA	NA

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Result Type Code	Definition	How the Code was Used in the Filter	Rationale for Inclusion in the Data Quality Filter
RX2	Re-extraction 2nd try	NA	NA
RX3	Re-extraction 3rd try	NA	NA
RX4	Re-extraction 4th try	NA	NA
RX5	Re-extraction 5th try	NA	NA
RX6	Re-extraction 6th try	NA	NA
RX7	Re-extraction 7th try	NA	NA
RX8	Re-extraction 8th try	NA	NA
RX9	Re-extraction 9th try	NA	NA
S	Spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
S1	Spike 1st try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
S2	Spike 2nd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
S3	Spike 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
SD	Spike duplicate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
SP	Spike 3rd try	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
SPK	Spike	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
SUR	Surrogate	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
TB	Trip blank	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
TB1	Trip blank - 1st analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
TB2	Trip blank - 2nd analysis	Figures 2 & 3, Diamond 8, UWQ5	QC results must not be confused w/ "real" results when data is aggregated for characterization, risk assessment, or statistics.
TIC	Tentatively identified compound	NA	NA
TR1	Target analysis 1st try	NA	NA
TR2	Target analysis 2nd try	NA	NA
TR3	Target analysis 3rd try	NA	NA
TR4	Target analysis 4th try	NA	NA
TR5	Target analysis 5th try	NA	NA
TR6	Target analysis 6th try	NA	NA
TR7	Target analysis 7th try	NA	NA
TR8	Target analysis 8th try	NA	NA
TR9	Target analysis 9th try	NA	NA
TRG	Target	NA	NA
UNK	Historical value - unknown meaning	NA	NA

NA This result type code was not used in the data quality filter.

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**Table H6
Validation Reason Codes**

Reason Code	Reason Description
101	Holding times were exceeded (attributed to lab problem)
102	Holding times were grossly exceeded (attributed to lab problem)
103	Calibration correlation coefficient does not met requirements
104	Calibration verification recovery criteria were not met
105	Low-level check sample recovery criteria were not met
106	Calibration did not contain minimum number of STDs
107	Analyte detected but < RDL in calibration blank verification
109	Interference indicated in the ICP Interf Chk Smpl
110	Lab Control Sample recovery criteria were not met
111	Laboratory duplicate sample precision criteria were not met
112	Predigestion matrix spk crit werent met (+/- 25%)
113	Predigestion matrix spike recovery is <30%
114	Postdigestion matrix spk crit were not met
115	MSA was required but not performed
116	MSA calibration correlation coefficient <0.995
117	Serial dilution percent D criteria not met
123	Improper aliquot size
128	Laboratory duplicate was not analyzed
129	Verification criteria for frequency or sequence were not met
130	Replicate precision criteria were not met
131	confirmation % difference criteria not met
132	Lab control samples >+/- 3 sigma
136	Minimum detectable activity (MDA) exceeded the RDL
139	Tune criteria not met
140	Requirements for independent calibration verification were not met
141	Continuing calibration verification criteria were not met
142	Surrogates were outside criteria
143	Internal standards outside criteria
145	Results were not confirmed
147	Percent breakdown exceeded 20 percent
148	Linear range of measurement system was exceeded
149	Method, Preparation, or Reagent Blank contamination > RDL
150	Unknown carrier volume
152	Reported data does not agree with raw data
153	Calculation error
155	Result excds linear range, serial dilut val rptd
159	Magnitude of calibration verification blank result exceeded the RDL
164	Standard traceability or certification requirements not met
166	Carrier aliquot non-verifiable
168	QC sample frequency does not meet requirements
170	Resolution criteria not met
172	Calibration counting statistics not met
174	LCS data not submitted
175	Blank data not submitted

Reason Code	Reason Description
177	Detector efficiency criteria not met
188	Blank corrected results
199	See hardcopy for further explanation
201	Preservation requirements not met by the laboratory
205	Unobtainable Omissions or errors on SDP deliverables (Required for Data Assessment)
206	Analyses were not requested according to SOW.
207	Sample pretreatment or sample preparation method is incorrect
211	Poor cleanup recovery
212	Instrument detection limit was not provided
213	Instrument detection limit is greater than the associated RDL
214	IDL is older than 3 months from date of analysis
215	Blank results were not reported to the IDL/MDL
216	Post digestion spike recoveries were outside of 85 -115% criteria
217	Post digestion spike recoveries were less than 10%
218	Sample COC was not verifiable (attributed to lab)
219	Standards have expired or are not valid
220	Toxicity characteristic leaching procedure (TCLP) sample percent solids are less than 0.5%
222	TCLP particle size was not performed
224	Incomplete TCLP extraction data
225	Insufficient TCLP extraction time
226	Tentatively identified compound (TIC) Misidentification
227	No Documentation regarding deviations from methods or SOW
228	Calibration requirements affecting data quality have not been met
229	Element not analyzed in ICP Interf Check Sample
230	QC sample/analyte (e.g. Spike, Dup, LCS) not analyzed
231	MS/MSD criteria not met
232	Control limits not assigned correctly
233	Sample Matrix QC does not represent samples analyzed
234	QC sample does not meet method requirement
235	Duplicate sample control limits do no pass
236	LCS control limits do not pass
237	Prep blank control limits do not pass
238	Blank correction was not performed
239	Winsorized mean and std deviation of the same were not calculated or calculated wrong
240	Sample prep for soil, sludge or sediments have not been homogenized or aliquotted properly
241	No micro ppt. or electroplating data available
242	Tracer requirements were not met
243	Std values were not calculated correctly (LCS, Tracer or Standards)
244	Standard or tracer is not National Institute of Standards Technology (NIST) traceable
245	Energy calibration criteria was not met
246	Background calibration criteria was not met
247	Sample or control analytes not chemically separated from each other
248	Single combined TCLP result was not repted for sample with both miscible and non-miscible liquids
249	Result qualified due to Blank Contamination
250	Incorrect analysis sequence
251	Miss identified target compounds
252	Result is suspect due to level of dilution

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Reason Code	Reason Description
701	Holding times were exceeded (not attributed to lab)
702	Holding times were grossly exceeded (not attributed to lab)
703	Samples were not preserved properly in the field (not attributed to lab)
704	Sample COC was not verifiable (not attributed to lab)
801	Missing Deliverables (Required for Data Assessment)
802	Missing Deliverables (Not required for Data Assessment)
803	Omissions or errors on SDP deliverables (Required for Data Assessment)
804	Omissions or errors on SDP deliverables (Not required for Data Assessment)
805	Information missing from narrative
806	Site Samples not used for Sample Matrix QC
807	Original documentation not provided
808	Incorrect or incomplete DRC
809	Non-Site samples reported with Site samples
COMMENTS	
131	Added 8/10/99 per TechLaw request
252	Added 11/3/00 per letter 01EAB003

**Table H7
Validation Qualifiers**

Qualifier	Description
V	No problems with the data were observed at the indicated review level.
J	The associated value is an estimated quantity.
JB	Result qualified due to blank contamination for results below the RDL
U	The associated value is considered undetected at an elevated level of detection
NJ	The associated value is presumptively estimated
UJ	The associated value is considered estimated at an elevated level of detection
R	The data are unusable. (Note: Analyte may or may not be present.)

3.2.3 Data Quality Assessment

Data Quality Assessment (DQA) is the scientific and statistical evaluation of data to determine whether data are adequate to support project decisions and to quantify uncertainties. DQA consists of two basic processes, verification and validation, with application of statistical tests as necessary. Verification and validation ensure that data used to design and conclude the project are usable and defensible.

Verification and Validation

All data (100%) collected during ER characterization and remediation sampling will be verified and validated relative to the ER Data Management Plan (in progress) and QA requirements. Verification will consist of ensuring that all data received from the vendor(s) are complete and correctly formatted. Validation will consist of a systematic comparison of all QC requirements with QC results reported by the vendor (e.g., relative to LCS, MS, MSD, blanks, etc). The verification and validation (V&V) module (process) will establish ultimate usability of the data

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by determining, reporting, and archiving the following criteria relative to each measurement set or batch:

- Precision;
- Accuracy;
- Bias;
- Sensitivity; and,
- Completeness.

Representative portions of hardcopy data will be formally validated. Formal validation is currently performed on a Sitewide basis at approximately 25% frequency of all RFETS subcontracted laboratories managed by K-H ASD. Satisfactory validation at this frequency indicates that the subcontracted laboratories are operating competently on an industry-wide basis. More specifically, analytical procedures are implemented under adequate quality controls. Sitewide data validation coupled with annual laboratory audits also provides the inference that all analytical and radiochemical results that are not specifically validated are under adequate control as well.

PARCC Parameters

Data will be evaluated relative to the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters as described in the following subsections. Data aggregation and statistical tests are described in the appropriate sections throughout the BZSAP.

Precision

Precision is a measure of the reproducibility of results, and is measured through the following sample types:

- Lab replicates (radionuclides);
- MS duplicates (MSD); and
- Field duplicates.

Through use of these samples, precision is evaluated from two perspectives:

1. Analytical standpoint (reproducibility within the laboratory that reflects analytical precision inherent to the method); and,
2. Overall project standpoint, which combines both analytical precision and reproducibility of the field sampling method specific to the matrix type.

Precision may be expressed quantitatively by at least two functions. The most typical measure for nonradiological analyses is the relative percent difference (RPD) term, whereas, because of the stochastic nature of radioactivity, a statistical measure is better suited for evaluating radiological reproducibility - the duplicate error ratio (DER).

Chemical

$$RPD = \frac{C_1 - C_2}{(C_1 + C_2)/2} * 100$$

Where

C₁=first sample

C₂=duplicate sample

The relative percent difference targets are 35% for solids and 20% for liquids. If QC results exceed these tolerances, the data must be qualified and/or additional samples may be required.

Radiological

$$DER = \frac{C_1 - C_2}{\sqrt{(TPU^2 + TPU^2)}}$$

Where

TPU = total propagated uncertainty

(Note: counting error, also known as the 2-sigma error, may be used in lieu of the TPU as a conservative measure; if precision exceeds the critical value of 1.96, TPU should be used in the equation prior to qualifying precision of the measurements in question.)

The DER must be less than 1.96 as defined in Evaluation of Radiochemical Data Usability (Lockheed Martin 1997). If DER values exceed the test statistic, associated data must be qualified and additional samples may be necessary; alternatively, an RPD may also be evaluated to put the statistical exceedance in perspective (i.e., the RPD value may be used as a benchmark value). Commentary will be provided as to how qualifications in precision affect overall uncertainty in the sample results.

Ongoing precision of the radiological survey instrumentation will be evaluated based on logging periodic (daily) source check measurements. Any measurement that exceeds defined tolerance limits (+20%) will result in corrective action (e.g., instrument repair or replacement) before measurement of real samples. Further tolerance specifications may be found in the applicable RSPs.

Accuracy

Accuracy is a measure of how closely a measurement corresponds to a standard reference (or the “true”) value.

Accuracy will be based on the following criteria:

- Calibrations, with reference standards, periodic full range and 1-point “performance checks” (all equipment);
- Laboratory control samples/spikes (LCS);

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- Laboratory matrix spikes (MS);
- Relative standard deviation (%RSD);
- Laboratory blanks (method-, equipment-);
- Chemical yield (radionuclides);
- Counting time (radionuclides; XRF); and
- Sensor efficiency (radionuclides).

In general, accuracy of instrumentation will be based on annual calibrations of instrumentation and daily source checks that perform within specified tolerances (e.g., $\pm 20\%$) as specified in the RSPs (radionuclides) or manufacturer's specifications (non-radiological field instrumentation). Novel or prototypical instrumentation also requires satisfactory passage of blind PE samples (within 20% of standard value), where existing validation and verification documentation does not cover the equipment (configuration), geometry, or matrix of interest.

Accuracy relative to a standard reference value is typically evaluated relative to percent recovery (%R) or, stated differently, a percent difference (%D), expressed as

$$\%D = \frac{X_1 - X_2}{X_1} * 100$$

Where

x = Observation (concentration or activity)

n = number of observations

Bias will also be considered as a component affecting accuracy, as it indicates the tendency of a measurement system to be consistently higher or lower than the true value. Bias will be discussed relative to its impact on final project decisions.

Representativeness

Representativeness will be achieved through use of the BZSAP, together with the use of standard field, sampling, and analytical procedures. All work-controlling documents undergo required reviews and approvals to ensure representativeness of the sampling and analysis effort.

Compliance with controlling documents coupled with implementation of other quality controls contributes to corroboration of representative sampling. If representativeness of any sample set is ambiguous, the data will be qualified and/or additional samples may be required.

Completeness

Completeness is a quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from the project relative to each medium and analytical suite of interest. The completeness goal for each discrete BZ sampling effort is 90%. If completeness of any sample set is not achieved, additional data will be required or the data set (and decisions) qualified.

Completeness will be established based on a comparison (ratio, expressed as a percentage) of actual sample results reported versus the number of samples planned.

The formula for calculating completeness is presented below:

$$\% \text{ completeness} = \frac{\text{number of valid results}}{\text{number of planned results}}$$

A summary table, such as the one outlined below, will be used to summarize the data subsets; specific analytes will be broken-out as necessary.

Hazard type	Planned Number of Samples	Actual Number of Samples	Completeness	Comments
Chemical				
Radiochemical				
Radiological Survey unit				
Other				

Comparability

All results will be comparable with characterization analyses (methods and media) on a national- and DOE-complex wide basis. This comparability will be based on nationally recognized methods (especially EPA-approved methods), systematic quality controls, use of standardized units of measure, and thorough documentation of the planning, sampling, and analysis process.

Sample collection methods and analyses in accordance with the protocols specified in the BZSAP provide comparability with other similar media types and COCs across the DOE complex and the commercial sector.

Sensitivity

All measurements must have adequate sensitivity, or resolution, to confidently compare results with action levels (ALs). For chemical constituents, MDLs will be provided based on formal MDL studies as stated in Appendix E. For radiochemical constituents, MDLs must also be less than half the associated action level. Derivations of radiological MDLs will be provided for all measurement equipment used, and will follow guidance provided in §6.7.1 of MARSSIM (EPA 1997b).

3.3 PROCUREMENT

Quality requirements will be specified in procurement and subcontract documents. All contracts (subcontracts) that have the potential to affect quality of BZ Project services or deliverables will be reviewed for QA requirements to ensure that adequate quality controls are established and implemented. Quality control of procurements will be implemented as described in PRO-572-PQR-001, *Procurement Quality Assurance Requirements*.

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3.4 INSPECTION AND ACCEPTANCE TESTING

Items or activities that require inspections and/or acceptance testing will be specified in work-controlling documentation (e.g., work plans, SOPs, and data management plans). Acceptance criteria and any hold points will be clearly defined, and will be based on manufacturer's specification unless otherwise stated. Measurement and test equipment (M&TE) will be accepted or rejected based on calibration information and pre-established tolerances, including unique identification, traceability, accuracy, resolution, measurement ranges, and acceptance/rejection criteria. Materials and equipment that affect quality (of items or services) or H&S will be controlled (i.e., identified, maintained, and traceable) according to their intended purpose. Measurement, monitoring, and data collection equipment will be of the accuracy and resolution needed for their intended purposes based on calibrations. Calibrations will be traceable to nationally recognized or industry standards. Essential policies, plans, procedures, decisions, data, and transactions of the project will be documented to an appropriate level of detail.

4.0 ASSESSMENTS

4.1 MANAGEMENT ASSESSMENT

At least once during the fielding of the project, management will evaluate the organization to determine the effectiveness of the QAPjP and overall K-H organization performance.

Management assessments will be documented in formal reports, and will be implemented in accordance 3-W24-MA-002, *K-H Management Assessment Program*.

4.2 INDEPENDENT ASSESSMENT

Independent assessments, rather than management assessments, will be performed by personnel who are not directly responsible for the work being performed. Independent assessments will be performed according to MAN-013-SIOM, *Site Integrated Oversight Manual*.

5.0 REFERENCES

10 CFR 830.120, Quality Assurance.

ANSI/ASQC E4-1994, *American National Standard, Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs*.

DOE 1999, DOE Order 414.1A.

EPA, 1994a, Guidance for the Data Quality Objectives Process, EPA QA/G-4.

EPA, 1994b, USEPA Contract Laboratory Program National Function Guidelines for Inorganic Data Review.

EPA, 1995, Superfund Innovative Technology Evaluation Program, Final Demonstration Plan for the Evaluation of Field Portable X-Ray Fluorescence Technologies, EPA Contract No. 68-CO-0047.

EPA, 1997a, EPA Requirements for Quality Assurance Project Plans, QA/R-5.

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EPA, 1997b, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016, December.

EPA, 1998, Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis; QA/G-9.

EPA, 1999, Guidance on Environmental Data Verification and Validation, QA/G-8.

ERDMP, Environmental Restoration Data Management Plan.

Lockheed Martin, 1997, Evaluation of Radiochemical Data Usability, ES/ER/MS-5, Lockheed Martin Environmental Restoration Program, April.

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ATTACHMENT H1

In Situ Gamma Spectroscopy Quality Requirements

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ccc

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ACRONYM LIST

%	percent
ADC	analog to digital converter
ANSI	American National Standards Institute
BG	background area
BZSAP	Buffer Zone Sampling and Analysis Plan
CA	control area
CTR	Contract Technical Representative
DQO	data quality objective
E	activity exceeds calibration range of instrument
EDD	electronic data deliverable
FOV	field of view
FWHM	full-width half maximum
FWTM	full-width tenth maximum
GPS	Global Positioning Satellite System
HPGe	high-purity germanium
ICD	interference check sample
J	Estimated value < MDA
K-H	Kaiser Hill Company, LLC
keV	kiloelectron volts
M	replicate instrument readings not within control limits
M&TE	measurement and test equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
NIST	National Institute of Standards Technology
pCi/g	picocuries per gram
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
REAL	target isotope
RFETS	Rocky Flats Environmental Technology Site
ROI	region of interest
RP	replicate area
SC	source check
SME	subject matter expert
SOP	Standard Operating Procedure
SOW	Statement of Work

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SRM standard reference material
TBD to be decided
TPU total propagated uncertainty
U undetected, analyzed for, but not detected

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1.0 REPORTING AND DELIVERABLES REQUIREMENTS

1.1 QUALITY ASSURANCE PROJECT PLAN

The subcontractor will be responsible for maintaining a Quality Assurance (QA) Project Plan (QAPjP) that outlines their plan for implementing quality control on the project. The QAPjP will describe the policy, organization, functional responsibilities, and quality assurance requirements and methods (Standard Operating Procedures [SOPs]) necessary to assure that the quality of data meets the objectives dictated by its intended use. The SOPs detail the techniques to be utilized during the investigation and provide guidance for the performance of all field work. The QAPjP will be provided to Kaiser-Hill Company, LLC (K-H) within two weeks of notification of award.

1.2 ANSI STANDARDS AND STANDARD OPERATING PROCEDURES

The subcontractor will be responsible for identifying activities required under this SOW which require the use of SOPs. The subcontractor will also be responsible for identifying any and all ANSI standards that are determined to be applicable to work activities. These standards are to include, but not limited to, the development, documentation, and control of computer software.

A list of SOPs and applicable ANSI standards will be provided to the project, or referenced if already established at the Rocky Flats Environmental Technology Site (RFETS). The Subcontractor will provide K-H with copies of all applicable SOPs, as referenced in their QAPjP for review and approval. The SOPs will be submitted within two weeks of notification of award.

The Subcontractor will provide K-H with copies of applicable American National Standards Institute (ANSI) standards upon request

1.3 DATA PACKAGE REQUIREMENTS

The general data package deliverable requirements for this project are provided in Table H1-1. All deliverables consisting of final hardcopy data will be transmitted to K-H and will be provided within 14 calendar days of the in situ “shot” or sample. The Electronic Data Deliverable (EDD) (Table H1-2) is required within 48 hours of completion of the measurement set.

