NOTICE

All drawings located at the end of the document.

00003362 4

ORRES. CONTROL
OUTGOING LTR NO.

DOE ORDER # 4700.1
4 RF 4700.1

DIST.	LTR	ENC
MARAL, M.E.		
ERMAN, H.S.		
RANCH, D.B.		
ARNIVAL, G.J.		
OPP, R.D.		
AVIS, J.G.		
ERRERA, D.W.		
ANNI, B.J.		
ARMAN, L. K.		
EALY, T.J.		
EDAHL, T.		
ILBIG, J.G.		
UTCHINS, N.M.		
ELL, R.E.		
IRBY, W.A.		
UESTER, A.W.		
IAHAFFEY, J.W.		
IANN, H.P.		
IARX, G.E.		
IcDONALD, M.M.		
IcKENNA, F.G.		
IONTROSE, J.K.		
IORGAN, R.V.		
OTTER, G.L.		
IZZUTO, V.M.		
ISING, T.L.		
ANDLIN, N.B.		
ETLOCK, G.H.		
TEWART, D.L.		
TIGER, S.G.		
ULLIVAN, M.T.		
WANSON, E.R.		
VILKINSON, R.B.		
VILSON, J. M.		
VYANT, R.D.		
D.S. Busby	X	
K. Madel	X	
A.D. Klein	X	
R.J. McLaughlin	X	
CORRES CONTROL	x	x
ADMN RECORD/080	X	
TRAFFIC		
PATS/T130G		

CLASSIFICATION:

UCNI		
UNCLASSIFIED		
CONFIDENTIAL		
SECRET		

AUTHORIZED CLASSIFIER SIGNATURE

DATE 7/5/94

IN REPLY TO RFP CC NO:

ACTION ITEM STATUS
☐ PARTIAL/OPEN
☐ CLOSED

LTR APPROVALS:

ORIG & TYPIST INITIALS
REM:bll

RF-46469 (Rev. 01/94)

EG&G ROCKY FLATS

2C102

EG&G ROCKY FLATS, INC.
ROCKY FLATS PLANT, P.O. BOX 464, GOLDEN, COLORADO 80402-0464 • (303) 966-7000

July 5, 1994

94-RF-07170

Scott R. Grace
Environmental Restoration Division
DOE/RFFO

DRAFT SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL ACTION SOIL VAPOR EXTRACTION PILOT TEST PLAN, TEST SITE NO. 2, ENHANCED VAPOR EXTRACTION OF ORGANIC COMPOUNDS WITH SIX-PHASE SOIL HEATING - GRK-021-94

Action: *Requesting comments on the Test Plan by July 27, 1994*

EG&G Rocky Flats, Inc., is transmitting eight (8) copies of the Test Plan titled "Enhanced Vapor Extraction of Organic Compounds with Six-Phase Soil Heating," to the Department of Energy/ Rocky Flats Field Office, in accordance with the Interagency Agreement milestone submittal date of July 6 1994. Two (2) copies of the Test Plan are to be transmitted to the Environmental Protection Agency and two (2) copies to the Colorado Department of Health. As previously agreed, copies of the Test Plan will also be submitted to the Technical Review Group for review.

EG&G Rocky Flats, Inc., is requesting comments on the Test Plan by July 27, 1994, in order to finalize the Test Plan and begin work on the Implementation Plan. If you have any questions regarding the attached report, please contact R. E. Madel of Operable Unit 2 Closure at extension 6972.

G. R. Konwinski
Manager
Treatability Studies/Feasibility Studies

REM:bll

cc:
original and 1 cc - S. R. Grace

Enclosures:
As Stated (8)

cc:
E. A. Dille - Aguirre Engineering w/o Enc.
T. C. Greengard - SAIC, Inc. w/o Enc.

1/101

000033624
RFP/ERM-94-00031

Draft

Subsurface Interim Measures/Interim Remedial Action
Soil Vapor Extraction Pilot Test Plan
Test Site No. 2

Enhanced Vapor Extraction of Organic Compounds with Six-Phase Soil Heating

Operable Unit No. 2

East Trenches Area

U.S. Department of Energy

Rocky Flats Plant
Golden, Colorado

Environmental Restoration Management

July 6, 1994

EXECUTIVE SUMMARY

The U.S. Department Of Energy (DOE), in accordance with the InterAgency Agreement with the Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH), has prepared a Test Plan for completion of the Subsurface Interim Measures/Interim Remedial Action (IM/IRA) at Operable Unit No. 2 (OU 2) at the Rocky Flats Plant (RFP). The Subsurface Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document (IM/IRAP) addressed residual, free-phase Volatile Organic Compound (VOC) contamination in the subsurface within three areas of OU 2. The purpose of the IM/IRA is to gain site-specific remedial information to support a final remedial action at OU 2.

The IM/IRAP identified Soil Vapor Extraction (SVE) as an applicable *in-situ* technology for remediation of VOCs in the subsurface. Test Site No. 1 of the Pilot Test Program, which was performed at Individual Hazardous Substance Site (IHSS) 110 (also known as Trench T-3), applied a conventional SVE system to the subsurface VOC contamination. Results from Test Site No. 1 indicated that the permeability of subsurface soils is low; therefore, the soils are not amenable to conventional SVE.

Test Site No. 2 will incorporate resistive heating, specifically Six-Phase Soil Heating (SPSH), as an enhancement to conventional SVE. Six-Phase Soil Heating is an emerging technology for the *in-situ* remediation of subsurface VOCs. The technology uses six-phase electricity to resistively heat soils, boiling and volatilizing contaminants and to facilitate collection using conventional SVE technology.

The primary objective of the pilot test at Test Site No. 2 is to evaluate SPSH as an applicable *in-situ* technology for remediating VOC contaminated soils at OU 2. The evaluation of the technology will be based on EPA guidance criteria for effectiveness, implementability, and cost (EPA 1988). Effectiveness will be evaluated as the ability of SPSH, compared with conventional SVE, to accelerate VOC removal and increase the extent of removal of VOCs existing with an inhibiting co-contaminant. Implementability will be evaluated as the technical and administrative feasibility of

3

implementing SPSH at OU 2 including operation and maintenance reliability. Cost data will be collected in order to project cost effectiveness of SPSH at other OU 2 sites.

