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**DRAFT FINAL  
TECHNICAL MEMORANDUM 5**

**ADDENDUM TO FINAL PHASE III  
RFI/RI WORK PLAN**

**Surface Soil Sampling and Analysis Plan**

**Rocky Flats Plant  
881 Hillside Area**

**(Operable Unit No. 1)**

**U.S. DEPARTMENT OF ENERGY**

**Rocky Flats Plant  
Golden, Colorado**

**February 1992**

ADMIN RECORD

REVIEWED FOR CLASSIFICATION BY

By *[Signature]*  
Date 2/10/92

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# SURFACE SOIL SAMPLING AND ANALYSIS PLAN

## OPERABLE UNIT NO. 1

### TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
1	OBJECTIVES AND APPROACH .....	1-1
1.1	INTRODUCTION .....	1-1
1.2	DQO PROCESS .....	1-3
1.2.1	Stage 1 — Decision Types .....	1-3
1.2.1.1	Data Users .....	1-4
1.2.1.2	Current Understanding of Nature and Extent of Contamination .....	1-4
1.2.1.3	Site Conceptual Model .....	1-16
1.2.1.4	Objectives/Approach .....	1-17
1.2.2	Stage 2 — Data Uses/Needs .....	1-20
1.2.2.1	Data Uses .....	1-20
1.2.2.2	Data Types .....	1-21
1.2.2.3	Data Quality .....	1-30
1.2.2.4	Data Quantity .....	1-40
1.2.2.5	PARCC Parameter .....	1-45
1.2.3	Stage 3 — Documentation .....	1-45
2	SAMPLING AND ANALYSIS PLAN .....	2-1
2.1	SAMPLING PLAN .....	2-1
2.1.1	Surficial Soil Sampling for Radionuclides .....	2-1
2.1.2	Surficial Soil Sampling for Non-Radioactive Contaminants .....	2-6
2.1.3	Background Surficial Soil Sampling .....	2-13
2.1.4	Sediment Sampling .....	2-18
2.1.5	Air Sampling .....	2-20
2.2	ANALYSIS PLAN .....	2-21
2.2.1	Radiochemistry .....	2-21
2.2.2	Non-Radioactive Analytical Parameters .....	2-21
2.3	DATA MANAGEMENT .....	2-23

TABLE OF CONTENTS (Continued)

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
3	QA/QC .....	3-1
3.1	INTERNAL QC CONTROL SAMPLES .....	3-1
3.2	ACCURACY .....	3-2
3.2.1	Metals Analysis .....	3-5
3.2.2	Organic Analyses .....	3-5
3.3	SENSITIVITY .....	3-6
3.4	QUALITY ASSURANCE OBJECTIVES FOR PRECISION ..	3-6
3.4.1	Metals Analyses .....	3-9
3.4.2	Organic Analyses .....	3-9
3.5	REPRESENTATIVENESS .....	3-10
3.6	DATA COMPARABILITY .....	3-10
3.7	COMPLETENESS .....	3-11
3.8	SAMPLE MANAGEMENT .....	3-11
3.9	DATA REPORTING .....	3-13
4	REFERENCES .....	4-1

**TABLE OF CONTENTS (Continued)**

**LIST OF FIGURES**

<b><u>FIGURE NO.</u></b>	<b><u>TITLE</u></b>	<b><u>PAGE</u></b>
1-1	Phase III RFI/RI Monitor Well, Borehole, Piezometer, and Sediment Station Locations .....	1-2
1-2	Individual Hazardous Substance Site Locations .....	1-5
1-3	Phase I and Phase II RI Borehole and Monitor Well Locations .....	1-9
1-4	Surface Scrape Sampling Locations (September 1988) .....	1-15
1-5	Conceptual Model .....	1-18
1-6	Risk Assessment Conceptual Model .....	1-19
2-1	Surficial Soil Sampling Plot Identification Numbers .....	2-2
2-2	Rocky Flats Method Sample Scheme .....	2-4
2-3	Surficial Soil Sampling Locations .....	2-5
2-4	Proposed Sampling Scheme .....	2-9
2-5	Background Surface Soil Sample Area .....	2-17

**LIST OF TABLES**

<b><u>TABLE NO.</u></b>	<b><u>TITLE</u></b>	<b><u>PAGE</u></b>
1-1	Operable Unit No. 1 Waste Disposal History .....	1-6
1-2	Background Geologic Materials Tolerance Interval Upper Limits or Maximum Detected Value .....	1-10
1-3	Background Sediment Tolerance Interval Upper Limits or Maximum Detected Value .....	1-12
1-4	881 Hillside 1988 Surficial Soil Radionuclide Concentrations .....	1-14

## TABLE OF CONTENTS (Continued)

### LIST OF TABLES (Continued)

<u>TABLE NO.</u>	<u>TITLE</u>	<u>PAGE</u>
1-5	Considerations for Identifying the Surface Soil Site-Specific Chemical Analysis Roster (S-SCAR) . . . . .	1-23
1-6	Summary of Environmental Inter-Media Migration Characteristics . . .	1-24
1-7	Site Specific Chemical Analysis Roster . . . . .	1-27
1-8	Exposure Limit Calculations for Noncarcinogenic Chemicals in Soils .	1-34
1-9	Exposure Limit Calculations for Carcinogenic Chemicals in Soil . . . . .	1-35
1-10	Exposure Limit Calculations for Radionuclides in Soils . . . . .	1-36
1-11	Toxicity Values Used to Compute Exposure Limits . . . . .	1-38
1-12	Exposure Limits - Ecological Researcher . . . . .	1-41
1-13	Exposure Limits - Resident . . . . .	1-43
2-1	Tolerance Factors for Normal Tolerance Limits for 95% Population at 95% Confidence . . . . .	2-15
2-2	Soil Types in the Selected Background Area . . . . .	2-19
2-3	Proposed OU1 Surface Soil Sampling Parameters . . . . .	2-22
3-1	Guidelines for Field Quality Control Sample Collection Frequency . . . . .	3-3
3-2	Sample Frequency . . . . .	3-4
3-3	Quality Assurance Objectives for Accuracy for Organic Surrogate Analyses . . . . .	3-7
3-4	Quality Assurance Objectives for Accuracy and Precision for Organic Target Compound Analyses . . . . .	3-8
3-5	Sample Containers, Volume, Preservation, and Holding Times . . . . .	3-12

## TABLE OF CONTENTS (Continued)

### LIST OF PLATES

<u>PLATE NO.</u>	<u>TITLE</u>
Plate 1	Proposed Surface Soil Sampling Locations

### LIST OF ACRONYMS

ANOVA	Analysis of Variance
BN/AE	Base Neutral/Acid Extractables
BW	Body Weight
CDH	Colorado Department of Health
CDI	Chronic Daily Intake
CLP	Colorado Laboratory Program
cm	centimeters
CSF	Carcinogenic Slope Factor
DI	Daily Intake
DOE	U.S. Department of Energy
dpm/kg	disintegrations per minutes per gram
DQOs	Data Quality Objectives
ED	Exposure Duration
EF	Exposure Frequency
EL	Exposure Limit
EMD	Environmental Management Division
EPA	Environmental Protection Agency
FS	Feasibility Study
g	gram
GC/MS	Gas Chromatograph/Mass Spectrometer
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
IHSSs	Individual Hazardous Substance Sites
IR	Ingestion Rate
IRIS	Integrated Risk Information System
kg	kilogram

## TABLE OF CONTENTS (Continued)

LCS	Laboratory Control Sample
mg/kg	milligrams per kilogram
mg/l	micrograms per liter
mg/m <sup>3</sup>	milligrams per cubic meter
MS/MSD	Matrix spike/Matrix Spite Duplicate
NCP	National Contingency Plan
OU1	Operable Unit No. 1
OU2	Operable Unit No. 2
PAH	Polynuclear Aromatic Hydrocarbons
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCB	Polychlorinated Biphenyls
pCi	picoCuries
pCi/g	picoCuries per gram
QC	Quality Control
QAPjP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAS	Routine Analytical Services
RfD	Reference Dose
RFEDS	Rocky Flats Environmental Data Base System
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI	Remedial Investigation
RPD	Relative Percent Difference
RME	Reasonable Maximum Exposure
SAP	Sampling and Analysis Plan
SID	South Interceptor Ditch
SOPs	Standard Operating Procedures
TAL	Target Analyte List
TCL	Target Compound List
TRU	Transuranic Waste
VOCs	Volatile Organic Compounds

# SECTION 1

## OBJECTIVES AND APPROACH

### 1.1 INTRODUCTION

The purpose of the Operable Unit No. 1 (OU1) surface soil sampling and analysis program is to determine the nature and extent of contamination in surface soils at and downslope of the operable unit for assessing potential human health risks from exposure to the soils. Recent review of the Phase III RCRA Facility Investigation/Remedial Investigation (RFI/RI) Work Plan (EG&G, 1991a) identified the absence of surface soil samples as a significant data gap for the conduct of the human health risk assessment. Secondary objectives for the surface soil sampling program is to provide supporting data for the environmental evaluation and allow assessment of remedial alternatives for clean-up of the contaminated soils in accordance with the National Contingency Plan (NCP). Risks will be presented in the OU1 Baseline Risk Assessment, and remedial alternatives will be developed and evaluated in the Feasibility Study (FS). Remedial alternatives will address remediation of all contaminated soils (surface and subsurface), ground water, surface water, and sediments at OU1 as necessary.

The Phase III RFI/RI Work Plan (EG&G, 1991a) identifies the locations of numerous boreholes within OU1 (881 Hillside Area) that were drilled and sampled to characterize the nature and extent of contamination in the overburden materials (Figure 1-1). In general, the data generated by this OU1 soil sampling program (Technical Memorandum 5) will be adequate to determine the volume of contaminated soil requiring remediation, and, therefore, will be suitable for evaluating remedial alternatives in the FS. However, the uppermost soil sample collected from a borehole is a six foot composite which includes the ground surface (EG&G, 1991a) and therefore the Phase III Work Plan is inadequate in addressing surface soil (upper two inches of soil profile) contamination. Data from these samples will not be representative of surface soil contamination. The Phase III Work Plan Field Sampling Plan does not address sampling of the surface soils specifically other than the actinides sampling program addressed below. Surface soil characterization is necessary to evaluate human health and environmental risks for the risk assessment from a variety of exposure pathways including direct contact, incidental ingestion,

and inhalation. Furthermore, the results of the surface soil sampling program may indicate a need to remove and/or remediate surface soils at OU1. This exercise is not intended to support the environmental evaluation for OU1, but may provide useful information for the study.

A detailed surficial soil sampling program to investigate actinide contamination at Rocky Flats is in progress. This program includes surface soils at OU1 and is discussed further in Section 2.1.1. Data from this program will be available for incorporation into the OU1 RFI/RI report. However, this program does not investigate non-radioactive contamination at OU1.

Section 1 of this sampling and analysis plan provides background information and data for OU1, a site conceptual model, and a discussion of Data Quality Objectives (DQOs) for the program. Section 2 presents the Sampling and Analysis Plan (SAP), and Section 3 discusses Quality Assurance/Quality Control (QA/QC) considerations. This work plan supplements the Phase III RFI/RI Work Plan for OU1 (EG&G, 1991a).

## 1.2 DQO PROCESS

The primary objective of a Remedial Investigation (RI) is to collect data necessary to determine the nature, distribution, and migration pathways of contaminants in support of the baseline risk assessment as well as to support the evaluation of remedial alternatives. DQOs are qualitative and quantitative statements which specify the quality of the data required to support a RI (EPA, 1987). DQOs should be specified for each data collection activity and the work should be conducted and documented in a manner that ensures that sufficient data of known quantity and quality are collected to support remedial action selection decisions (EPA, 1987). DQOs are developed using the three stage process described in the following sections as tailored to the surface soil sampling program.

### 1.2.1 Stage 1 — Decision Types

Stage 1 of the DQO process involves the identification and involvement of data users (Section 1.2.1.1), development of the site conceptual model (Section 1.2.1.3), and definition of

objectives and decision types that will be made during the RI process (Section 1.2.1.4). Available existing data must also be obtained and evaluated during this stage to aid in the DQO process in order to develop a conceptual model of the study area (EPA, 1987). The conceptual model identifies suspected sources, contaminant pathways, and potential receptors. The primary focus of the activities conducted during Stage 1 of the DQO process is to identify why new data are needed.

#### **1.2.1.1 Data Users**

Physical and chemical data on the surface soils will be used by the U.S. Department of Energy (DOE) for site characterization, and preparation of the Baseline Risk Assessment and FS. As such, the primary data users will be risk assessment scientists, statisticians, and feasibility study engineers. If detailed information is necessary for remedial design/remedial action, it will be collected as needed.

#### **1.2.1.2 Current Understanding of Nature and Extent of Contamination**

##### Site Location and Description

The 881 Hillside Area is located on the south side of the Rocky Flats Plant security area. These sites were designated high priority sites because of their suspected relationship to ground-water contamination (DOE, 1987). There are 12 sites designated as Individual Hazardous Substance Sites (IHSSs) within OU1. Several sites are included in the area because of their physical proximity to each other. Figure 1-2 shows the location of OU1 and the IHSS locations. Table 1-1 summarizes the disposal history for each of the IHSSs as well as the suspected contaminant classes that may be present. The majority of the IHSSs are disposal sites which involved the shallow burial of wastes in pits covered by fill. More specifically, three of the disposal sites (IHSS 102, 103, and 104) were pits used for burial of wastes. IHSS 105.1 and 105.2 are out-of-service fuel oil tanks which were closed in place by filling the tanks with asbestos containing material and concrete in 1976. There are also several sites which represent surface drum storage sites for hazardous, low level mixed, or mixed transuranic (TRU) wastes

**Table 1-1**  
**Operable Unit No. 1**  
**Waste Disposal History**

IHSS NO./NAME	DISPOSAL HISTORY	POTENTIAL SITE CONTAMINANT CLASSES*	POTENTIAL FOR SURFACE SOIL CONTAMINATION
102/Oil Sludge Pit Site	30-50 drums of oil sludge from fuel oil tanks disposed in a pit in late 1950's.	Oil and Grease; VOCs; Radionuclides	None due to burial beneath fill.
103/Chemical Burial Site	Burial of unknown chemicals in circular pit (approximately 1963).	VOCs; BNAs; Metals; Radionuclides; Pesticide/PCBs	None due to burial beneath fill.
104/Liquid Dumping Site	Pit for disposal of unknown liquids and empty drums prior to 1969.	VOCs; BNAs; Metals; Radionuclides; Pesticide/PCBs	None due to burial beneath fill.
105.1 And 105.2/ Out-of-Service Fuel Oil Tanks	1958-1976: Tanks were filled with asbestos contaminating material and then with concrete; tanks tested tight in 1973.	Oil and Grease; VOCs; Radionuclides	None due to burial beneath fill.
106/Outfall Site	6-inch diameter vitrified clay pipe which discharged water in December 1977; pipe is either a cleanout pipe for an overflow line from 881 cooling tower or overflow line from the sanitary sewer sump in Building 881.	VOCs; BNAs; Metals; Radionuclides; Pesticide/PCBs	Yes - outfall discharge
107/Hillside Oil Leak Site	Oil leak from the 881 Building footing drain outfall in May 1973; ditch and concrete skimming pond were built to contain leak.	Oil and Grease; VOCs; Radionuclides; Pesticide/PCBs	Yes - leak site. However, the area has been covered with concrete, therefore, no surface soil to sample.
119.1 And 119.2/Multiple Spill Sites	1967: Barrel storage; unknown quantities and types of solvents and waste; barrels removed by 1972.	VOCs; BNAs; Metals; Radionuclides; Pesticide/PCBs	Yes - surface spill sites

Table 1-1 (Continued)

Operable Unit No. 1  
Waste Disposal History

IHSS NO./NAME	DISPOSAL HISTORY	POTENTIAL SITE CONTAMINANT CLASSES*	POTENTIAL FOR SURFACE SOIL CONTAMINATION
130/Radioactive Site 800 Area #1	1969-1972: Soil and asphalt contaminated with plutonium from: 1) 1969 fire; buried under 1-2' of fill. 2) Radionuclides from Central Avenue; quantity and concentrations unknown. 3) Soil removed from around the 774 Building process waste tanks; covered with approximately 3 feet of fill.	VOCs; BNAs; Metals; Radionuclides; Pesticide/PCBs	Yes - Potential for uncovering near surface buried wastes.
145/Sanitary Waste Line Leak Site	4-inch cement asbestos sanitary sewer line south of Building 881 leaked in January 1981; low level radionuclides from laundry until 1973 then only sanitary wastes.	VOCs; BNAs; Metals; Radionuclides; Pesticide/PCBs	None due to leakage within a buried waste line.
177/Building Drum Storage Site	Satellite collection and 90-day accumulation of RCRA regulated wastes.	VOCs; BNAs; Metals; Radionuclides; Pesticide/PCBs	Yes - surface storage area for regulated waste; however, this IHSS is being investigated under OU15 RCRA closure.

\* Listed contaminant classes do not necessarily indicate expected presence of these parameters in the wastes. A comprehensive list is provided for IHSSs used as disposal sites for unknown quantities and types of substances.

Source: EG&G, 1991b.

(IHSS 177, 119.1, and 119.2) and areas identified as leak or discharge points (IHSS 106, 107, and 145). Radioactive Site 800 Area #1 (IHSS 130) is a disposal site which involved the burial of radioactive soil and debris.

### Nature and Extent of Contamination

Sites at the 881 Hillside Area were selected as High Priority Sites as a result of Plant-wide characterization activities which showed elevated concentrations of volatile organic compounds (VOCs) in ground water upgradient from Woman Creek (DOE, 1987). The Phase I and Phase II RIs indicated that the unconfined ground-water flow system is contaminated. The most pronounced organic contamination appears to be in the eastern portion of the OU as tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,1-dichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, and carbon tetrachloride reach several thousand micrograms per liter ( $\mu\text{g/l}$ ) in many samples. Organic contamination in the western portion of the 881 Hillside Area occurs at much lower concentrations. Metal and inorganic concentrations exceeding background concentrations were recorded periodically. Total dissolved solids, nickel, strontium, selenium, zinc, copper, and uranium occurred above background in several ground-water samples from numerous wells (EG&G, 1991b).

Soil sample analyses obtained from the drilling of boreholes during the Phase I and Phase II investigations (Figure 1-3) indicated volatile organic contamination (trichloroethene, tetrachloroethene, and 1,1,1-trichloroethane) in some soil samples (EG&G, 1991b). In addition, toluene was detected in soil samples during the French Drain Geotechnical Investigation. There is some question as to the significance of the presence of methylene chloride, acetone, and phthalates found in soil samples as they may represent laboratory artifact. However, there is insufficient evidence available at this time to verify this hypothesis. Plutonium and americium were detected above background in several samples collected from boreholes. The background tolerance interval upper limits for geologic materials and sediments are provided in Table 1-2 and 1-3, respectively. These samples were generally from the uppermost interval that included the ground surface. Because the samples were composited, the concentrations may not be representative of near surface soil, i.e., there is the possibility that the plutonium and americium

Table 1-2

Background Geologic Materials  
Tolerance Interval Upper Limits  
or Maximum Detected Value

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
<b>Total Metals</b>					
Aluminum	mg/kg	25312	21663	13495	10300*
Antimony	mg/kg	ND	ND	16.2*	ND
Arsenic	mg/kg	15.86	7.7	15.05	3.6*
Barium	mg/kg	155.8	345.8	240.1	165*
Beryllium	mg/kg	11.27	17.75	11.8	2.2*
Cadmium	mg/kg	3.2*	1.8*	ND	ND
Calcium	mg/kg	43079	20811	10183	5940*
Cesium	mg/kg	ND	274*	ND	ND
Chromium	mg/kg	37.9	26.8	16.57	10.7*
Cobalt	mg/kg	18.2*	15.9*	29.7*	20.5*
Copper	mg/kg	20.03	26.7	30.62	19.6*
Iron	mg/kg	22916	29991	41295	12300*
Lead	mg/kg	18.04	26.4	34.5	13.4*
Lithium	mg/kg	44.4	32.1	33.37	7.0*
Magnesium	mg/kg	4425	6151	4896	2520*
Manganese	mg/kg	422.9	545.1	656	305*
Mercury	mg/kg	0.58*	0.44*	0.35*	0.27*
Molybdenum	mg/kg	38.65	32.78	33.68	11.2*
Nickel	mg/kg	43.27	35.4	56.95	14.3*
Potassium	mg/kg	3336	2789	1400*	ND
Selenium	mg/kg	ND	ND	ND	ND
Silver	mg/kg	40.9*	33.5*	18.7*	12.7*
Sodium	mg/kg	ND	3680*	ND	ND
Strontium	mg/kg	226*	111.1	144.42	69.2*
Thallium	mg/kg	ND	441*	ND	ND
Tin	mg/kg	338*	441*	274*	268*
Vanadium	mg/kg	54.67	58.2	47.7	22.2*
Zinc	mg/kg	52.64	98.1	106.7	79.9*

Table 1-2 (Continued)

Background Geologic Materials  
Tolerance Interval Upper Limits  
or Maximum Detected Value

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
<u>Other</u>					
Sulfide	mg/kg	13*	5*	5*	2*
Nitrate	mg/kg	4.3*	4.274	2.0*	1.9*
pH	----	9.64 (6.06)	9.48 (6.96)	10.14 (7.04)	9.2* (8.0)**
<u>Total Radionuclides</u>					
Gross Alpha	pCi/g	37.108	51.710	52.302	37
Gross Beta	pCi/g	36.886	35.135	35.743	29
Uranium 233, 234	pCi/g	1.491	1.759	1.985	0.8
Uranium 235	pCi/g	0.087	0.169	0.258	0.1
Uranium 238	pCi/g	1.353	1.675	1.643	1.0
Strontium 89, 90	pCi/g	0.768	0.776	0.786	0.4
Plutonium 239, 240	pCi/g	0.017	0.023	0.020	0.01
Americium 241	pCi/g	0.018	NR	NR	NR
Cesium 137	pCi/g	0.082	NR	ND	0.0
Tritium	pCi/g	0.410	0.299	0.322	0.39

ND - Not Detected  
 NR - Data Not Received  
 \* - Maximum Detected Value  
 \*\* - Minimum Detected Value  
 ( ) - Tolerance Interval Lower Limit for Two-Sided Parameter  
 mg/kg - milligrams per kilogram  
 pCi - PicoCuries per gram

Table 1-3

**Background Sediment  
Tolerance Interval Upper Limits  
or Maximum Detected Value**

Analyte	Units	Upper Limit (9 Samples)
<u>Total Metals</u>		
Aluminum	mg/kg	24789
Antimony	mg/kg	ND
Arsenic	mg/kg	13.0*
Barium	mg/kg	182*
Beryllium	mg/kg	ND
Cadmium	mg/kg	ND
Calcium	mg/kg	72551
Cesium	mg/kg	ND
Chromium	mg/kg	43.38
Cobalt	mg/kg	ND
Copper	mg/kg	22.0*
Iron	mg/kg	28308
Lead	mg/kg	39.502
Lithium	mg/kg	ND
Magnesium	mg/kg	4110*
Manganese	mg/kg	372.20
Mercury	mg/kg	ND
Molybdenum	mg/kg	ND
Nickel	mg/kg	29.9*
Potassium	mg/kg	ND
Selenium	mg/kg	ND
Silver	mg/kg	6.8*
Sodium	mg/kg	ND
Strontium	mg/kg	175*
Thallium	mg/kg	ND
Tin	mg/kg	ND
Vanadium	mg/kg	50.2*
Zinc	mg/kg	92.688
<u>Other</u>		
Nitrate	mg/kg	ND
pH	----	9.03 (8.77)
<u>Total Radionuclides</u>		
Gross Alpha	pCi/g	60
Gross Beta	pCi/g	50
Uranium 233, 234	pCi/g	1.669
Uranium 235	pCi/g	0.176
Uranium 238	pCi/g	1.755
Strontium 89, 90	pCi/g	1.390
Plutonium 239, 240	pCi/g	0.096
Americium 241	pCi/g	0.029
Cesium 137	pCi/g	1.578
Tritium	pCi/g	0.408
ND	-	Not Detected
*	-	Maximum Detected Value
( )	-	Tolerance Interval Lower Limit for Two-Sided Parameter
mg/kg	-	milligrams per kilogram
pCi/g	-	picoCuries per gram

concentrations at the surface were diluted due to the compositing with soils unlikely to be affected by waste disposal activities or affected through contaminant migration processes. The surface is of particular interest because current data suggest plutonium and americium contaminated surface soil was redistributed from the 903 Pad Area by wind.