**Table H1-1
Data Package Deliverables**

Deliverable Section Number	Deliverable Section Title
1	Cover Page
2	Narrative
3	Sample Summary
4	Data Review Checklist
5	Analysis Reports
6	Attachments EDD and CAM Files

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**Table H1-2
Gamma Spectroscopy Electronic Digital Data Format**

Space	Field	Format	Comment
1-10	File Name	Character (10)	Provide File Name as identified on the EDD
11-20	Project Identification	Character (10)	Identification Number as defined by the Project Manager
21-30	File Date	Character (10)	(MM/DD/YYYY) - Date of EDD creation
31-50	Measurement Set Identification Number	Character (10)	Unique number associated w/ ≤ 20 in situ measurements and required QC measures
51-60	Measurement Location - Northing	Numerical (10)	Measurement-specific area location, as specified using the GPS
61-70	Measurement Location - Easting	Numerical (10)	Measurement-specific area location, as specified using the GPS
71-80	Measurement Date	Date (10)	(MM/DD/YYYY) - Date the measurement was collected
81-90	Result Identifier	Character (5)	Code that differentiates between analytical results, replicates, reals, and QC items
91-100	Associated Sample	Character (10)	Provides the real-sample file name to correlate duplicate samples with real samples
101-130	Isotope	Character (30)	Descriptive name of the isotope
131-140	Result (measured value)	Number (10)	Analytical result associated with the analysis for this isotope (pCi/g)
141-150	Result Units	Character (10)	pCi/g, %, keV etc.
151-155	Result Qualifier	Character (5)	See Table H1-3 for acceptable values
156-165	Counting error	Number (10)	Reported value of measurement uncertainty due to counting error (typically 2σ)
166-175	MDA	Number (10)	Minimum detectable activity (pCi/g)
176-185	F/E	Number (10)	Precision measure used for comparison with a test statistic
186-190	Control Area Yield	Number (5)	Percentage of the established control area value
191-210	CAS Number	Character (20)	See Table H1-3 below
211-220	Total Propagated Error	Number (10)	(TBD by SME; to be used in evaluating precision control)
221-245	Test Method	Character (25)	A referenceable method type, e.g., the procedure title, revision #, and date used by the subcontractor
246-255	Source Check	Number (10)	Value in energy units (keV)
256-260	Count Time	Number (5)	Count time of measurement, in minutes
261-265	Efficiency	Number (5)	Efficiency of the detector system, in percent
266-280	Instrumentation/ System Identification Number	Character (15)	Identification of the measurement system
<p>Note: All parameter fields are left-justified and padded to the right with blanks. The File Name field may be omitted if all records are provided as one file.</p>			

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1.3.1 Data Package Cover Page Requirements

All data packages, which correspond to data sets as established in the EDD, will be provided as a measurement set not to include more than 20 real measurements. The Cover Page will include the following: site location, title, subcontractor name, subcontract number, report date, author's name and authentication and peer reviewer's name and authentication.

1.3.2 Data Package Narrative

Data Package Narratives will be included in the data package and will include a description of all problems, unusual circumstances, and weather conditions encountered during the measurement process. At a minimum this will include: descriptions of interferences, an explanation of any Quality Control (QC) deficiencies, reasons for re-shooting a location, SOP title and revision, an explanation of any deviations from SOPs or protocols and any other information that might affect the data quality. Additionally, the spectral acquisition and processing software and version used to acquire and process data will be provided. The narrative will also include all Site specific input parameters used in the model including but not limited to moisture content, radionuclide depth distribution, soil bulk density, air temperature, and barometric pressure.

1.3.3 Summary of Results

All measurement results will be arranged by Site location or sample identification number. All QC measurements will be identified as QC measurements and identify the batch of real measurements the QC measurement is associated with. The Site will retain all original data generated during the course of this project, including:

- radioactive source calibration certificates for any source used during the project;
- certificates of calibration for all balances and other measuring equipment;
- electronic and hard copies of spectral libraries, if any;
- copies of the original spectral acquisition before any additional processing,;
- copies of the spectra after additional processing has been performed; and,
- a hard copy print out of the report produced for each;
 - Sample,
 - QC sample,
 - Energy calibration,
 - Efficiency calibration, and
 - Source check.

For each shot or sample, the results will include the following:

- Isotope(s), see Table H1-3;
- Isotope(s) activity; minimum detectable activity (MDA) is reported as the result if the measurement is below MDA;
- Activity units;
- Overall measurement uncertainty at 3-sigma;

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- MDA (same units as the reported activity);
- The method or formula by which spectral processing software calculates the MDA;
- System identification (and/or detector identification);
- Location identification;
- Geometry; and
- Any comments associated with the measurement that may affect the results.

The QC sample type will be designated as follows:

- Replicate is the corresponding location identification + "D";
- Standard reference control area is designated as "CA"; and
- Background locations will be designated as "BG".

**Table H1-3
CAS Numbers**

CAS No	Isotope	RDL	Units
14596-10-2	Am ²⁴¹	1.0	pCi/g
15117-96-1	U ²³⁵	0.5	pCi/g
7440-61-1	U ²³⁸	5.0	pCi/g

The QC sample results will include the following:

- QC type and unique identification;
- Isotope(s);
- Isotope activity;
- Activity units;
- MDA (same units as the reported activity);
- Total propagated uncertainty (same units as the reported activity);
- Location identification;
- Geometry; and
- Any comments associated with the measurement that may affect the results.

For the replicate, the following additional information will be reported:

- MDA (same units as the reported activity);
- Location identification;
- Comparative isotope results; and
- Associated real sample.

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For the CA, the following additional information will be reported:

- CA standard value;
- CA standard value uncertainty at 3-sigma; and
- CA % Recovery.

For the background measurement the following additional information will be reported:

- MDA (same units as the reported activity) will also be reported for each radionuclide detected at the location; and
- Location of background measurement.

Significant figures: the target isotope activities, QC results, measurement uncertainties, and MDAs will be reported to a number of significant digits commensurate with associated measurement accuracy and precision (typically 3 significant figures).

The Instrument Calibration Summary is a summary of the energy calibration, backgrounds and efficiency determinations for all High-Purity Germanium (HPGe) detectors used to analyze Site locations and the associated QC areas. The following information will be reported for the energy calibration:

- Instrument and detector identification;
- Date of the energy calibration;
- Calibration Source identification;
- Energy span used and geometry used;
- linear response of system over range of energy spectrum; and
- Gain expressed as keV/channel.

The following information will be reported for the background shot or sample:

- Instrument and detector identification;
- Date of the background shot or sample;
- Respective "Start" and "End" region of interest (ROI) in channels or energy for the determination of the specific radionuclides requested; and
- Respective ROI Background for the determination of the specific radionuclides requested.

The following information will be reported for the detector efficiency determinations:

- Instrument and detector identification;
- Date of the efficiency analysis;
- Calibration source identification;
- Matrix;
- Geometry;
- Detector characterization data; and

- Characterization verification data.

The gamma spectroscopy instrumentation, analysis, and preparation SOP(s) will be identified and listed.

Data Package Review Checklist

The Data Package Review Checklist documents the completeness and the quality control status of the Sample Data Package. Table H1-4 depicts the required minimum information to complete this check for in situ analysis. A completed Data Review Checklist form will be submitted with each Sample Data Package and will conform with the formatting and content of the form provided in Table H1-4.

**Table H1-4
Data Package Review Checklist**

	Caveat?	Compliance?	
		√Yes	XNo
1. COVER PAGE			
All components are present per SOW § 2.7.1			
2. NARRATIVE			
All components are present per SOW § 2.7.2, including all results & controls out of tolerance			
3A. SAMPLE RESULTS SUMMARY			
a) For each shot or sample, the results will include the following: isotopes, activity, units, uncertainty at 3-sigma (TPU), MDA, method for calculating MDA, system identification, location identification, geometry, and any comments.			
b) All results reported for each requested radionuclide (SOW Exhibit C)			
c) Appropriate use of significant figures			
e) Electronic and/or hardcopy of spectral library (one-time submittal)			
f) Electronic and/or hardcopy of final spectra from measured areas/sources			
g) Results from measured areas correlated to location, measurement set identification, and any related QC measurements (i.e., energy calibrations, efficiency calibrations, replicates, blanks {background}, and control area)			
3B. QC SAMPLE RESULTS SUMMARY			
a) Calibrations certificates for radioactive sources (one-time submittal)			
b) Source check results within tolerance			
c) Blank (background) measurements are reported, including location and MDA			
d) For locations that required re-analysis, all measurement set information is included with the results.			
e) For each QC sample type (replicate, control area, and background) the QC type (SOW § 2.7.3.2) and QC location identification is provided.			
f) For each QC sample, the results will include the following: QC type and identification, isotopes, activity, units, uncertainty at 3-sigma, MDA, location identification, geometry, and any comments.			
g) All QC deficiencies are detailed above in the Narrative.			
h) The following information is required for each replicate sample: MDA, location identification, and the comparative isotope results.			
i) The following information is required for the Control Area (CA) Results: CA standard value, CA standard uncertainty at 3-sigma and CA % recovery.			

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	Caveat?	Compliance?	
3B. QC SAMPLE RESULTS SUMMARY (cont.)			
j) The Preparation Blank activity meets the requirements specified in RC03, Exhibit E. if applicable			
k) Detector characterization specifications, for each detector, including peak shapes (one-time submittal)			
l) MDA determination at 95% confidence w/ ≥ 5 replicate measurements (one-time submittal)			
4. INSTRUMENT CALIBRATION SUMMARY			
a) The energy calibration parameters are within established tolerances, and are reported as specified in § 2.8.2 of the SOW, including: instrument and detector identification, date, source identification, energy span and geometry used, linear response of system and gain.			
b) The background shot or sample information includes the following: instrument and detector identification, date, "Start" and "End" ROI.			
c) Detector efficiency information will include the following: instrument and detector identification, date of the efficiency analysis, calibration source identification, matrix, geometry, detector characterization data and characterization verification data.			
5. COUNTING RAW DATA SUMMARY			
At a minimum, the raw data summary will consist of the following: analysis date and time, instrument identification, SOP identifier, location identification, QC locations and identifications, and the analysts initials.			
6. ELECTRONIC DATA DELIVERABLE (EDD)			
a) The EDD is in compliance with Table B-2 of the SOW.			
b) Completeness of data $\geq 95\%$ (§ 6.5).			

Respond to each checklist item in the "Caveat?" column with a footnote as applicable and provide the caveat in the Footnotes section below.

FOOTNOTES:

I certify that all responses to this checklist accurately reflect the completeness and quality aspects of this sample data package as outlined in the associated Statement of Work. Furthermore, I understand that inaccuracies in the completion of this checklist will be considered a nonconformance to Subcontract Requirements as evidenced by the following signature of the laboratory manager or designee.

Printed/Typed Name: _____ Title: _____

Signature: _____ Date: _____

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Analysis Report

The subcontractor will include analysis output records in this section to include the gamma spectrum analysis output, peak analysis output, nuclide identification report, interference corrected reports and nuclide minimum detectable activity reports. All output and reports will provide a unique identification number to easily correlate to the associated measurement location.

Raw Data

The raw data for all measurements will be provided for each reported value. The raw data will also include shot or samples performed but not used for reporting. This data will include, at a minimum, the following: analysis date and time, instrument identifications, SOP identifier, location identifications, QC locations identifications and the analysts initials. The raw data will be in a format that is compatible for uploading into Canberra's software packages e.g., Gennie 2000 Ver. 1.2, ProCount Ver. 1.1, and ISCOS software Ver. 1.1 for reprocessing the data (version updates must be documented as appropriate).

1.4 ELECTRONIC DATA DELIVERABLE FORMAT REQUIREMENTS

This section describes the required format for the gamma spectroscopy electronic data delivery requirements. Files will be in fixed width format that is readily convertible for use with MS ACCESS or EXCEL software. Format may vary from the template displayed below. However, the key requirement is that unique and individual records are produced with the minimum parameters specified, and the data are readable by the commercial software cited.

1.4.1 Spectral Acquisition, Processing and QA/QC Software

The Site is aware that several commercial and custom spectral acquisition and processing software packages exists. The Subcontractor will declare which software package(s) will be used to analyze Site measurements and will provide documentation of assumptions, calculations, and unique terms incorporated into, or used by, the software. The Subcontractor will supply evidence of software verification and validation that will be approved by the K-H prior to first use. Any changes to the software package(s) must be approved by the K-H prior to analysis of Site measurements.

Subcontractor will maintain a program that addresses measures taken to ensure computer programs used to generate data are validated, verified, and documented for both vendor-supplied and in-house software packages. This program will incorporate the "Computer Hardware and Software" requirements from ANSI/ANQC E4-1994. This program will include the following minimum requirements:

- Software validation will occur before initial use, and following subsequent revisions;
- A correlation between the validation documentation and the software will be established;
- A historical file of software revisions and associated validation documentation will be maintained. The historical file will be maintained in chronological order; and
- Computer program and analytical data on electronic media will be handled, stored, safeguarded, and controlled to prevent damage and deterioration.

1.4.2 Spectral Libraries

The Site is aware that some commercial spectral analysis software requires a spectral library be established and searched to identify peaks present in a sample spectrum. The isotopes, gamma energies and search order of such libraries will be reviewed by the K-H prior to use by the Subcontractor. Any changes to the content, gamma energies or search order of an approved library must be approved, in writing, by the K-H prior to use on samples.

Result Identifiers

QC Item types

BG - Background Area
CA- Control Area
SC- Source Check
RP- Replicate Area
REAL-Target Isotope

Units of Measure

pCi/g - Picocuries per gram
% - percent recovery or efficiency
keV- kiloelectron-Volts

Result Qualifiers

E - Activity exceeds calibration range of instrument
J - Estimated value < the MDA
M - Replicate instrument readings not within control limits
U - Undetected, analyzed for, but not detected

1.5 MEASUREMENT SET CONTROLS

QC measurements, for each individual HPGe system used, will be implemented at systematic and regularly defined frequencies or time intervals. Although physical samples are not acquired for these analyses, the idea of controlling quality based on sample batching is analogous and applicable to controlling quality (in the field) relative to a minimum number of measurements, or “shots” by the HPGe system. Twenty (20) real (excluding QA/QC) measurements per individual detector will be designated as a measurement set.

All instrument/system settings used in measurement (calibrations and real measurements) will be logged, e.g., MCA energy range, analog to digital converter (ADC) gain and zero, and Lower Level Discriminator.

All measurements will be traceable to specific 3-dimensional point-locations based on concurrent use of a Global Positioning System.

The frequency and types of QC samples described below will be based on control of the measurement sets (or batches, when containerized samples are measured), except where time is defined as the frequency basis of choice.

1.5.1 Measurement Identification

All measurements will be assigned unique identifiers that are traceable to both sample type (QC type or real measurement) and location. Electronic data deliverable requirements are delineated in Table H1-2.

1.5.2 QC Traceability to Primary SRM Certificate

Source checks and calibration standards will be current and traceable to a primary Standard Reference Material (SRM) Certificate or appropriate inter-laboratory control sample program identity. The Subcontractor may use secondary standards, in an appropriate matrix, that were purchased from a reputable supplier as an LCS. Previous inter-laboratory comparisons samples and secondary standards may be used as standards provided that they are current and traceable.

1.5.3 Daily Source Checks

At least three sources spanning the energy range 5 to 3000 keV will be counted at the beginning of each day to demonstrate that the energy calibration of the instrument has not changed. Americium 241 at 59.4 keV will be used as one of these sources. The results of the source check will be recorded and submitted as described in Table H1-2. For each source check, error tolerance is acceptable if less than 3σ (using the standard deviation value provided by the source manufacturer). For any actual value that exceeds the associated source's error tolerance, corrective action will be implemented before any further real (in situ) measurements are performed.

1.5.4 Energy Calibration/Detector Characterization Requirements

The peak shape, as defined by the full-width half maximum (FWHM) and full-width tenth maximum (FWTM) specification of the detector, will be supplied. The resolution of the detector will not exceed 10% of the manufacturer's original specification. Any geometric arrangements of sources or treatments within software reduction will be documented.

The energy calibration for each detector will be performed. A linear curve will be fit for Energy (Y-axis) versus Channel (X-axis) of the curve, and the constants for the equation will be documented. The correlation coefficient (r) will be provided. The slope of the equation will approximate 0.375 keV/Channel for a 8192 channel analyzer.

Effective area for each detector will be documented as a function of gamma energy and angle of incidence.

1.5.5 Efficiency Determination Requirements

The efficiency determinations will be performed on each detector using matrix and geometry-specific National Institute of Standards Technology (NIST) traceable calibration source(s). After consultation with the K-H and project personnel, problems with difficult matrices will be resolved and documented. Americium-241 will be included in the efficiency calibration source.

It is expected that the certified value for each isotope in the efficiency standard has been determined at a specific energy, therefore the efficiency determination will also use that specific energy.

The Subcontractor will document the reason that any of the peaks present in the original efficiency calibration source are not used to determine the efficiency curves above or below the knee. The efficiency error and confidence level will be documented.

1.5.6 Background Measurements

At least one background measurement will be performed for every measurement set. The background is constituted by measuring a fixed area as defined by the K-H project personnel onsite. The location of the background measurement will be determined. Background measurements will be measured in the same manner as all other standard in situ measurements.

1.5.7 Replicate Measurements

At least one replicate measurement will be performed for every measurement set. The replicate is constituted by remeasuring an in situ measurement within the measurement set of interest. Error tolerance must comply with the statistically-based comparison (equivalence test) given below:

$$F = |S - R| \quad \text{(Equation H-2)}$$

$$F/E < 1.96 \quad \text{(Equation H-3)}$$

Where

- F = Delta between real and replicate
- S = Original in situ activity
- R = Replicate in situ activity
- ER = Total Propagated Uncertainty of Replicate
- ES = Total Propagated Uncertainty of Original Measure

1.5.8 Corrective Actions

Corrective actions will be implemented following any exceedance of tolerances by a QC sample (source checks, blanks, calibrations, replicates, or control areas), including the possibility of rejecting the entire measurement (data) set. Should questionable anomalies occur during in situ measurements (based on the operator's or the oversight's professional judgment), K-H project personnel will be contacted and a mutually suitable resolution of data and/or corrective actions will be accomplished. Actions might include qualification of data, or system modification and re-measurement if data are rejected. All re-measurements will have different identifications than their precursors.

QC Counting

All QC sources or source areas will be processed in the same manner as the in situ measurements. QC count times may be less than that for in situ measures, but may not exceed in situ measurement count times. This requirements includes using the same instrument calibration parameters, analysis algorithms, libraries, etc. QC samples will not have count rates greater than 1,000 counts per sec or a dead time greater than 5% to reduce counting errors.

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1.5.9 Continuing Calibration Checks

At the conclusion of the analysis of a measurement set, the control area measurement results will be analyzed and dispositioned.

Spectrum Assessment

All measurement spectra will be assessed and peer reviewed. Unidentified peaks will be recorded and discussed with the Contract Technical Representative (CTR). The presence of unidentified peaks will be noted and discussed in the case narrative.

1.5.10 Control Charting

The Site requires data adequate to produce control charting, if control charts are deemed necessary at some point in the project. All such data are currently captured based on requirements in the QAPjP. Examples include dates, blanks (background), and daily source checks, geometry settings, replicates, efficiencies, FWHM, control areas, and results.

Control Areas

The subcontractor will perform HPGe measurements at a minimum of five locations (HPGe FOVs) where soil samples have been previously collected (or will be collected) to correlate HPGe results with soil samples analyzed by gamma and alpha spectrometry (wet chemistry). The purpose of these measurements is to verify the accuracy of the field measurements. One set (five measurements) will be collected at the completion of routine in situ measurements. Rather than specifying a set tolerance range of acceptability, error will be quantified by K-H project personnel to define an upper confidence limit in the measurements to support project decisions

In summary, the following general sequence of quality control measurements is required: daily source check, background measurement, calibration (as needed per each measurement set), real measurements, replicate, and control area measurement. After all real measurements are completed, five calibration verification measurements, as described above are required.

1.5.11 Control of Key Parameters

Several parameters directly influence data reduction and final gamma spectroscopy values. For the values listed below, and any others the subcontractor deems necessary, determination of values will be clearly explained and documented with final deliverables:

- Actinide depth distribution in soil profile and averaging depth;
- Soil density;
- Soil moisture; and
- Air density.