Implementation of the IM/IRA at Test Site No. 2 will also include design and construction of an off-gas treatment system to treat the increased contaminant concentration, high flowrates and high steam content anticipated in the SPSH pilot test off-gas. The off-gas treatment system will include a thermal oxidation unit, condenser, air stripper, caustic scrubber, and HEPA filter.

An Observational Approach will be used to determine the extent of contaminant migration beneath the trench and the corresponding depth of the treatment zone required. The maximum depth of the treatment zone will be 20 feet to 25 feet as set by the seasonal groundwater level fluctuations, so that only unsaturated soil is targeted. Multiple heating arrays will be installed over the length of the IHSS 110 trench. The use of multiple arrays allows for optimization of VOC removal and expedited remediation as each array is heated sequentially along the trench. A combination of vertical and horizontal wells and a surface plenum will be used to extract contaminants for treatment.

The pilot test will be performed in three operational phases:

- Baseline SVE,
- SPSH-SVE, and
- Cool down SVE.

Baseline SVE operations will provide the data required to extrapolate remediation costs using SVE alone and a benchmark for measuring improved VOC extraction due to SPSH. Heating operations will require an estimated 20 to 45 days per array depending on the electrical resistivity and water content of the heated region and contaminant extraction rates observed in the off-gas. Contaminants will continue to be extracted in the cool down phase of the test. The extent of heating and the direction of subsurface flow will be monitored during the test. Assessment of the technology will be performed through data collection, analysis, and interpretation.

Technical data will be collected to measure the performance of the SPSH pilot test against its objectives. Two primary data sets will be collected to evaluate the technical performance of the test; comparison of off-gas concentrations observed during SPSH operations to those observed during conventional SVE operation, and comparison of pre- and post-test soil VOC concentrations. The analysis and interpretation of this data will be presented in a final pilot test report.

This Test Plan is not intended to be used as a design document, Implementation Plan, or Operations and Maintenance Plan. Specific details governing the implementation, operation, sampling and monitoring, health and safety, and waste management for the pilot test at Test Site No. 2 will be provided in supplemental documentation.

TABLE OF CONTENTS

6

8

LIST OF FIGURES

10

11

LIST OF TABLES

LIST OF ACRONYMS

APEN .... Air Pollution Emission Notice
CCl4 .... Carbon Tetrachloride
CDH .... Colorado Department of Health
CERCLA .... Comprehensive Environmental Response, Compensation, and Liability Act
1,1-DCA 1,1-Dichlorethane
DMR .... Document Modification Request
DOE .... Department of Energy
DQO .... Data Quality Objectives
EPA .... Environmental Protection Agency
FS .... Feasibility Study
ft .... foot or feet
GAC .... Granular Activated Carbon
HCl .... Hydrochloric Acid
HEPA .... High Efficiency Particulate Air
Hg .... Mercury
IHSS .... Individual Hazardous Substance Site
IM/IRA .... Interim Measure/Interim Remedial Action
IM/IRAP/EADD .... Interim Measure/Interim Remedial Action Plan/ Environmental Assessment Decision Document
kg .... kilogram
lbs .... pounds
mm .... millimeter
NAPL .... Non-Aqueous Phase Liquid
O&M .... Operation and Maintenance
OU .... Operable Unit
PA .... Protected Area
PARCC .... Precision, accuracy, representativeness, completeness, and comparability
PCE .... Tetrachloroethylene

PID	Photoionization Detector
ppb	Parts per billion
ppm	Parts per million
psia	Pounds per Square Inch Absolute
P&ID	Process Instrumentation Diagram
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RFFO	Rocky Flats Field Office
RFP	Rocky Flats Plant
RI	Remedial Investigation
RMS	Root-Mean-Squared
scfm	Standard Cubic Feet per Minute
SO	System Operations
SOP	Standard Operating Procedures
SPSH	Six-Phase Soil Heating
SVE	Soil Vapor Extraction
TCE	Trichloroethylene
VOC	Volatile Organic Compound
W/m3	Watt per cubic meter
µg/l	Micrograms/liter
°C	Degrees Celsius

14

SECTION 1

INTRODUCTION

The U.S. Department Of Energy (DOE), in accordance with the InterAgency Agreement with the Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH), has prepared a Test Plan for completion of the Subsurface Interim Measures/Interim Remedial Action (IM/IRA) at Operable Unit No. 2 (OU 2) at the Rocky Flats Plant (RFP). The Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document (IM/IRAP) addressed residual, free-phase Volatile Organic Compound (VOC) contamination in the subsurface within three areas of OU 2. The IM/IRA is designed to gain site-specific remedial information to support a final remedial action at OU 2.

The IM/IRAP identified Soil Vapor Extraction (SVE) as an applicable *in-situ* technology for remediation of VOCs in the subsurface. The SVE Pilot Test Program was the only action identified in the IM/IRAP. Test Site No. 1 of the Pilot Test Program, which was performed at Individual Hazardous Substance Site (IHSS) 110 (also known as Trench T-3), applied a conventional SVE system that utilized granular activated carbon (GAC) as an off-gas treatment system. Test Site No. 1 was conducted within both the Rocky Flats Alluvium (RFA) and the No. 1 Sandstone geologic units.

Results from Test Site No. 1 have indicated that the permeability of both geologic units is low. Application of conventional SVE alone was not effective in those units, because low flowrates allowed only a minimal amount of VOCs to be recovered from the soil. In addition, it is believed that the VOC contamination in the subsurface at IHSS 110 exists within a non-volatile co-contaminant and is present as a residual Non-Aqueous Phase Liquid (NAPL). The co-contaminant, most likely oil, reduces the concentration of VOCs in the off-gas. The low flowrate, combined with the non-volatile co-contaminant, minimized the effectiveness of SVE alone at Test Site No. 1.

15

Test Site No. 2 will incorporate *in-situ* resistive soil heating, specifically Six-phase Soil Heating (SPSH), to address the low contaminant removal rate at IHSS 110. The SPSH system will be added as an enhancement to SVE. Six-Phase Soil Heating (SPSH) heats the soil by applying a voltage to electrodes installed in the subsurface. Contaminant removal is enhanced by increasing the temperature of the treated region, generating steam and increasing the vapor pressure of the VOCs, leading to increased VOC concentrations in the off-gas. The vapor flowrate extracted from the soil is increased due to steam generation and soil drying. The increased flowrate and VOC concentration raises the overall VOC mass removal rate. A new off-gas treatment system will be constructed to treat the higher concentrations of contaminants and steam expected for Test Site No. 2.