Subsequent to the Phase II RI soil sampling, surficial soil at nineteen locations was sampled for plutonium, uranium<sup>238</sup>, and uranium<sup>233+234</sup> (Lawton, 1989). The data are presented in Table 1-4 and the sample locations are shown in Figure 1-4. The plutonium concentrations are typical of those found in this vicinity and to the east within the Plant boundary (Rockwell International, 1987). It is noted that the highest concentrations are nearest the 903 Pad. High uranium concentrations occurred in samples 881-16 through 881-19. Depleted uranium is used at the Rocky Flats Plant. Unlike natural uranium which has a uranium<sup>233 + 234</sup> to uranium<sup>238</sup> activity ratio of approximately one, the depleted uranium isotopic ratio is significantly less than one. The uranium isotope ratios for these surface soils samples indicate the uranium is depleted (low ratio). The contamination presumably resulted from drums that had leaked in the past, or from past spills.

Tetrachloroethene and trichloroethene are the principal volatile organic compounds which may have been detected in surface water samples from a few stations, although the concentrations and frequency of occurrence are low. Semi-volatiles and pesticide/PCBs were detected in some surface water samples collected in 1986. In these instances, pesticides/PCBs were reported at concentrations estimated below the detection limit. Low concentrations of methylene chloride, acetone, and toluene in surface water occur at many sampling stations. Samples from the furthest downgradient surface water station located in the South Interceptor Ditch (SID) did not show organic contamination. Metals and other inorganic compounds occurred intermittently above background, and gross alpha, gross beta, uranium, and plutonium exceeded background in many of the samples collected from surface water stations positioned in the SID and Woman Creek (EG&G, 1991a).

Mercury and molybdenum were occasionally detected above background in sediment stations located on Woman Creek. Several metals however were reported at concentrations exceeding

Table 1-4

881 Hillside 1988 Surficial Soil Radionuclide Concentrations

Sample No.*	Uranium <sup>233 + 234</sup> (pCi/g)	Uranium <sup>238</sup> (pCi/g)	Plutonium (pCi/g)
881-1	0.56±0.26	0.6±0.15	4.3±0.5
881-2	0.78±0.26	0.86±0.15	2.4±0.2
881-3	0.82±0.26	0.91±0.15	4.8±0.5
881-4	1.0±0.3	0.97±0.2	0.18±0.006
881-5	0.86±0.26	0.88±0.15	0.59±0.008
881-6	1.5±0.3	5.5±0.5	2.2±0.2
881-7	0.74±0.26	0.75±0.15	0.63±0.09
881-(8)**	0.86±0.26	0.82±0.15	1.8±0.2
881-9	3.1±0.3	1.0±0.2	0.47±0.006
881-(10)**	11.1±0.3	0.98±0.2	3.5±0.4
881-11	1.0±0.3	1.3±0.2	2.6±0.3
881-12	0.93±0.26	1.4±0.	0.4±0.06
881-13	0.94±0.26	1.3±0.2	0.16±0.06
881-14	1.1±0.3	1.0±0.2	3.0±0.4
881-15	2.0±0.3	1.5±0.16	0.01±0.06
881-16	50±190	1300±100	0.3±0.06
881-17	19±74	590±70	0.78±0.19
881-18	60±230	3000±300	0.42±0.08
881-19	10±740	550±602	0.09±0.06
Mean	8.8	287	1.5
Variance	292	542, 875	2.4
Standard Deviation	17	737	1.5
Coefficient of Variation	1.9	2.6	1.0

\* See Figure 1-4 for sample locations

\*\* (8), (10) - Sample identification inferred from original data.

pCi/g = picoCuries per gram

Data from: Personal Communication, Richard Lawton, 1989

background in several samples collected in the SID drainage. In addition, plutonium was found above background in SID sediments but no radionuclides exceeded background in samples collected from the sediments in Woman Creek. Volatile organic compounds were consistently reported as not detected or reported as below the detection limit in all sediment samples. However, there were detectable concentrations of both classes of these compounds in previously collected sediment samples (EG&G, 1991a).

### Data Adequacy

Volatile organic analytical results from the borehole soil sampling activities conducted during the Phase I and Phase II investigations were rejected during data validation primarily due to the use of an insufficient aliquot size for analysis. In addition, there is some question as to the significance of certain solvent contaminant concentrations reported in both soils and ground water as they may represent laboratory contamination. Therefore, the volatile organic soil data previously collected can only serve as a qualitative indication of organic contamination in the soils. With the exception of the volatile organic analyses described above, the majority of the soil and water quality data are either valid or acceptable with qualifications, based on limited data validation conducted in accordance with guidance provided in the Quality Assurance Project Plan (QAPjP) (EG&G, 1990a) and General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1990b).

With respect to representativeness, the previous results are from boreholes, monitoring wells, surface water, and sediment stations that span the entire OU. However, boreholes did not penetrate all the IHSSs; therefore, previous soil data cannot be considered representative of all buried wastes.

#### **1.2.1.3 Site Conceptual Model**

An integral part of the DQO process is the development of a conceptual model to identify contaminant pathways to support data collection needs. Figure 1-5 illustrates the site conceptual model for OU1 portraying the pathways for surficial soil contaminant migration. Surficial soil

contamination at the 881 Hillside potentially has resulted from waste spills and leaks, and surface exposure of shallow buried waste (Table 1-1) as well as from the redistribution of radionuclide contaminated dust via wind from the 903 Pad area.

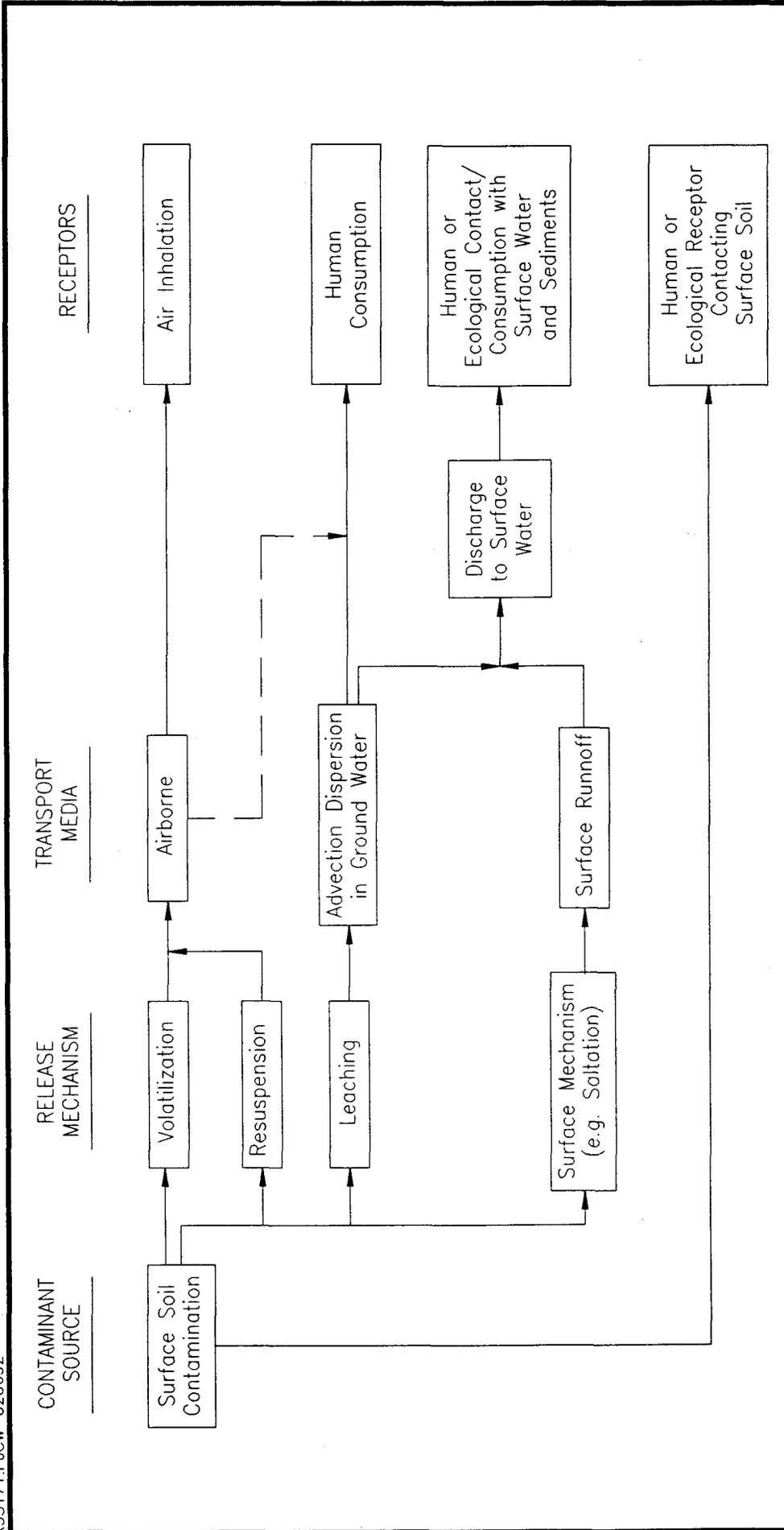
The principal potential release mechanisms of contaminants from surface soils are volatilization (volatile organics), fugitive dust and wind erosion (non volatile contaminants), leaching into ground water and surface runoff, infiltration/percolation, and biotic uptake (Figure 1-6).

Exposure (human and biota) to contaminants in surface soils can occur through multiple pathways; however, the actual pathways of significance will be determined during the risk assessment. Of primary importance is exposure through direct inhalation of contaminated dust or by ingestion of contaminated soils. An important secondary exposure route is through ingestion of or dermal contact with surface water or sediments contaminated via runoff. The potential receptor populations for each exposure pathway will be determined during the risk assessment.

#### **1.2.1.4 Objectives/Approach**

"Near-surface" soil samples will be collected in selected areas to characterize shallow contamination in OU1. The objective of the surface soil characterization program is to provide physical and chemical soil data that is representative of the OU and can be used to:

- (1) Develop source terms for exposure pathways evaluated in the risk assessment.
- (2) Compare with relevant health-based criteria.
- (3) Evaluate potential risks from inhalation of resuspended particulates.
- (4) Evaluate potential risks from incidental ingestion of, and dermal contact with contaminated soils.
- (5) Evaluate for purposes of the FS, the area and volume of contaminated surface soils that may require containment or treatment and/or disposal. (The sampling program is not comprehensive in attaining this objective but will indicate specific areas requiring remediation and will support extrapolation of additional areas that may require remediation. Sampling and analysis techniques during remediation



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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

RISK ASSESSMENT CONCEPTUAL MODEL

FIGURE 1-6

will be used if necessary to better define the areal extent of these soils. It is assumed at this time that surface soils requiring removal will be excavated to a depth of 6 inches (practical depth for earth moving equipment)).

- (6) Evaluate the conceptual model.

The sampling program has been designed so that samples are collected in a uniform manner and that the results of the sample analysis are representative of the area selected for characterization. In order to facilitate representative, uniform sampling, random sampling of polygons distributed throughout the area will be conducted using approved Environmental Management Division (EMD) standard operating procedures (SOPs)(EG&G, 1991d) as identified in Section 2. In addition, biased sampling will be conducted at IHSSs to ensure that the surficial soil contamination within each of these IHSSs is adequately characterized. Though a breach of statistical rigor, this bias sampling will tend to result in a more conservative estimate of risks and should not limit the application of statistical data treatment techniques intended for the evaluation. They are the most likely IHSSs to have indigenous surface soil contamination. The SAP is presented in Section 2.

### **1.2.2 Stage 2 — Data Uses/Needs**

Stage 2 of the DQO process involves the identification of data uses and types as well as data quality and quantity needs to meet the objectives specified in Stage 1. It also includes the selection of the sampling approach and the analytical options for the task including the economic and technical feasibility of the technique chosen. Finally, DQOs must address the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters of the planned activities (EPA, 1987).

#### **1.2.2.1 Data Uses**

In order to ensure that the sampling effort will address the objectives outlined during Stage 1 of the DQO process, the anticipated uses for the collected data must be specifically stated. The data from the surficial soil sampling activities proposed herein will be used to characterize surficial soil contamination in OU1. The information will be used to evaluate remedial

alternatives, but more importantly, to evaluate the threat posed to public health and environment. Specifically, surface soil contamination shall support development of source-terms for exposure pathways including:

- 1) Current Use Scenario: Off-site inhalation and ingestion of soil and plants contaminated by deposition of dust.
- 2) Future Use Scenarios (Technical Memorandum 6 which is currently being prepared will identify exposure scenarios to be used in the Baseline Risk Assessment for OU1):
  - a) Off-site as described above in 1.
  - b) On-site residential exposure including inhalation of resuspended dust, and incidental ingestion.
  - c) On-site ecological researcher exposure including inhalation of resuspended dust, and incidental ingestion. Researcher activities will cover all areas in the OU including Woman Creek and its banks.
- 3) Environmental Evaluation: Data will support evaluation of potential exposure to ecological receptors and development of food web models.

#### 1.2.2.2 Data Types

Upon identification of the intended users and use of the data to be collected, the specific data types needed can be developed. This is an integral step in the DQO process. Data types include general categories such as background and investigative samples as well as more specific information such as proposed analytical parameters. The analytical requirements are dictated by the intended use of the data (EPA, 1987).

A Site-Specific Chemical Analyte Roster (S-SCAR) has been developed for OU1. A summary of the criteria used to select the analytes is presented in Table 1-5. The criteria include:

- Records of surface releases of analyte classes (i.e., radionuclides, semi-volatiles etc.).
- Previously detected in surface soils.

- Relative mobility (solubility, adsorption). Table 1-6 presents a summary of the inter-media migration characteristics of each of the analyte classes.
- Previously detected in soil boring or sediment samples.

As indicated in Table 1-1, there are several potential site contaminants associated with the IHSSs in OU1 due to the lack of information available on the types and quantity of the stored, buried, and spilled wastes. Section 1.2.1.2 details the nature and extent of contamination at the site based on a review of available data. The previous discussions and data evaluation indicate that, to be conservative, several contaminant classes should be analyzed for during the surface soil sampling program.

#### Analyte Class I - Radionuclides

Radionuclides are included on the S-SCAR because records indicate historical surface releases and radionuclides were detected in surface, soil boring, and sediment samples. The non-volatile nature of radionuclides coupled with their low to moderate solubility suggests they would persist in the environment near the ground surface. Therefore, surface soil samples collected during this proposed sampling effort will be analyzed for gross alpha; gross beta; Pu<sup>239,240</sup>; U<sup>233,234,235,238</sup>; Am<sup>241</sup>; and Ra<sup>226,228</sup>. Background samples will also be analyzed for these radionuclides.

Tritium, Sr<sup>89,90</sup>, and Cs<sup>137</sup> are not on the S-SCAR because they are not expected to be found above background. Tritium exits in the environment as tritiated water, if it were released to surface soils at OU1, it would have been removed by infiltration and runoff since the time of release. Sr<sup>89,90</sup> and Cs<sup>137</sup> are products of a nuclear fission. An independent assessment of criticality safety at Rocky Flats Plant conducted by Scientech, Inc., found no evidence of a criticality at Rocky Flats Plant. This study noted that the levels of Cs<sup>137</sup> activity in the Rocky Flats area are in the range of 0.3 to 0.6 pCi/g averaged over a soil depth of six centimeters based on a July 1989 aerial radiological survey of the Plant. These values are consistent with world-wide fallout levels, and there is no indication of Cs<sup>137</sup> deposition due to Rocky Flats Plant operations (DOE, 1989).

Table 1-5

Considerations for Identifying the Surface Soil Site-Specific Chemical Analysis Roster (S-SCAR)

ANALYTE CLASS	SURFACE DISPOSAL	FOUND IN SURFACE SOILS	MOBILITY	FOUND IN BORING OR SEDIMENT SAMPLES	INCLUDE IN SURFACE S-SCAR
Radionuclides	Yes	Yes	Low to Moderate	Yes	Yes(1)
Heavy Metals	Unknown	Not Sampled	Low to Moderate	Yes	Yes(2)
Volatile Organics	Unknown	Not Sampled	Would Evaporate from Surface Soils	Yes	No(3)
Semi-Volatiles (Base/Neutrals)	Unknown	Not Sampled	Generally Immobile	Yes	Yes
Semi-Volatile (Acid Extractables)	Unknown	Not Sampled	Generally Mobile	No	No(4)
Pesticides/PCB's	Unknown	Not Sampled	Immobile	Yes	Yes

- (1) Surface soil samples will be collected and analyzed for gross alpha; gross beta, Pu<sup>239,240</sup>, U<sup>233,234,235,238</sup>; Am<sup>241</sup>, Ra<sup>226,228</sup>. Background samples will also be analyzed for these radionuclide parameters.
- (2) Priority pollutant metals (As, Sb, Cu, Cd, Cr, Hg, Ni, Pb, Se, Ag, Tl, and Zn, and Fc and Mn).
- (3) As previously discussed in the text, volatile organics will not be included in S-SCAR. It is expected that these compound would have volatilized from surface soils and would no longer exist in detectable concentrations.
- (4) There are only three detections of chemicals from this analyte class in soil/sediment samples from OU1. As discussed in the chemical analysis plan for OU1 (Technical Memorandum 1), the reported levels were estimated below the method detection and are below health based acceptable concentrations. Also considering the moderate to high soil mobility of this compound class (Technical Memorandum 1), it is unlikely that acid extractable compounds deposited in the surface soils would remain in this disposition. Thus, this class has been excluded from the S-SCAR.

**Table 1-6**  
**Summary of Environmental Inter-Media Migration Characteristics**

INTER-MEDIA MIGRATION CHARACTERISTIC	ALDEHYDES KETONES	MONOCYCLIC AROMATICS	CHLORINATED ALIPHATICS	ACID EXTRACTABLES	BASE-NEUTRAL EXTRACTABLES	PCB'S	PESTICIDES
Soil to Ground water	Yes	Yes	Yes	Yes	No	No	No
Soil or Soil Water to Air	No	Yes	Yes	No	No	No	No
Migration in Groundwater	Yes	Yes	Yes	Yes	No	No	No

### Analyte Class II - Metals

There are no documented surface releases of heavy metals; however, previous surface soil samples were not analyzed for these elements. Heavy metals are included in the S-SCAR because they are generally relatively insoluble and are non-volatile suggesting persistence in the environment near the ground surface. The metals on the S-SCAR are the Priority Pollutant Metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc). These elements are considered to be the most toxic of the heavy metals. In addition, manganese and iron have been added to the S-SCAR at the request of CDH.