The subcontractor will verify model input parameters meet variable conditions in the field for soil density and soil moisture. Soil densities will be measured in situ for three geologic lithologies encounter in the investigation area to include; Rocky Flats Alluvium, Landslide Deposits, and Artificial Fill Material. The subcontractor will determine soil moisture content with bulk density measurements and collect additional samples for this determination when climatic conditions indicate that a significant increase or decrease has occurred or at the request of K-H. Additional soil moisture content measurements will not exceed six sampling events.

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MDA Determination

The initial MDA determinations for the subcontract will be consistent with Section 6.7 of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (EPA 1997) using a 95% confidence level and at least 5 replicate measurements. The Subcontractor will provide the algorithm and all necessary information used to calculate the MDAs. MDAs should meet the data quality objectives (DQOs) set forth in Section 3 of the Buffer Zone Sampling and Analysis Plan (BZSAP); if not, rationale must be provided.

Total Propagated Uncertainty (TPU)

Total propagated uncertainty, not just the counting error, will be reported with the result for each target analyte. The total propagated error is the square root of the sum of the squares of the 1 sigma error of each measurement or process that contributes to the measurement. TPU will be determined consistent with the MARSSIM (EPA 1997), Section 6.8.3.

Traceability of Measuring and Testing Equipment (M&TE).

Any ancillary measurement or testing equipment used to support HPGe measurements will be traceable to associated calibration logs and standards.

1.5.12 Final Acceptability of Deliverables

Final acceptability of deliverables from the subcontractor will be determined by K-H in writing. Noncompliance with any of the requirements provides the basis for rejection of the associated deliverable(s).

1.5.13 Completeness

Data submitted must be 95% complete to be considered acceptable, i.e., 95% of the data produced must be usable for project decisions.

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APPENDIX I

903 Pad Linear Regression Case Study

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ACRONYM LIST

AL	Action level
Am	americium
ANOVA	analysis of variance
BZ	Buffer Zone
cm	Centimeter
DOE	Department of Energy
FOV	field of view
HPGe	High purity germanium
IHSS	Individual Hazardous Substance Site
ISOCS	In situ Object Counting System
m	meter
OU	Operable Unit
PAC	Potential Area of Concern
pCi/G	picocuries per gram
Pu	plutonium
R ²	correlation coefficient
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RPD	relative percent difference
RSAL	Remediation Soil Action Levels
U	uranium

1.0 LINEAR REGRESSION ANALYSES - CASE HISTORY

Radionuclide contamination in surface and subsurface soil will be characterized using field-deployed gamma spectroscopy technology, i.e., High Purity Germanium (HPGe) detectors. The HPGe measurements will follow the same procedures and methodologies that were effectively utilized during previous Rocky Flats Environmental Technology Site (RFETS) environmental restoration projects, specifically the 903 Drum Storage Area, 903 Lip Area, and Americium Zone Characterization (903 Pad Characterization, [Kaiser-Hill, 2000]). The "best fit" regression modeling approach used to standardize the HPGe results to alpha spectroscopy results during the 903 Pad Characterization will be implemented for the remaining portion of the Buffer Zone (BZ) characterization. A similar regression modeling technique will be utilized for evaluating metals.

The BZ characterization is similar to the 903 Pad Characterization in that radionuclides in surface soil will be analyzed in situ using a nonintrusive HPGe field method. This field analytical technique was successfully used to characterize the lateral extent of radiological contamination in the Americium Zone and a portion of the 903 Lip Area (Kaiser-Hill 2000). In addition, ex situ HPGe measurements of subsurface soil samples will be performed in a mobile laboratory. This appendix provides an overview of the HPGe methodologies used in the 903 Pad Characterization. Topics of discussion include (1) sample collection techniques for the alpha spectroscopy analyses, which were used to standardize the HPGe results; (2) the physics of the HPGe in situ measurements; (3) the results of the "best fit" linear regression model used to standardize the HPGe results; and (4) the application of in situ HPGe survey methods to be used for the BZ characterization.

2.0 OVERVIEW OF 903 PAD CHARACTERIZATION FIELD HPGE SURVEY

2.1 SURFACE SOIL INVESTIGATION

Delineation of radiologically contaminated soil in the Americium Zone was performed in situ using gamma-ray spectroscopy methods and an HPGe instrument. The HPGe instrument was used to obtain 1,110 contiguous gamma ray measurements with a circular field of view (FOV) of 10 meters (m) in diameter within the investigation area. The activities of ²⁴¹Americium (Am), ²³⁹Plutonium (Pu), ²³⁴Uranium (U), ²³⁵U, and ²³⁸U in surface soil within the Americium Zone and a portion of the Lip Area were measured or estimated in situ using an HPGe survey. The HPGe measurements were standardized by correlation with laboratory-derived alpha spectroscopy measurements.

2.1.1 In Situ HPGe Methodology

The sensitivity of the HPGe instrument is capable of measuring in situ activities of ²⁴¹Am, ²³⁵U, and ²³³U. For the 903 Pad Characterization, the HPGe measurement had a FOV of 10 m in diameter with the detector placed 1 m over the ground surface. The Compendium of In Situ Radiological Methods and Applications at Rocky Flats Plant (EG&G 1993) provides a detailed discussion on the physics of in situ measurement of radionuclides in the environment.

The HPGe survey was primarily performed in the Americium Zone (Figure I1) and includes all surface soils with elevated activities of ^{239/240}Pu and/or ²⁴¹Am identified during the Operable Unit (OU) 2 Resource conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI). The following areas were also evaluated using HPGe:

- The 35 HPGe measurements that exhibit elevated (above 10 picocuries per gram [pCi/g]) ²⁴¹Am activities;
- The area directly below the culvert which drains the 903 Pad and Lip Area where sediments are deposited during surface runoff events; and
- The five 2.5-acre plots where surface soils exceed Tier I Rocky Flats Cleanup Agreement (RCFA) Action Levels (ALs).

The HPGe system used to perform in situ measurements for the investigation employed the Canberra In Situ Object Counting System (ISOCS) software. To estimate counting efficiencies, this software requires the entry of various parameters that accurately represent the actual field conditions at the site. One important parameter is the vertical distribution of radionuclides. In the HPGe investigation area, contamination was deposited via airborne and/or surface water releases. This resulted in a distribution with high activities near the surface and decreasing activities with depth. Surface soil sampling was previously performed in the study area to determine the vertical distributions. In general, the radionuclides are concentrated in the top 5 centimeters (cm). Based on available data, the ISOCS model assumes all contamination is contained in the top 5 cm, and is distributed with 66 percent in the top 3 cm and 33 percent in the next 2 cm. This distribution was used to be consistent with the surface soil sampling methodologies (RMRS 1998a), which specifies sampling surface soil to a depth of 2 inches (5 cm). In addition, the contribution from ²⁴¹Am below a depth of 5 cm in soil is quite small in undisturbed surface soil. It is possible that the actual distributions in the top 5 cm may be more concentrated near the surface or more uniformly distributed throughout the 5-cm layer. A set of efficiencies with different vertical distributions was prepared and the standard acquisition analyzed. As shown in Table I1, the overall error of a likely range of possible distributions is about +1- 10 %¹.

Table I1
²⁴¹Am Activity Profile

Sample Layer	²⁴¹ Am pCi/g
Default 2 layer 0-3 cm 66%, 3-5 cm 33%	12.2
Single layer, 0-5 cm uniform	14.3
3 layers, 0-1.5cm 50%, 1.5-3 cm 30%, 3-5 cm 20%	11.6
3 layers, default with 1-cm grass cover	13.2
2 layer with 0-3 cm 60%, 3-5 cm 40%	12.2

¹ These ISOCS modeling parameters used to define the vertical distribution of radionuclides will initially be used for in situ screening during the Buffer Zone (BZ) characterization. However, these modeling parameters may be reevaluated as additional data are collected and adjusted accordingly to meet the site-specific conditions. For HPGe screening of subsurface samples, modeling parameters will be adjusted accordingly to the specifications of the sample container.

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2.2 VERIFICATION SAMPLING CORRELATION TECHNIQUE

To “standardize” the in situ method, a double sampling technique was employed whereby soil samples were collected from select HPGe measurement locations (RMRS 1998a). These samples were analyzed in the laboratory for ²⁴¹Am, ^{239/240}Pu, ^{233/234}U, ²³⁵U, and ²³⁸U using alpha spectroscopy, and gamma spectroscopy for ²⁴¹Am and ²³⁵U. The gamma spectroscopy data were collected by the laboratory to simply “validate” the alpha spectroscopy results, and the two sets of results show a high degree of correlation as indicated by their linear relationship (e.g., R² > 0.90).

In order to acquire a good duplicate sampling correlation over the anticipated range of ²⁴¹Am activities, eight HPGe measurement locations were selected that encompass five ²⁴¹Am activity intervals; 0-10 (three measurements), 10-20, 20-50 (two measurements), 50-100, and 100-200 pCi/g. These intervals were selected based on detection frequencies of ²⁴¹Am activities measured in surface soil samples collected in support of the OU2 Phase II RFI/RI (DOE, 1995; RMRS, 1998a) and to bound the high and low measurements collected in the field during the HPGe investigation.

Multiple HPGe measurements were taken at some of the double sampling locations for quality control. These results are provided in Table I2. In these cases, the measurements at each duplicate sampling location were averaged to create the HPGe data set used in the correlation. Table I2 also indicates the HPGe measurements at each duplicate sampling location are relatively uniform.

Best Available Copy

Table I2
HPGe Gamma Spectroscopy Measurements – Precision Summary

HPGe Measurement 30		HPGe Measurement 104		HPGe Measurement 265		HPGe Measurement 266		HPGe Measurement 305		HPGe Measurement 406		HPGe Measurement 460		HPGe Measurement 669	
²⁴¹ Am (pCi/g)	RPD %														
1.1	NA	14.5	19.4	34.3	2.2	9.1	NA	7.0	21.3	70.2	8.2	106.3	7.0	32.2	8.3
		17.6	0.1	39.0	10.6			7.5	28.1	62.9	2.8	113.2	13.3	32.8	6.5
		20.6	15.6	39.1	10.9			4.7	18.4	61.7	4.7	80.2	21.1	39.5	12.1
		15.5	12.8	37.3	6.2			6.0	6.0	62.6	3.2	98.3	0.8	35.3	0.9
		22.6	24.8	31.7	10.1			4.9	14.2	65.9	1.9	115.7	15.5	35.2	0.6
		17.6	0.1	29.2	18.3			5.7	0.9			80.8	20.3		
		23	26.5	31.3	11.4			5.4	4.5						
		15.1	15.4	39.3	11.4			4.0	34.2						
		17.6	0.1	34.4	1.9										
		13	30.2												
		18.6	5.4												
		19.4	9.6												
		15.8	10.9												
		15.8	10.9												
1.1 ^a		17.6 ^a		35.1 ^a		9.1 ^a		5.7 ^a		64.7 ^a		99.1 ^a		35 ^a	

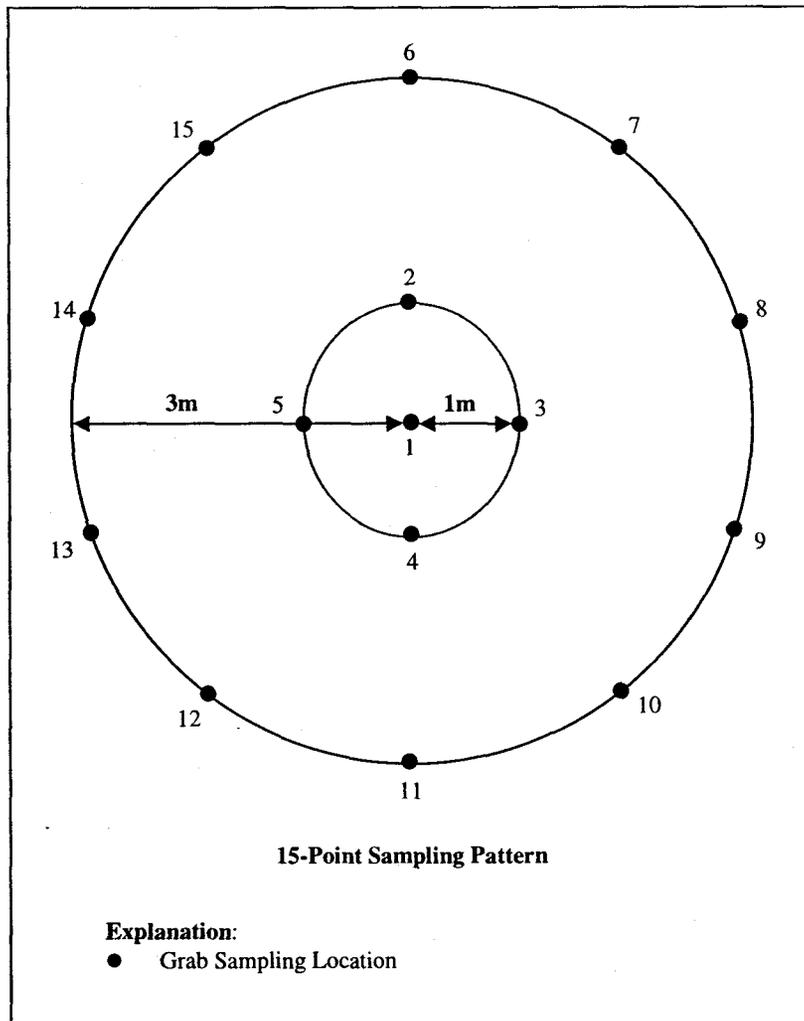
RPD relative percent difference between individual measurements and group mean

^a Group mean

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Fifteen grab samples were then collected at each duplicate sampling location; 1 grab sample from the center; 4 grab samples collected at 1-m radius, and 10 grab samples from 3-m radius. Figure I2 provides this surface soil sampling geometry, which was developed by the U.S. Department of Energy (DOE) (DOE 1997) at the Fernald Environmental Management Project site in Ohio to correlate HPGe results to surface soil results. The 1-m and 3-m radius grab samples were then composited into a 1-m and 3-m sample representative of each individual band. Therefore, three separate alpha (and gamma) spectroscopy analyses were performed at each duplicate sampling location. Samples were collected in this "bull's eye" pattern to mimic the averaging done by the field HPGe detector over the instrument's FOV. The HPGe detector receives gamma-ray photons from every point within the circle; however, it receives more gamma rays from soil closer to the detector than from soil further from the detector. If the circle is divided into concentric bands, the relative weighting factor for each band can be calculated based upon the percentage influence of gamma photons at the detector which originates from a given band of soil, assuming a uniform source distribution with depth and a one MeV photon energy. The relative weighting factor is the relative importance of each band with respect to the probability of gamma rays emitted from within that band being detected by the HPGe.

Figure I2
HPGe 15-Point Surface Soil Sampling Pattern



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The sample results were multiplied by the weighting factor per band, then the products were summed to determine the activity of the soils in the FOV area. It should be noted that these results were adjusted for moisture content in order to report results on a wet weight or "in situ moisture" basis.

At every duplicate sampling location, the "real" and "duplicate" data were averaged (denoted as "combined"), and the "combined" data used in the weighted averaging process to develop the data for the correlation.

2.2.1 Alpha Spectroscopy: HPGe $^{239/240}\text{Pu}$ and ^{241}Am Correlations

The linear regressions (using the method of least squares) between the alpha spectrometry data (^{241}Am and $^{239/240}\text{Pu}$) and the HPGe data (^{241}Am) show very high degrees of correlation (Figures I3 and I4). The correlation coefficients (R) are greater than or equal to 0.97. The ^{241}Am (alpha spectrometry) to ^{241}Am (HPGe) correlation has a slope (1.25) near 1.0 and a intercept (4.43 pCi/g) near zero as would be expected when correlating the activities of the same radionuclide (Figure I3). The $^{239/240}\text{Pu}$ (alpha spectrometry) to ^{241}Am (HPGe) correlation has a slope of 8.08, which is within the expected range of $^{239/240}\text{Pu}$ to ^{241}Am activity ratios given the in-growth of ^{241}Am in weapons-grade plutonium over 30 to 40 years (elapsed time since the release). The intercept (3.24 pCi/g) of this regression is also near zero (Figure I4). These results indicate the regression lines are appropriate models to correlate HPGe data to alpha spectroscopy data.

The $^{239/240}\text{Pu}/^{241}\text{Am}$ ratio derived from the "best fit" line regression model compares favorably to those ratios derived from previous studies. The National Bureau of Standards (NBS) (1980) collected soil samples from RFETS for isotopic analyses, which were eventually used as a standard radioactive source reference. The NBS (1980) sampling and analysis of RFETS soil indicated a $^{239/240}\text{Pu}$ to ^{241}Am ratio of 6.42. A second study performed by Ibrahim et al. (1996) included an isotopic inventory (using alpha spectroscopy) of RFETS soil to determine the activity ratio of $^{239/240}\text{Pu}$ to ^{241}Am . The regression model between ^{241}Am and $^{239/240}\text{Pu}$ resulted in a strong correlation ($R=0.96$) between the two radionuclides, and a $^{239/240}\text{Pu}$ to ^{241}Am activity ratio of 5.29. Based on their findings, Ibrahim et al. (1996) concluded that $^{239/240}\text{Pu}$ values could be inferred from gamma spectroscopy results of ^{241}Am . The $^{239/240}\text{Pu}$ to ^{241}Am ratio (8.08) derived from the "best fit" line regression model compares favorably to the 6.42 and 5.29 ratios derived from the NBS (1980) and Ibrahim et al. (1996) studies, respectively. It is also conservatively high with respect to the previously measured $^{239/240}\text{Pu}/^{241}\text{Am}$ ratios.

2.2.2 Alpha Spectroscopy: HPGe ^{235}U and ^{238}U Correlations

As shown in Figures I5 and I6, correlation for the alpha spectroscopy/HPGe data for ^{235}U and ^{238}U were not performed because in both cases the uranium isotopes were not detected by in situ HPGe. The plots show minimum detectable activities because the isotope measurements were less than method detection limits. Also, alpha spectroscopy did not measure detectable levels of ^{235}U , and only in a few instances was ^{238}U detected at estimated activities. Therefore, ^{235}U and ^{238}U results derived from the HPGe survey were used directly as the surface soil radiological data for these isotopes (i.e., values were not standardized to laboratory alpha spectroscopy measurements). The lack of correlation for the uranium data does not impact the findings reported in the 903 Pad Characterization Report (Kaiser-Hill 2000), because the activities for uranium isotopes are well below the Tier II Remediation Soil Action Levels (RSALs) throughout the investigation area.