The scope of the pilot test at Test Site No. 2 includes implementation and operation of multiple, overlapping heating arrays, operated sequentially, over the length of the trench. Each array will consists of six electrodes installed in a hexagonal pattern with a vertical central vent that also serves as an electrical neutral. Vapors will be extracted throughout the test along the length of the trench through horizontal vents situated parallel to and underneath the trench, and a vented surface plenum that covers the heated region. The soil vapor from the test area will be extracted through the three types of vents into the off-gas treatment system.

Blowers within the off-gas treatment system provide the vacuum for extraction of soil vapor. The VOCs will be separated from the water vapor with a condenser. The remaining gas phase VOCs will be destroyed in a thermal oxidation unit. VOCs remaining in the condensate will be removed in an air stripper and also destroyed in the thermal oxidation unit. A caustic scrubber will be used to neutralize the HCl formed from the destruction of chlorinated organic compounds. A HEPA filter will remove potential radionuclide particulates.

In order to obtain the data required to achieve optimal heating operations, the SPSH-SVE system will be operated in three modes. The first mode will use venting only to establish a baseline of performance for SVE without SPSH. The baseline will be established in the first array only. The second mode will add SPSH thermal enhancement to the SVE. The highest removal rate of VOCs will occur during this mode. The third mode will be the cool down period, which will take advantage of the hot, dry soil conditions to continue extracting off-gas as the soil cools. The second and third modes will occur sequentially for each array along the length of the trench. Data will be collected and evaluated during testing to promote optimization of contaminant removal and to meet test objectives. Further testing at IHSS 110, if warranted, could include a period of extended operations.

1.1 PILOT TEST OBJECTIVES

The primary objective of the Subsurface IM/IRA is to provide information that will aid in the selection and design of final remedial actions at OU 2. The primary objective of the pilot test at Test Site No. 2 is to evaluate Six-Phase Soil Heating, an enhancement to SVE, as an applicable *in-situ* technology for remediating VOC contaminated soils at OU 2. The evaluation of the technology will be based on EPA guidance evaluation criteria of effectiveness, implementability and cost (EPA 1988).

The effectiveness of SVE enhanced with SPSH, compared to conventional SVE alone, will be evaluated as a qualitative and quantitative comparison between the two technologies. The comparison will be based on several considerations, including the ability of the process to handle the volume and type of contaminants, and the potential impact to human health and the environment during construction and implementation. The maturity and reliability of the technologies will be evaluated with respect to the type of contaminants and conditions at the site. Specifically, the following quantitative elements of effectiveness will be addressed:

• Acceleration of VOC removal over conventional SVE from soils at OU 2.

• Increase in the extent of removal of VOCs existing with inhibiting co-contaminants in subsurface soils using SPSH verses conventional SVE alone.

Evaluation of implementability encompasses both the technical and administrative feasibility of implementing the technology. Sufficient data on the implementability of the SPSH-SVE system will be collected to project operation and maintenance (O&M) reliability for additional applications of SPSH-SVE at other OU 2 sites.

Cost is used to compare and screen process options. The cost of the SPSH treatment will be compared to the cost of unheated SVE treatment. Cost data will be collected in order to project cost effectiveness of applications of SPSH-SVE at other OU 2 sites.

The pilot test will be conducted using the Observational Approach. VOCs in oil are believed to exist primarily at a depth of 5 to 10 feet in the shallow IHSS 110 trench. If sufficient contamination at greater depths is encountered during electrode installation, the electrodes will be extended to a maximum depth of 20 feet. This maximum depth is set by seasonal water table fluctuations and defines the vadose zone treatment area. The possibility of contamination at greater depths does not justify the added technical complication of heating in the saturated zone for this pilot test. If a perched saturated zone is encountered at depths less than 20 feet, an evaluation on the potential impact to lower hydrostratigraphic units will be made and electrode depth adjusted accordingly.

Included in the Test Plan is a site conceptual model of both the subsurface geology and contamination.. Also provided is a brief technology description of SVE and SPSH and the associated off-gas treatment system. Summary level testing procedures for system operations testing, performance monitoring, and field testing (including a break down of the phases of operation) to be implemented at Test Site No. 2 and the data collection strategy are included.

This Test Plan is intended to provide a conceptual plan of the project. The document is not intended to be utilized as a design document or as an Implementation Plan. The specific details associated with the implementation, operation, health and safety, sampling and analysis, data management, and waste management will be provided in supplemental documents which are described in Section 8. The pilot test procedures presented in this plan have been developed in accordance with the U.S. Environmental Protection Agency's (EPA) guidance for conducting SVE treatability studies (EPA 1991).

1.2 TEST PLAN ORGANIZATION

Section 2 of this report provides a characterization of IHSS 110 and includes descriptions of site background, geology, hydrogeology, and contamination history. Subsection 2.1 has largely been derived from the IM/IRA Plan and more recent data from well logs, ground water sampling, and soil gas surveys. In addition, an overview of the SVE and SPSH technologies and their applicability to suspected subsurface contamination at the IHSS 110 trench is presented in Section 2.2.

Section 3 describes the equipment required for implementing the SPSH technology. Design considerations are applied in this section to develop a design basis for the pilot SPSH system at IHSS 110.

Section 4 outlines the experimental methods to be implemented for this pilot test. The phases of operation, including the operation of a multiple array configuration, are presented at a summary level.

Section 5 summarizes the data collection strategies for evaluating the success in meeting the objectives of the pilot test. Data collection activities will include technical data for post-test interpretation and cost data to evaluate the cost effectiveness.

Section 6 includes a discussion of data analysis and interpretation for evaluation of success in meeting the objectives of the pilot test.

Section 7 provides the schedule for conduct of the Subsurface IM/IRA pilot study at the SPSH pilot test at IHSS 110, and includes an outline of the final pilot test report.

Section 8 describes the supplemental documentation to this Test Plan that will provide specific details of the project.

Section 9 lists the regulatory agency permits and patent requirements for the SPSH process.

19

SECTION 2

SITE AND REMEDIATION BACKGROUND

The expected hydrogeologic and contamination conditions at IHSS 110 described in this section are based on OU 2 Phase I and Phase II RFI/RI data coupled with historical contaminant release information. The development of an area-wide and site-specific hydrogeologic and contaminant distribution model is a continuing process. New data from the Phase II Alluvial RFI/RI will be incorporated as it becomes available.