The need to analyze the surface soils for hexavalent chromium was evaluated due to its toxicity and potential to affect the environment. Analysis of chromium (VI) in soils requires extraction and analysis techniques which will preserve the valence states of the metals. These techniques are not readily available from commercial laboratories and the effectiveness of the techniques in preserving the state is not documented. In addition, chromium (VI) is highly reactive and will be reduced to chromium (III) when in contact with organic matter, which is likely to be the case for surface soils at the Rocky Flats Plant. Therefore, chromium (VI) has been excluded from the S-SCAR.

### Analyte Class III - Volatile Organics

Surface soils need not be analyzed for VOCs due to their high volatilization potential and solubility (mobility in soil, water and runoff, i.e., they are not expected to be present in detectable quantities).

## Analyte Class IV - Semi-Volatile Organics

### Base/Neutral Extractables

There are no documented releases of semi-volatile compounds and previous surface soil samples were not analyzed for these compounds. However, base/neutral extractable, semi-volatile compounds are included in the S-SCAR because they have been detected in soil boring and sediment samples. In addition, they are relatively insoluble and display low volatility suggesting they would persist in the environment near the ground surface.

### Acid Extractables

There were only three detections of these chemicals in the soils/sediments at OU1 (EG&G, 1991c). The reported concentrations were estimated levels below detection limits. These findings, coupled with the high mobility of this class of compounds in the environment (i.e., from soil to ground water) (Table 1-6) suggest the occurrence of those compounds in the surface soils is improbable. Furthermore, as a class, acid extractables are generally not toxic. This analyte class has been deleted from the analytical suites for future samples collected in OU1 [see Technical Memorandum 1 Chemical Analysis Plan for OU1 (EG&G, 1991c)]. They are accordingly not included in the surface soil sampling S-SCAR.

## Analyte Class V - Pesticides/PCBs

There are no documented surface releases of organochlorine pesticides or PCBs; however, previous surface soil samples were not analyzed for these compounds. Organochlorine pesticides and PCB's are included in the S-SCAR because they have been detected in borehole and sediment samples. In addition, they are relatively insoluble and non-volatile suggesting persistence in the environment near the ground surface.

The S-SCAR and associated analytical methods and detection limits are presented in Table 1-7.

Table 1-7

## Site-Specific Chemical Analysis Roster (S-SCAR)

SUBSTANCE (Radionuclides)	ANALYTICAL METHOD	METHOD DETECTION LIMIT (pCi/g)
Gross Alpha	a,b,c,d,e,f,g,h	4
Gross Beta	a,b,c,d,e,f,g,h	10
Pu <sup>239,240</sup>	i,j	0.03
U <sup>235,238</sup>	a,c,d,g,h	0.3
U <sup>235</sup>	a,c,d,g,h	0.3
U <sup>238</sup>	a,c,d,g,h	0.3
Americium <sup>241</sup>	j,k	0.02
Radium <sup>226</sup>	a,b,c,g	0.5
Radium <sup>228</sup>	a,b,c,g	0.5
SUBSTANCE (Metals)	ANALYTICAL METHOD	METHOD DETECTION LIMIT (mg/kg)
Antimony	200.7	12
Arsenic	200.7	1.0
Beryllium	200.7	1.0
Cadmium	200.7	1.0
Chromium	200.7	2.0
Copper	200.7	5.0
Iron	200.7	5.0
Lead	239.2	1.0
Manganese	200.7	3.0
Mercury	245.5	0.2
Nickel	200.7	8.0
Selenium	270.2	1.0
Silver	200.7	2.0
Thallium	270.2	2.0
Zinc	200.7	4.0
SUBSTANCE (Semi-Volatiles)	ANALYTICAL METHOD	METHOD DETECTION LIMIT (µg/kg)
Dibenzofuran	625	330
2,4-Dinitrotoluene	625	330
Diethylphthalate	625	330
4-Chlorophenyl-phenylether	625	330
Fluorene	625	330
4-Nitroaniline	625	1600
N-nitrosodiphenylamine	625	330
4-Bromophenyl-phenylether	625	330
Hexachlorobenzene	625	330
Phenanthrene	625	330
Anthracene	625	330
Di-n-butylphthalate	625	330
Fluoranthene	625	330
Pyrene	625	330
Butylbenzylphthalate	625	330
3,3'-Dichlorobenzidine	625	660
Benzo(a)anthracene	625	330
Chrysene	625	330
bis(2-Ethylhexyl)phthalate	625	330
Di-n-octylphthalate	625	330
Benzo(b)fluoranthene	625	330
Benzo(k)fluoranthene	625	330
Benzo(a)pyrene	625	330
Indeo(1,2,3-cd)pyrene	625	330
Dibenz(a,h)anthracene	625	330
Benzo(g,h,i)perylene	625	330
bis(2-Chloroethyl)ether	625	330
1,3-Dichlorobenzene	625	330
1,4,-Dichlorobenzene	625	330
1,2-Dichlorobenzene	625	330
bis(2-Chloroisopropyl)ether	625	330

Table 1-7

## Site-Specific Chemical Analysis Roster (S-SCAR) (Continued)

SUBSTANCE (continued) (Semi-Volatiles)	ANALYTICAL METHOD <sup>1</sup>	METHOD DETECTION LIMIT (µg/kg)
N-Nitroso-di-n-dipropylamine	625	330
Hexachloroethane	625	330
Nitrobenzene	625	330
Isophorone	625	330
bis(2-chloroethoxy)methane	625	330
1,2,4-Trichlorobenzene	625	330
Naphthalene	625	330
4-Chloroaniline	625	330
Hexachlorobutadiene	625	330
2-Methylnaphthalene	625	330
Hexachlorocyclopentadiene	625	330
2-Chloronaphthalene	625	330
2-Nitroaniline	625	1600
Dimethylphthalate	625	330
Acenaphthylene	625	330
2,6-Dinitrotoluene	625	330
3-Nitroaniline	625	1600
Acenaphthene	625	330
SUBSTANCE (Pesticides/PCBs)	ANALYTICAL METHOD <sup>1</sup>	METHOD DETECTION LIMIT (µg/kg)
alpha-BHC	608	8.0
beta-BHC	608	8.0
delta-BHC	608	8.0
gamma-BHC(Lindane)	608	8.0
Heptachlor	608	8.0
Aldrin	608	8.0
Heptachlor epoxide	608	8.0
Endosulfan I	608	8.0
Dieldrin	608	16.0
4,4'-DDE	608	16.0
Endrin	608	16.0
Endosulfan II	608	16.0
4,4'-DDD	608	16.0
Endosulfan Sulfate	608	16.0
4,4'-DDT	608	16.0
Methoxychlor	608	80.0
Endrin ketone	608	16.0
alpha-Chlordane	608	80.0
gamma-Chlordane	608	80.0
Toxaphene	608	160.0
Aroclor-1016	608	80.0
Aroclor-1221	608	80.0
Aroclor-1232	608	80.0
Aroclor-1242	608	80.0
Aroclor-1248	608	80.0
Aroclor-1254	608	160.0
Aroclor-1260	608	160.0

Table 1-7

Site-Specific Chemical Analysis Roster (S-SCAR) (Continued)

SUBSTANCE	ANALYTICAL METHOD <sup>1</sup>	METHOD DETECTION LIMIT ( $\mu\text{g}/\text{kg}$ )
pH	9040	0.1 pH unit
Specific Conductance	9050	1
Carbonate	310.1	50 mg/kg
Oil and Grease	413.1	100 mg/kg
Total Suspended Particulate	NIOSH 0500 <sup>a</sup>	0.2 mg/m <sup>3</sup>
Respirable Particulate Matter	NIOSH 0600 <sup>a</sup>	0.2 mg/m <sup>3</sup>
Ammonia	350.2	50 mg/kg
Nitrate-Nitrite	353.2	50 mg/kg

- a. U.S. Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No. EMSL-LY-0539-1, Las Vegas, NV, U.S. Environmental Protection Agency.
- b. American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985. Standard methods for the Examination of Water and Wastewater, 16th ed., Washington, D.C., Am. Public Health Association.
- c. U.S. Environmental Protection Agency, 1976. Interim Radiochemical Methodology for Drinking Water, Report No. EPA-600/4-75-008. Cincinnati U.S. Environmental Protection Agency.
- d. Harley, H.H., ed., 1975, HASL Procedures Manual, HASL-300; Washington, D.C., U.S. Energy Research and Development Administration.
- e. "Handbook of Analytical Procedures," USAEC, Grand Junction Lab. 1970, page 196.
- f. "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/-80-032, August 1980 Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.
- g. "Methods for Determination of Radioactive Substance in Water and Fluvial Sediment," U.S.G.S. Book 5, Chapter A5, 1977.
- h. "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979.
- i. "Procedures for the isolation of Alpha Spectrometrically Pure Plutonium, Uranium, and Americium," by E.H. Essington and B.J. Drennon, Los Alamos National Laboratory, a private communication.
- j. "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories.
- k. "Radioactivity in Drinking Water," EPA 570/9-81-002.
- l. USEPA Methods for Chemical Analysis of Water and Wastes.
- m. Nuisance Dust, Total, NIOSH Manual of Analytical Methods, National Institute for Occupational Safety and Health (NIOSH) Method No. 0500, Cincinnati, Ohio.
- n. Nuisance Dust, Respirable, NIOSH Manual of Analytical Methods, National Institute for Occupational Safety and Health (NIOSH) Method No. 0600, Cincinnati, Ohio.

mg/kg milligrams per kilogram  
 mg/m<sup>3</sup> milligrams per cubic meter  
 pCi/g picoCuries per gram  
 $\mu\text{g}/\text{kg}$  micrograms per kilogram

### 1.2.2.3 Data Quality

#### Analytical Level

Analytical methods and support levels must be evaluated during the development of site specific DQOs. The parameters for which the analytical method is valid, its limitations, and any special considerations which will affect data quality must be understood in order to select appropriate analytical methods for specific uses.

The analytical options available to support data collection activities are presented in five general levels (EPA, 1987). These levels are distinguished by the types of technology and documentation used, and their degree of sophistication.

- LEVEL V - Non-standard methods. Analyses which may require method modification and/or development. These data can be used for toxicology applications.
- LEVEL IV - Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is characterized by rigorous QA/QC protocol and documentation and provides qualitative and quantitative analytical data. These data can be used for toxicology applications.
- LEVEL III - Laboratory analysis using methods other than CLP RAS. This level is used primarily to support engineering studies and risk assessments using standard EPA approved procedures. Some procedures may be equivalent to CLP RAS without the CLP requirements for documentation.
- LEVEL II - This level is characterized by the use of portable analytical instruments which can be used on-site, or in mobile laboratories stationed near a site. This level is appropriate for determining presence or absence of contaminants, relative concentrations and screening of samples.
- LEVEL I - This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations.

Soil chemistry data derived from the proposed surface soil sampling and analysis program at OUI will be used, in part, to evaluate human health and ecological risks posed by contamination, if any. Toxicological interpretation of soil chemistry requires validation of analytical data. Only LEVEL V and LEVEL IV analytical reports provide sufficient documentation to allow for data validation. Although LEVEL III analytical procedures are

similar to LEVEL IV, the documentation provided is not sufficient for data validation. Therefore, soil samples collected as part of this plan will be subjected to LEVEL IV analytical procedures and reporting requirements; however, LEVEL III may be adequate but is not feasible at this time due to administrative constraints (i.e., laboratory contracts, costs, procurement). Therefore, LEVEL III analyses may be proposed for subsequent sampling programs if appropriate.

### Detection Limits

In this section, a comparison is made between analytical detection limits for the S-SCAR and the concentration of each analyte which will pose a marginally acceptable health risk. This concentration is referred to as an acceptable exposure limit (EL) and is given in mg/kg. EL's have been calculated for those analytes detected in OU1 soils and sediments, and that are recognized as having chronic or carcinogenic health effects in humans (i.e., Oral Reference Dose (RfD) or Carcinogenic Slope Factor exists for the substance). Reference Dose (RfD) and Carcinogenic Slope Factors were taken from the Integrated Risk Information System (IRIS) and/or Health Effects Assessment Summary Tables (HEAST) (EPA, 1991). EL's have been calculated using exposure scenarios for both a resident and ecological researcher. As discussed previously, exposure scenarios employed in the baseline risk assessment for OU1 will be identified in Technical Memorandum 6. Exposure limits for a residential and ecological researcher have been developed in this document to evaluate a range of potential applications. Detection limits for analytes are specified in the GRRASP (EG&G, 1990a). The purpose of this exercise is to identify those analytes which may require special analytical procedures to achieve detection limits equal to or less than a calculated EL.

ELs have been compiled based on non-carcinogenic (systemic) and/or carcinogenic properties of the contaminants. The basic difference in methodology for assessing non-carcinogenic and carcinogenic risk is the assumption that non-carcinogenic health effects are threshold events, whereas carcinogenic risk is a cumulative effect. For non-carcinogens, threshold level intake must be exceeded before potential adverse health effects are expected.

The potential for non-carcinogenic health effects are quantified by comparing the daily intake (DI) to a RfD as shown below.

$$\begin{aligned} \text{Non-cancer Hazard Quotient (HQ)} &= \text{DI/RfD} && (1) \\ \text{Where: DI} &= \text{daily intake (mg/kg-day)} \\ \text{RfD} &= \text{reference dose (mg/kg-day)} \end{aligned}$$

Non-carcinogenic risks from multiple contaminants are conservatively assumed to be additive. A noncancer hazard index (HI) is computed by summing HQs for each contaminant.

$$\text{HI} = \text{DI}_1/\text{RfD}_1 + \text{DI}_2/\text{RfD}_2 + \dots \text{DI}_n/\text{RfD}_n \quad (2)$$

A HI less than 1 implies there will not be systemic health effects from exposure to the contaminants. Therefore, for each contaminant, the HQ has been set at 0.1 in computation of the EL to allow for the additive effects of other contaminants.

Calculated carcinogenic risks estimate the increased likelihood of an individual contracting cancer during his/her lifetime due to contaminant exposure. Carcinogenic risks from multiple contaminants are also assumed to be additive.

$$\begin{aligned} \text{Where: Risk} &= \text{CDI} \times \text{CSF} && (3) \\ \text{CDI} &= \text{Chronic Daily Intake (mg/kg-day) or (pCi)} \\ \text{CSF} &= \text{Carcinogenic Slope Factor (mg/kg-day)}^{-1} \text{ or (pCi)}^{-1} \end{aligned}$$

For each contaminant, the risk has been set at  $10^{-6}$  in computation of the EL to allow for the additive effects of the other contaminants. This would result in the cumulative risk from all site carcinogens in the range of  $10^{-4}$  to  $10^{-6}$ , which is the target risk range for remediation of the site.

The following equation is used to estimate the intake (CDI or DI) resulting from non-radioactive contaminant ingestion.

$$\text{Intake (mass contaminant/ body mass/time)} = \frac{\text{EL} \times \text{IR} \times \text{ED} \times \text{EF}}{\text{BW} \times \text{AT}} \quad (4)$$

Where:

- EL = Concentration in soil, at the point of exposure (EL) (mass contaminant/mass soil)
- IR = Ingestion Rate (mass soil/time)
- BW = Body Weight (mass)
- ED = Exposure Duration (time)
- AT = Averaging Time (time)
- EF = Exposure frequency (unitless)

The following equation is used to estimate the intake (CDI or DI) resulting from radionuclide contaminant ingestion.

$$\text{Intake (Activity)} = \text{EL} \times \text{IR} \times \text{ED} \times \text{EF} \quad (5)$$

- Where: EL = Concentration in soil at the point of exposure (activity/mass soil)

From these equations, (1) and (4), (3) and (4), or (3) and (5) the EL is calculated using the pre-selected values for HQ and Risk. These resulting equations and the parameters used for calculating the ELs for soil, are presented in Tables 1-8 through 1-10.

The combined soil and dust ingestion rates used in Table 1-8 through 1-10 are presented in OSWER Directive 9850.4 (EPA, 1989), which specifies 200 mg per day for children ages 1 through 6 (6 years of exposure) and 100 mg per day for others. These factors account for ingestion of both outdoor soil and indoor dust and are believed to represent upper-bound values

Table 1-8

Exposure Limit Calculations  
For Noncarcinogenic Chemicals In Soil

$$EL = \frac{RfD \times HQ \times BW \times AT}{IR \times CF \times ED \times EF}$$

EL = exposure limit for soil (mg/kg)

RfD = oral reference dose (mg/kg-day)

HQ = hazard quotient (unitless)  
= 0.1

BW = body weight (kg)  
= worker - 70 kg  
= resident<sup>a</sup> - 70 kg adult and 15 kg child

AT = averaging time (period over which exposure is averaged)  
= ED × 365 days/year

IR = ingestion rate (mg/day)  
= worker - 61 mg/day  
= resident<sup>a</sup> - 100 mg/kg adult and 200 mg/day child

CF = conversion factor (1E-6 kg/mg)

ED = exposure duration (years)  
= worker - 20 years  
= resident<sup>a</sup> - 24 years adult and 6 years child

EF = exposure frequency (days/year)  
= worker - 100 days/year  
= residential - 350 days/year

<sup>a</sup> Residential exposure has been time-weighted averaged to consider both child and adult exposure during the 30-year exposure duration per OSWER Directive 9850.4 (EPA, 1989).

Table 1-9

Exposure Limit Calculations  
For Carcinogenic Chemicals In Soil

$$EL = \frac{RISK \times BW \times AT}{IR \times CF \times ED \times EF \times CSF \times RP}$$

EL = exposure limit for soil (mg/kg)

RISK = 1E-6

BW = body weight (kg)  
= resident<sup>a</sup> - 70 kg adult and 15 kg child

AT = averaging time (period over which exposure is averaged)  
= 70 years × 365 days/year

IR = ingestion rate (mg/day)  
= worker - 61 mg/day  
= resident<sup>a</sup> - 100 mg/day adult and 200 mg/day child

CF = conversion factor (1E-6 kg/mg)

ED = exposure duration (years)  
= worker - 20 years  
= resident<sup>a</sup> - 24 years adult and 6 years child

EF = exposure frequency (days/year)  
= worker - 100 days/year  
= residential<sup>a</sup> - 350 days/year

CSF = carcinogenic slope factor (kg-day/mg)

RP = relative potency (factor considered only for PAHs)<sup>b</sup>

<sup>a</sup> Residential exposure has been time-weighted averaged to consider both child and adult exposure during the 30-year exposure duration per OSWER Directive 9850.4 (EPA, 1989).

<sup>b</sup> OSWER Directive: Risk Assessment Guidance on Polycyclic Aromatic Hydrocarbons

**Table 1-10**

**Exposure Limit Calculations  
For Radionuclides In Soil**

$$EL = \frac{RISK}{CSF \times IR \times ED \times EF \times CF}$$

- EL = exposure limit for soil (pCi/g)
- Risk = 1E-6
- CSF = carcinogenic slope factor (pCi)<sup>-1</sup>
- IR = ingestion rate (g/day)  
= worker - 61 mg/day  
= residential - 100 mg/day adult and 200 mg/day child
- ED = exposure duration (years)  
worker - 20 years  
resident - 24 years adult and 6 years child
- EF = exposure frequency (day/year)  
worker - 100 days/year  
resident - 350 days/year
- CF = conversion factor (10<sup>-3</sup> g/mg)

for soil and dust ingestion (Calabrese, et al., 1989; Calabrese, et al., 1990a,b; Davis, et al., 1990; Van Wijnen, et al., 1990). Presently there is no widely accepted method for determining the relative contribution of each medium (i.e., soil vs. dust) to these daily totals, and the effect of climatic variations (e.g., snow cover) on these values has yet to be determined. Thus, a constant, year round exposure is assumed (i.e., 350 days/year).

The equation for calculating a 30-year residential exposure to soil/dust is divided into two parts. First, a 6-year exposure duration is evaluated for young children which accounts for the period of highest soil ingestion (200 mg/day) and lowest body weight (15 kg). Second, a 24-year exposure duration is assessed for older children and adults by using a lower soil ingestion rate (100 mg/day) and an adult body weight (70 kg).

Reference doses, carcinogenic slope factors, and relative potency factors used in the calculations are provided in Table 1-11. Relative potency factors represent the relative carcinogenicity of the polycyclic aromatic hydrocarbons (PAHs) to Benzo(a)pyrene. These relative potency factors are proposed (OSWER Directive: Risk Assessment Guidance on Polycyclic Aromatic Hydrocarbons). Table 1-12 compares ELs calculated for an ecological researcher with analytical detection limits as specified by GRRASP. A review of this table reveals that GRRASP specified detection limits are lower than calculated ELs, therefore no special analytical procedures will be required.

Table 1-13 compares detection limits with ELs calculated for a resident. With the exception of antimony, beryllium, thallium, benzo(a)pyrene (BaP) and benzo(b)flouranthene (BbF), GRRASP specified detection limits are lower than calculated ELs. For antimony and thallium, the detection limit allows quantification of a HQ of 0.4. In the case of beryllium, the detection limit allows quantification of a 6E-6 cancer risk. For both BaP and BbF, the detection limit will allow quantification of a 5E-6 risk. Although the above noted detection limits somewhat compromise the risk assessment objectives, non-carcinogenic and carcinogenic health effects for these compounds can still be quantitated in an acceptable range, i.e., a HQ < 1 and a cancer risk less than 10<sup>-4</sup>.