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Figure I3
Linear Regression Americium-241

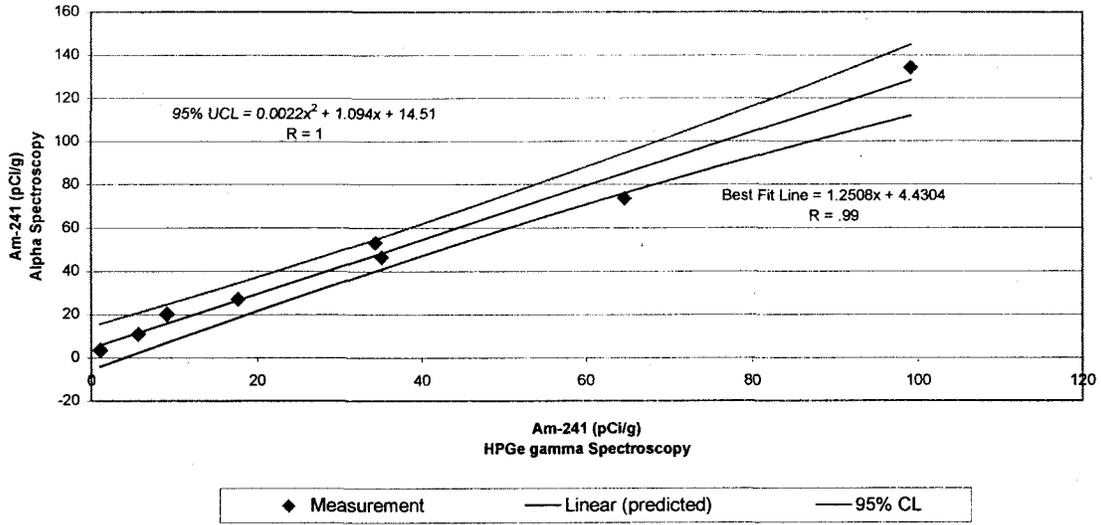
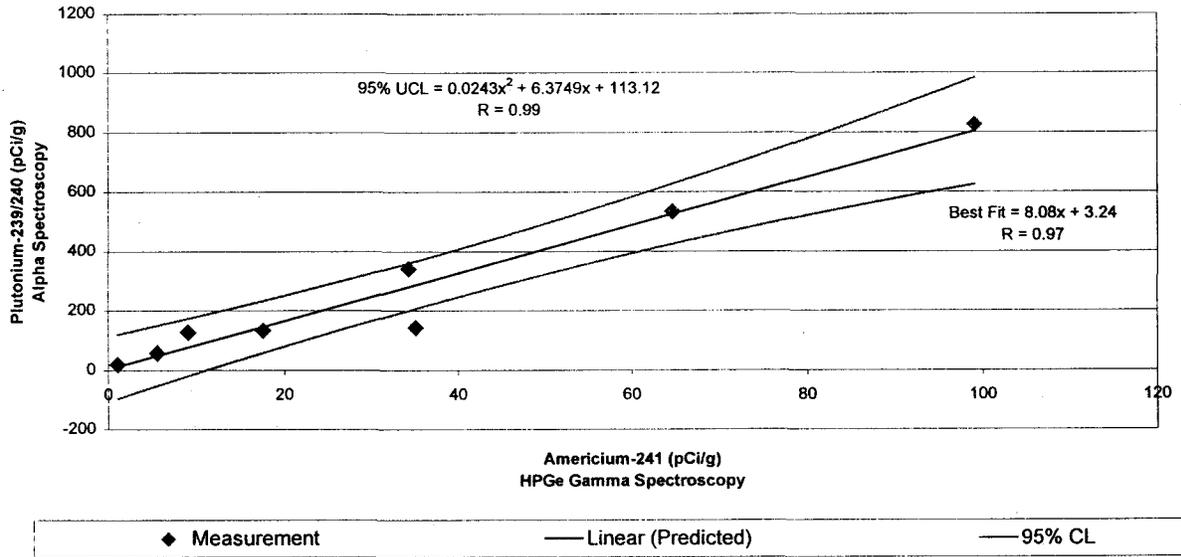


Figure I4
Linear Regression Plutonium-239/240



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Figure I5
Minimum Detectable Activities Uranium-235

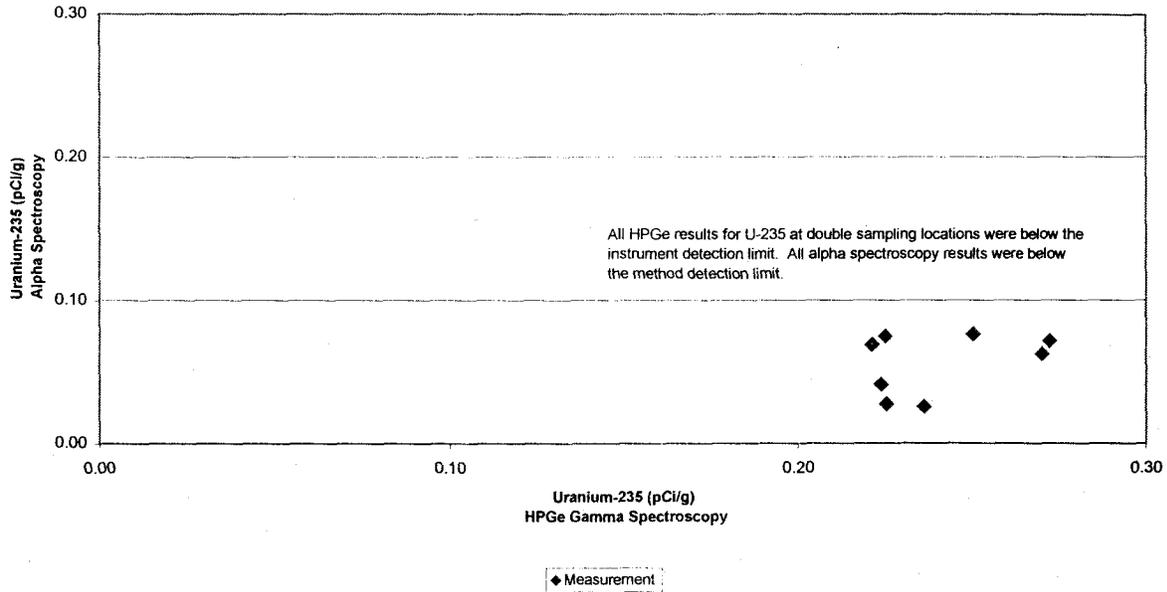
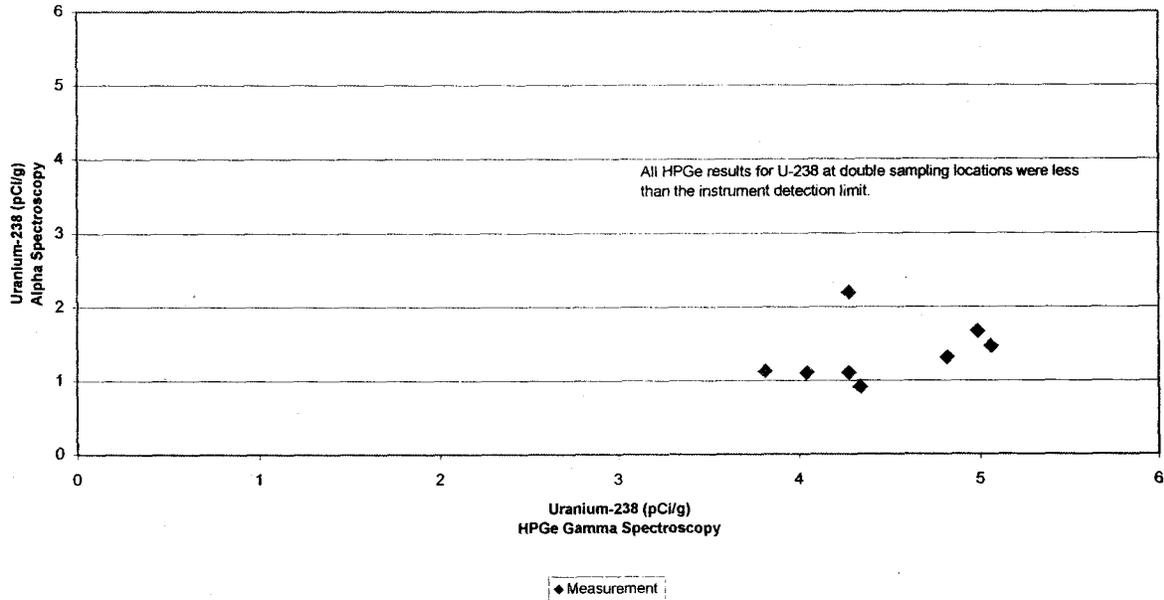


Figure I6
Minimum Detectable Activities Uranium-238



The activity of $^{233/234}\text{U}$ was estimated based on the fact that under natural conditions, ^{234}U is in equilibrium with ^{238}U (the contribution of ^{233}U activity is insignificant). The equilibrium between the radioactive parent (^{238}U) and daughter (^{234}U) suggests the activity ratio between these two isotopes should be 1.0. Surface soil data collected in support of the OU 2 Phase II RFI/RI supports this relationship with an average activity ratio of 0.97 between the two isotopes. Therefore, the activity of $^{233/234}\text{U}$ in surface soil was assigned the value measured by the HPGe survey for ^{238}U .

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3.0 HPGE METHODS TO BE EMPLOYED DURING THE BZ CHARACTERIZATION

The fundamental approach of the HPGe methodology used during the 903 Pad Characterization will be incorporated into the BZ characterization. This will provide a basis for establishing the setup parameters for the HPGe detector and regression modeling for standardizing the HPGe measurements. However, variation in physical conditions and process knowledge (i.e., spills and releases of hazardous constituents) of specific Individual Hazardous Substance Sites (IHSSs) and Potential Areas of Concern (PACs) may warrant changes in the HPGe methodology. Despite such changes, the physics and fundamental processes of the HPGe measurements will remain the same. The HPGe methodology discussed previously in Sections 2.1 and 2.2 will provide the outline for the HPGe techniques to be employed during the BZ characterization.

3.1 LINEAR REGRESSION MODELS

The “best fit” regression modeling approach used to standardize the HPGe ^{241}Am and $^{239/240}\text{Pu}$ alpha spectroscopy measurements for the 903 Pad Characterization will also be used for the BZ characterization. The following equations will initially be used to standardize the HPGe measurements:

$$^{239/240}\text{Pu}_{yi} = 8.08 * x_i + 3.24 \quad \text{(Equation I-1)}$$

$$^{241}\text{Am}_{yi} = 1.25 * x_i + 4.43 \quad \text{(Equation I-2)}$$

Where:

$x_i = ^{241}\text{Am}$ activity measured by the HPGe instrumentation

Equations I1 and I2 will provide the basis for standardizing the HPGe measurements but may be changed as additional data are obtained during the BZ characterization (see Section 3.1.1). As discussed in Section 2.2.1, the majority of the ^{235}U and ^{238}U measurements were nondetectable, which prevented a correlation between HPGe and laboratory alpha spectroscopy measurements. Therefore, for lower activities, ^{235}U and ^{238}U activities will be obtained by direct HPGe measurements. However, activity levels of ^{235}U and ^{238}U measured by HPGe near or above the ALs may warrant verification sampling (i.e., soil sampling) for analysis by laboratory alpha spectroscopy. If a linear relationship is observed between the HPGe and laboratory ^{235}U and ^{238}U activities, then the HPGe results will be standardized using the appropriate regression equation. Activities of $^{233/234}\text{U}$ will be based on the HPGe direct reading of ^{238}U , given the equilibrium state between the two isotopes (i.e., 1:1 ratio).

3.1.1 Verification of “Best Fit” Regression Model

The “best fit” regression models (Equations I1 and I2) will be verified by routine duplicate

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sampling events. As discussed in Section 5.1.1, Linear Regression Analysis, observations within the range of interest will be obtained to validate the acceptability of the regression model. Validity of the observations will be evaluated relative to the 95% confidence interval (CI) of the "best fit" regression line (Figures I3 and I4). The 95% CI defines the range about the sample mean where the true population mean is expected to lie at a 95% level of probability. This type of evaluation not only provides quantified boundaries about the "best fit" regression line but also provides a quick visual inspection of the data sets. Observations that fall outside the 95% CI indicate a higher degree of variability about the "best fit" regression line (or predicted values) and therefore, may warrant a reevaluation of the regression model. The acceptability criteria of the regression model(s) will be based on a high degree of correlation ($R^2 > 0.90$) and statistical comparison between the predicted values and independent variables using an Analysis of Variance (ANOVA) and corresponding F-Test.

Regression models will need to be developed for subsurface soil samples. Unlike the HPGe survey of surficial soils, these samples will be analyzed ex situ. The HPGe instrumentation will have to account for such variations as the FOV and physical and chemical properties of the sample container. In addition, some IHSS and PACs may require a site-specific regression model that varies slightly from Equations I-1 and I-3. For example, the presence of enriched ^{241}Am in soil at OU 4 will likely result in a reduction in the $^{239/240}\text{Pu}/^{241}\text{Am}$ ratio of 8.08 (Equation I-1). In general, the regression model should be appropriate for the given site conceptual model.

3.2 HPGE SURVEY DESIGN

In situ HPGe surveys to be conducted during the BZ characterization will follow the methodology presented in Section 2.1.1. The instrumentation FOV (10 m in diameter), detector height above the soil (1-m), and ISOCS modeling parameters will be consistent with those settings used during the 903 Pad Characterization. However, these settings/parameters may be altered to account for changes in site conditions and materials being measured (i.e., asphalt is denser than natural soil). Ex situ measurements of subsurface soil samples will follow standard guidelines presented in Determination of Radionuclides by Gamma Spectroscopy, Module RC03-A.1 (RMRS 1998b).

Methods to be employed for the verification sampling and analysis (i.e., duplicate sampling) will follow the methods presented in Section 2.2. However, some deviations for ex situ HPGe measurements of subsurface soils will be performed. For subsurface soil samples, core samples will be homogenized prior to being placed in containers. Final sample preparation will follow the guidelines presented in SOP GT.08. It should be noted that normal procedure requires that coarse-grained fragments be separated from the finer-grained fragments because plutonium and americium have a tendency to absorb to the fine-grained fraction. However, sieving out the coarse-grained fragments may result in a high bias in the HPGe and alpha spectroscopy results. Therefore, deviations to the existing standard operating procedures may be implemented to minimize the apparent sample bias.

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APPENDIX J

Example Data Aggregation Problem

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ACRONYM LIST

AL	Action Level
AOC	Area of Concern
df	degrees of freedom
EMC	elevated measurement comparison
HCB	hexachlorobenzene
HS	hot spot
IHSS	Individual Hazardous Substance Site
mg/kg	milligrams per kilogram
PAC	Potential Area of Concern
pCi/g	picocuries per gram
Pu	plutonium
RFCA	Rocky Flats Cleanup Agreement
UBC	Under Building Contamination
UCL	upper confidence limit

Example Problem

This appendix consists of an example problem that illustrates how the Buffer Zone Sampling and Analysis Plan statistical methods will be implemented. The locations, and analytical results that appear in this appendix have been fabricated and do not provide data on any part of the Rocky Flats Environmental Technology Site. This appendix includes the following:

Map 1 – Existing sampling locations and analytical data for Individual Hazardous Substance Site (IHSS) 1.1. This map is used to determine whether additional data are needed to characterize the IHSS.

Map 2 – A triangular grid superimposed over IHSS 1.1 using a random start point. This map is used to illustrate the 36-foot triangular grid that has been proposed for IHSS and PAC characterizations.

Map 3 – Additional soil sampling points at the nodes of the grid system

Map 4 – Analytical results from new sampling points

Map 5 – Contoured Rocky Flats Cleanup Agreement (RFCA) Tier I and Tier II exceedances

Map 6 – Remediation confirmation sampling locations for nonradionuclide analytes

Map 7 – Remediation confirmation sampling locations for radionuclide analytes

Table J-1 Sum of Ratios and Elevated Measurement Comparison (EMC) for Hot Spots

**Table J-1
Hot Spot Methodology Sample Problem Data**

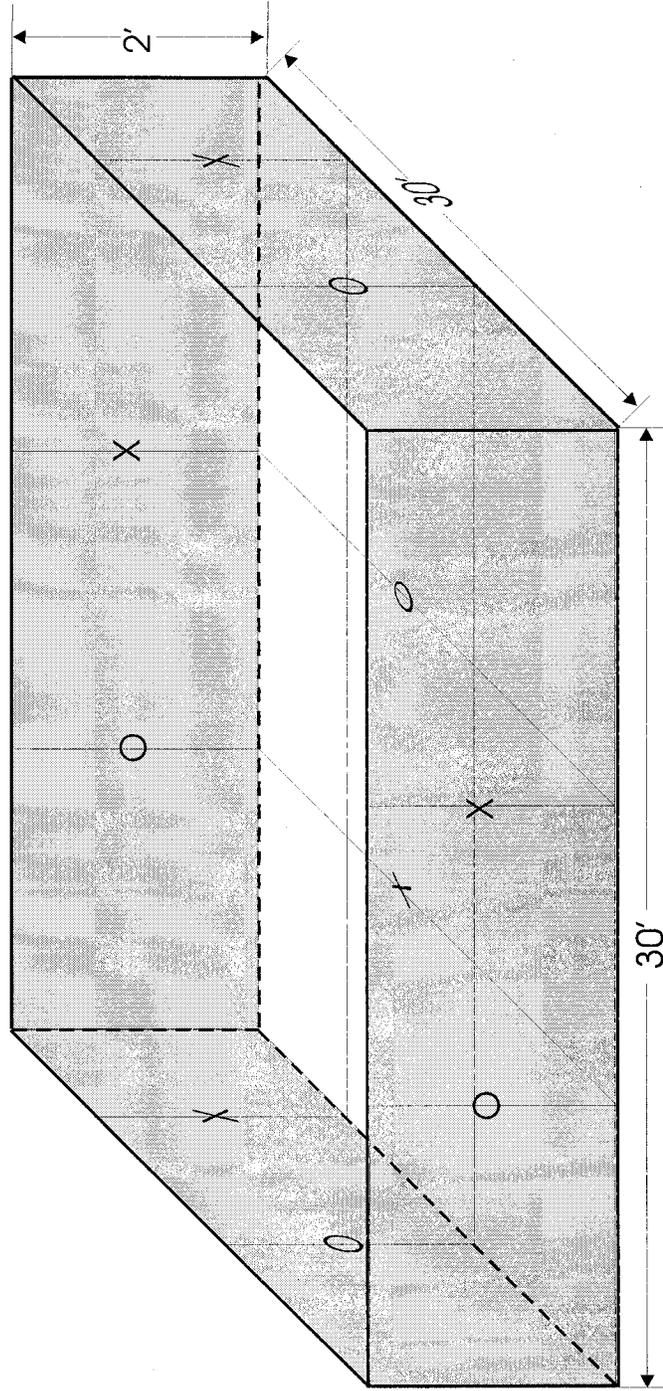
Sample Location	Sample Results		Tier I Exceedence	Tier II Exceedence	2nd Term of EMC Sum>Tier 1
	Pu (pCi/g)	HCB (mg/Kg)			
S1	232	2			
S2	235	2.2			
S3	4	3.2		HCB	
S4	41	4.1		HCB	
S5	41	2.6			
S6	30	2.1			
S7	5521	1.8	Pu	Pu	0.3350
S8	4712	2.1	Pu	Pu	0.2845
S9	101	11.2		HCB	
S10	8	320	HCB	HCB	0.0462
S11	11	9.6		HCB	
S12	12	2.1			
S13	968	1.6		Pu	
S14	301	2.6		Pu	
S15	129	39		HCB	
S16	48	10.1		HCB	
S17	30	2.5			
S18	17	0.8			
S19	12	1.1			
S20	14	2.4			
S21	20	2.5			
S22	72	1.9			
S23	32	2.8			
S24	12	0.9			
L1	305	2.2		Pu	
L2	4687	1.4	Pu	Pu	0.2830
L3	62	2.6			
L4	16	98		HCB	
L5	2	405	HCB	HCB	0.0590
L6	107	13.4		HCB	
L7	59	2.7			
L8	12	1.9			
L9	34	2.4			
No. of Sample Results	33	33			
Mean Concentration (excl. > Tier 1)	98.9	7.6			
Standard Deviation (excl. > Tier 1)	185.6	18.2			
t =	1.699	1.697			
n =	30	31			
df = (n-1) =	29	30			
Tier I Action Level	1429	299			
Area AOC (sq feet)	20000	20000			
Area HS (sq feet)	1785	900			
95% UCL AOC	156.46	13.16			
95% UCL/AL	0.109	0.044			
Tier I EMC =	1.012	0.149			