2.1 ROCKY FLATS SITE BACKGROUND

The Rocky Flats Plant (RFP) is a government-owned, contractor operated facility. It is part of the nationwide nuclear weapons research, development, production, and plutonium reprocessing complex, and is administered by the Rocky Flats Field Office (RFFO) of the DOE. The facility was in operation from 1951 to 1989 to manufacture components for nuclear weapons and conducted plutonium reprocessing. The RFP fabricated components from plutonium, uranium, beryllium, and stainless steel. Historically, production activities have included metal fabrication, machining, and assembly. Both radioactive and nonradioactive wastes are generated in the process; including, radioactive and solvent contaminated machine cutting oil, lathe coolant consisting of mineral oil (ie. petroleum distillate oil) and carbon tetrachloride (CCl_4) in varying proportions, hydraulic oils, vacuum pump oils, TCE, PCE, silicone oils, and acetone (Rockwell International 1987), sanitary sewage sludge, and empty flattened steel drums.

The RFP is currently a RCRA hazardous waste treatment/storage facility and is a CERCLA site on the National Priorities List. In the past, both storage and disposal of hazardous and radioactive wastes occurred at on-site locations. Preliminary assessments conducted under the Environmental Restoration Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

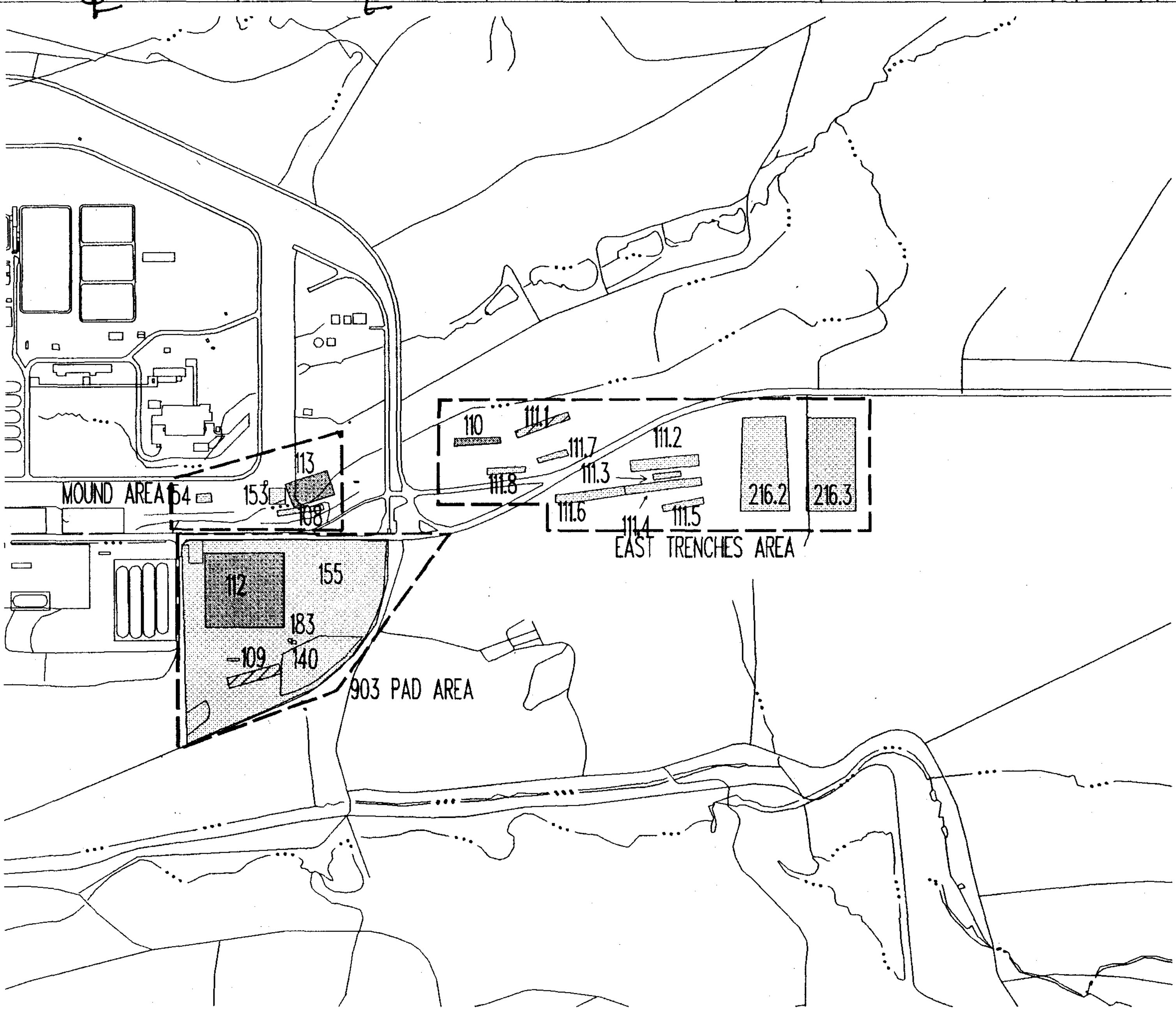
Operable Unit No. 2 (OU 2) is comprised of the 903 Pad, Mound, and East Trenches Areas, which are located east-southeast of the Protected Area (PA). The East Trenches Area consists of nine burial trenches (one of which is the IHSS 110 trench, also called Trench T-3) and two spray irrigation areas. Figure 2-1 shows the locations of these facilities as well as the location of IHSS 110, the location chosen for this pilot test.

2.1.1 Contamination History

A review of literature revealed little specific information about the historical use of any one disposal trench in the East Trenches Area. The available information described waste disposal practices at the East Trenches Area as a whole. According to the historical release report, the burial trenches in this area were used between 1954 and 1968 for the disposal of sanitary sewer sludge contaminated with uranium and plutonium, approximately 300 flattened empty drums contaminated with uranium and plutonium (Illseley 1983), and possibly solvents and machining/cutting oils. Based on a magnetometer survey, IHSS 110 is not expected to contain flattened drums. Although the radiation content of the sewage sludge disposed of in the East Trenches reportedly ranged from 382 picoCuries per gram (pCi/g) to 3,590 pCi/g (Owen and Steward 1973), there are no reports of metallic nuclear materials deliberately buried in IHSS 110, and no radionuclides have been detected in current investigative and remedial activities.