Table 1-11

Toxicity Values Used to Compute Exposure Limits

SUBSTANCE	CHRONIC ORAL RFD mg/kg-day	ORAL CARCINOGENIC SLOPE FACTOR mg/kg-day <sup>-1</sup>	RELATIVE POTENCY
<u>Radionuclides</u>			
U <sup>233</sup>	NA	1.4E-10	NA
U <sup>234</sup>	NA	1.4E-10	NA
U <sup>235</sup>	NA	1.3E-10	NA
U <sup>238</sup>	NA	1.3E-10	NA
Sr <sup>89</sup>	NA	3.0E-12	NA
Sr <sup>90</sup>	NA	3.3E-11	NA
Pu <sup>239</sup>	NA	3.1E-10	NA
Pu <sup>240</sup>	NA	3.1E-10	NA
Am <sup>241</sup>	NA	3.1E-10	NA
Cs <sup>137</sup>	NA	2.8E-11	NA
H <sup>3</sup>	NA	5.5E-14	NA
Ra <sup>226</sup>	NA	1.2E-10	NA
Ra <sup>228</sup>	NA	1.0E-10	NA
<u>Metals</u>			
Antimony	mg/kg-day 4E-4	mg/kg-day <sup>-1</sup> NA	NA
Arsenic	1E-3	NA	NA
Beryllium	5E-3	4.3	NA
Cadmium	1E-3	NA	NA
Chromium	5E-3	NA	NA
Copper	NA	NA	NA
Iron	NA	NA	NA
Lead	NA	NA	NA
Manganese	1E-1	NA	NA
<u>Metals, continued</u>			
Mercury	3E-4	NA	NA
Nickel	2E-2	NA	NA
Selenium	5E-3	NA	NA
Silver	3E-3	NA	NA

**TABLE 1-11**

**Toxicity Values Used to Compute Exposure Limits (Continued)**

SUBSTANCE	CHRONIC ORAL RFD mg/kg-day	ORAL CARCINOGENIC SLOPE FACTOR mg/kg-day <sup>-1</sup>	RELATIVE POTENCY
Thallium	7E-5	NA	NA
Zinc	2E-1	NA	NA
<u>Semi-volatiles</u> Diethylphthalate	8E-1	NA	NA
Acenaphthene	6E-2	NA	NA
Fluorene	4E-2	NA	NA
N-Nitrosodiphenylamine	NA	1.4E-3	NA
Anthracene	3E-1	11.5 <sup>a</sup>	0.01
Pyrene	3E-2	NA	NA
Benzo(a)Anthracene	NA	11.5 <sup>a</sup>	0.01
Bis(2-Ethylhexyl)Phthalate	2E-2	1.4E-2	NA
Chrysene	NA	11.5 <sup>a</sup>	0.01
Benzo(b)Fluoranthene	NA	11.5 <sup>a</sup>	1.0
Benzo(k)Fluoranthene	NA	11.5 <sup>a</sup>	0.01
Benzo(a)Pyrene	NA	11.5	1.0
Indeno(1,2,3-cd)Pyrene	NA	11.5 <sup>a</sup>	0.01
Benzo(g,h,i)Perylene	NA	11.5 <sup>a</sup>	0.01
Arochlor	NA	7.7	NA
Beta-BHC	NA	1.8	NA

NA Not available

a The carcinogenic slope factor value for Benzo(a)pyrene has been used for all B2 polycyclic aromatic hydrocarbons (PAHs).

Detection limits were also compared to many world-wide regulatory criteria and guidance for soil cleanup (Fish and Wildlife Service, 1990a). Detection limits are lower than most of the cited criteria and guidance. In addition, several references were reviewed in an attempt to document concentrations of contaminants that are marginally acceptable for protection of ecological receptors (U.S. Fish and Wildlife, 1986a, 1986b, 1987a, 1987b, 1990b, 1990c). These "acceptable concentrations" were not identified for soil. However, considering the zfavorable comparison to the ELs and above noted regulatory criteria, and that CLP-RAS detection limits have been successfully used in environmental evaluations at Superfund sites, it is likely the detection units established for this surface soil sampling program are adequate for this purpose.

### Background Samples

Representative background analytical data are necessary for meaningful interpretations of surface soil data at OU1. Background data will determine naturally-occurring spatial variability and concentration levels of a constituent. Background surface soil data can then be compared with data from OU1 to determine the likelihood that concentrations of chemicals or elements, particularly those that are naturally occurring, represent waste activities at the OU. Background sampling is discussed in Section 2.

#### **1.2.2.4 Data Quantity**

The number of samples which should be collected can be determined using a variety of approaches. In situations where data are available, statistical techniques may be utilized to determine the required number of samples to meet the program objectives (EPA, 1987). The SAP described in Section 2 provides a statistical approach for determining the sample numbers and locations. Evaluation of the data upon completion of the data collection activity is necessary to determine the adequacy of the data collected.

Table 1-12

Exposure Limits  
Ecological Researcher

SUBSTANCE	EL NONCARCINOGENIC (pCi/g)	EL CARCINOGENIC (pCi/g)	DETECTION LIMIT (pCi/g)
<u>Radionuclides</u>			
U <sup>233</sup>	NA	58	0.3
U <sup>234</sup>	NA	58	0.3
U <sup>235</sup>	NA	63	0.3
U <sup>238</sup>	NA	63	0.3
Sr <sup>89</sup>	NA	2,732	1.0
Sr <sup>90</sup>	NA	248	1.0
Pu <sup>239</sup>	NA	26	0.3
Pu <sup>240</sup>	NA	26	0.03
Am <sup>141</sup>	NA	26	0.02
Cs <sup>137</sup>	NA	292	0.1
H <sup>3</sup>	NA	149,030	400
Ra <sup>226</sup>	NA	68	0.5
Ra <sup>228</sup>	NA	82	0.5
<u>Metals</u>			
	(mg/kg)	(mg/kg)	(mg/kg)
Antimony	167	NA	12
Arsenic	418	NA	1
Beryllium	2,094	3.4	1
Cadmium	418	NA	1
Chromium	2,094	NA	2
Copper	NA	NA	5
Iron	NA	NA	5
Lead	NA	NA	1.0
Manganese	41,885	NA	3
Mercury	125	NA	0.2
Nickel	8,377	NA	8
Selenium	2,094	NA	1

TABLE 1-12

**EXPOSURE LIMITS  
ECOLOGICAL RESEARCHER (Continued)**

SUBSTANCE	EL NONCARCINOGENIC (pCi/g)	EL CARCINOGENIC (pCi/g)	DETECTION LIMIT (pCi/g)
Silver	1,256	NA	2
<u>Metals, continued</u>			
Thallium	29.3	NA	2
Zinc	83,770	NA	4
<u>Semi-Volatiles</u>			
Diethylphthalate	335,080	NA	0.33
Acenaphthene	25,131	NA	0.33
Fluorene	167,540	NA	0.33
N-Nitrosodiphenylamine	NA	10,471	0.33
Anthracene	125,655	127	0.33
Pyrene	12,566	NA	0.33
Benzo(a)Anthracene	NA	127	0.33
Bis(2-Ethylhexyl)Phthalate	8,377	1,047	0.33
Chrysene	NA	127	0.33
Benzo(b)Fluoranthene	NA	1.27	0.33
Benzo(k)Fluoranthene	NA	127	0.33
Benzo(a)Pyrene	NA	1.27	0.33
Indeno(1,2,3-cd)Pyrene	NA	127	0.33
Benzo(g,h,i)Perylene	NA	127	0.33
<u>Pesticide/PCB</u>			
Arochlor 1254	NA	1.9	0.160
Beta-BHC	NA	8.14	0.008

NA Not Available

Table 1-13

Exposure Limits  
Resident

Substance	EL Noncarcinogenic (pCi/g)	EL Carcinogenic (pCi/g)	Detection Limit (pCi/g)
<u>Radionuclides</u>			
U <sup>233</sup>	NA	5.7	0.3
U <sup>234</sup>	NA	5.7	0.3
U <sup>235</sup>	NA	6.1	0.3
U <sup>238</sup>	NA	6.1	0.3
Sr <sup>89</sup>	NA	264	1.0
Sr <sup>90</sup>	NA	24.1	1.0
Pu <sup>239</sup>	NA	2.6	0.3
Pu <sup>240</sup>	NA	2.6	0.03
Am <sup>241</sup>	NA	2.5	0.3
Cs <sup>137</sup>	NA	28	0.1
H <sup>3</sup>	NA	14,430	400
Ra <sup>226</sup>	NA	6.6	0.5
Ra <sup>228</sup>	NA	7.9	0.5
<u>Metals</u>			
Antimony	(mg/kg) 2.8	(mg/kg) NA	(mg/kg) 12*
Arsenic	7.1	NA	1
Beryllium	35.4	0.17	1.0*
Cadmium	7.1	NA	1
Chromium	35.4	NA	2
Copper	NA	NA	5
Iron	NA	NA	5
Lead	NA	NA	1
Manganese	708	NA	3
Mercury	2.1	NA	0.2
Nickel	142	NA	8
Selenium	35.4	NA	1
Silver	21.2	NA	2

Table 1-13 (Continued)

Exposure Limits  
Resident

Substance	EL Noncarcinogenic (mg/kg)	EL Carcinogenic (mg/kg)	Detection Limit (mg/kg)
Thallium	0.50	NA	2*
Zinc	1,416	NA	4
<u>Semivolatiles</u>			
Diethylphthalate	5,664	NA	0.33
Acenaphthene	425	NA	0.33
Fluorene	2,832	NA	0.33
N-Nitrosodiphenylamine	NA	536	0.33
Anthracene	2,124	6.5	0.33
Pyrene	212	NA	0.33
Benzo(a)Anthracene	NA	6.5	0.33
Bis(2-Ethylhexyl)Phthalate	142	53.6	0.33
Chrysene	NA	6.5	0.33
Benzo(b)Fluoranthene	NA	0.07	0.33*
Benzo(k)Fluoranthene	NA	6.5	0.33
Benzo(a)Pyrene	NA	0.07	0.33*
Indeno(1,2,3-cd)Pyrene	NA	6.5	0.33
Benzo(g,h,i)Perylene	NA	6.5	0.33
<u>Pesticide/PCBs</u>			
Aroclor-1254	NA	0.10	0.160
Beta - BHC	NA	0.42	0.008

\* Detection limits for antimony, beryllium, thallium, benzo(b)fluoranthene, and benzo(a)pyrene as specified in General Radiochemistry and Routine Analytical Services Protocol (GRRASP) will not achieve Residential Exposure Limit.

NA - Not available

mg/kg = milligram/kilogram

pCi/g = picoCurie/gram

### 1.2.2.5 PARCC Parameters

The PARCC parameters are indicators of data quality. Precision is a quantitative measurement of the reproducibility of the data under a given set of conditions and may be determined by collecting field duplicate (replicate) samples. Accuracy measures the bias in a sampling program. Sampling accuracy can be assessed through the collection and analysis of field and trip blanks. Analytical accuracy is evaluated through the analysis of laboratory quality control (QC) samples and matrix spikes. The degree to which a data set is representative of the study area is known as representativeness. This criterion is best addressed by ensuring that the SAP justifies sampling locations and that a sufficient number of samples are collected. Completeness is defined as the percentage of valid measurements and comparability is a qualitative indicator of how well newly collected data will be comparable with previously collected data. PARCC parameters for the surface soil sampling program are discussed in Section 3.

### 1.2.3 Stage 3 — Documentation

Stage 3 results in the description of the procedures that will be implemented to obtain data of acceptable quality and quantity to make the required decisions. Through the implementation of the DQO process, components required for completion of Stage 3 should be available.

The SAP presented in Section 2 describes the data collection program for the surface soil sampling task. The plan discusses the protocols for sample collection including the types, locations, and frequency of samples to be collected. Section 3 presents QA/QC considerations.

## SECTION 2

### SAMPLING AND ANALYSIS PLAN

#### 2.1 SAMPLING PLAN

##### 2.1.1 Surficial Soil Sampling for Radionuclides

Plutonium is elevated above background levels in Phase II RI borehole samples from several sites in the 881 Hillside Area. Plutonium contamination may be limited to the uppermost soil, for its suspected origin is windblown particulates from the 903 Pad Area. In order to characterize the vertical and horizontal extent of surficial soil actinide contamination, surficial soil scrapes and vertical soil profiles have been collected in remedial investigation areas, and in the Plant buffer zone south and east of these areas to Indiana Street as part of the 903 Pad, Mound, and East Trenches Areas (OU2) Phase II RI. This surficial soil sampling also includes the 881 Hillside Area and is summarized below. The surficial soil field sampling plan is presented in Attachment 1.0 of the Phase II RFI/RI Work Plan (Alluvial) OU2 (EG&G, 1991b). Soil samples were analyzed for plutonium and americium. Uranium analyses (233, 234, 235, and 238) were also performed, although not specified in the plan.

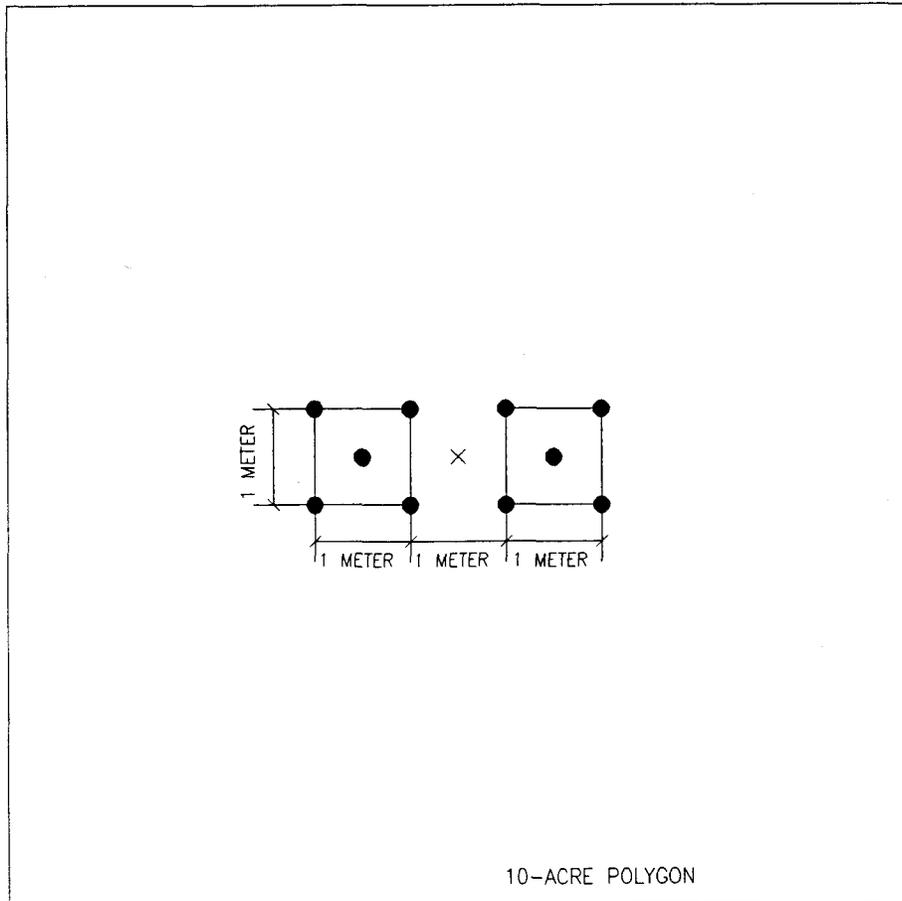
In order to assess the spatial distribution of plutonium, uranium, and americium in surficial soils within the Plant boundaries, pedologic soil samples were collected across the 800 acre area which includes OU1 as shown in Figure 2-1. Figure 2-1 was constructed based on review of previous investigation results, data analysis of unpublished material, and radiological surveys. The geostatistical analysis of previous investigation results are presented in the surficial soil sampling plan (Attachment 1.0; OU2 Final Phase II RFI/RI Work Plan [Alluvial] [EG&G, 1991b]). The State of Colorado requires special techniques of construction on lands with plutonium concentrations greater than 2.0 disintegrations per minute per gram (dpm/g) (0.9 pCi/g) of dry soil. To evaluate the soil-plutonium values relative to this standard, the CDH soil sampling protocol for evaluating large tracts of land remote from the source of contamination was used.

The CDH protocol involves sampling the upper 1/4 inch of the soil using a template which results in a sample size of 1/4 inch deep by 2 inches wide and 2-3/8 inch long. According to the protocol, 25 subsamples are collected within a 10-acre area and composited for radionuclide analysis. The method is described in detail in the EG&G Environmental Management Division (EMD) SOPs (EG&G, 1991d), Procedure GT.8.

The northwest corner of each grid was surveyed and marked with a steel post. Grids are oriented on the cardinal compass directions. The 25 subsamples for each composite sample were located with a hand-held compass and tape measure using the northwest corner as the starting point.

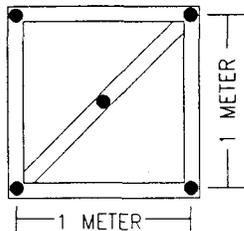
In addition to the CDH method, the Rocky Flats surface soil sampling method was used during the OU1 and OU2 sampling. The center of the eight 10-acre plots and two 2.5-acre plots of which portions fall within OU1 (Figure 2-1) were located and these positions served as the center for the Rocky Flats sample configuration. Ten discrete soil samples were collected as illustrated in Figure 2-2 and composited for plutonium, uranium, and americium analyses. The method involved using a soil sampling jig with a sample configuration of 10 by 10 by 5 centimeters (cm) deep. The subsamples were then composited into one sample resulting in a sample volume of 5,000 cm<sup>3</sup>. This method is described in detail in EMD SOP GT.8.

An in-depth study has been proposed to investigate the vertical distribution of plutonium and americium in the buffer zone east and south of the 903 Pad Area and at the 881 Hillside. Twenty-six locations have been identified as proposed soil pit locations (Figure 2-3). Three soil pits are located at OU1. These pits were excavated to expose the soil profiles which were then described and sampled in order to assess the vertical distribution of plutonium<sup>-239</sup>, <sup>-240</sup>, and americium<sup>-241</sup> in the surficial soils east and south of the Rocky Flats Plant. In addition to investigating the spatial and vertical extent of plutonium and americium, the surficial soil sampling program has been designed to study the physiochemical association of those actinides in both the static and mobile soil phases. The movement of both water and radionuclides (colloidal and dissolved) down the soil column is being studied as well as the hydrochemical relationships between the soil interstitial water and the seeps downslope.



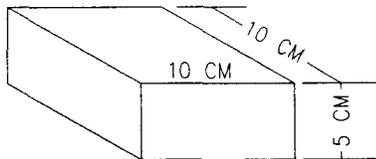
NOT TO SCALE

PLAN VIEW OF ROCKY FLATS METHOD TEMPLATE:



WOOD TEMPLATE WITH HOLES DRILLED IN EACH CORNER AND THE CENTER. NAILS WERE PLACED IN THE HOLES TO MARK THE SUBSAMPLE LOCATIONS. THE TEMPLATE WAS REMOVED AND THE SAMPLE JIG WAS USED TO COLLECT SAMPLES AT EACH SUBSAMPLE LOCATION.

SIDE VIEW OF ROCKY FLATS JIG:



- × CENTER OF 10-ACRE POLYGON
- SUBSAMPLE LOCATIONS

U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

OPERABLE UNITS NO. 1 AND 2  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

ROCKY FLATS METHOD  
SAMPLE SCHEME

FIGURE 2-2

February, 1992

Because previously collected data indicate that uranium contamination exists in surface soils at OU1, and that plutonium/americium contamination may be present from OU1 waste disposal (not simply arising from the 903 Pad Site), more detailed surface radionuclide data is necessary, i.e., the previous CDH and Rocky Flats Method Sampling provides only 10 samples each over the entire area of interest. In order to obtain information on the concentrations of these and other radionuclides as well as the levels of non-radioactive contaminants in the surface soils, a modified Rocky Flats sample collection technique will be used. Additional methods for sample collection were evaluated during the preparation of this sampling and analysis plan including two methods used at sites under the jurisdiction of EPA Region VIII. However, in order to obtain data to meet the comparability DQO objective, in conjunction with the fact the Rocky Flats Method for surface soil sample collection will provide the required information, Rocky Flats technique was selected. The proposed sampling program is described in Section 2.1.2 and the proposed analytical program is discussed in Section 2.2. This additional information will supplement the previously collected data to provide a more comprehensive evaluation of surface soil contamination at OU1.

### **2.1.2 Surficial Soil Sampling for Non-Radioactive Contaminants**

The objective of this sampling program is to collect data representative of non-radioactive (and radioactive) contamination in surface soil at OU1 that can be used to estimate mean contaminant concentrations within an acceptable error of estimation. The average human health and environmental risks for each contaminant can then be estimated based on the mean concentrations, and the upper bound risks can be estimated from the upper limit of the 95% confidence interval of the mean. Random sampling will be conducted to fulfill this objective. The samples will be randomly selected surface soil composites taken from polygons that entirely cover the area of interest. This approach is valid because there is an equal likelihood that human or biotic exposure will occur in any one polygon in the area of interest. In order to design the sampling program, the following must be defined:

- 1) Objective of the sampling and analysis plan.

- 2) The area of interest.
- 3) The size of a polygon and the total number polygons (population size (N)).
- 4) Prescribed margin of error.
- 5) The compositing methodology for sampling a polygon.
- 6) The acceptable error of estimation of the mean.
- 7) The number of polygons to be sampled (sample size (n)).
- 8) The locations of the polygons to be sampled.

The principal objective of the sampling plan is to estimate contaminant concentration parameters such as the mean, variance, and confidence intervals so that exposure and source term estimates can be computed. This objective is primarily to support the baseline risk assessment where exposure scenarios that include incidental ingestion, inhalation of resuspended particulates, and dermal contact will be evaluated.

The area of interest is that encompassing the IHSSs within OU1 and the area topographically downgradient of those IHSSs to Woman Creek (Plate 1). The latter area is included because runoff has potentially spread contamination in surface soils as far as Woman Creek. Although wind dissemination of contaminated dust from OU1 would potentially spread contamination over a greater area, source concentrations are expected to be of such a low magnitude that contamination in this greater area would be insignificant.