Shaded cells indicate Tier I exceedence

239
257

Map 6

HCB > Tier I Remedial Area with Confirmation Samples

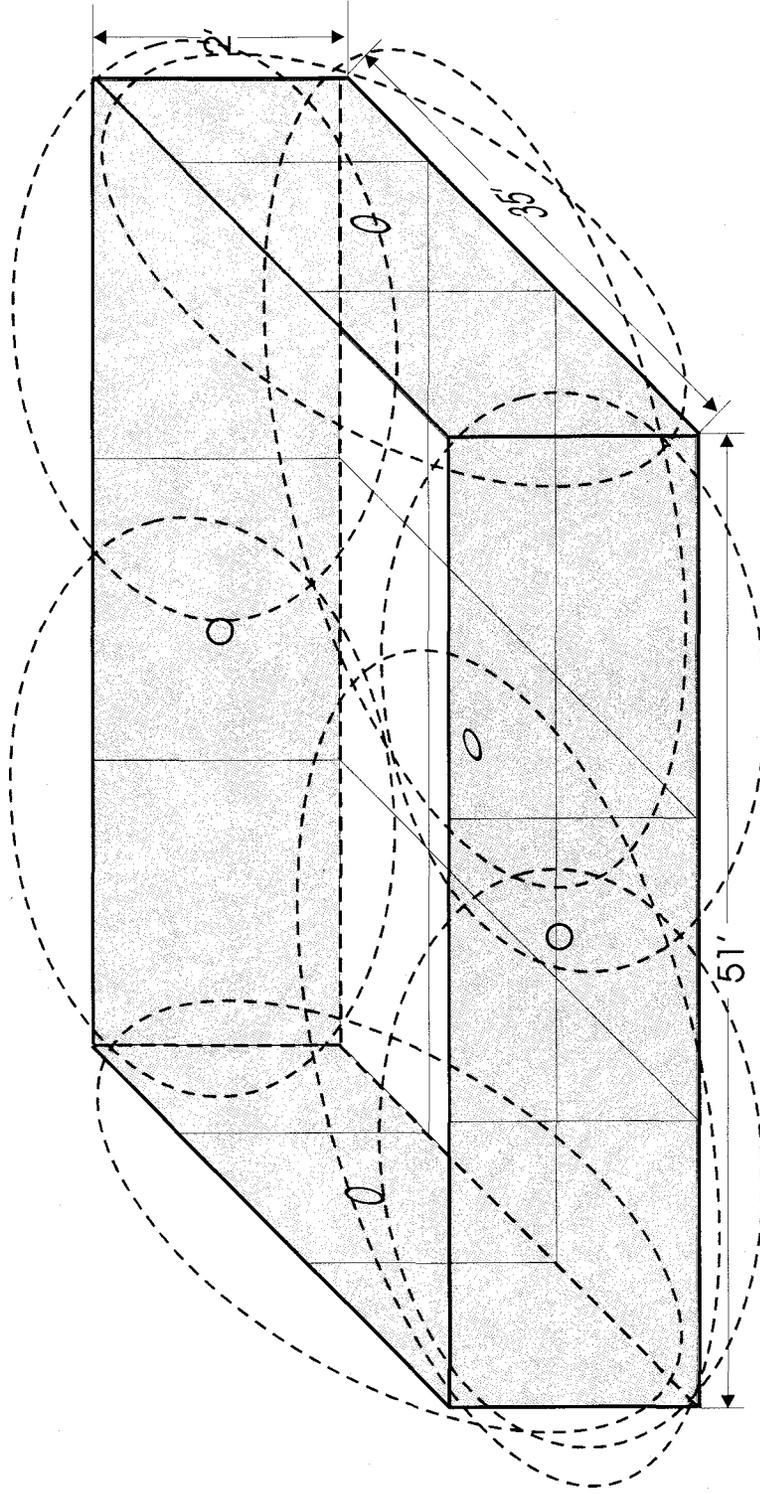


X = Field Analytical Sample Collection Point
 O = Analytical Sample Collection Point

900 Sq. Ft. Area
 1800 ft.³ Soil Removal

Map 7

Pu > Tier I Remedial Area with Confirmation Samples



1785 Sq. Ft. Area
3570 ft.³ Soil Removal

○ = HPGe Sample Location
○ = Analytical Sample Collection Point

2011
246

APPENDIX K

Response to Comments

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~~247/247~~

HPGe Measurement Location Map

Figure I-1

EXPLANATION

- Investigation Area
- FOV (Field of View) Stake Number

Standard Map Features

- Steep Topography
- Wetland Area
- Cement
- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
 Buildings, fences, hydrography, roads and other structures from 1994 aerial photo data
 Topography from the orthophotograph, 1995
 Topology (contours) were derived from digital elevation model (DEM) data by American Kronos (AK) using ESRI Arc 7.0 and the DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Photo, 1:10,000 resolution.
 DEM post-processing performed by M.C. Water 2007.

DISCLAIMER:
 While the United States Government and Kaiser Hill Co., Inc. make every effort to ensure the accuracy of this data, the Government and Kaiser Hill Co., Inc. do not warrant the accuracy or completeness of the information contained herein, and the user assumes all liability for any errors or omissions that may appear in this document.



Scale = 1 : 2370
 1 inch represents approximately 188 feet

State Plane Coordinate Projection
 Colorado Central Zone
 Datum: NAD87

U.S. Department of Energy
 Rocky Flats Environmental Technology Site

GIS Dept. 303-955-7707
 Prepared for:



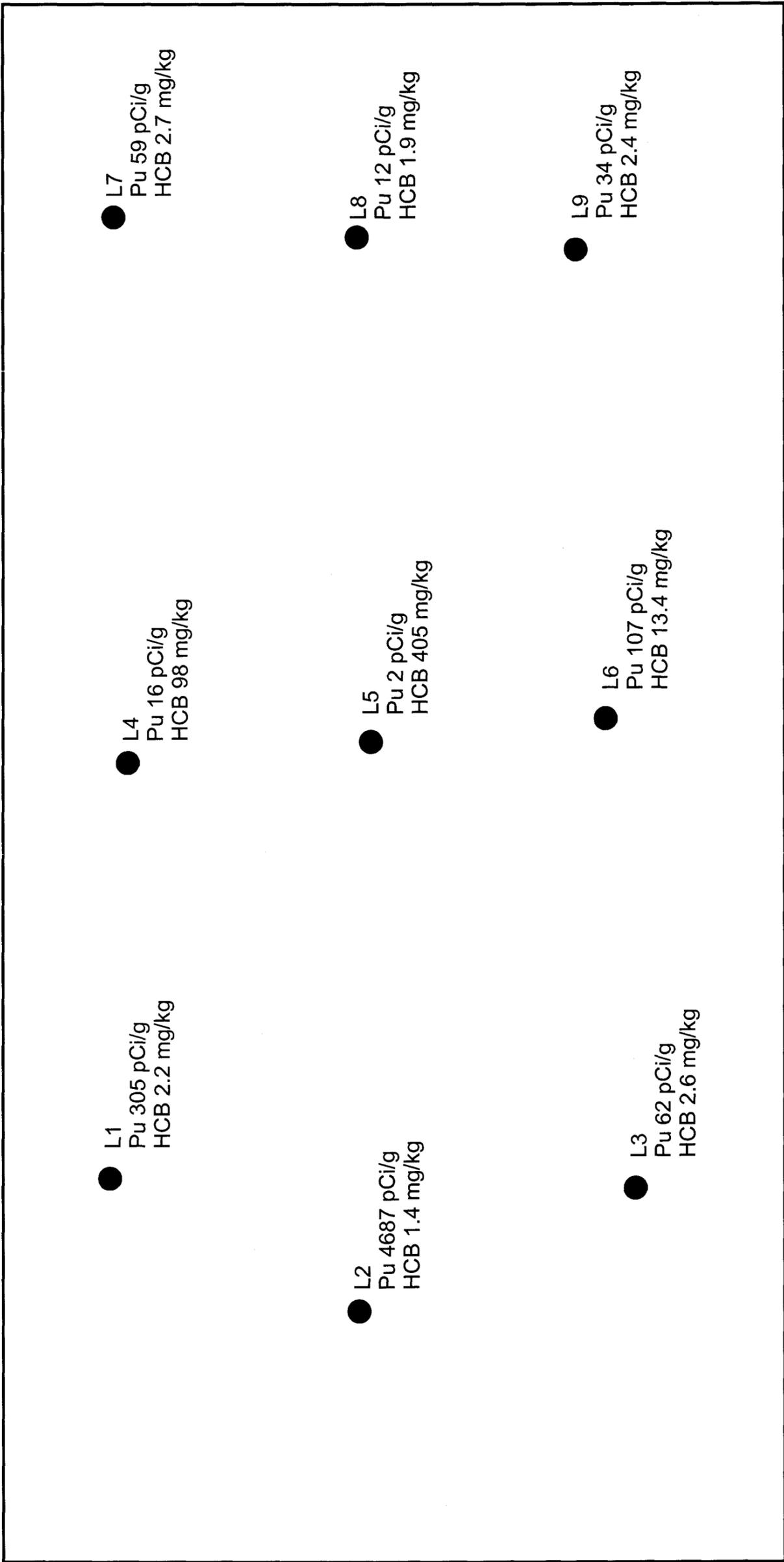
MAP ID: 98-0408
 Original map contents are preserved. Logo and data have changed.
 June 28, 2001



Handwritten initials: *hmc*

IHSS 1.1

BUILDING 172.66



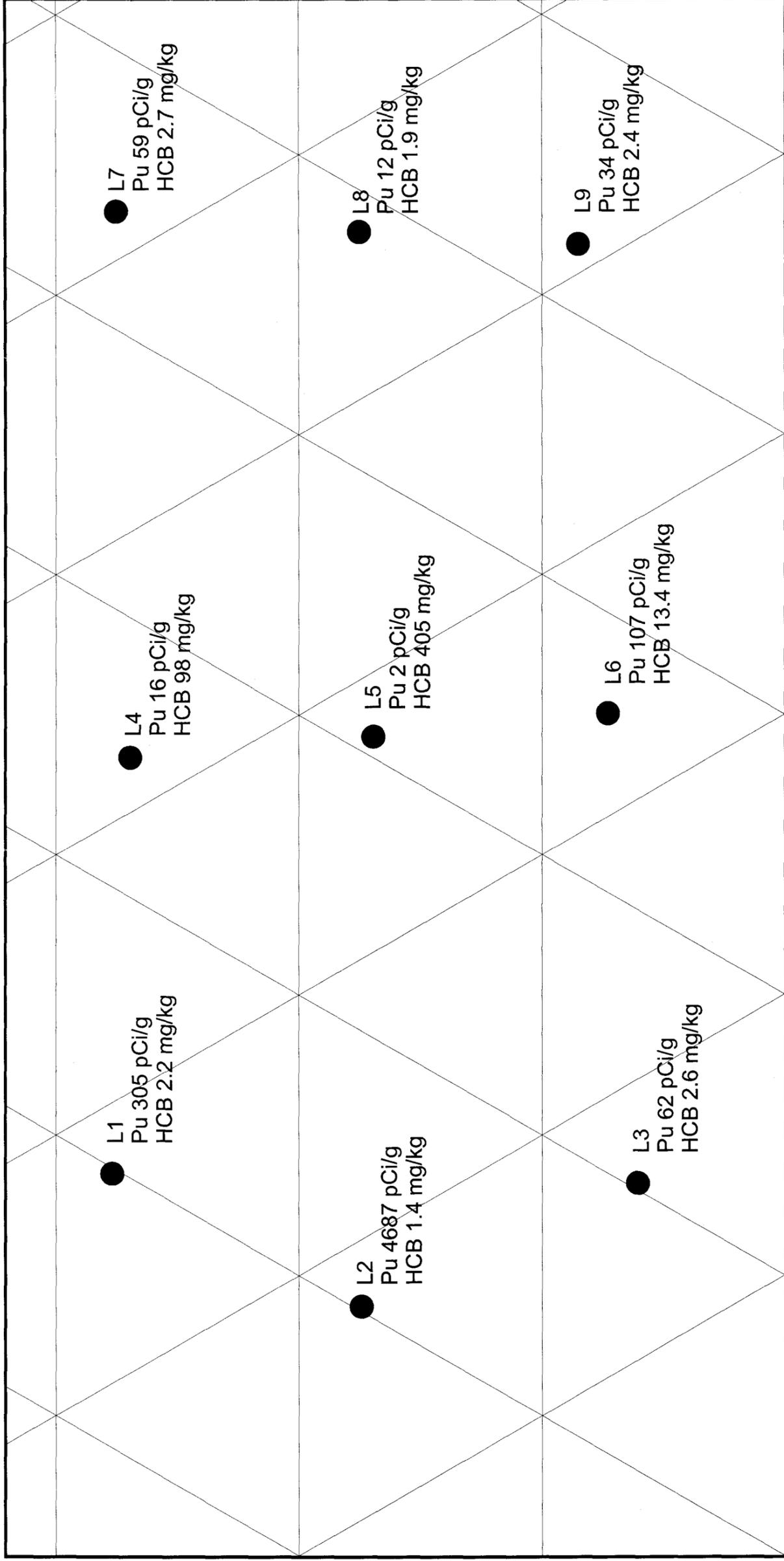
20,000 SQUARE FT

Map 1 Existing Soil Data

* This IHSS and building does not exist. Data has been fabricated to provide an example of how the BZSAP process will work.

240258

IHSS 1.1



Grid Spacing = 36 Feet

20,000 SQUARE FT

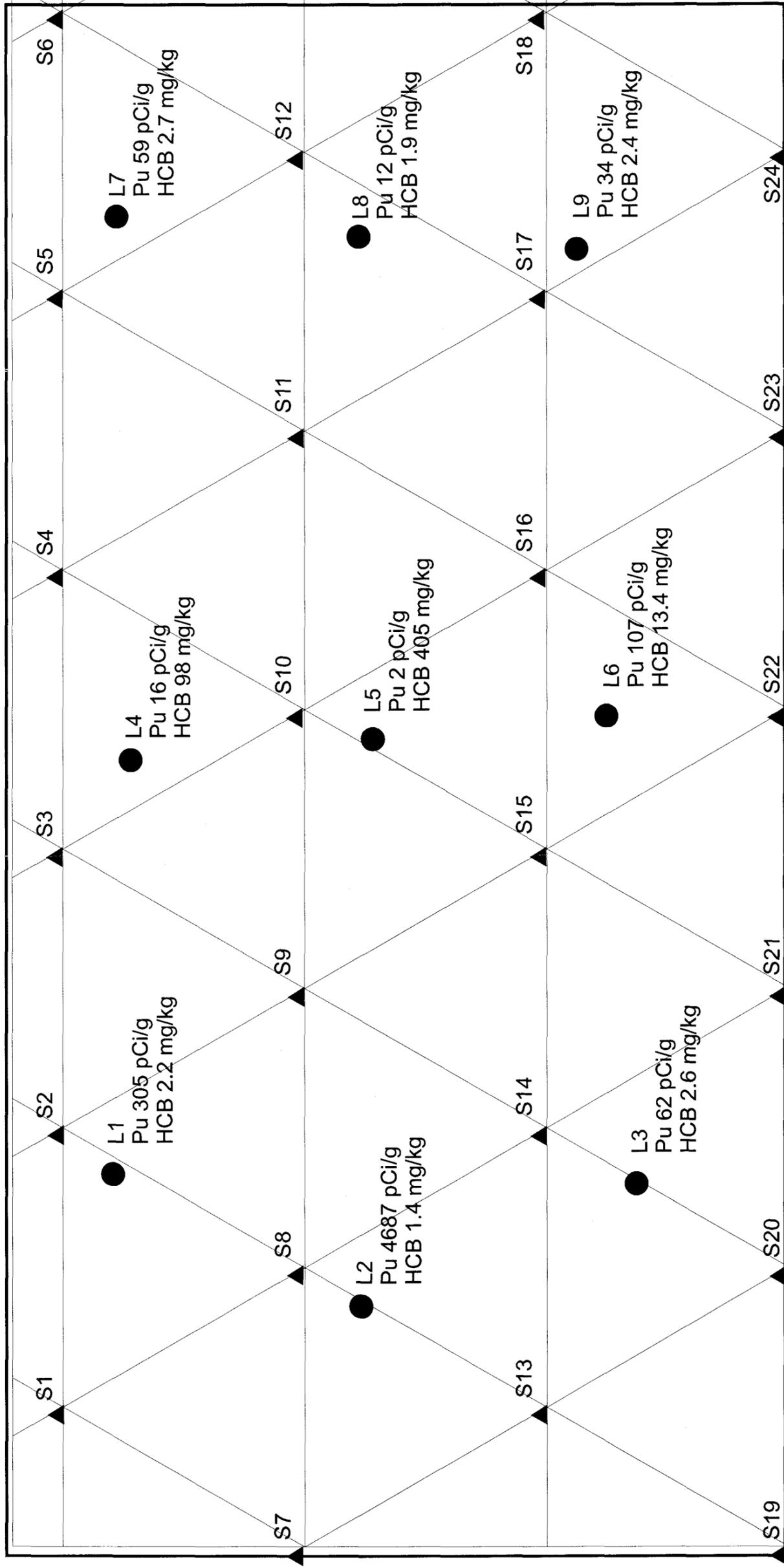
Map 2 Triangular Grid Superimposed Over IHSS Using Random Start

BUILDING 172.66

* This IHSS and building does not exist. Data has been fabricated to provide an example of how the BZSAP process will work.

24/2/99

IHSS 1.1



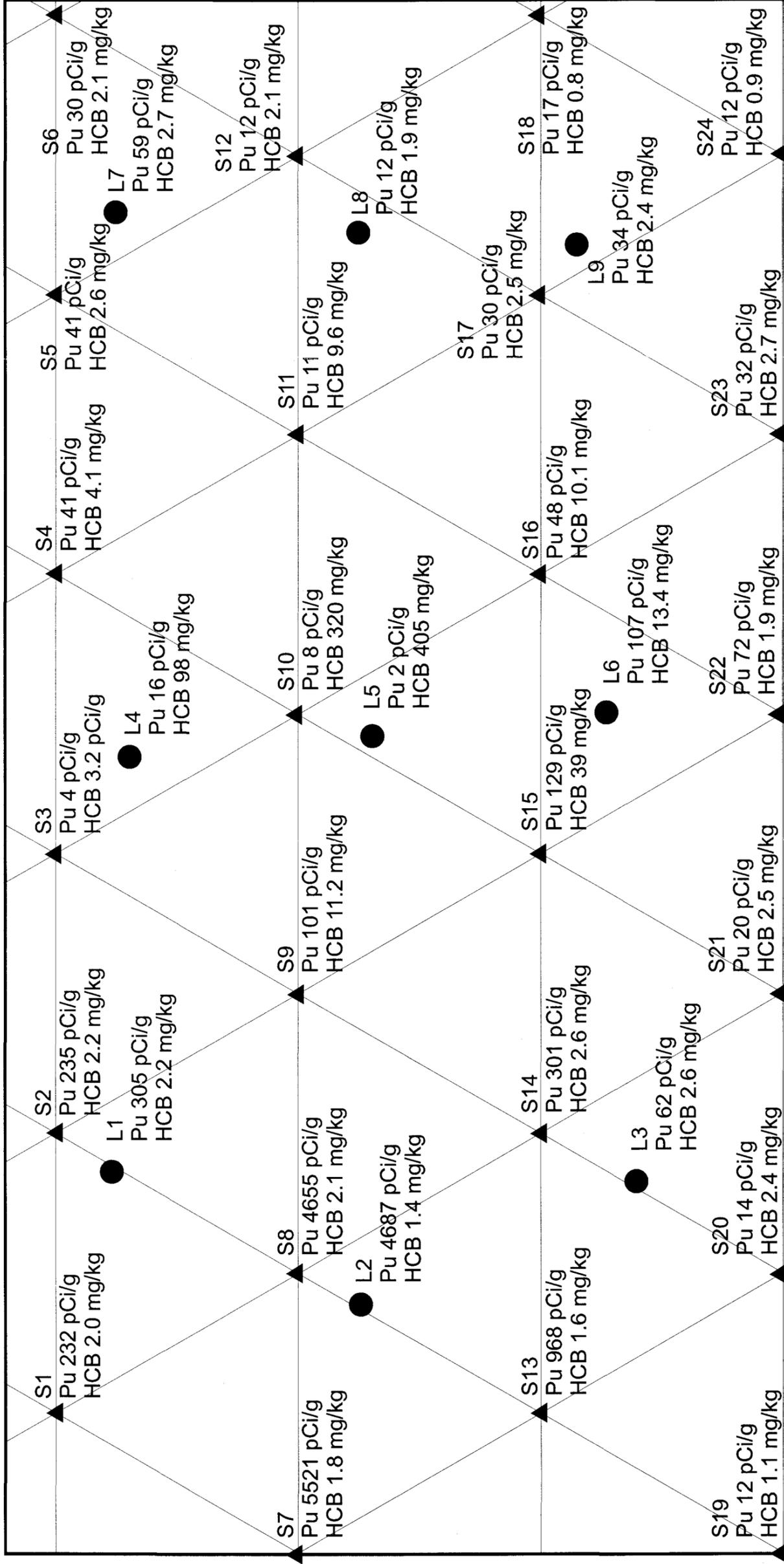
Map 3 Additional Soil Sampling Points Designated

* This IHSS and building does not exist. Data has been fabricated to provide an example of how the BZSAP process will work.