21

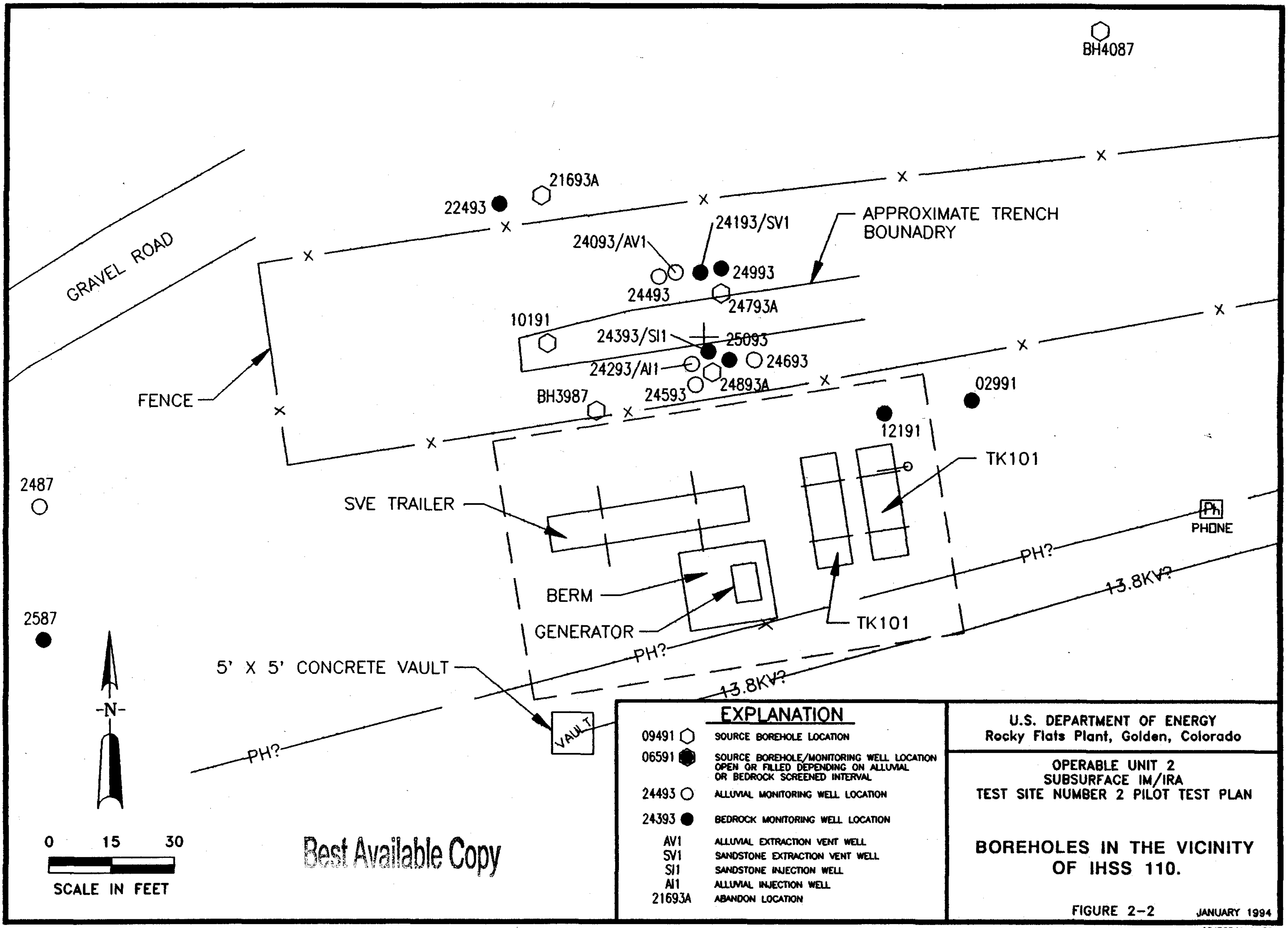
CHECKED BY:	APPROVED BY:	DRAWN BY: K. Stephens	DATE: February 09, 1994	FILENAME: /arc/data/soilvapor/svs3411.aml	REVISION NO: 1



PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

SITE MAP OF REMEDIAL INVESTIGATION AREAS AND IHSSs, OPERABLE UNIT NO. 2

FIGURE 2-1



EXPLANATION

09491	SOURCE BOREHOLE LOCATION
06591	SOURCE BOREHOLE/MONITORING WELL LOCATION OPEN OR FILLED DEPENDING ON ALLUVIAL OR BEDROCK SCREENED INTERVAL
24493	ALLUVIAL MONITORING WELL LOCATION
24393	BEDROCK MONITORING WELL LOCATION
AV1	ALLUVIAL EXTRACTION VENT WELL
SV1	SANDSTONE EXTRACTION VENT WELL
SI1	SANDSTONE INJECTION WELL
AI1	ALLUVIAL INJECTION WELL
21693A	ABANDON LOCATION

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

OPERABLE UNIT 2
SUBSURFACE IM/IRA
TEST SITE NUMBER 2 PILOT TEST PLAN

BOREHOLES IN THE VICINITY OF IHSS 110.

FIGURE 2-2 JANUARY 1994

4045004A 1=30

The IHSS 110 trench is believed to have been constructed by bulldozing the RFA to a depth of between 5 and 10 feet (O'Melia 1994). Waste was stored in the trench, then the RFA was backfilled over the top. The disturbed RFA, now covering the trench, is believed to be more permeable than the undisturbed RFA, by approximately one order of magnitude.

2.1.3 Contamination Characterization

Contamination exists within OU 2 in several locations and has been measured using multiple techniques. These sampling methods include groundwater analysis, soil vapor surveys, and soil sample analyses. Both groundwater and soil vapor survey data are difficult to interpret since they do not detect the source of contamination. The water or gas sampled could have become contaminated as a distant location and traveled to the sampling location, giving a false indication of a nearby contaminant source. Soil sampling gives a better indication of contamination source, but if a source is not wide spread, it may be difficult to locate using soil sampling techniques.

Groundwater sampling has indicated a plume of VOC contamination originating at the 903 Pad (an abandoned storage site for plutonium laden oil stored in drums), and at the Mound area. Contamination enters the groundwater at these areas and flows to the NE under the East Trenches. Contamination levels increase as the plume passes under the East Trenches areas indicating an additional contamination source within the East Trenches; however, it is unclear which trenches are actually contributing to this contamination. Figures 2-3 through 2-5 show the groundwater contamination plume for PCE, TCE, and CCl_4 (DOE 1993).