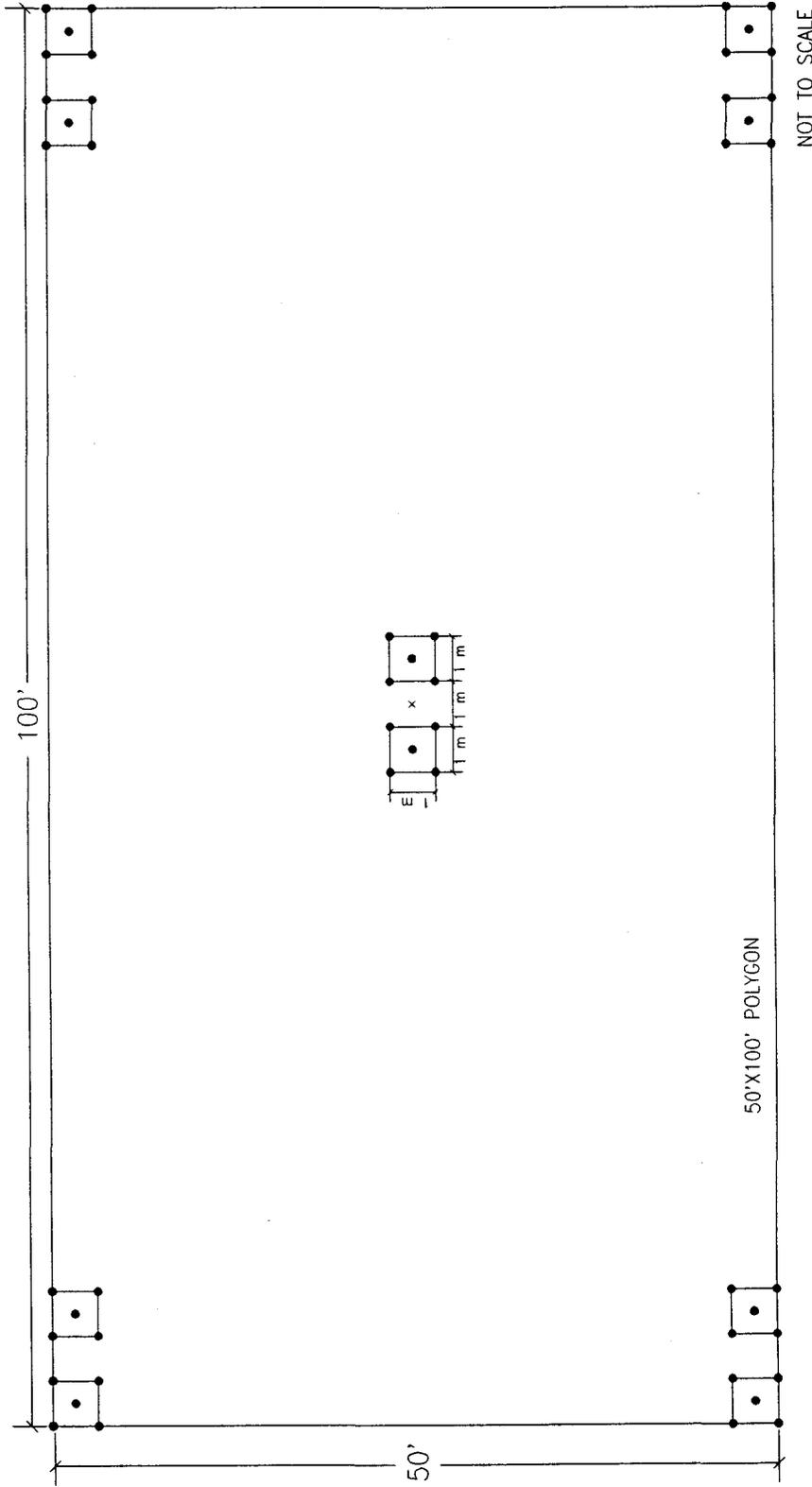
The size of a polygon was selected considering the expected size of a target area of contamination. The site has been divided into 100-foot by 50-foot contiguous squares (Plate 1). Collection of a composite surface soil sample from within each of these polygons will be adequate to detect contamination that may be present relative to the exposure scenario for which it is intended. The existence of contamination in surface soils would be a result of contaminated soil dumping (IHSS 130) or from spills or leaks from the storage of numerous drums (IHSSs 119.1 and 119.2). This contamination, if present, would have been further spread by tracking from investigative activities and by runoff. Based on these past disposal practices and the subsequent additional disturbances to the soil, a target area of contaminated soil could conceivably be larger than 100 feet by 50 feet, and if smaller, may be identified by the

compositing strategy. Selection of the target area (100 feet by 50 feet [5,000 square feet]) also considers the "exposure unit" and "clean-up unit" concepts. For example:

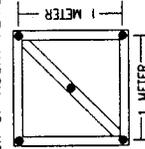
- Neptune and Blacker (1986) identify the area of 5,000 square feet as a reasonable approximation of the area of a residential yard (an exposure unit). Also, 5,000 square feet is a sufficient area to intercept traplines, soil plots, and similar exposure areas that an ecological worker might encounter.
- Remedial alternatives that involve soil removal require information regarding contamination levels for practical sized "clean-up units" (Exner, et al; 1984) 100-by 50-foot units represent plausible dimensions for considering remedial options that may involve earth-moving equipment, that are amenable to statistical treatment, and that yield sample numbers that do not present undue logistical problems or exorbitant costs.

One composite soil sample will be taken from each polygon selected for sampling. Compositing method applicable for randomly selected, equal-size sampling units is discussed in Gilbert (1987). Discrete samples will be taken from the corners and center of the polygon and will be composited (Figure 2-4). The Rocky Flats Method of surficial soil sampling will be used to collect "discrete" samples although the method actually produces a local area composite. The method consists of sampling two 1-square meter areas or plots placed 1 meter apart. The method involves using a soil sampling jig with a sampling configuration of 10 by 10 by 5 cm deep. This method is described in detail in EMD SOP GT.8. The subsamples will be collected and composited into one sample resulting in a sample volume of 25,000 cm<sup>3</sup>, and lithologic descriptions of the sample will be recorded.

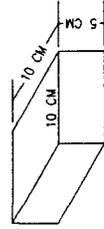
A subset of approximately 20% of the samples (6 samples from OU1 and 2 background samples) will be collected and submitted for laboratory particle size analyses (hydrometer test) and bulk density testing. This information will be used to evaluate the relationship between contaminants and grain size as soil texture and content may control contaminant mobility and/or the presence of certain analytes. The bulk density analysis will enable the concentration units to be converted to concentration per unit area for comparison to the CDH standard. The suggested 20% frequency for collection of these samples will provide sufficient information to characterize the soils since the samples will be collected from the same soil type as discussed in Section 2.1.3.



PLAN VIEW OF ROCKY FLATS METHOD TEMPLATE:



SIDE VIEW OF ROCKY FLATS JIG:



- ROCKY FLATS METHOD SUBSAMPLE LOCATIONS

U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

OPERABLE UNITS NO. 1 AND 2  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

PROPOSED SAMPLING SCHEME

FIGURE 2-4

Finally, the actinide study conducted in the OU1 and OU2 study areas (EG&G, 1990b) will provide additional information on these parameters to supplement the proposed work if needed.

The laboratory will also perform analyses on the very fine fraction for 20% of the samples. The very fine fraction is defined as that which passes through the smallest standard sieve size (a -200 mesh sieve allows 74 micron particles to pass through). This analysis of the very fine fraction can be used to estimate the metal and radionuclide content of respirable ( $\leq 10$  micron) and entrainable (50-100 micron) particles that may pose a risk via the air pathway. In addition, 3 samples will be collected from the background area and analyzed for specific conductance, carbonate, pH, and total organic carbon for comparison with the previously collected data from the OU1 study area.

The northwest corner of each sample location polygon will be surveyed and identified with a marked steel post. The subsamples locations will be approximately located using a hand held compass and tape measure. A description of the sample location will be provided which will include the percent of vegetative cover in accordance with EMD Ecology SOP procedure No. 5.10 revision 1 DF.

The number of polygons (i.e., composite samples) to be sampled to estimate the population mean is a function of 1) the absolute margin of error (d) that can be tolerated; and 2) the acceptable probability (alpha) of exceeding that error. The basic equation for estimating the number of samples according to Gilbert (1987) is:

$$n = \left( t_{1-\alpha} \frac{\sigma}{d} \right)^2$$

Where: n = number of samples required  
t<sub>1-α</sub> = Student T variate  
σ = s = Sample standard deviation of the mean estimate  
d = margin of error

For purposes of estimating n, the available surface soil data for estimating these parameters is the 881 Hillside Surface Soil Radionuclide Concentrations presented in Table 1-4. As shown

in Table 1-4 and Figure 1-4, plutonium concentrations are highest near the 903 Pad which is the expected source of contamination from resuspension and windborne transport of soil particles. Conversely, as indicated above and on Table 1-4, there are some elevated concentrations of uranium in surface soils at OU1 that could be indicative of a release from past disposal practice, e.g., a leaking drum or spill of uranium contaminated liquid waste (IHSS 119 was a past storage site for drummed waste). Uranium<sup>238</sup> was used as the surrogate for parameter estimation because the wide data range suggests possible anthropogenic activity as its source. Uranium<sup>238</sup> data also demonstrated the greatest degree of variation (compared to uranium<sup>233,234</sup> and plutonium) including several relatively high detections as well as the highest coefficient of variation (2.6). Further, it is likely there is an association of uranium and other waste constituents that may have been released. Using this data, the following parameters are obtained:

Student T variate: 1.734 (alpha 0.05, one-sided confidence limit and 18 degrees of freedom)

Sample standard deviation(s)	:	737 pCi/g
Sample mean (y <sub>m</sub> )	:	287 pCi/g

Margin of error (d) = 0.9 y<sub>m</sub>

For risk assessment, a reasonable bound on the error of estimation is 0.9 y<sub>m</sub>, i.e., the 95% confidence interval for the mean is the mean plus or minus 90% of the mean. This level of uncertainty is small relative to the uncertainty associated with toxicological parameters used to estimate risk. Also, derivation of "d" in this manner is consistent with EPA Guidance (1989) which places special emphasis on the 95% upper confidence limit of the mean exposure concentration in developing the reasonable maximum exposure (RME).

Using this approach, a sample size of 24 polygons is estimated as follows:

$$n = (1.734(\frac{737}{(0.9)(287)}))^2$$

$$n = 24$$

Each of the polygons shown in Plate 1 were numbered sequentially and a random number generator was used to select 24 polygons for sampling. If a sample polygon was determined to be located within a disturbed area (road, french drain, etc.), the sample location was eliminated and replaced by another randomly selected polygon. These are identified on Plate 1. In addition to these polygons, to be conservative, biased sampling (4 additional composites) will be performed in polygons located at IHSSs 106, 130, 119.1 and 119.2 resulting in a total of 28 investigative composite samples. The biased sample locations within 119.1 has been selected to sample the area in the 1988 surface soil sampling (Table 1-4 and Figure 1-4) indicating the highest uranium concentration. These IHSSs are most likely to have surface soil contamination because there are areas where contaminated liquids were discharged (IHSS 106), drummed waste were stored (IHSSs 119.1 and 119.2) or wastes were buried at shallow depths (IHSS 130).

The previous computation of the number of polygons to be sampled is based on the need to estimate the population mean (contaminant concentration) with a bound on the error of estimation. This is satisfactory for assessing risks from contamination provided the contaminant concentrations do not include a significant background component. However, interpretation of the risk assessment results must consider the risk contribution simply due to background levels (for naturally occurring chemicals that may also be contaminants). Therefore, one must consider the eventual need for a statistical comparison to background in determining the number of polygons to be sampled. As discussed in the next section, analysis of variance (ANOVA) would be used to determine if significant differences exist between the mean background and OU1 concentrations, and thus determine the background component of the chemical concentrations at OU1. In determining the number of samples necessary to detect a particular difference in the means of two populations, the following formula can be used (EPA, 1990a):

$$n = [Z_{\alpha} + Z_{\beta}]^2 \sigma^2 / d^2 + 0.5 Z_{\alpha}^2$$

Where:  $Z_{\alpha}$  = Percentile of the standard normal distribution such that  $P(Z \geq Z_{\alpha}) = \alpha$

$Z_{\beta}$  = Percentile of the standard normal distribution such that  $P(Z \geq Z_{\beta}) = \beta$

$\sigma = s$  Standard deviation

$d =$  Minimum detectable difference expressed as a fraction of the mean  
 $y_m$  (0.2  $y_m$  recommended)

$1-\alpha =$  Confidence (80% recommended)

$1-\beta =$  Power (90% recommended)

Using the recommended values for the above parameters and the  $U^{238}$  statistics:

$$n = [(0.842 + 1.282)(737)/(0.2)(287)^2 + 0.5 (0.842)^2] = 744$$

As can be seen, hundreds of samples should be taken to achieve the specified detectable difference, confidence, and power. However, cost and time constraints do not permit implementation of a surface soil sampling program of this magnitude. Furthermore, the above equation assumes the OU1 and background population variances are the same. The background population variance is not known but is certain to be less than the OU1 variance based on the presence of  $U^{238}$ , a site contaminant. Therefore the acceptable number of polygons to sample in order to achieve the desired power cannot be predicted at this time. As a result, the 24 polygons previously identified on page 2-11 will be used for the sampling plan.

### **2.1.3 Background Surficial Soil Sampling**

Each OU1 sample concentration will be compared to the range (where range is defined as a statistical tolerance interval) of concentrations in background samples. A tolerance interval defines, with specified probability, a range of values that contain a discrete percentage of the population. OU1 samples whose concentrations which exceed the upper tolerance interval may indicate the influence of waste - related activities.

A tolerance interval defines a range that contains at least  $p\%$  of population with  $P\%$  probability (level of confidence), i.e., upon repeated sampling  $P\%$  of the calculated intervals will contain  $p\%$  of the population. It answers the question where do most of the observations lie. A probability (level of confidence) is associated with the tolerance interval since the interval is estimated from the data and therefore has some level of uncertainty associated with it. For the

tolerance interval to be useful in decision making, both "p" and "P" are chosen to be large, in this case,  $p = 0.95$  and  $P = 0.95$ .

A 95% confidence level provides a reasonable compromise between the probability of Type I and Type II errors (Till, 1974). The number of sampling stations (n) in the background area determines the width of the tolerance interval, i.e., the more background stations, the narrower the interval and the more likely it will be that contamination at OU1 will be detected. Nine background stations have been established in order to obtain a 95% tolerance interval (95% of population within the one-sided interval) with a tolerance factor (Table 2-1) of three at the 95% confidence level, i.e., nine samples produce an upper limit of the tolerance interval at the mean plus three standard deviations of the sample population. A tolerance factor of three is used extensively to define engineering tolerances (Doctor, Gilbert, and Kinnison, 1986).

The equation for computation the 95% tolerance limits of normally distributed data is:

#### 95% Tolerance Limits

$$L_1 = \bar{x} - Ks \text{ and}$$
$$L_2 = \bar{x} + Ks$$

Where:	$L_1$	=	lower 95% tolerance limit
	$L_2$	=	upper 95% tolerance limit
	$\bar{x}$	=	mean of the sample population of size n
	s	=	standard deviation of the sample population
	K	=	the normal tolerance factor. (Dependent on p, P, n and on whether the limit is one sided or two sided.)

The equation for the 95% tolerance limits of lognormally distributed data is:

**TABLE 2-1**

**TOLERANCE FACTORS FOR NORMAL TOLERANCE LIMITS  
FOR 95% POPULATION AT 95% CONFIDENCE**

<u>n</u>	<u>Two-Sided</u>	<u>One-Sided</u>
2	37.67	
3	9.916	7.655
4	6.370	5.145
5	5.079	4.202
6	4.414	3.707
7	4.007	3.399
8	3.732	3.188
9	3.532	3.031
10	3.379	2.911
11	3.259	2.815
12	3.162	2.736
13	3.081	2.670
14	3.012	2.614
15	2.954	2.566
16	2.903	2.523
17	2.858	2.486
18	2.819	2.453
19	2.784	2.423
20	2.752	2.396
21	2.723	2.371
22	2.697	2.350
23	2.673	2.329
24	2.651	2.309
25	2.631	2.292
26	2.612	
27	2.595	
28	2.579	
29	2.554	
30	2.549	2.220
35	2.490	2.166
40	2.445	2.126
45		2.092
50	2.379	2.065
60	2.333	
80	2.272	
100	2.233	1.924
200	2.143	1.836
500	2.070	1.763
1000	2.036	1.727
infinity	1.960	

## Upper 95 % Tolerance Limit

$$L_2 = \exp(\bar{y} + Ks_y)$$

Where:	$L_2$	=	Upper 95 % Tolerance Limit
	$\bar{y}$	=	average of $\log_e$ transforms of raw data
	K	=	the normal tolerance factor. (Dependent on p, P, n and on whether the limit is one sided or two sided.)

No lower limit equation is provided because pH is not expected to have a lognormal distribution.

If concentration of contaminants in surface soil exceed the background tolerance intervals, classical ANOVA techniques will be employed to determine if the mean concentration of a chemical in surface soil at OU1 is significantly different from the mean background concentration. The power of the ANOVA cannot be estimated at this time because the variance of the background population is unknown.

Surface soil samples will be collected in areas west and north of the Plant in order to characterize background conditions (Figure 2-5). The Rocky Flats methodology will be used for comparability to OU1 data.

A review of the proposed background area (northwest area of the plant property near the wind site) revealed that soil types consistent with the soil types identified in the OU1 study area (Figure 2-1) are present in the Rock Creek Drainage vicinity. As the prevailing wind direction is from the northwest, this area is presumed to nominally or imperceptibly impacted by redistribution of contaminants from plant operations. For comparison with OU1 data, the background sample locations will be collected in soils which are comparable in content as soil texture and structure affect the presence and/or mobility of certain analytes. Therefore, the background surface soil samples will be collected on a south facing slope of the Rock Creek Drainage for comparison with OU1 data (Figure 2-4) within the Denver-Kutch-Midway soil series. Table 2-2 provides a brief description of the soil types in the selected background area. It is recognized that due to the variability in wind direction, the selected background area, may not provide sample data representative of true background concentrations; however, the collected

data will provide useful information for comparison with the data collected at OU1. Although an off-site location may provide better data, administrative constraints currently prevent off-site sampling. In conjunction with this program, a literature search for information on representative surface soil concentrations in potential background areas will be conducted.

The proposed background area has been divided into 100-foot by 50-foot polygons and sequentially numbered. Nine polygons were selected for sampling with the use of a random number generator. Nine locations were specified to ensure consistency with the background geochemical characterization program. Nine sample locations have been established for background characterization to obtain a 95% tolerance interval with a 95% confidence level. The proposed locations are presented in Figure 2-5. Samples will be collected for analysis of all parameters presented in Table 2-1 and will be obtained by using the Rocky Flats Method. In the OU1 and OU2 study areas, the CDH method was used to collect information for comparison with the CDH construction standard, and provides sufficient data for evaluation; therefore, it is not necessary to determine background concentrations using this method. The CDH method is primarily used for investigating the resuspendible fraction and not for total contaminant inventory. The Rocky Flats method is an effective method for evaluating the presence and concentrations (i.e., inventory) of surface soil contamination. In conjunction with the chemical analyses, particle size analysis, and bulk density testing will be conducted on randomly selected samples from the OU1 and background areas.

#### **2.1.4 Sediment Sampling**

Completion of the DQO process, aided by the conceptual model, revealed a data gap in the quantity of sediment data downgradient of OU1. To facilitate completion of the OU1 baseline risk assessment, three additional sediment stations are proposed for OU1 as the conceptual model indicates the potential for surface soil contamination migration to the stream. These locations are in Woman Creek and are displayed on Plate I. As illustrated in the conceptual model (Figure 1-5), there is a potential of contamination migration from the surface soils to the SID and Woman Creek sediments via resuspension by wind and surface runoff. Sufficient sampling locations are located in the SID (SED 37, 38, 39, and 28). The three proposed stations (SED

**Table 2-2**  
**Soil Types in the Selected Background Area**

Series	Family	Phase	Min-Max Slope (%)	Infiltration Rate	Soil Type*
Denver-Kutch-Midway	Torrertic Arguistolls	clay loam	9-25	slow	31
Flatirons	Aridic Plaeustols	sandy loam	0-3	slow	46
Haverson	Ustic Torrifuvents	loam	0-3	moderate	60
Nederland	Aridic Arguistolls	sandy loam	15-50	moderate	100

\* Soil type number corresponds to soil type exhibited in Figure 2-5.  
 Source: U.S. Department of Agriculture, 1980.

40, 41, and 42) within Woman Creek will provide information required to characterize the sediments and will be added to the stations currently being sampled as part of the site wide surface water and sediment characterization program. The samples will be collected in accordance with the appropriate EMD SOPs (SW.07, R1). The proposed stations coupled with the existing stations will provide adequate data points to detect contamination in the sediments of the Woman Creek drainage and the SID. The analytical should include the analytes presented in the S-SCAR table (Table 1-4) as well as the Target Compound List VOCs to investigate the migration potential for ground water to surface water and sediments.