247256

IHSS 1.1

BUILDING 172.66



Grid Spacing = 36 Feet

20,000 SQUARE FT

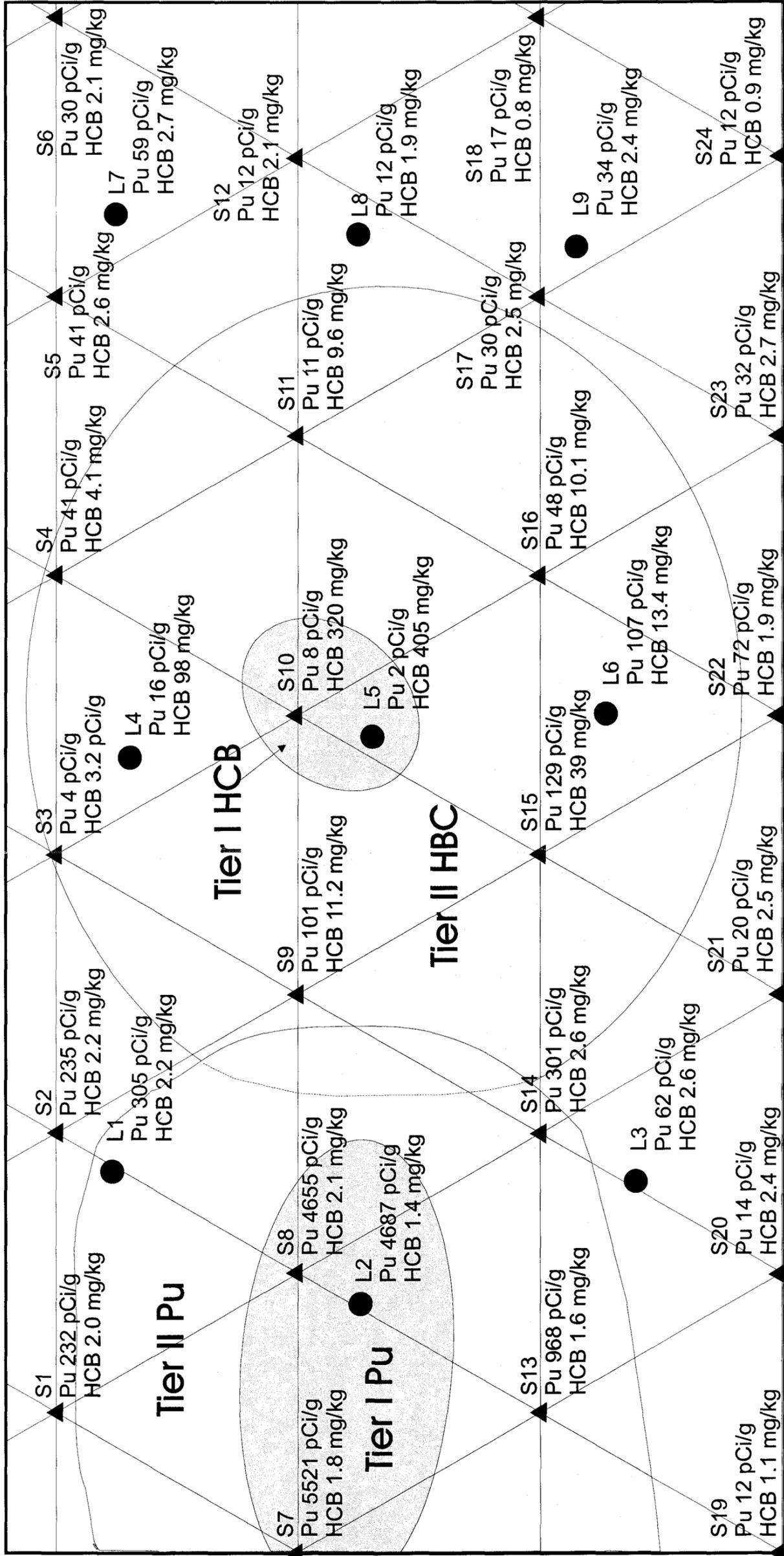
Map 4 Analytic Results

Legend:
 — = Triangular Grid
 ● = Existing Sampling Points
 ▲ = New Additional Sampling Points

* This IHSS and building does not exist. Data has been fabricated to provide an example of how the BZSAP process will work.

247/141

IHSS 1.1



BUILDING 172.66

Map 5 Tier I and Tier II Exceedences

* This IHSS and building does not exist. Data has been fabricated to provide an example of how the BZSAP process will work.

172.66
244

Figure 2
AOC Determination

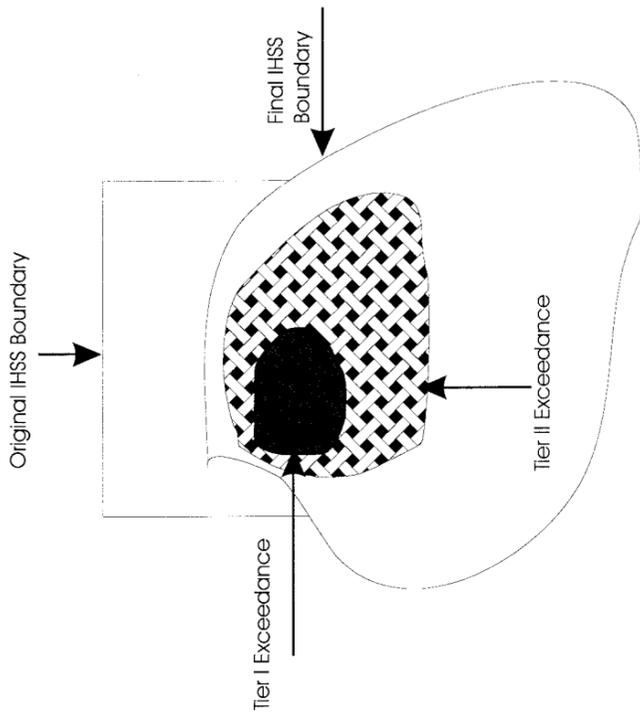
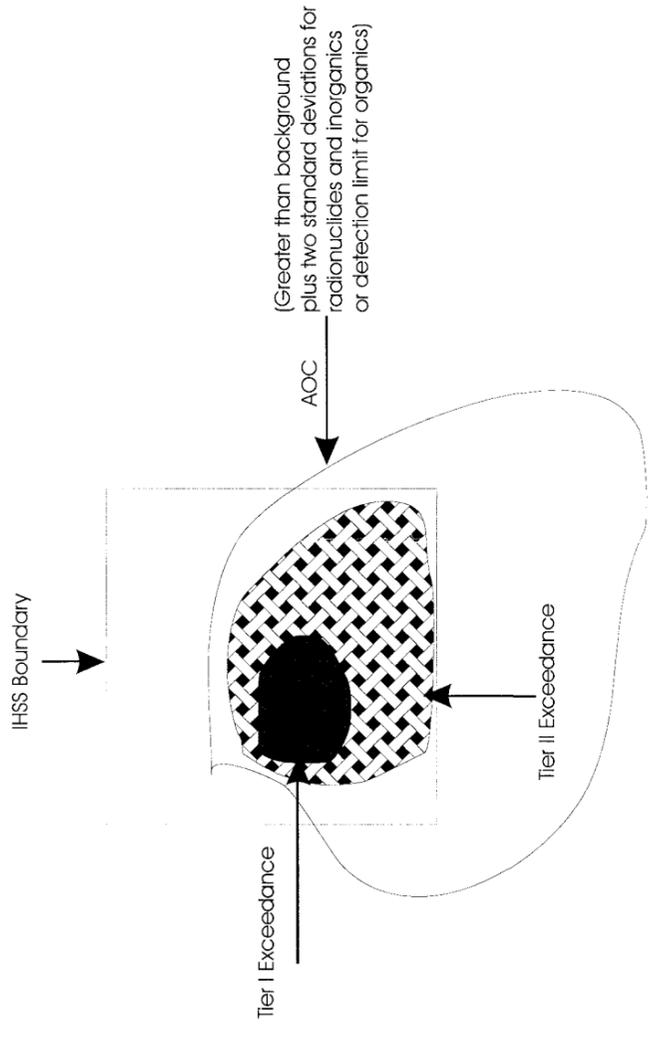
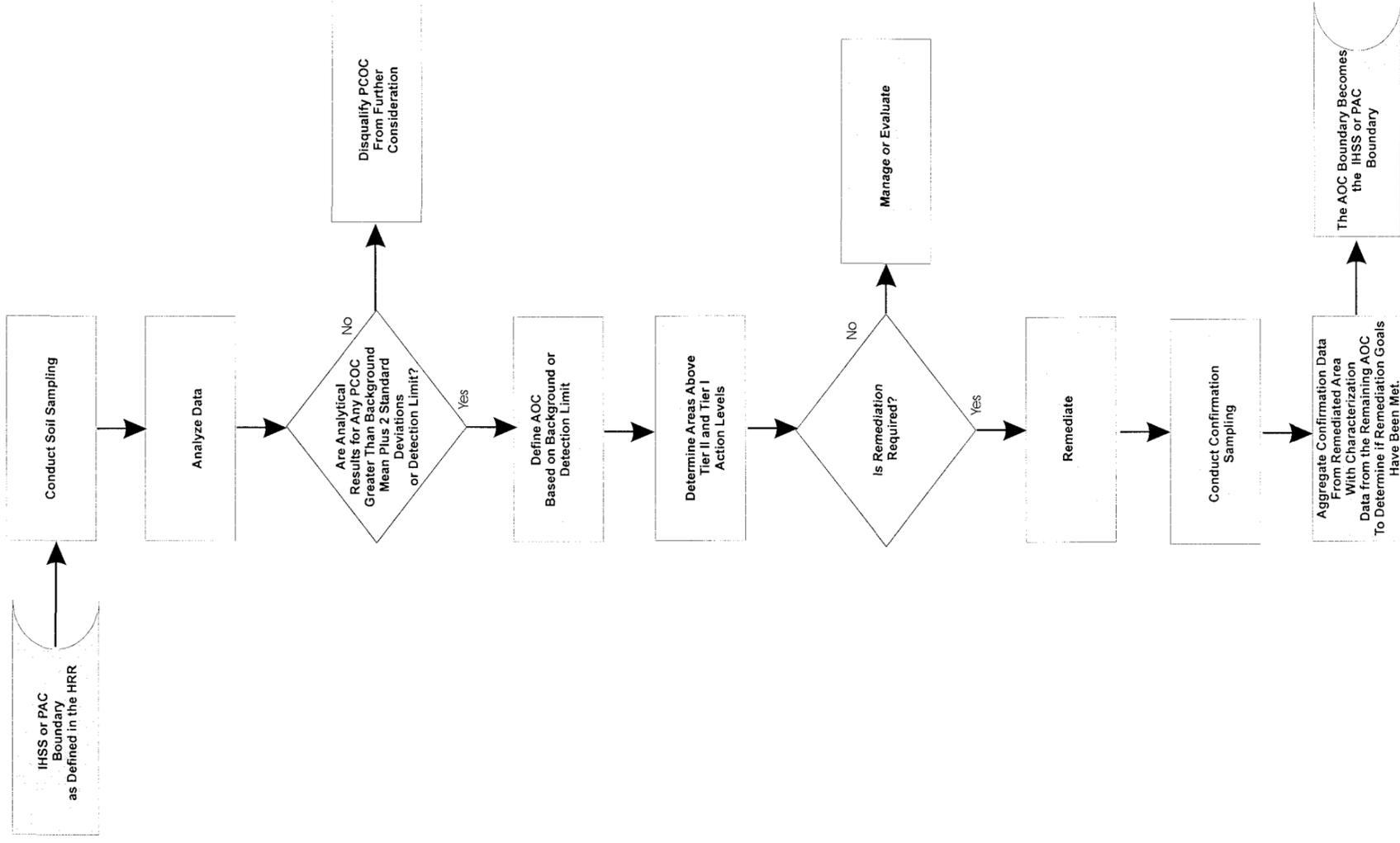


Figure 4
Characterization Sampling Data Quality Assessment Logic Flow Diagram
Decision: Determine the Nature and Extent of Contamination in IHSSs and PACs

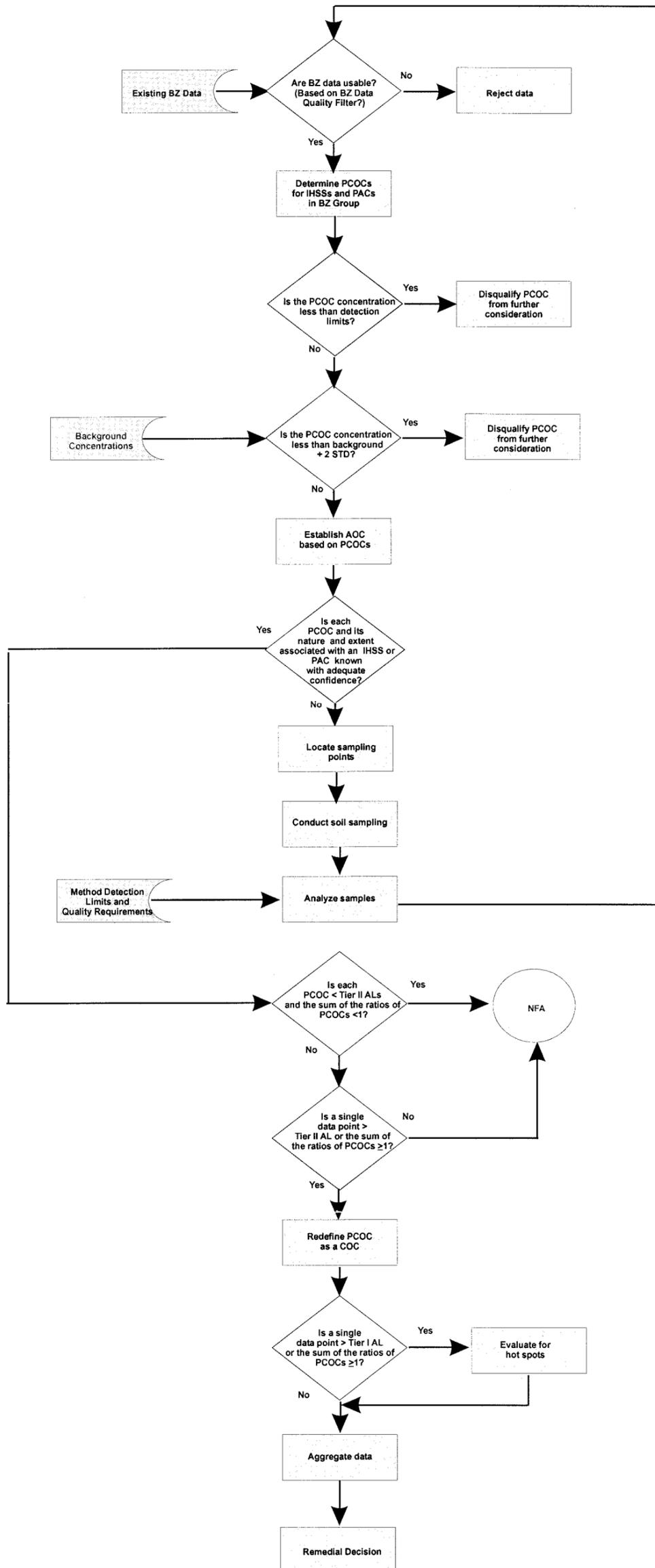


Figure 5
PCOC to COC Transition

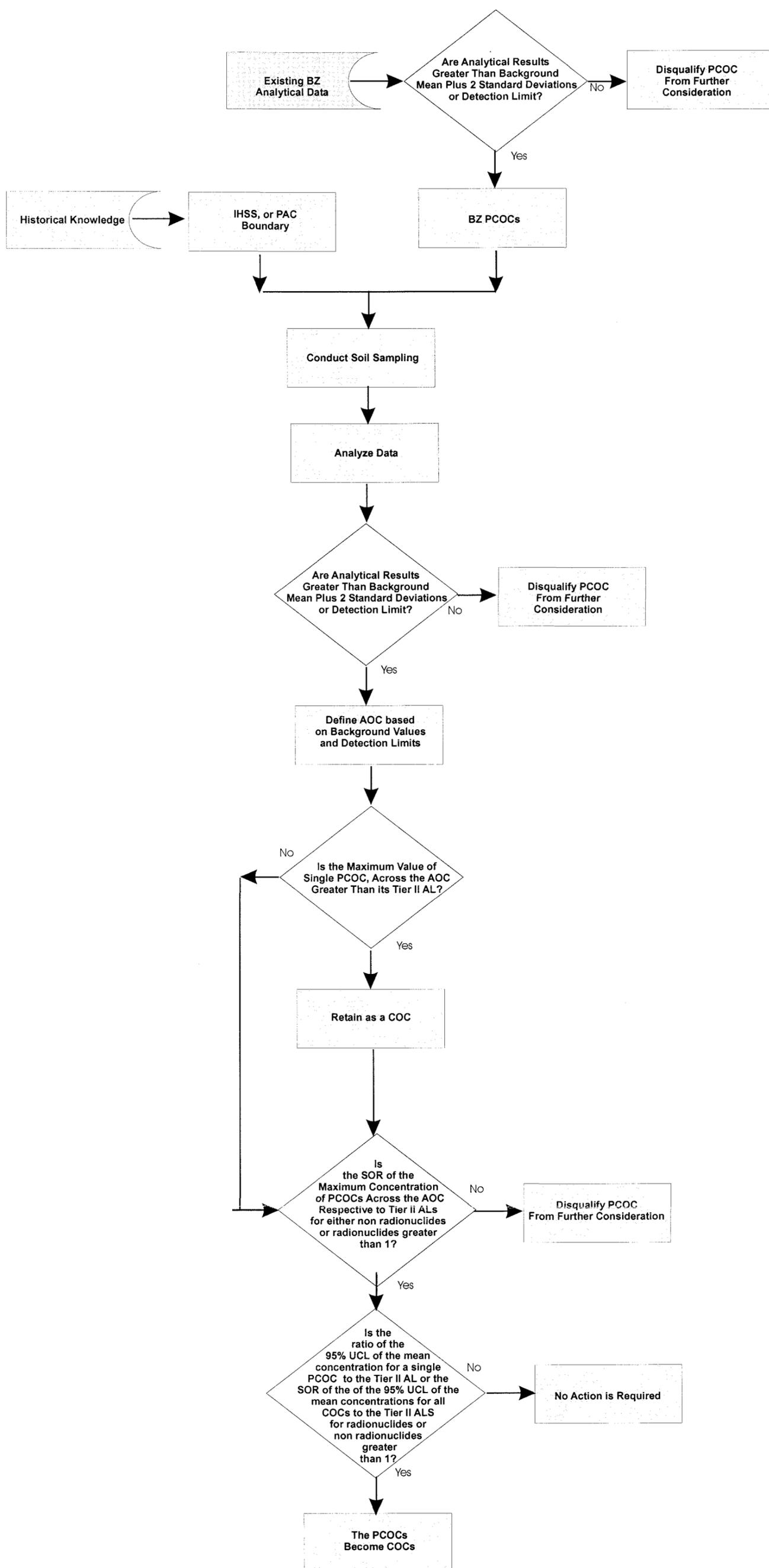


Figure 6
 Confirmation Sampling Data Quality Assessment Logic Flow Diagram
 Decision: Determine Whether Confirmation COCs Have Been Adequately Characterized