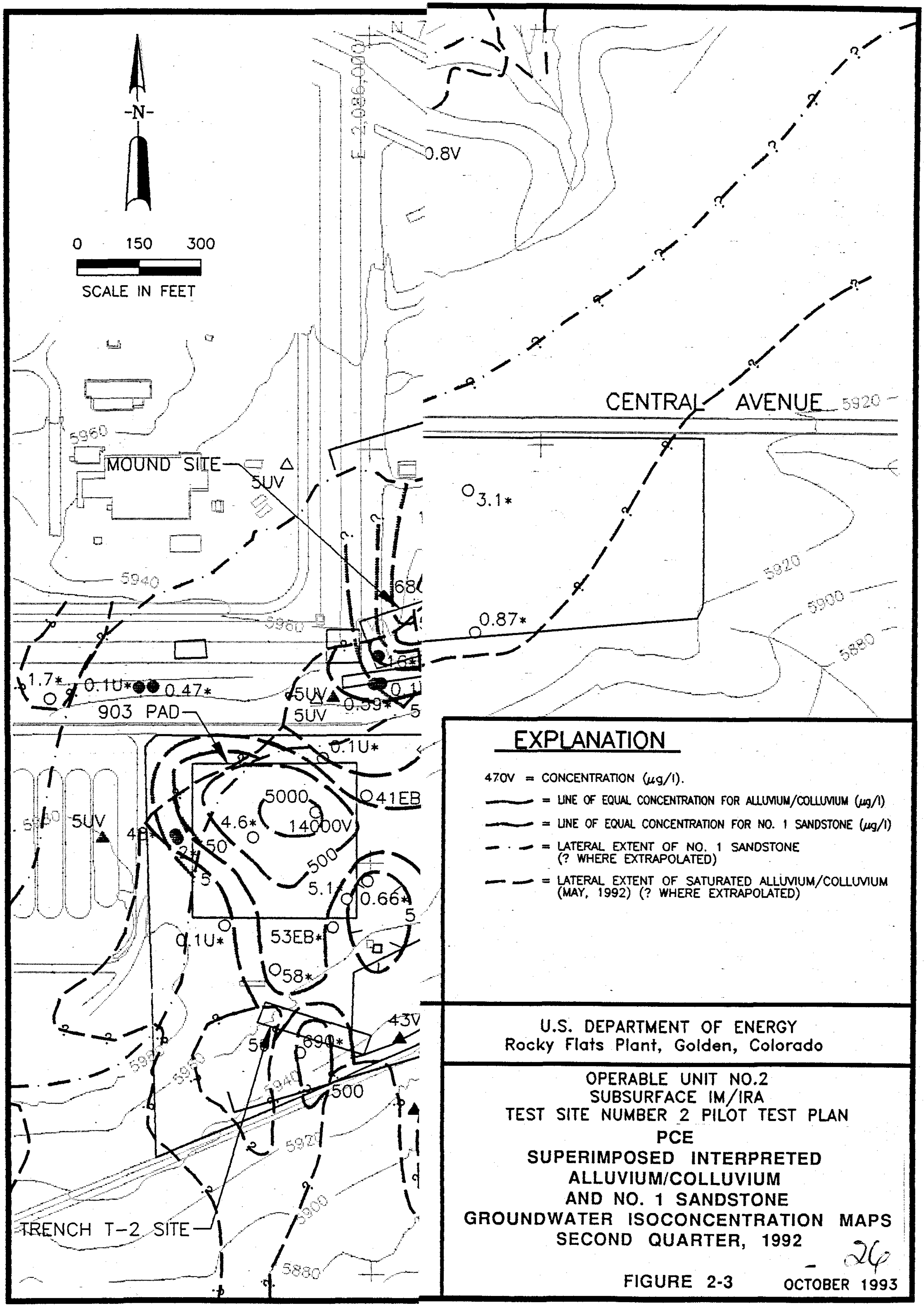
A pure phase NAPL is likely to be present when groundwater concentrations exceed 1% of the solubility limit in water for the contaminants (1.5 ppm by mass for PCE, 11.0 ppm for TCE, and 8.0 ppm for CCl_4) (Cohen & Mercer 1993). Based on this guidance, the groundwater contamination levels do not clearly indicate the presence of a pure phase VOC NAPL in contact with the groundwater.

A soil vapor survey was performed in and around IHSS 110 in December 1993 (EG&G 1993b). The survey included 35 soil gas samples, 22 samples 5 feet below the surface and 7 samples 10 feet below the surface in approximately 20' intervals along the trench. The samples showed VOC concentrations as plotted in Figures 2-6 though 2-11. These figures must be interpreted with caution since contours shown were generated from a limited number of data points and the confidence level is low. Maximum observed concentrations for CCl_4, 1,1-DCA, PCE, and TCE are listed in Table 2-1.

Table 2-1: CCl_4, 1,1-DCA, PCE, and TCE Maximum Observed Concentrations from Soil Gas Survey Data for IHSS 110 (EG&G 1993b).

Contaminant	Maximum Concentrations			
	@ 5' (μg/l)	@ 5' (ppmv)	@ 10' (μg/l)	@ 10' (ppmv)
CCl_4	111	17.6	410	65.0
1,1-DCA	410	101.1	0	0.0
PCE	310	45.6	690	101.5
TCE	21	3.9	12	2.2

25



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

OPERABLE UNIT NO.2
SUBSURFACE IM/IRA
TEST SITE NUMBER 2 PILOT TEST PLAN
PCE
SUPERIMPOSED INTERPRETED ALLUVIUM/COLLUVIUM AND NO. 1 SANDSTONE GROUNDWATER ISOCONCENTRATION MAPS
SECOND QUARTER, 1992

- 26

FIGURE 2-3 OCTOBER 1993

The maximum concentrations (101.5 ppm by volume [ppmv] PCE, 3.9 ppmv TCE, & 65.0 ppmv CCl_4) give no indication that large quantities of pure phase VOC NAPL exist in the subsurface, although, strictly speaking, they do not rule out the possibility. To indicate existence of pure product, soil gas concentrations would have to have been much higher (>100 to 1000 ppmv (Cohen & Mercer 1993)).