### 2.1.5 Air Sampling

Review of the surface soils-based Site Conceptual Model (Figure 1-5) in conjunction with the discussion of Data Uses in Section 1.2.2.1 indicates that inhalation of resuspended particulate matter will be a significant pathway for evaluation of exposure for all on-site scenarios. Inhalation exposure is often evaluated by assuming (1) a conservative suspended particulate concentration such as 1 milligrams per cubic meter ( $\text{mg}/\text{m}^3$ ) and (2) that the contaminant concentration of the suspended particulate matter is equal to the mean soil concentration. Using this approach, intakes and exposure doses are readily computed. To eliminate some of the uncertainty in this process, suspended particulate measurements will be obtained using personal air sampling equipment and traditional industrial hygiene techniques. Low-flow air samples will be placed on site by personnel conducting intrusive field activities to identify actual suspended particulate levels. One air sample will be collected on four different days from each of three field personnel. The fourth sample will be obtained from a fixed position upwind to provide background concentrations data. All samples will be collected for 8 hours to provide time-weighted average measurements. Analyses will include total suspended particulate and respirable particulate matter. An attempt will be made to collect at least one day's samples during ambient conditions which reflect a worst-case scenario (e.g., high wind). The process will be repeated on four separate days, providing a total of 16 measurements. Using the Gilbert (1987) equation, PM-10 data collected in the vicinity of the 903 Pad site during 1991, 16 samples are more than adequate for estimating mean particulate concentrations as well as for calculating 95%

confidence intervals. The sampling and analyses will be performed in accordance with National Institute of Occupational Safety and Health (NIOSH) methods.

## 2.2 ANALYSIS PLAN

The proposed analytical program for surface soils at OU1 is presented in Table 2-3. As indicated, the list is comprehensive to include are expected contaminant classes based on the disposal history for the site. However, VOCs and acid extractables are not included because of the unlikelihood that these classes of compounds would be present in the surface soils.

### 2.2.1 Radiochemistry

Composite pedologic samples collected during the surficial soil sampling program for OU1 from the three 10 acre grids (Figure 2-1) are being analyzed for plutonium<sup>239, 240</sup>, americium<sup>241</sup>, and uranium<sup>233, 234, 235, and 238</sup>. However, to provide additional information on radionuclide surface soil contamination, the samples collected in OU1 during this program will be analyzed for the parameters listed in Table 2-1. Background soil samples will also be analyzed for these radionuclides for comparison with the OU1 data. Radionuclide analyses will be performed in accordance with method referenced in the GRRASP.

### 2.2.2 Non-Radioactive Analytical Parameters

Organic and metal analyses as well as additional analyses will be performed using CLP RAS as specified in the GRRASP. The analytical parameters are presented in Table 2-3.

**Table 2-3  
Proposed OU1 Surface Soil Sampling Parameters**

**TOTAL METALS**

Antimony  
Arsenic  
Beryllium  
Cadmium  
Chromium  
Copper  
Iron  
Lead  
Manganese  
Mercury  
Nickel  
Selenium  
Silver  
Thallium  
Zinc

**OTHER PARAMETERS**

Ammonia  
Nitrate-Nitrite  
Oil and Grease  
Specific Conductance\*  
Carbonate\*  
pH\*  
Total Organic Carbon\*  
Particle Size Analysis\*\*  
Bulk Density Testing\*\*  
Total Suspended Particulate\*\*\*  
Respirable Particulate  
Matter\*\*\*

**TOTAL RADIONUCLIDES**

Gross Alpha  
Gross Beta  
Uranium <sup>233, 234, 235, and 238</sup>  
Radium <sup>226, 288</sup>  
Plutonium <sup>239, 240</sup>  
Americium <sup>241</sup>  
Radium <sup>226, 228</sup>

**ORGANICS: SEMI-VOLATILES BASE/NEUTRAL EXTRACTABLES**

Target Compound List -  
bis(2-Chloroethyl)ether  
1,3-Dichlorobenzene  
1,4-Dichlorobenzene  
1,2-Dichlorobenzene  
bis(2-Chloroisopropyl)ether  
N-Nitroso-Dipropylamine  
Hexachloroethane  
Isophorone  
bis(2-Chloroethoxy)methane  
1,2,4-Trichlorobenzene  
Naphthalene  
4-Chloroaniline  
Hexachlorobutadiene  
2-Methylnaphthalene  
Hexachlorocyclopentadiene  
2-Chloronaphthalene  
2-Nitroaniline  
Dimethylphthalate

**ORGANICS: SEMI-VOLATILES BASE/NEUTRAL EXTRACTABLES (con't.)**

Acenaphthylene  
3-Nitroaniline  
Acenaphthene  
Dibenzofuran  
2,4-Dinitrotoluene  
2,6-Dinitrotoluene  
Diethylphthalate  
4-Chlorophenyl Phenyl ether  
Fluorene  
4-Nitroaniline  
N-nitrosodiphenylamine  
4-Bromophenyl Phenyl ether  
Hexachlorobenzene  
Phenanthrene  
Anthracene  
Di-n-butylphthalate  
Fluoranthene  
Pyrene  
Butyl Benzylphthalate  
3,3'-Dichlorobenzidine  
Benzo(a)anthracene  
bis(2-ethylhexyl)phthalate  
Chrysene  
Di-n-octyl Phthalate  
Benzo(b)fluoranthene  
Benzo(k)fluoranthene  
Benzo(a)pyrene  
Indeno(1,2,3-cd)pyrene  
Dibenz(a,h)anthracene  
Benzo(g,h,i)perylene

**ORGANICS: PESTICIDES/PCBs**

Target Compound List -  
alpha-BHC  
beta-BHC  
delta-BHC  
gamma-BHC (Lindane)  
Heptachlor  
Aldrin  
Heptachlor Epoxide  
Endosulfan I  
Dieldrin  
4,4'-DDE  
Endrin  
Endosulfan II  
4,4'-DDD  
Endosulfan Sulfate  
4,4'-DDT  
Endrin Ketone  
Methoxychlor  
alpha-Chlordane  
gamma-Chlordane  
Toxaphene  
AROCLOR-1016  
AROCLOR-1221  
AROCLOR-1232  
AROCLOR-1242  
AROCLOR-1248  
AROCLOR-1254  
AROCLOR-1260

\* On three background samples  
\*\* On 20% of the surface soil samples.  
\*\*\* On air samples only. Air samples to be collected by EG&G personnel.  
NOTE: Sediment samples will also be analyzed for TCL VOCs.

### 2.3 DATA MANAGEMENT

Field and laboratory data collected during the Phase II RFI/RI will be incorporated into the Rocky Flats Environmental Database System (RFEDS). The RFEDS is used to track store, and retrieve project data. Data will be input to the RFEDS via diskettes subsequent to data validation as outlined in the ER Program QAPjP (EG&G, 1991a). Hardcopy reports will then be generated from the system for data interpretation and evaluation.

## SECTION 3

### QA/QC

The SAP addresses the procedures for conduct of the proposed field activities as well as the proposed analytical suite for the samples collected during the surface soil sampling program. A QAPjP is an element of the SAP which identifies QA objectives for data collection, analytical procedures, calibration, and data reduction, validation, and reporting. The QAPjP, in conjunction with SOPs, complete the SAP. The ER Program QAPjP and the Rocky Flats EMD SOPs have been prepared by EG&G and submitted to the EPA and the CDH for review and comment. All field and analytical procedures will be performed in accordance with the methods described in the QAPjP and SOPs unless otherwise specified in this SAP.

#### 3.1 INTERNAL QC CONTROL SAMPLES

The objective of the QAPjP is to provide a framework to ensure that all sampling and analytical data achieve specific data quality standards. These standards ensure that PARCC parameters (Section 1.2.2.5) for the data are known and documented. All samples sent for CLP Level IV analyses will be handled in accordance with CLP guidelines. QC procedures for non-CLP method will be developed as needed using standard methods.

QC samples may be collected in conjunction with the investigative samples to provide information on data quality. Field (rinsate) blanks, trip blanks, field duplicates, laboratory blanks, laboratory replicates, and laboratory matrix spike and matrix spike duplicates are the commonly collected samples. Trip blanks generally pertain to volatile organic analyses, and because volatile organic analyses will not be performed on the samples collected during the surface soil sampling program, they are not further discussed.

However, a trip blank will be collected for TCL VOC analysis during the sediment sampling program to investigate sample container integrity and the potential for sample contaminant during transport to and from the laboratory.

Field blanks (rinsate blanks) will be collected by pouring distilled/deionized water through decontaminated sample collection equipment and submitting the sample for the same analyses as the investigative samples. Field (rinsate) blanks monitor the effectiveness of decontamination procedures. Field replicates will be collected and analyzed to provide information regarding the natural variability of the sampled media as well as evaluate analytical precision. Table 3-1 presents the suggested guidelines for collection of field QC samples (EPA, 1987) and are consistent with the suggested guidelines listed in the QAPjP. Table 3-2 presents the total number of investigative and background samples to be collected during implementation of this SAP.

Laboratory blanks and replicates test analytical procedures and conditions. Laboratory matrix spikes and matrix spike duplicates measure analytical accuracy by providing data on matrix interferences and components interfering with instrument responses. The frequency of collection and analysis of laboratory QC samples is dictated by the prescribed analytical method as cited in the GRRASP. The precision and accuracy standards detailed in the proposed analytical method, are sufficient for the project.

### 3.2 ACCURACY

Analytical accuracy is expressed as the percent recovery of an analyte which has been used to fortify an investigative sample or a standard matrix (e.g., blank soil, analyte-free water, etc.) at a known concentration prior to analysis, and is expressed by the following formula:

$$Accuracy = \% Recovery = \frac{A_T - A_O \times 100\%}{A_F}$$

Where:       $A_T$       =      total amount found in fortified sample  
                  $A_O$       =      amount found in unfortified sample  
                  $A_F$       =      amount added to sample

**Table 3-1**

**Guidelines for Field Quality Control Sample Collection Frequency**

Analytical Parameter	Trip Blank	Field (rinsate) Blank	Field Replicate
VOCs	1 in 20	1 in 20	1 in 20
Metals	NA	1 in 20	1 in 20
Oil and Grease	NA	1 in 20	1 in 20
Radionuclides	NA	1 in 20	1 in 20
TCL semi-volatiles	NA	1 in 20	1 in 20
TCL Pesticide/PCBs	NA	1 in 20	1 in 20
Other	NA	1 in 20	1 in 20

NA - Not applicable

Table 3-2

Surface Soil Sample Frequency

Analytical Parameter	Total Surface Soil Investigative Samples	Total Background Samples	Trip Blanks	Field Duplicates <sup>a</sup>	Field (rinsate) Blanks <sup>a</sup>	Total Samples for Lab
Metals <sup>b</sup>	34	11	0	4 <sup>c</sup>	3	52
Oil and Grease	28	9	0	3	3	43
Radionuclides <sup>b</sup>	34	11	0	4 <sup>c</sup>	3	52
TCL Semi-Volatiles (base/neutral extractable)	28	9	0	3	3	43
TCL Pesticide/PCBs	28	9	0	3	3	43
Other (specific conductance, carbonate, pH, total organic carbon)	0	3	0	1	NA	4
(ammonia, nitrate-nitrite)	28	9	0	3	3	43
(particle size analysis and bulk density testing)	6	2	0	1	NA	9
Air Samples (total suspended particulate and respirable particulate matter)	16	0	0	0	NA	16
Sediment Samples (Full suite plus TCL VOCs)	3	0	1 <sup>d</sup>	1	1	6

<sup>a</sup> 5% for soil samples.

<sup>b</sup> 20% will be also submitted for analysis of the very fine fraction.

<sup>c</sup> One duplicate analysis will be performed on the analysis of the very fine fraction.

<sup>d</sup> Trip Blank for TCL VOCs only.

NA = Not applicable

The fortified concentration will be specified by laboratory quality control requirements, or may be determined relative to background concentrations observed in the unfortified sample. In the latter case, the fortified concentration should be two to five times the background concentration to permit a reliable recovery calculation.

The quality assurance objectives for organic and inorganic analyses are tailored to the analytical technique used, and are discussed separately in subsequent sections.

### 3.2.1 Metals Analysis

For analysis of metals analytical accuracy is obtained from the analyte recovery measured in a laboratory control standard and/or sample fortified (spiked) with the element of interest. For this project, ten percent of the environmental samples submitted for analysis will be spiked. The QA objectives for accuracy in routine metals analysis for these QC samples are summarized below:

<u>Sample</u>	<u>Recovery (%)</u>
Laboratory Control Standard (LCS)	80-120
Spike Field Sample	75-125

Recovery values outside the QC limits for a Laboratory Control Standard (LCS) for the metals to be analyzed in this project will trigger compensatory action. Recovery values for fortified field samples are advisory only, and do not trigger corrective action.

### 3.2.2 Organic Analysis (GC and GC/MS)

For organic analysis, analytical accuracy is obtained from the surrogate recovery measured in each sample and blank and/or from the analysis of samples or blanks which have been fortified with a select number of target analytes. For this project ten percent of the samples submitted for analysis will be fortified.

The QA objectives for accuracy are summarized in Table 3-3 for GC/MS surrogates and in Table 3-4 for GC/MS fortified samples. The recovery values for surrogates and target analytes in investigative sample analyses are advisory for routine laboratory analysis, whereas only recovery values for standard matrix samples (e.g., blanks) are used for triggering corrective action.

### 3.3 SENSITIVITY

The sensitivity for each analytical parameter using the assigned methodology is sufficient to meet the project requirements. The project specific sensitivities (quantitation limits) for each parameter are listed in the GRRASP or CLP method and are listed in Table 1-7.

### 3.4 QUALITY ASSURANCE OBJECTIVES FOR PRECISION

Analytical precision is calculated by expressing the difference between duplicate sample analytical results relative to the average of those results for a given analyte expressed as a percentage. precision can be expressed by the formula:

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

where:        RPD    =    Relative percent difference  
                  C<sub>1</sub>    =    Concentration of analyte in sample  
                  C<sub>2</sub>    =    Concentration of analyte in replicate

On the occasion when three or more replicate analyses are performed, precision is expressed as the standard deviation of the analytical results of the replicate determination relative to the average of those results for a given analyte as a percentage. This precision measurement,

Table 3-3

Quality Assurance Objectives for Accuracy  
for Organic Surrogate Analyses

Fraction**	Surrogate Compound	% Recovery Limits*	
		Low/Medium Water	Low/Medium Soil/Sediment
BNA	Nitrobenzene-d5	35-114	23-120
BNA	2-Fluorobiphenyl	43-116	30-115
BNA	p-Terphenyl-d14	33-141	18-137
BNA	Phenol-d5	10-94	24-113
BNA	2-Fluorophenol	21-100	25-121
BNA	2,4,6-Tribromophenol	10-123	19-122

\*U.S. EPA (1986). SW-846, 3rd Edition. Methods 8240 and 8270.

\*\*BNA Semivolatile Base/Neutral Extractable.

Table 3-4

Quality Assurance Objectives for Accuracy and Precision  
for Organic Target Compound Analyses

Fraction	Matrix Spike Compound	% Recovery Limits		% RPD Limits	
		Water	Soil/Sed	Water	Soil/Sed
BN	1,2,4-Trichlorobenzene	39- 98	38-107	28	23
BN	Acenaphthene	46-118	31-137	31	19
BN	2,4-Dinitrotoluene	24- 96	28- 89	38	47
BN	Pyrene	46-127	35-142	31	36
BN	N-nitroso-di-N-propylamine	41-116	41-126	38	38
BN	1,4-Dichlorobenzene	36- 97	28-104	28	27
PESTICIDE	Lindane	56-123	46-127	15	50
PESTICIDE	Heptachlor	40-131	35-130	20	31
PESTICIDE	Aldrin	40-120	34-132	22	43
PESTICIDE	Dieldrin	56-126	31-134	18	38
PESTICIDE	Endrin	56-121	42-139	21	45
PESTICIDE	4,4-DDT	38-127	23-134	27	50
PCB	Arochlor 1254	Not established		30*	50*

% RPD - Relative Percent Difference

This list includes those compounds most commonly used for QA/QC accuracy and precision control in the groups of analytes shown based on current U.S. EPA CLP requirements. (USEPA SOW 2/88 as revised through 5/89.) Stated control limits will be updated to the current CLP protocol, as required.

\* Laboratory Determined Limits

percent relative deviation (% RSD), will have QA objectives identical to those for % RPD, and can be expressed by the formula:

$$\%RSD = \frac{\sum [C^2 - ((C)^2/n)]/(n-1) \times 100\%}{(C_1 + \dots C_n)/n}$$

where: RSD = percent relative deviation  
C = concentration of analyte in the sample, and (C<sub>1</sub> + C<sub>2</sub> + ...C<sub>n</sub>) represents the sum of the concentration of each replicate  
n = number of replicate analyses  
Σ = "the summation of"

The QA objectives for metals (and other inorganic parameters) analysis are different from those for organic analyses. These QA objectives are discussed separately in subsequent sections below.

### 3.4.1 Metals Analyses

For the metals analyses, the QA objective for precision is ± 20% RPD for soils (EPA, 1990b). Percent RPD values outside the QC limits for duplicate LCS analyses will trigger corrective action. Percent RPD for duplicate investigative sample analyses are advisory only. For this project, five percent of the investigative samples submitted for analysis will be analyzed in duplicate.

### 3.4.2 Organic Analyses (GC, GC/MS)

For organic analyses, precision is measured by comparison of the recovery of a select number of target analytes in duplicate fortified samples for duplicate fortified blanks (e.g., matrix spike/matrix spike duplicate (MS/MSD), and/or blank spike/blank spike duplicate (MS/MSD)). For typical GC/MS or GC analysis, two sample containers are collected for each analysis. Ten percent of the samples are collected in triplicate; one for investigative sample analysis, one for matrix spike analysis, and one for a matrix spike duplicate analysis. The QA objectives for precision as expressed by the % RPD for duplicate analysis of target analytes are given in Table

3-3. These RPD limits for investigative samples provide an indication of sample homogeneity and representativeness.

The laboratory QA Officer will be responsible for insuring analytical results meet QC criteria described for the appropriate EPA analytical method and for implementing corrective actions and specified in the analytical methods. Corrective actions may include a laboratory audit to resolve problems and reanalysis of the samples or, if difficulties cannot be resolved, resampling and submittal to another laboratory.

### 3.5 REPRESENTATIVENESS

Representativeness expresses the degree to which sample data accurately and precisely represent a population characteristic, parameter variations at a sampling point, or an environmental condition. Care has been taken in the design of the sampling program (described in Section 2 of the SAP) to ensure that sample locations are selected properly, consistency in sample collection techniques is maintained, that a sufficient number of samples are collected to accurately reflect conditions at the site, and that samples are representative of the sampling locations. The statistical method used to derive the number of investigative samples to be collected will provide data which is representative of the study area.

### 3.6 DATA COMPARABILITY

Published standard sampling and analytical methods will be used for chemical analyses. Reports will contain final results (uncorrected for blanks and recoveries), methods of analysis, levels of detection, surrogate recovery data, and method blank data. In addition, special analytical problems, and/or any modifications of referenced methods will be noted. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical methods. Consequently, most analytical results will be reported to no more than two (2) significant figures. Data are normally reported in units commonly used for the analyses performed. Concentrations in liquids are expressed in terms of weight per unit volume (e.g., milligrams per liter). Concentrations in solid or semi-solid matrices are expressed in terms of weight per unit weight of sample (e.g., micrograms per gram). Reported detection limits will

be the concentration in the original matrix corresponding to the low level instrument calibration standard after concentration, dilution, and/or extraction factors are accounted for, unless otherwise specified by program requirements. Through the use of the Rocky Flats method, the data collected during implementation of this SAP will be comparable with previously collected data. In addition, analysis of previously obtained samples were performed through the use of CLP-RAS and therefore will be comparable to the data resulting from the analyses of the samples collected during this program.

### 3.7 COMPLETENESS

Completeness is a measure of the amount of valid data compared to the amount of planned data for a specific set of measurements. It is expressed as a percentage. Historical completeness for CLP-RAS is 80 to 85%. For sampling completeness, a goal of 90% has been set for this program

### 3.8 SAMPLE MANAGEMENT

Field preparation requires organizing sample containers and sample labels, and documenting in an orderly, systematic manner that promotes consistency and traceability of data. Table 3-5 lists the appropriate sample containers, volume, preservative, and holding time for each proposed analytical suite/parameter. The precleaned sample containers will be furnished by the EG&G selected contract analytical laboratory conducting the analysis.

Each collected sample will be properly labeled, sealed, and placed in an appropriate container for transport to the analytical laboratory. Chain-of-custody seals which serve as tamper detection devices will be placed around the top of each sample container and shipping vessel. All collected samples will be logged onto an appropriate chain-of-custody form. Custody transfers made will be documented on the form with the signature of the relinquishing and receiving parties followed by the date of the transfer. All appropriate chain-of-custody protocols will be implemented throughout the collection, shipping, and analysis activities.

**Table 3-5**

**Sample Containers, Volume, Preservation, and Holding Times**

Analyte	Sample Container <sup>a</sup>	Sample Volume	Preservation	Holding Time
Metals	8 oz glass	10 g	None	6 months <sup>b</sup>
Oil and Grease	4 oz glass	10 g	Cool, 4 degree C	28 days
Radionuclides	8 oz glass	100 g	None	None
TCL Semi-Volatiles (base/neutral extractables)	8 oz glass	10 g	Cool, 4 degree C	7/40 <sup>c</sup>
TCL Pesticide/PCBs	8 oz glass	20 g	Cool, 4 degree C	14/40 <sup>d</sup>
Particle Size Analysis and Bulk Density Testing	16 oz glass	200-500 g	None	None
Ammonia and Nitrate-Nitrite	8 oz glass	110 g	Cool, 4 degree C	28 days
Other	16 oz glass	250 g	Cool, 4 degree C	14 days

<sup>a</sup> Clear wide mouth glass jars

<sup>b</sup> Holding time for mercury is 28 days

<sup>c</sup> 7 days from collection to extraction and 40 days from extraction to analysis

<sup>d</sup> 14 days from collection to extraction and 40 days from extraction to analysis

### 3.9 DATA REPORTING

The chain-of-custody documentation will be included in the data package received from the analytical laboratory. The analytical data will be submitted to EG&G via electronic diskette for input into the RFEDS data tracking system.