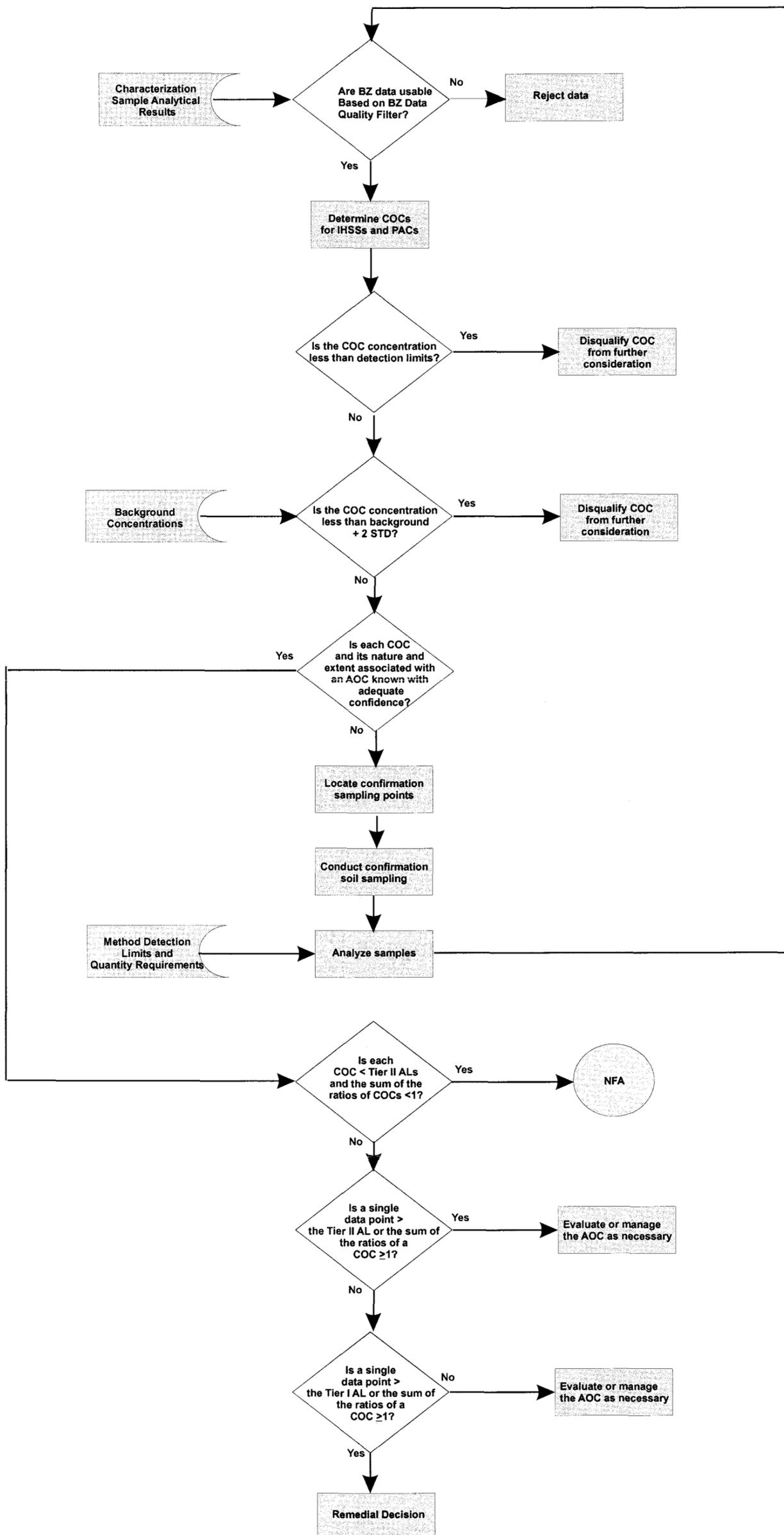


Figure 8
Buffer Zone Sampling and Analysis Plan
Sampling Process for IHSSs and PACs

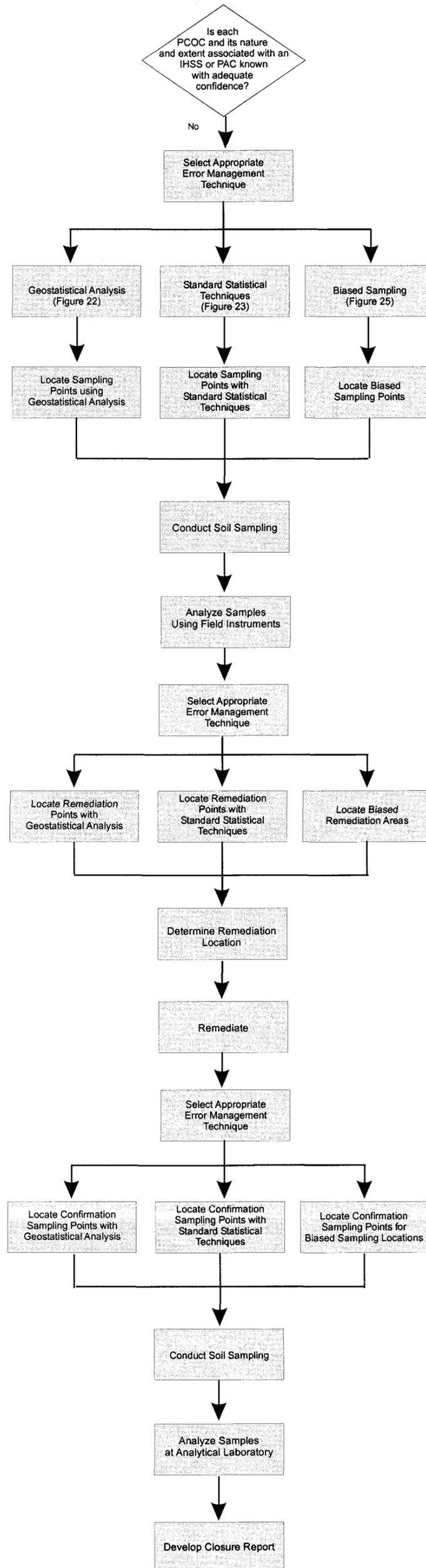
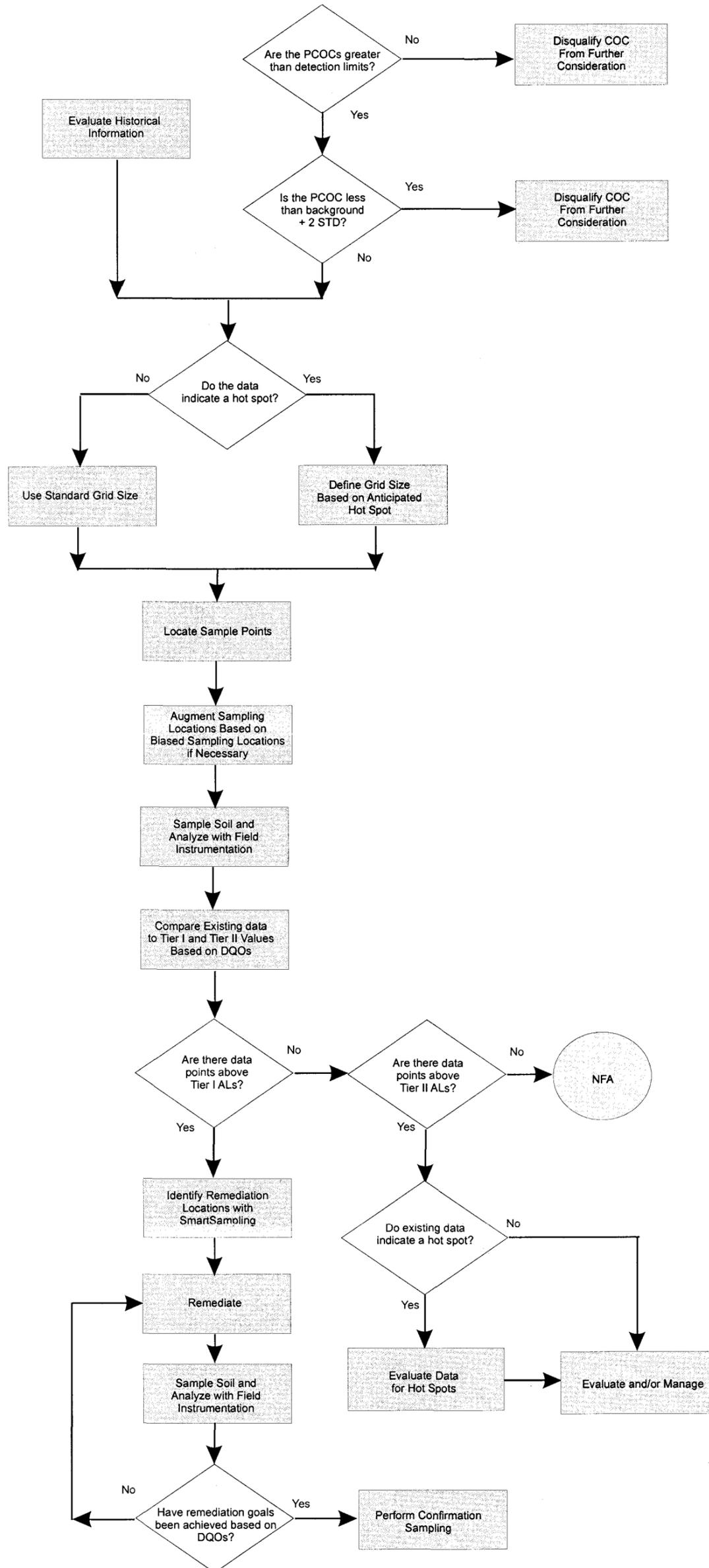


Figure 11
Buffer Zone Sampling and Analysis Plan
Standard Statistical and Biased Sampling Process
for IHSSs and PACs



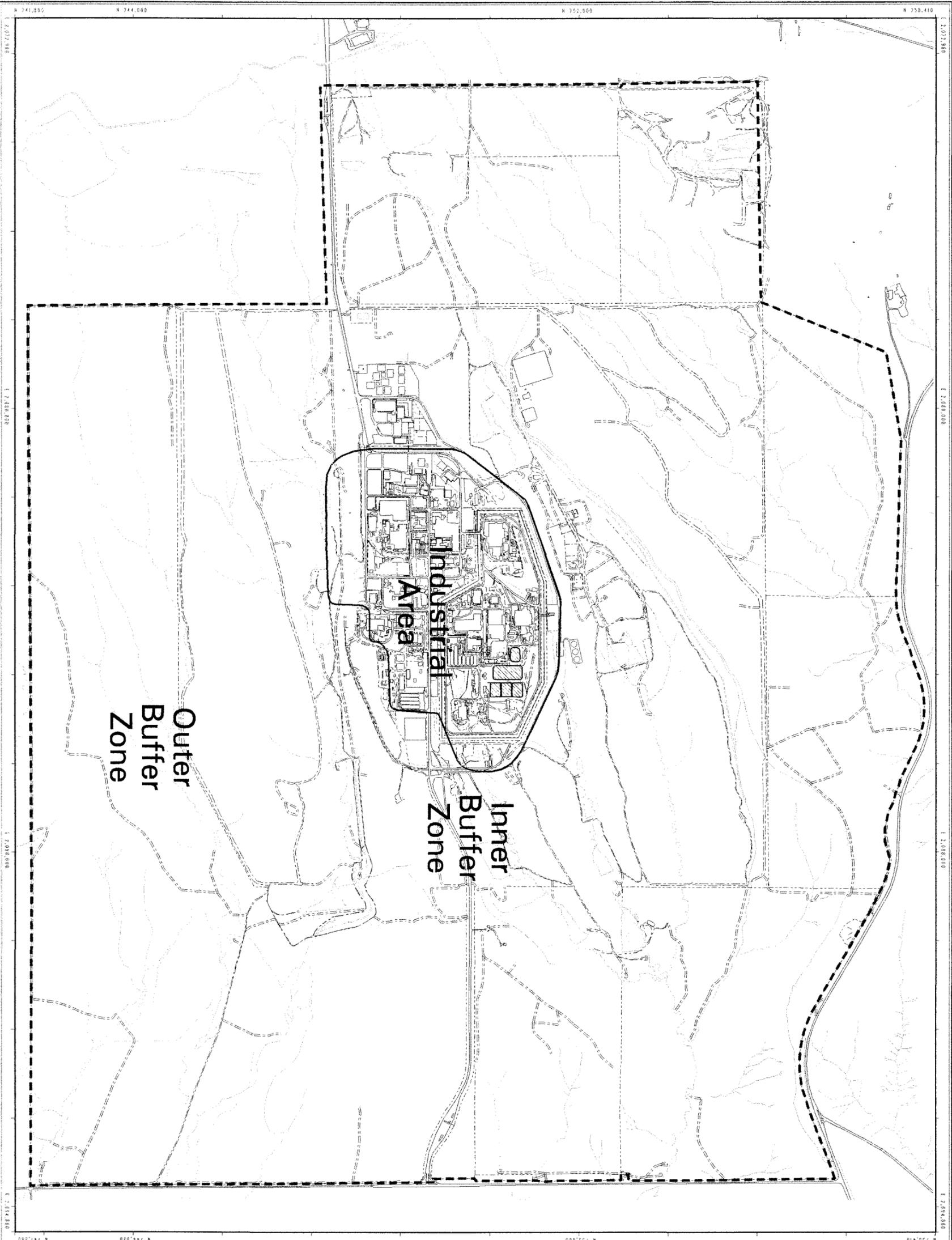


Figure 13
**Industrial Area,
 Inner Buffer Zone
 and Outer Buffer Zone**

EXPLANATION

- Industrial Area
- Outer Buffer Zone Boundary

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flat boundary
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
 Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EGIS RSL, Las Vegas.
 Data Source:
 Boundary data source unknown, please reference NCA Report.