There are two likely explanations for the low groundwater and soil gas survey VOC concentrations. The first explanation is that the VOCs exist in a mixture with a co-contaminant (such as oil) that suppresses the VOC concentration in the gas phase (according to Raoult's law). The second possibility is that there is minimal VOC contamination present.

Soil samples support the assessment that the VOCs are present with a co-contaminant. During drilling of the 10191 well, located within IHSS 110 near the west end, an oily-yellow NAPL was observed to be "dripping" from a soil sample collected approximately 4.2 feet from the surface (Gust 1994). The soil sample was analyzed and found to be $1.7x10^7$ ppb my mass (ppbm) PCE, $1.2x10^5$ ppbm TCE, $2.8x10^4$ ppbm CCl_4 (see Figure 2-12 for measured VOC concentrations at other depths from 10191 and surrounding wells). These concentrations can be used to estimate the VOC concentration in the NAPL.

Well B24793 (also located within IHSS 110) contained residual NAPL at 7.7 to 8 feet below the surface, as indicated in soil core samples. These results, along with the groundwater and soil gas survey findings, support the hypothesis that NAPL is present and may consist of both VOCs and a non-volatile co-contaminant.

Since the 10191 and B24793 wells only show indications of NAPL at a depth consistent with the bottom of the trench, it can be hypothesized that the bulk of the waste has not migrated far from its original storage location (as shown in Figure 2-13). Several scenarios exist that explain the measured increase in groundwater contamination without requiring a NAPL in direct contact with the groundwater.

35

The first scenario is that surface water coming in contact with the near surface NAPL while draining through the soil will become contaminated. This water will spread the contamination downward as it drains toward the water table.

Another possible contamination scenario is that gas phase VOCs are continuously released from the NAPL as equilibrium is reached between the NAPL and surrounding gas phase. These gas phase VOCs then diffuse through the soil and reach the water table. When the gas phase VOCs come in contact with the groundwater, they solubilize into it, increasing the groundwater contamination.

Both contamination scenarios support the hypothesis that groundwater contamination at OU 2 can increase as it passes the East Trenches area even if the groundwater does not come into direct contact with NAPL.

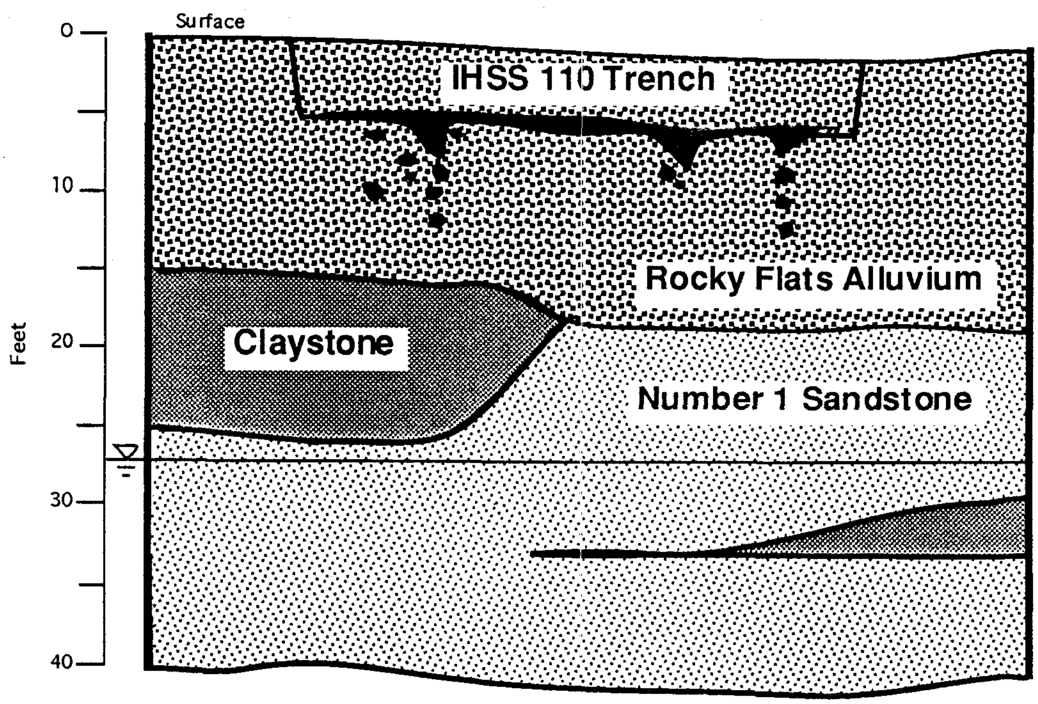


Figure 2-13: Geological and Contamination Conceptual Model

31

Based on the likely contamination history, it is believed that the co-contaminant with the VOCs is machine oil. Although no formal record exists of disposing VOC laden oil in IHSS 110, this contamination is not inconsistent with the records of sanitary sewage sludge disposal there (DOE 1993). In the time period before 1963, it is likely that such waste was disposed of in sanitary sewer drains. Some of the VOC/oil mixture thought to be present at IHSS 110 may have been deposited by such practices. VOCs in mixture with oil are difficult to extract from soil using SVE because the ability of the VOC to volatilize is reduced by the presence of the oil. The resulting low gas phase VOC concentrations lead to low extraction rates and long treatment times.

Based on the VOC concentration data from the 10191 well, an estimate was made for the total amount of VOCs present in the volume treated by a single electrode array. A preliminary design treatment area for the six-phase heating array was established and the 10191 soil VOC concentrations were integrated over this area. The design included a 30 foot diameter electrode array and 25 foot heated depth. The treatment volume resulting from this array geometry gave a maximum possible VOC mass of 7,000 kg (15,000 lbs).

2.2 TREATMENT OF VOC CONTAMINATED SOIL

Several candidate technologies currently exist or are under development to facilitate the removal of volatile contaminants from soil or sediments. Only *in-situ* methods were considered in the Subsurface IM/IRAP because of the volatile nature of the contaminants. *Ex-situ* methods could cause contamination of the environment and unsafe working conditions for personnel through volatilization of contaminants during excavation. *Ex-situ* methods are also typically more costly than *in-situ* methods.

Established *in-situ* technologies such as SVE, and developing technologies such as hot air injection and steam stripping, have proven useful in the remediation of VOC contaminated soils. Electrical soil heating, which is also a developing technology, offers some advantages over these technologies. SVE technology and the viability of resistive soil heating as an enhancement, are summarized in the following sub-sections.