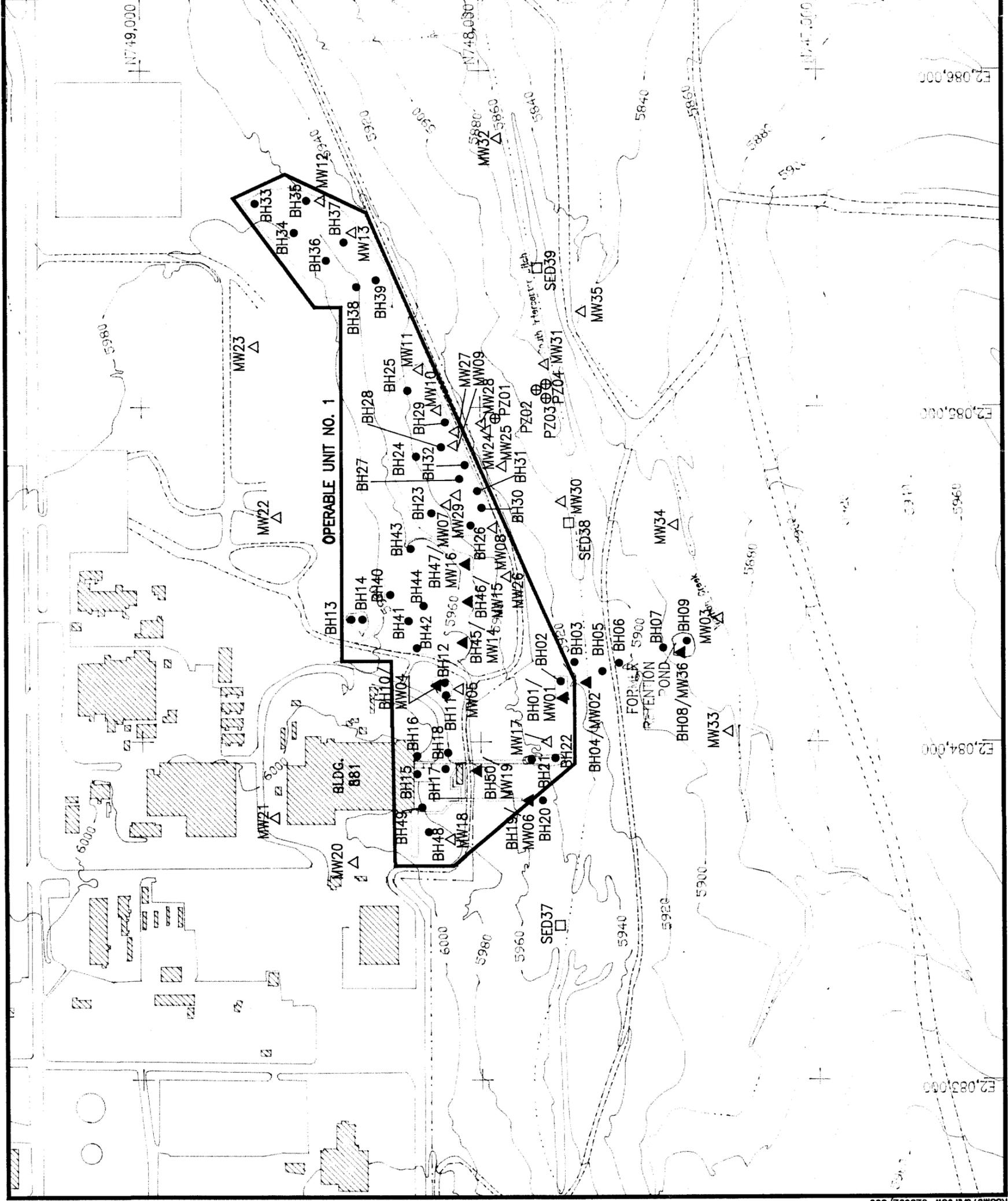
## SECTION 4

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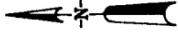
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**EXPLANATION**

Individual Hazardous Substance Site (IHSS)

- MW01 1991 Monitor Well
- BH01 1991 Borehole
- BH01/MW01 1991 Borehole and Monitor Well
- PZ01 1991 Piezometer
- SED39 1991 Sediment Stations



Scale: 1" = 300'



CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

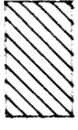
OPERABLE UNIT NO. 1  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

PHASE III RFI/RI  
MONITOR WELL, BOREHOLE, PIEZOMETER,  
AND SEDIMENT STATION LOCATIONS

FIGURE 1-1

February, 1992

**EXPLANATION**



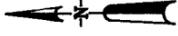
Individual Hazardous Substance Site (IHSS)

145

IHSS Designation



Maximum Extent of IHSS 119 Barrel Storage Based on Aerial Photographs dated 04/29/67, 04/10/68, 05/24/69, and 03/30/71.



Scale: 1" = 300'  
0' 150' 300'  
CONTOUR INTERVAL = 20'

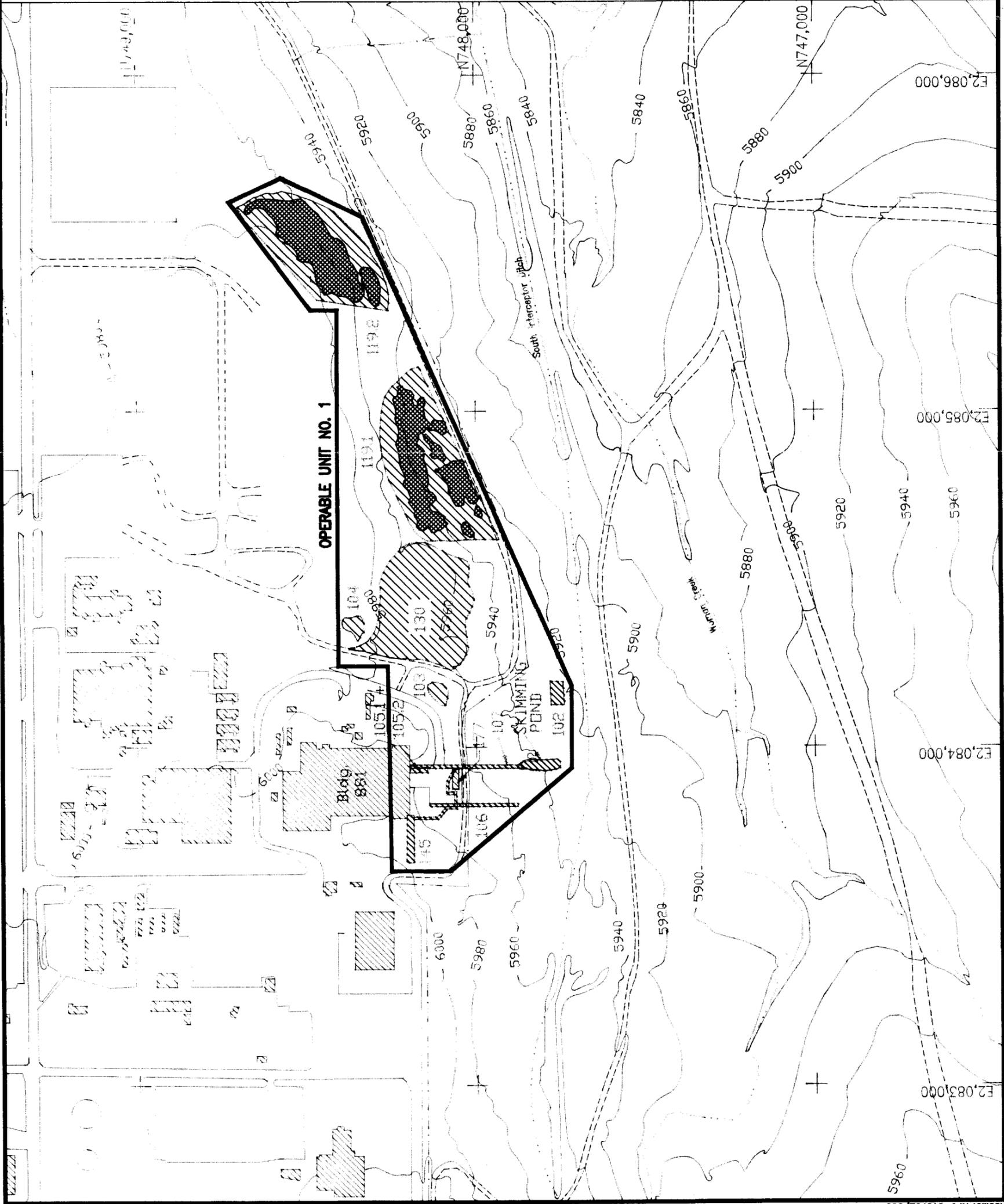
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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

INDIVIDUAL HAZARDOUS SUBSTANCE  
SITE LOCATIONS

FIGURE 1-2

February, 1992



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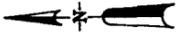
**EXPLANATION**

- B301889 ○ Alluvial Monitoring Well
- B304789 ● Bedrock Monitoring Well
- 0271 △ Pre-1986 Well
- 1187A + Abandoned Hole
- BH0987 ○ Borehole



Seepage from IHS 102 Based on Aerial Photographs Dated 05/11/55.  
 Maximum Extent of IHS 119 Barrel Storage Based on Aerial Photographs dated 04/29/67, 04/10/68, 05/24/69, and 03/30/71.

Individual Hazardous Substance Site (IHS)



Scale: 1" = 300'  
 0' 150' 300'  
 CONTOUR INTERVAL = 20'

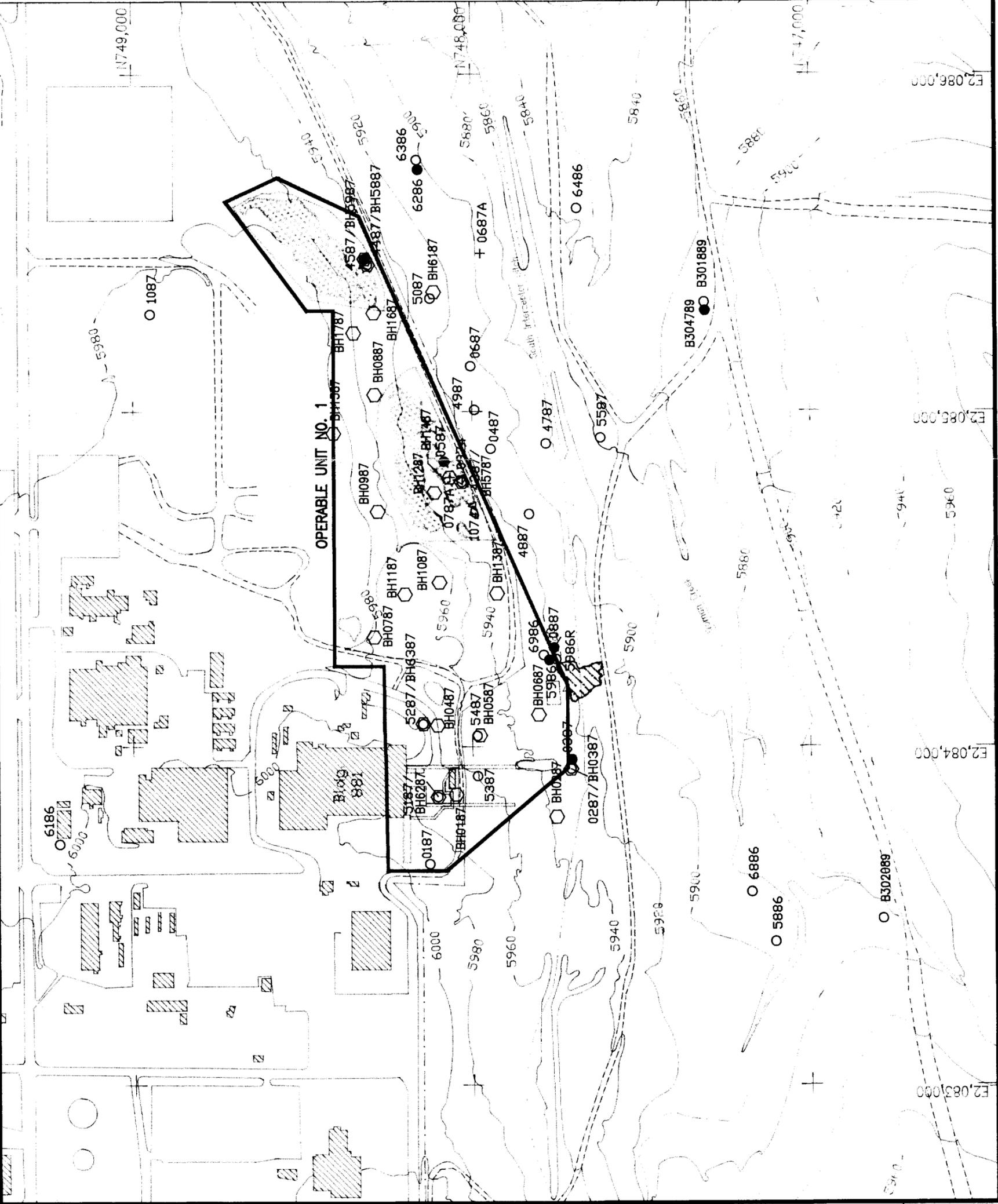
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OPERABLE UNIT NO. 1  
 SURFACE SOIL SAMPLING AND ANALYSIS PLAN

PHASE I AND PHASE II RI  
 BOREHOLE AND MONITOR WELL LOCATIONS

FIGURE 1-3

February, 1992



R33M077/Pd-010792/300

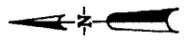
EXPLANATION

Individual Hazardous Substance Site (IHSS)

IHSS Designation

Maximum Extent of IHSS 119 Barrel Storage Based on Aerial Photographs dated 04/29/67, 04/10/68, 05/24/69, and 03/30/71.

Approximate Surface Soil Scrape Location



Scale: 1" = 300'  
0' 150' 300'  
CONTOUR INTERVAL = 20'

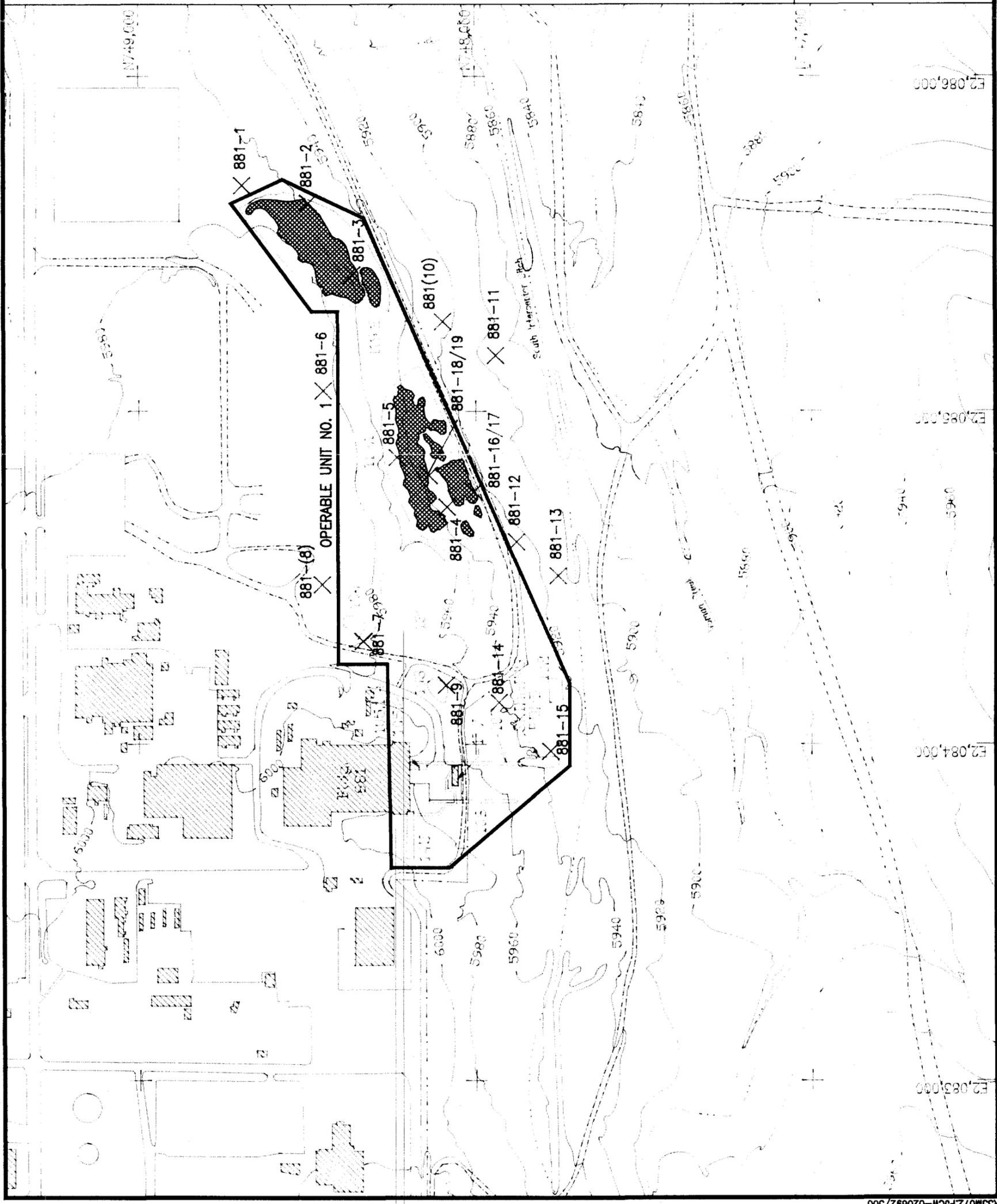
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OPERABLE UNIT NO. 1  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

SURFACE SCRAPE SAMPLING LOCATIONS  
(September 1988)

FIGURE 1-4

February, 1992



EXPLANATION

- Contact Between Surficial Materials
- Base of Weathering and Boundary between Hydrostratigraphic Units
- ▨ Disturbed Ground
- - - Volatilization
- Potential Ground-water Pathway
- ||||| Potential Radionuclide Contaminated Soils
- ~ Wind Blown Pathway (resuspension)
- Stream Surface
- Groundwater Surface
- Surface Runoff Pathway
- ⌒ Sediments

**CRETACEOUS ARAPAHOE FORMATION**  
 Kacu Unweathered Claystone/Siltstone  
 Kacw Weathered Claystone/Siltstone

**QUATERNARY UNITS**  
 Qrf Rocky Flats Alluvium  
 Qc Colluvium Deposits  
 Qvf Valley Fill Alluvium

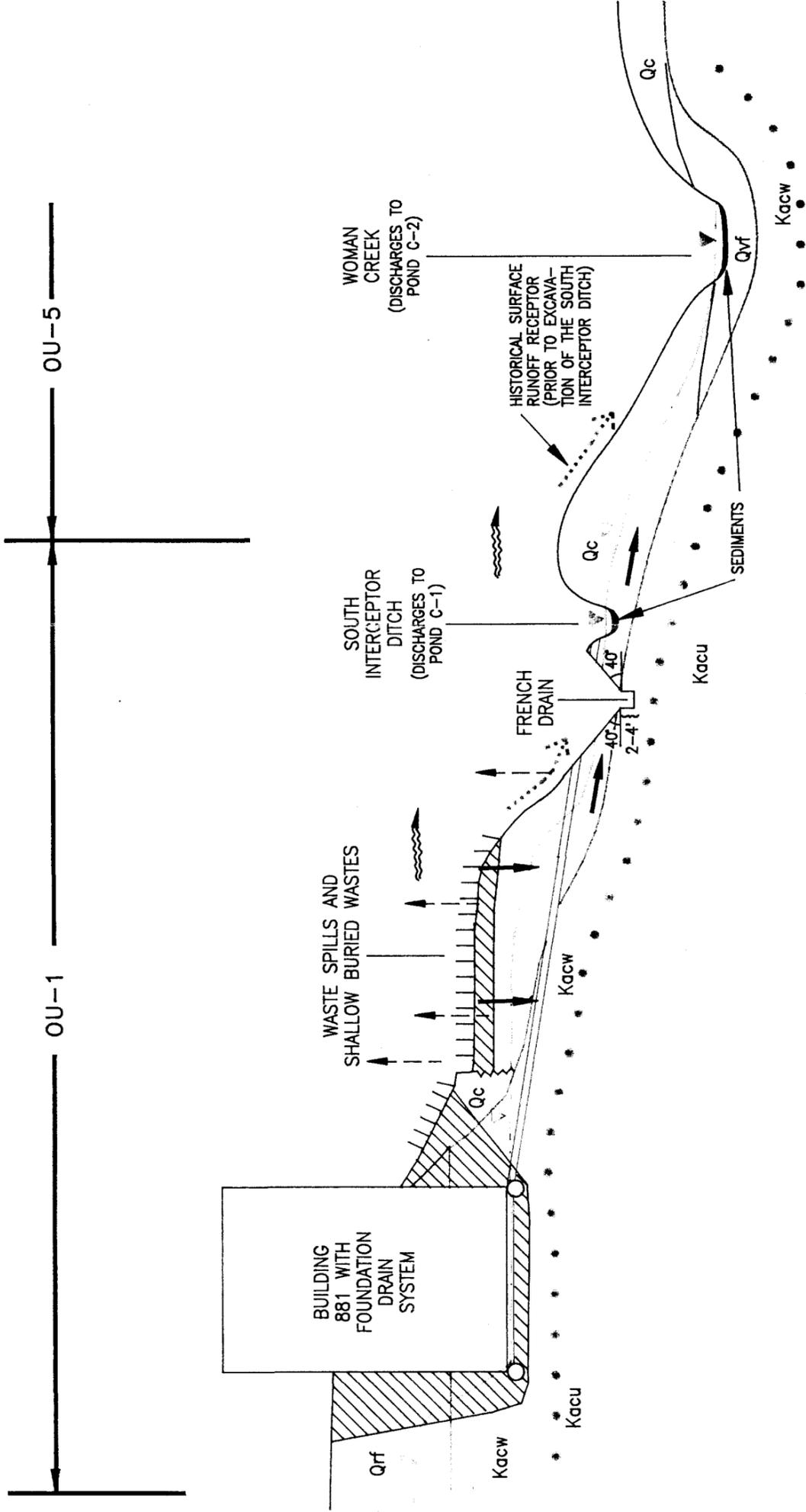
SCHEMATIC CROSS-SECTIONAL VIEW

NOT TO SCALE

U.S. DEPARTMENT OF ENERGY  
 Rocky Flats Plant, Golden, Colorado  
 OPERABLE UNIT NO. 1  
 SURFACE SOIL SAMPLING AND ANALYSIS PLAN