Scale = 1 : 21330
 1 inch represents approximately 1778 feet



State Plane Coordinate Projection
 Colorado Central Zone
 Datum: NAD27

U.S. Department of Energy
 Rocky Flats Environmental Technology Site

Prepared by: **DynCorp**
 THE ART OF TECHNOLOGY

Prepared for: **KAISER-HILL**
 ENGINEERS

MAP ID: 2k-0294/inner_bz_bdy_fig13-bb.aml
 July 23, 2001

Figure 14
Data Evaluation Flow Chart

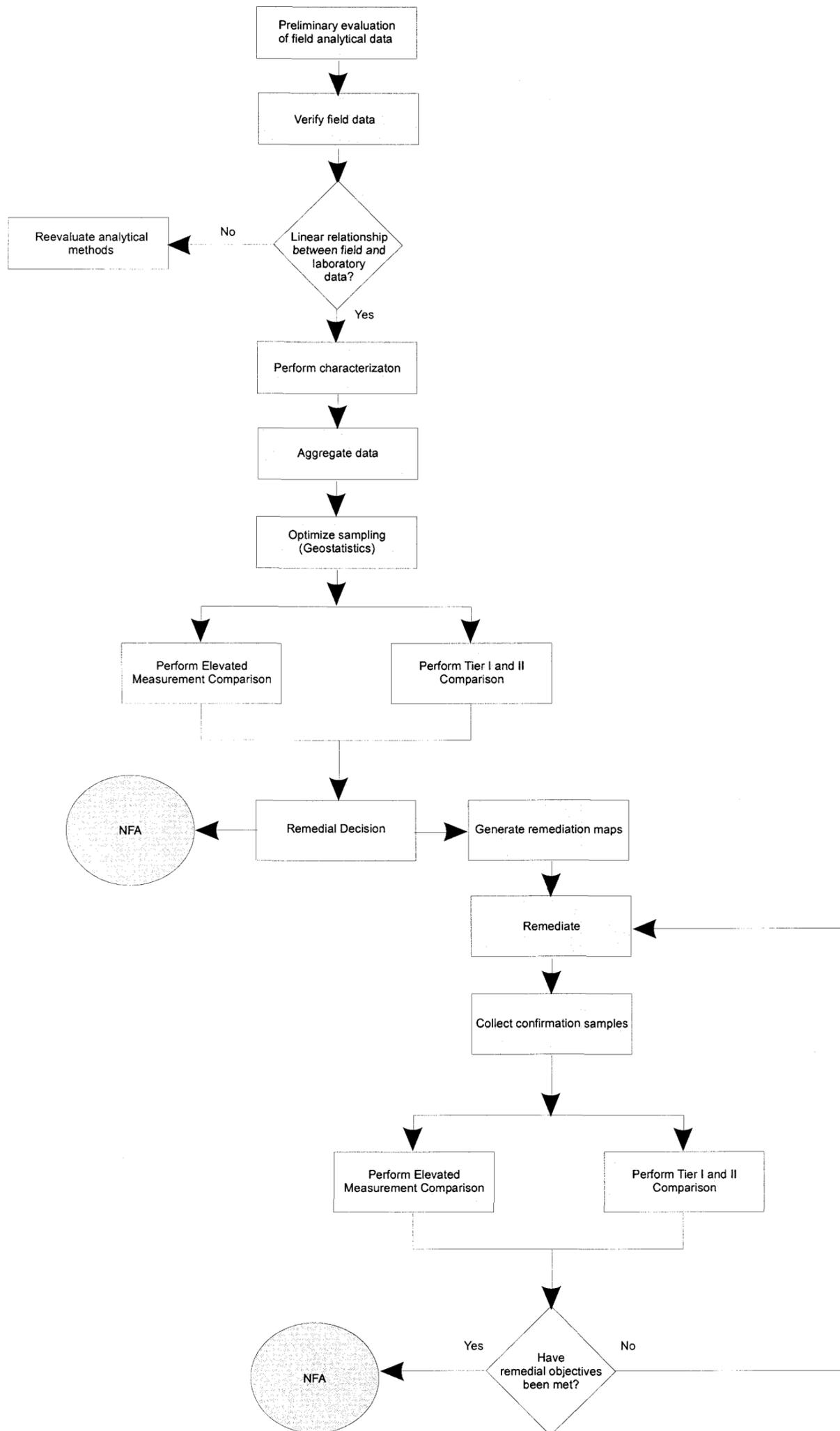


Figure 15
Elevated Measurement Flow Chart

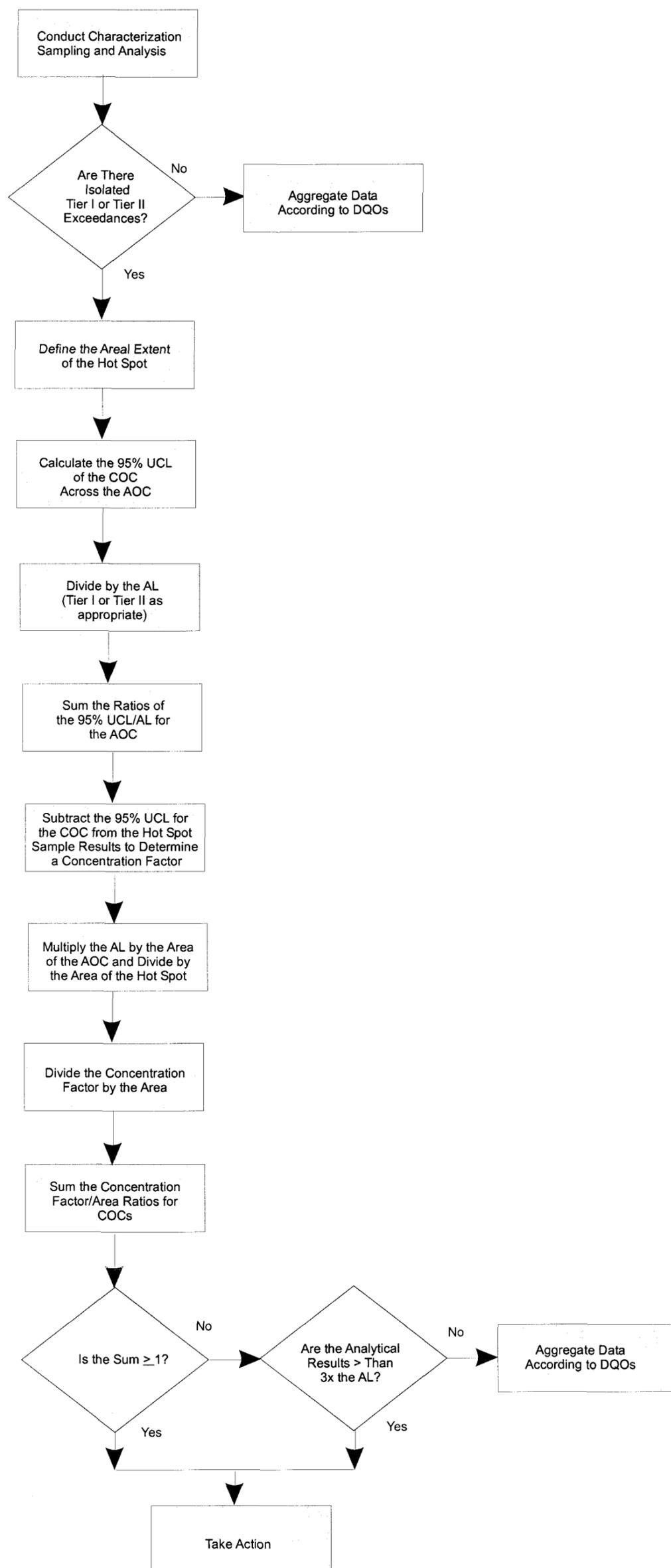


Figure 17 Data Management System Configuration

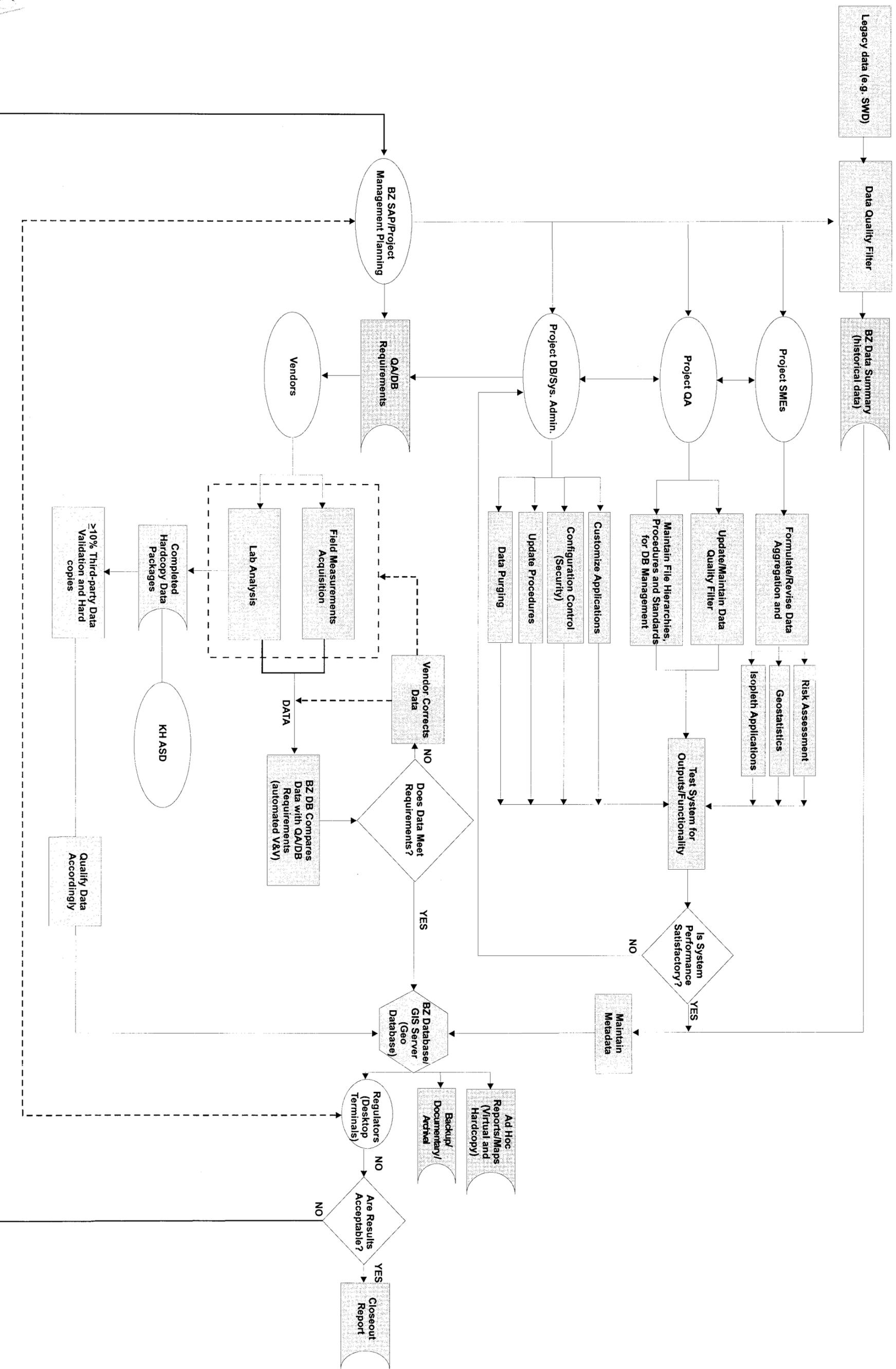
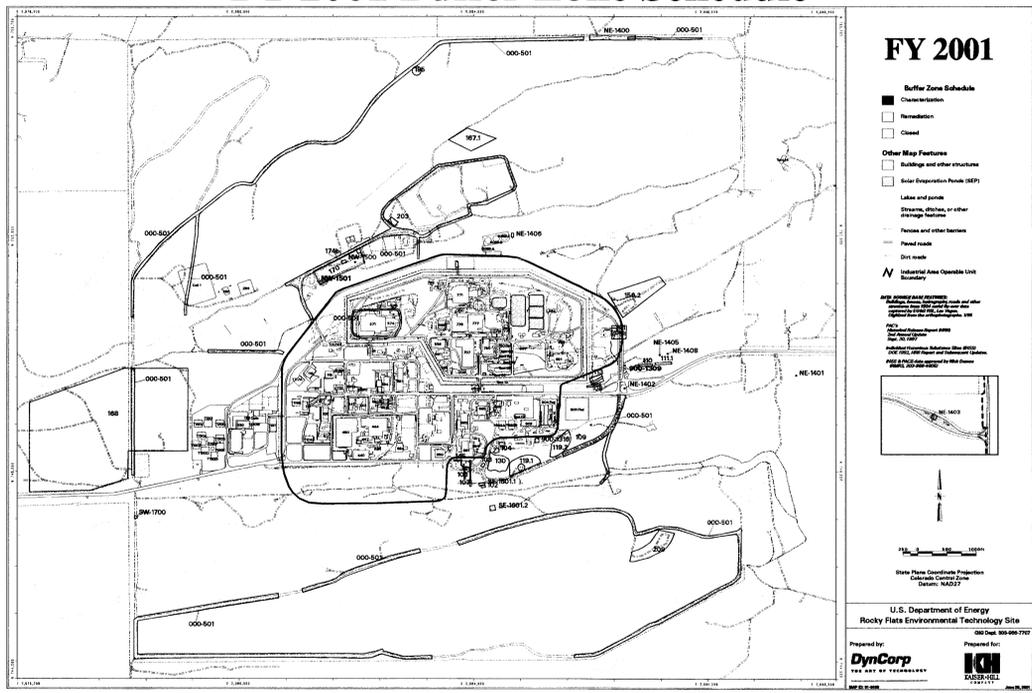


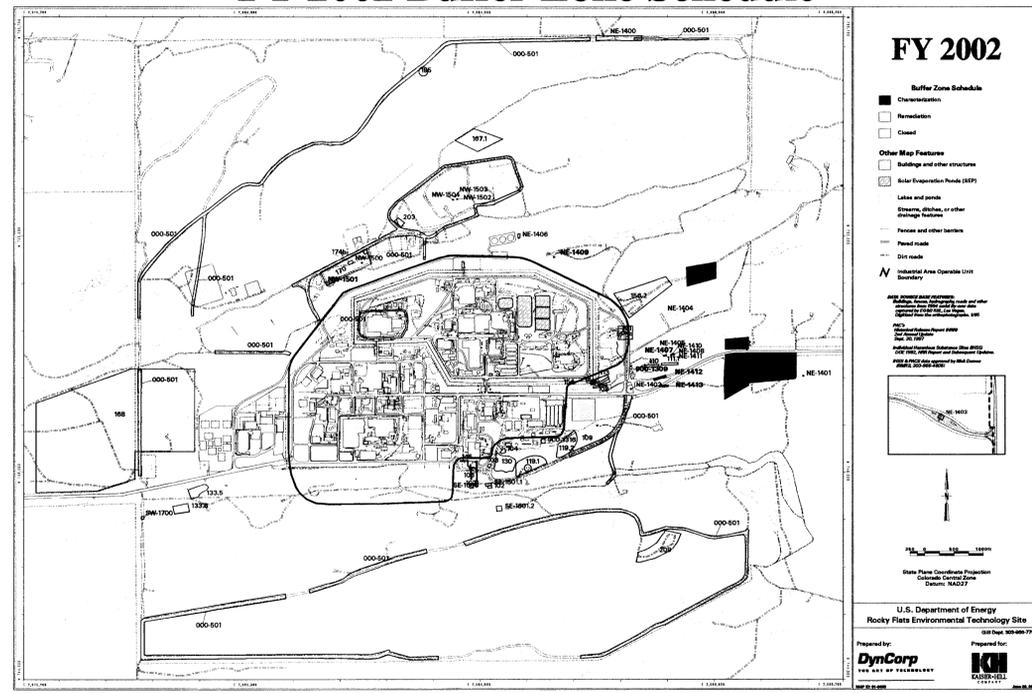
Figure 20

Buffer Zone Schedule

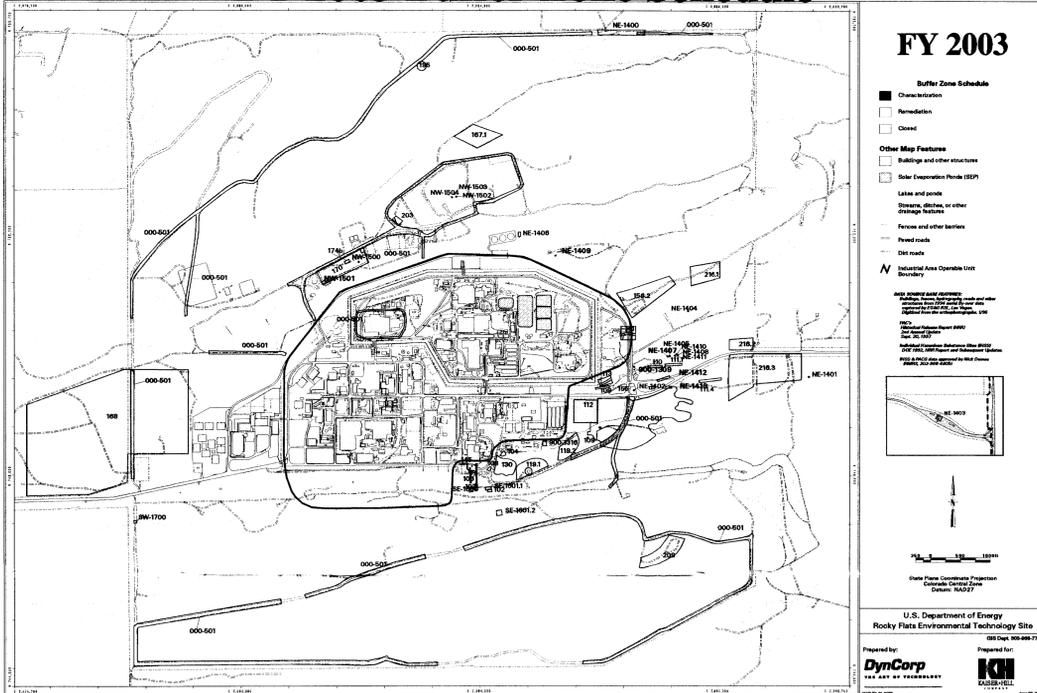
FY 2001 Buffer Zone Schedule



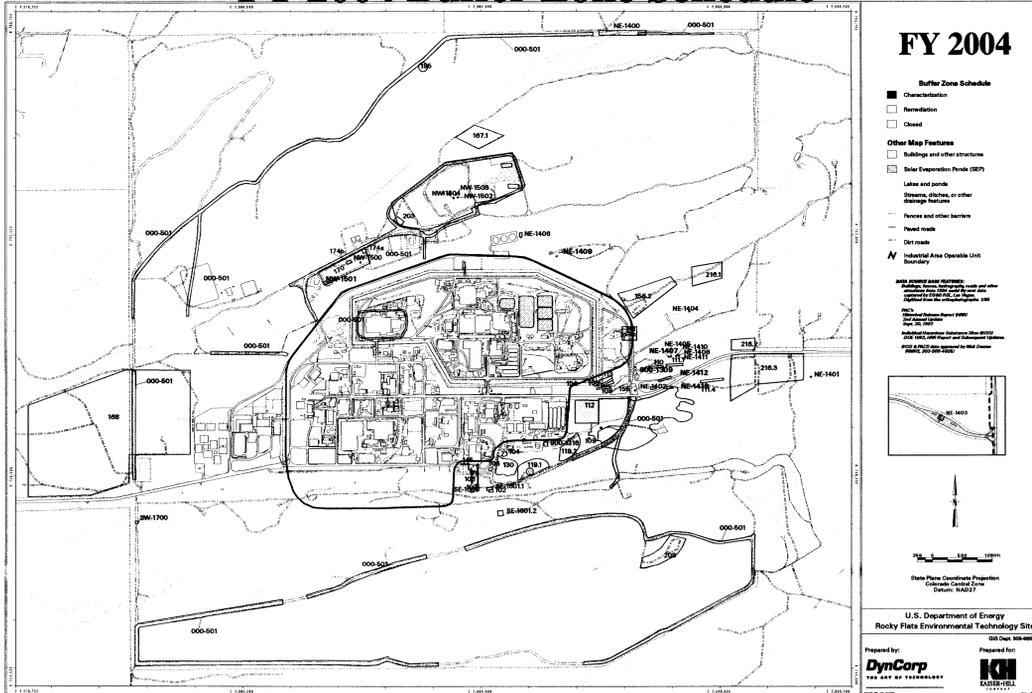
FY 2002 Buffer Zone Schedule



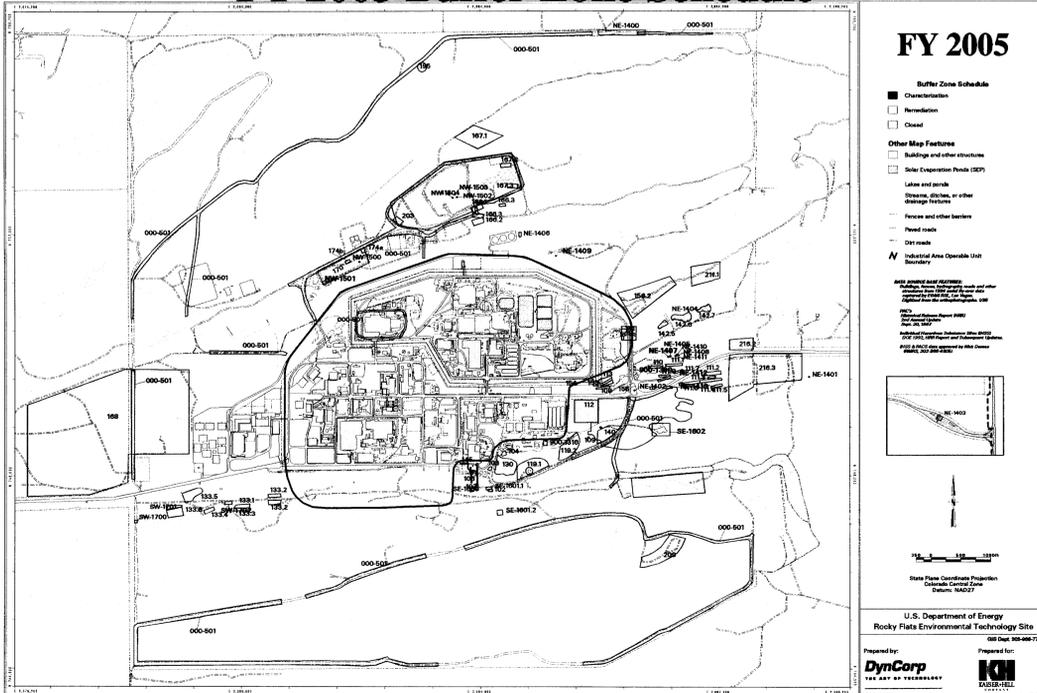
FY 2003 Buffer Zone Schedule



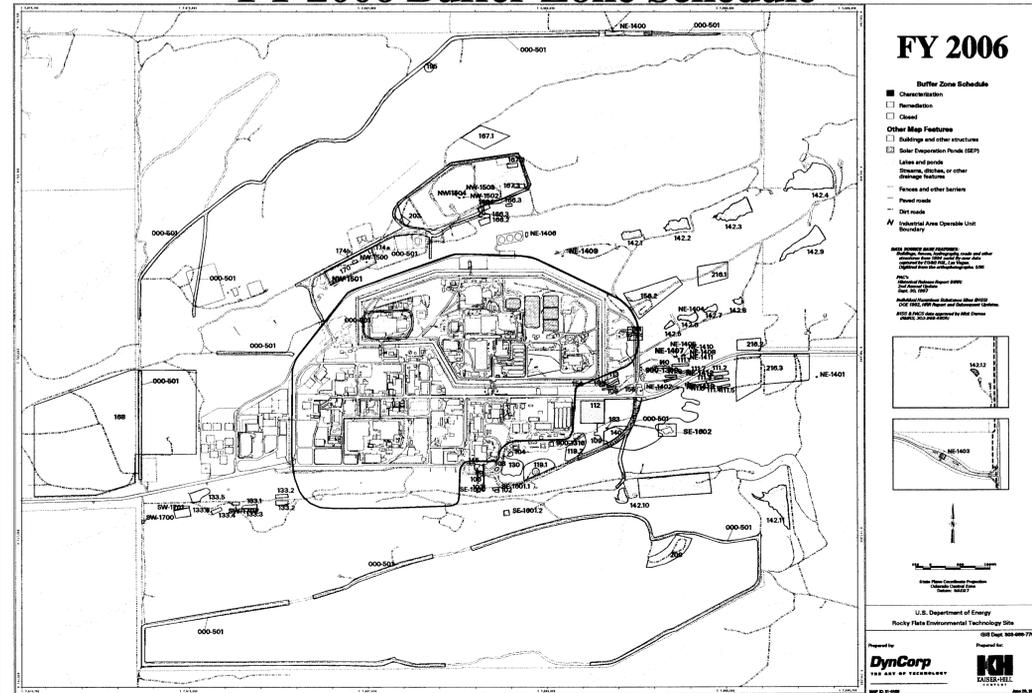
FY 2004 Buffer Zone Schedule



FY 2005 Buffer Zone Schedule



FY 2006 Buffer Zone Schedule



01-RF-01733 p.04 62A-000505

Buffer Zone Sampling and Analysis Plan

Plate 1

IHSSs and PACs Located in the RFETS Buffer Zone

EXPLANATION

- BZOU
- OU1
- OU5
- OU6
- OU7
- OU11
- OU16
- PAC
- Accepted NFAs

HRR Zone Boundary

Industrial Area Boundary

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from GIS data
Topography from 1:250,000 scale topographic maps
Digitized from the orthophotographs, 1/95



Scale = 1 : 7280
1 inch represents approximately 607 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site
GIS Dept. 303-986-7707

DRAFT

MAP ID: 01-0267

June 20, 2001

CFR-CT/53

RF-A-000525