CONCEPTUAL MODEL

FIGURE 1-5 February, 1992



**EXPLANATION**

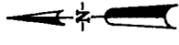
-  ESTIMATED MAXIMUM EXTENT OF SURFICIAL SOILS CONTAINING TWO dpm/g ACTIVITY BY CDH PROTOCOL
-  10 ACRE SAMPLING PLOT LOCATIONS
-  10 ACRE SAMPLING PLOT LOCATIONS NORTH AND SOUTH OF OPERABLE UNIT 2
-  2.5 ACRE SAMPLING PLOT LOCATIONS
-  SOIL TYPE BOUNDARY AND NUMBER

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, 1980

SOIL TYPE NUMBER

SERIES

- 27 DENVER
- 29 DENVER-KUTCH
- 31 DENVER-KUTCH-MIDWAY
- 42 ENGLEWOOD
- 45 FLATIRONS
- 60 HAVERSON
- 80 LEYDEN-PRIMEN-STANDLEY
- 98 MIDWAY
- 100 NEDERLAND
- 102 NUNN
- 103 NUNN
- 149 STANDLEY-NUNN
- 174 WILLOWMAN-LEYDEN



1" = 1000'



CONTOUR INTERVAL = 20'

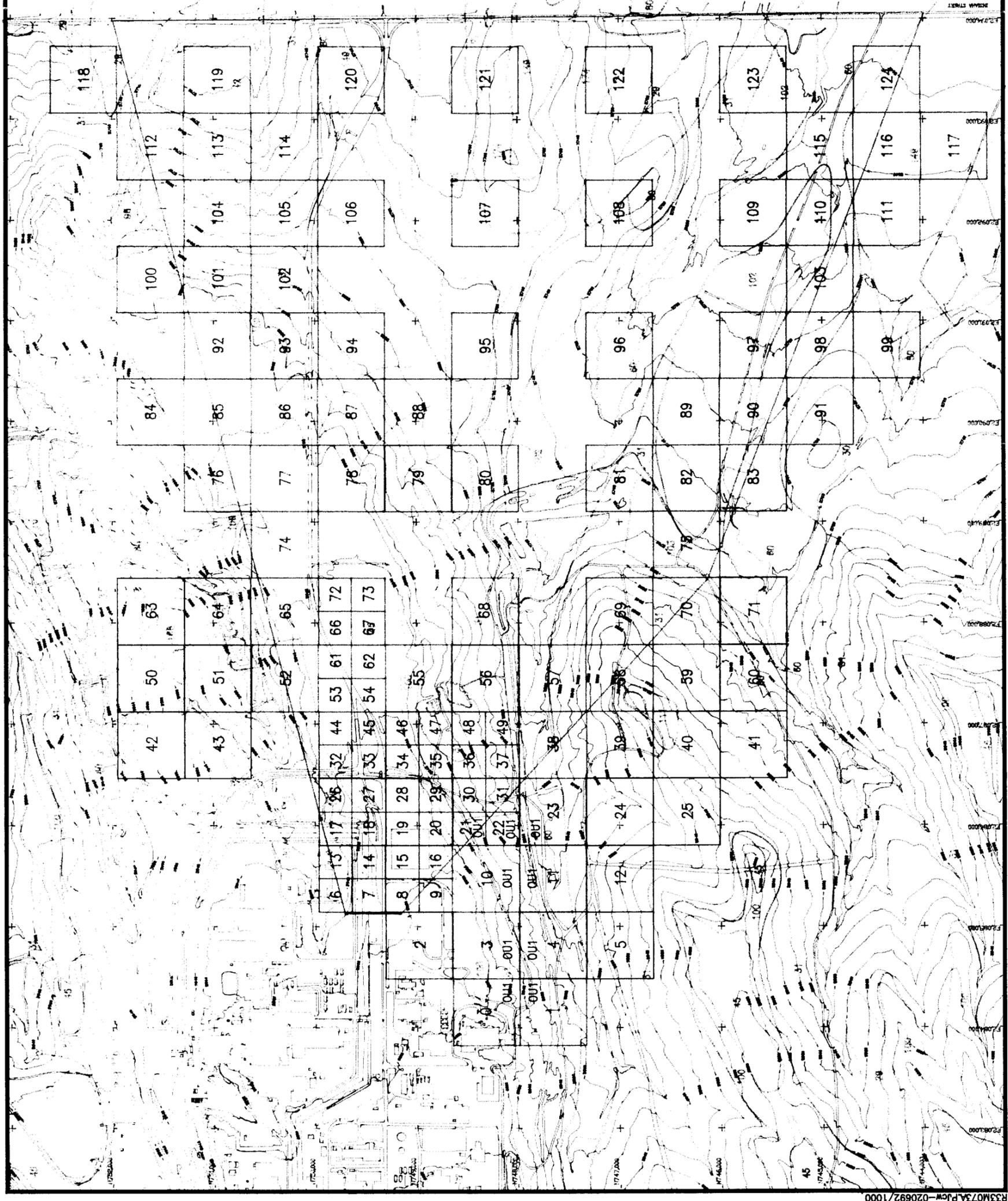
U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

OPERABLE UNITS NO. 1 AND 2  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

SURFICIAL SOIL SAMPLING  
PLOT IDENTIFICATION NUMBERS

FIGURE 2-1

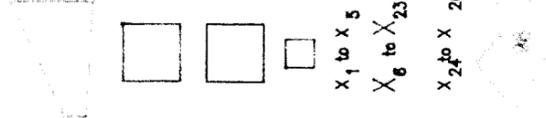
February, 1992



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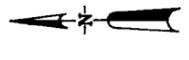
**EXPLANATION**

- ESTIMATED MAXIMUM EXTENT OF SURFICIAL SOILS CONTAINING TWO ppm/g ACTIVITY BY CDH PROTOCOL
- 10 ACRE SAMPLING PLOT LOCATIONS
- 10 ACRE SAMPLING PLOT LOCATIONS NORTH AND SOUTH OF OPERABLE UNIT 2
- 2.5 ACRE SAMPLING PLOT LOCATIONS
- LOCATION OF SOIL SOLUTION SAMPLERS
- SOIL PROFILE SAMPLING LOCATIONS FOR OPERABLE UNIT NO. 2
- SOIL PROFILE SAMPLING LOCATIONS FOR OPERABLE UNIT NO. 1
- SOIL TYPE BOUNDARY AND NUMBER



SOURCE: U.S. DEPARTMENT OF AGRICULTURE, 1980

SOIL TYPE NUMBER	SERIES
27	DENVER
29	DENVER-KUTCH
31	DENVER-KUTCH-MIDWAY
42	ENGLEWOOD
45	FLATRONS
60	HAYPERSON
80	LEYDEN-PRIMEN-STANDLEY
98	MIDWAY
100	NEDERLAND
102	NUNN
103	NUNN
149	STANDLEY-NUNN
174	WILLOWMAN-LEYDEN



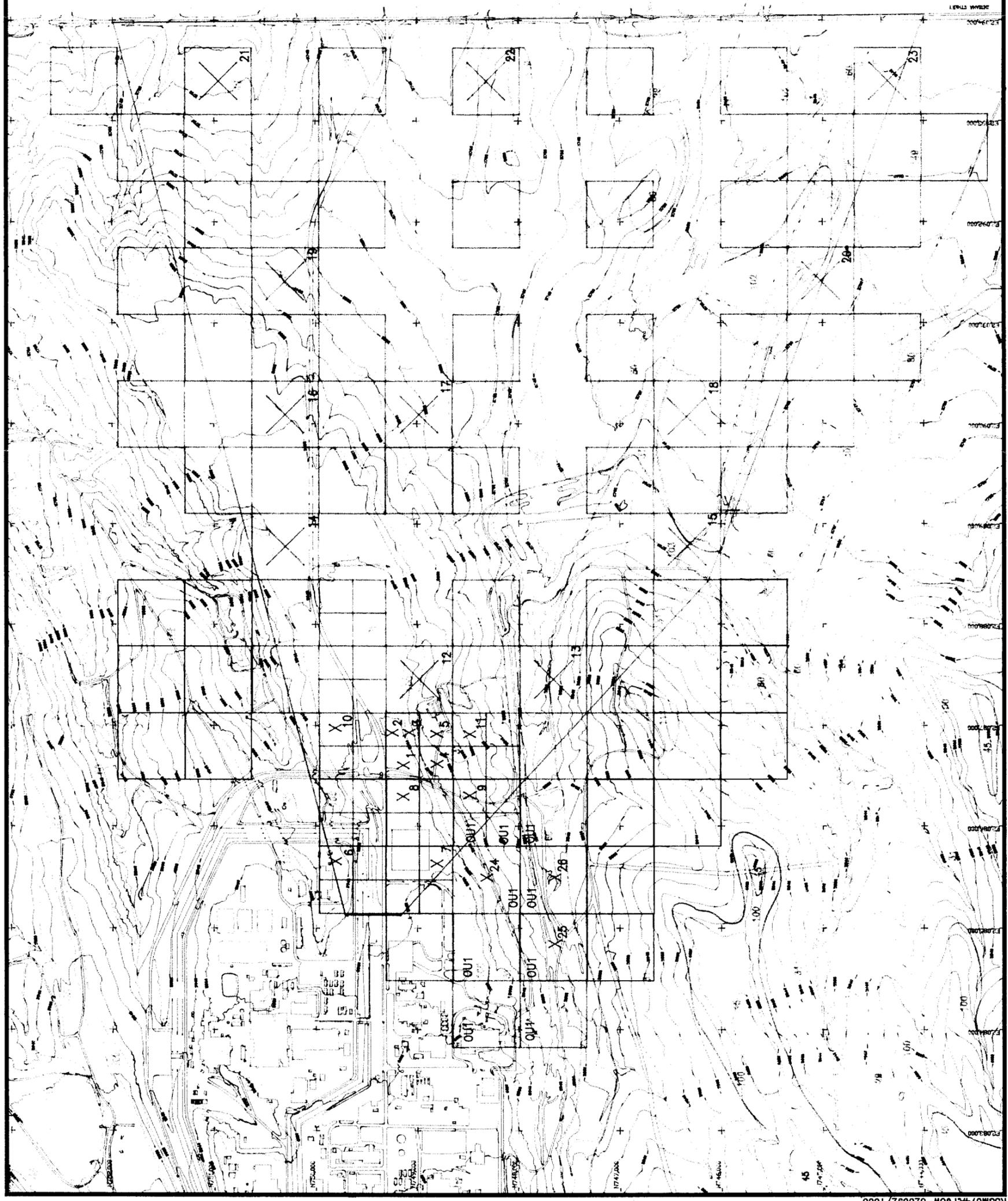
1" = 1000'  
 0' 500' 1000'  
 CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY  
 Rocky Flats Plant, Golden, Colorado  
 OPERABLE UNITS NO. 1 AND 2  
 SURFACE SOIL SAMPLING AND ANALYSIS PLAN

**SURFICIAL SOIL SAMPLING LOCATIONS**

FIGURE 2-3

February, 1992



EXPLANATION

SOIL TYPE BOUNDARY AND NUMBER

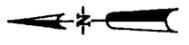
SOURCE: U.S. DEPARTMENT OF AGRICULTURE, 1980

SOIL TYPE NUMBER      SERIES

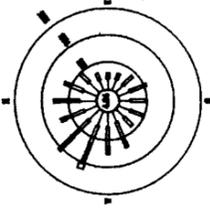
- 31 DENVER-KUTCH-MIDWAY
- 45 FLATRONS
- 46 FLATRONS
- 60 HAVERSON
- 100 NEDERLAND

PROPOSED SURFICIAL SOIL POLYGON  
(100' X 50')

BACKGROUND SURFACE SOIL  
SAMPLING LOCATIONS



Scale: 1" = 500'  
0' 250' 500'  
CONTOUR INTERVAL = 20'



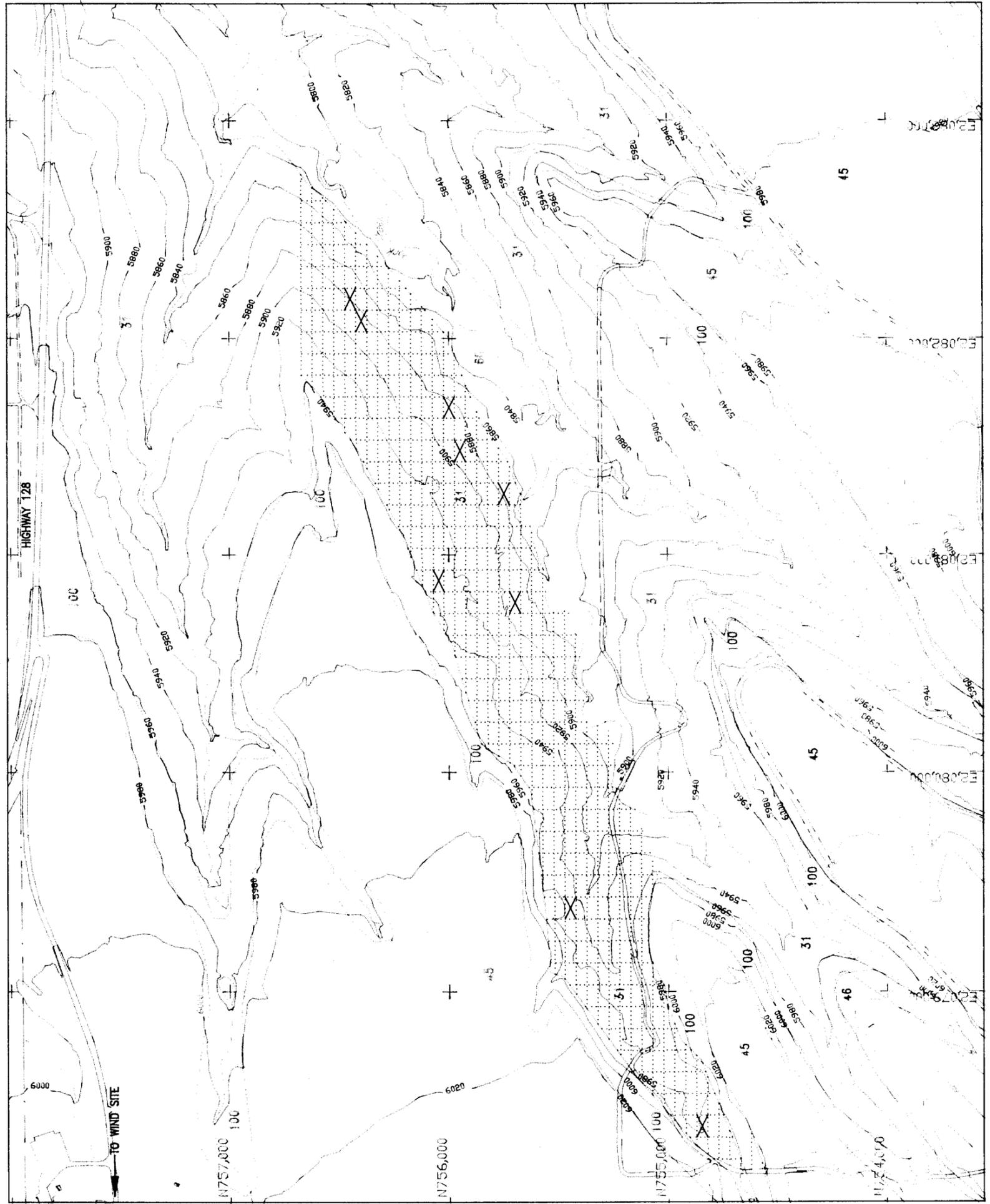
RFP 1990 WIND ROSE  
SOURCE: EC&G, 1990d

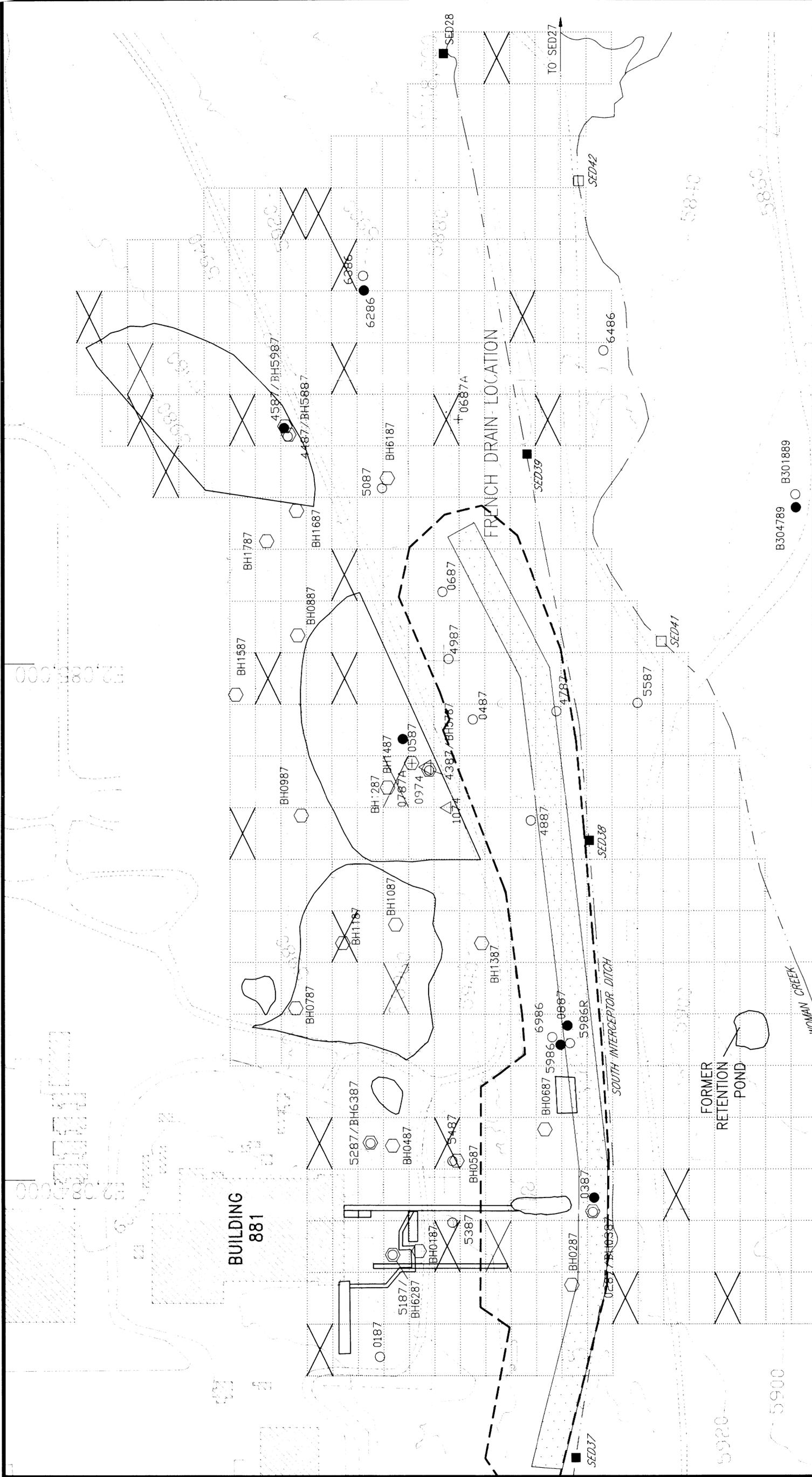
U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

BACKGROUND SURFACE SOIL  
SAMPLE AREA

FIGURE 2-5 February, 1992





U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1  
SURFACE SOIL SAMPLING AND ANALYSIS PLAN

**PROPOSED SURFACE SOIL  
SAMPLING LOCATIONS**

PLATE 1 February, 1992

EXPLANATION	
B301889 ○	Alluvial Monitoring Well
B304789 ●	Bedrock Monitoring Well
0271 △	Pre-1986 Well
1187A +	Abandoned Hole
BH0987 ○	Borehole
□	Individual Hazardous Substance Site (IHSS)
SED28 ■	Existing Sediment Stations
SED39 □	Proposed Sediment Stations
○	Proposed Surficial Soil Polygon (100'x50')
⊗	Proposed Biased Surface Soil Sampling Polygon
⊗	Proposed Surface Soil Sampling Polygon
○	Approx. Extent of Surface Disturbed Area due to French Drain Excavation Activities
○	Approximate Extent of French Drain

1" = 100'  
0' 100' 200'  
CONTOUR INTERVAL = 20'

N

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