38

2.2.1 Soil Vapor Extraction (SVE)

Soil Vapor Extraction is an EPA presumptive remedy for *in-situ* removal of volatile organic compounds like TCE, PCE, and CCl_4 from the subsurface. This technology succeeds when soil contaminants transfer readily into air drawn through the soil pore spaces. The contaminant is carried by the air through the soil to a vacuum vent and removed. Successful venting requires that the contaminant be at least semi-volatile and the soil be permeable to the flow of air. In homogeneous and permeable soils, SVE produces rapid results with a relatively low overall cost. Conventional SVE, however, becomes infeasible when remediating low-permeability soils ($<10^{-5}$ cm/sec) or when semi-volatile or non-volatile contaminants are present (EPA 1991; Pedersen and Curtis 1991).

Test Site No. 1 of the Subsurface IM/IRA Pilot Test Program involved a SVE pilot test at IHSS 110, within the proposed location of Test Site No. 2 of the IM/IRA. The test at Test Site No. 1 consisted of both pilot testing and a period of sustained operations. These tests investigated the effectiveness, implementability, and costs of conventional SVE for treating VOC contaminated soils in the RFA and No. 1 Sandstone formations. Multiple pilot tests varied operational parameters and system configurations to determine an optimal operation configuration for maximum contaminant removal rates. The sustained operations phase then implemented this optimized configuration .

The SVE configuration consisted of one injection and one extraction well in each geologic unit. Passive verses active air injection wells were evaluated, with a total of nine pilot tests performed. The optimal configuration determined from these tests was then implemented for six weeks under sustained operations. The radius of influence of the SVE system was monitored during testing through subsurface pressure monitoring wells.

Preliminary performance data have been collected from the pilot testing and sustained operations period of the SVE pilot test at Test Site No. 1. Results indicated that the injection wells were ineffective, therefore they were modified into additional extraction wells. Results from the Test Site No. 1 sustained operations period are shown in Table 2-2.

Table 2-2: Pilot Test No. 1, SVE Sustained Operation Preliminary Results

Gas extraction rate: 5 - 10 scfm at 9.6 psia from a single extraction well
VOC mass removal rate: 2.4 - 9.6 lbs/day
SVE radius of influence: 10 - 20 ft
Extracted soil gas composition: 50% PCE, 40% CCl_4, 10% others
Estimated time to remediate:
4.25 - 17 years
(assumes 15,000 lbs VOC present and no decay in off-gas concentrations)

The effectiveness of SVE for VOC remediation at IHSS 110 is affected by several factors including low soil permeability in general, the presence of a NAPL composed of VOC with an oil co-contaminant, and the presence of low permeability claystone layers. These limitations were illustrated in the results from Test Site No. 1.

The hydraulic conductivity of the RFA soil is approximately 10^{-4} cm/sec (DOE 1992). This is near the EPA's suggested cut-off of 10^{-10} cm^2 (10^{-5} cm/sec) for SVE effectiveness due to low permeability soils (EPA 1991). In low permeability soils, the region affected by the SVE process is small and the flowrate coming from the extraction well is low. In order to remediate a site with relatively tight soils, SVE extraction wells must be installed close together.

Gas flow through the soil in response to SVE is primarily through high permeability zones, bypassing any low permeability regions. If VOC contamination exists in the lower permeability claystone layers, it would not be treated by the SVE process in a reasonable period of time.

The presence of the NAPL phase adds additional difficulties for SVE remediation. A NAPL pool has relatively small surface area for the volume of contaminant present. Since contaminants can only enter the gas phase through the NAPL/gas interface, mass transfer of the contaminant is slow, leading to long treatment times. Also, the NAPL effectively plugs the pore space (reducing relative permeability to gas flow) in the regions it covers. This means that gas flow past the NAPL is decreased and extraction rates are further reduced.

The co-contaminant adds additional complications since the VOC concentration in the gas phase is reduced as a function of the concentration of the VOC in the NAPL. This low VOC concentration in the extracted gas results in slow remediation.

2.2.2 SPSH - Thermal Enhancement of SVE

Soil heating can extend the effectiveness of SVE to less volatile compounds, to less permeable soils (like claystone), and potentially, to contaminant depths near or at the water table. All soil heating processes increase the temperature of the soil and contaminant, causing an increase in the contaminant's vapor pressure and its removal rate (see Appendix A). At temperatures above the contaminant's boiling point, off-gas contaminant concentrations can be significantly increased. Electrical heating, however, can also create an *in-situ* source of steam to accelerate the removal of volatile organics from soils. Removal of soil moisture (as steam) also tends to increase the relative permeability of soils, which can increase the rate of contaminant removal during venting. Effective soil heating may provide a cost effective alternative to conventional SVE or soil excavation followed by *ex-situ* treatment.

Applied electrical fields have the advantage over other soil heating methods of heating soils internally, where the soil acts as a heat source. This heating boils the water films surrounding soil particles within the NAPL pools. Steam is created and forced out through the NAPL, effectively steam stripping it *in-situ*. Resistive electrical heating also preferentially heats lower permeability soil zones that often contain the majority of contaminants.

Six-Phase Soil Heating (SPSH) uses common low frequency AC electricity to heat soils. A bank of conventional single-phase transformers are used to convert standard three-phase electricity into six-phase electricity. Electrodes are inserted into the ground in a circular array of six electrodes, each supplied with a separate phase voltage. At any time, each electrode is at a different voltage. This means that current flows from one electrode to each of the other five. Heat is dissipated in the soil as electrical current flows through the resistive soil. A seventh electrically neutral electrode located at the center of the array doubles as an extraction vent.

Because the SPSH electrode system can be installed using standard drilling equipment and constructed of modified well casing materials, it is anticipated, based on results of a field demonstration at the DOE Savannah River site, that SPSH will be competitive in terms of overall cost with other *in-situ* soil heating processes.

Six-Phase Soil Heating requires enough electrical conductivity in the soil to allow sufficient resistive heating to overcome heat losses from the surface and to surrounding soil. Soil electrical conductivity varies with soil composition, water content, and temperature. When soil dries out, the electrical conductivity decreases, especially near the electrodes where heating is relatively great. To alleviate this situation, a small amount of water is added to the soil near the electrodes during heating.

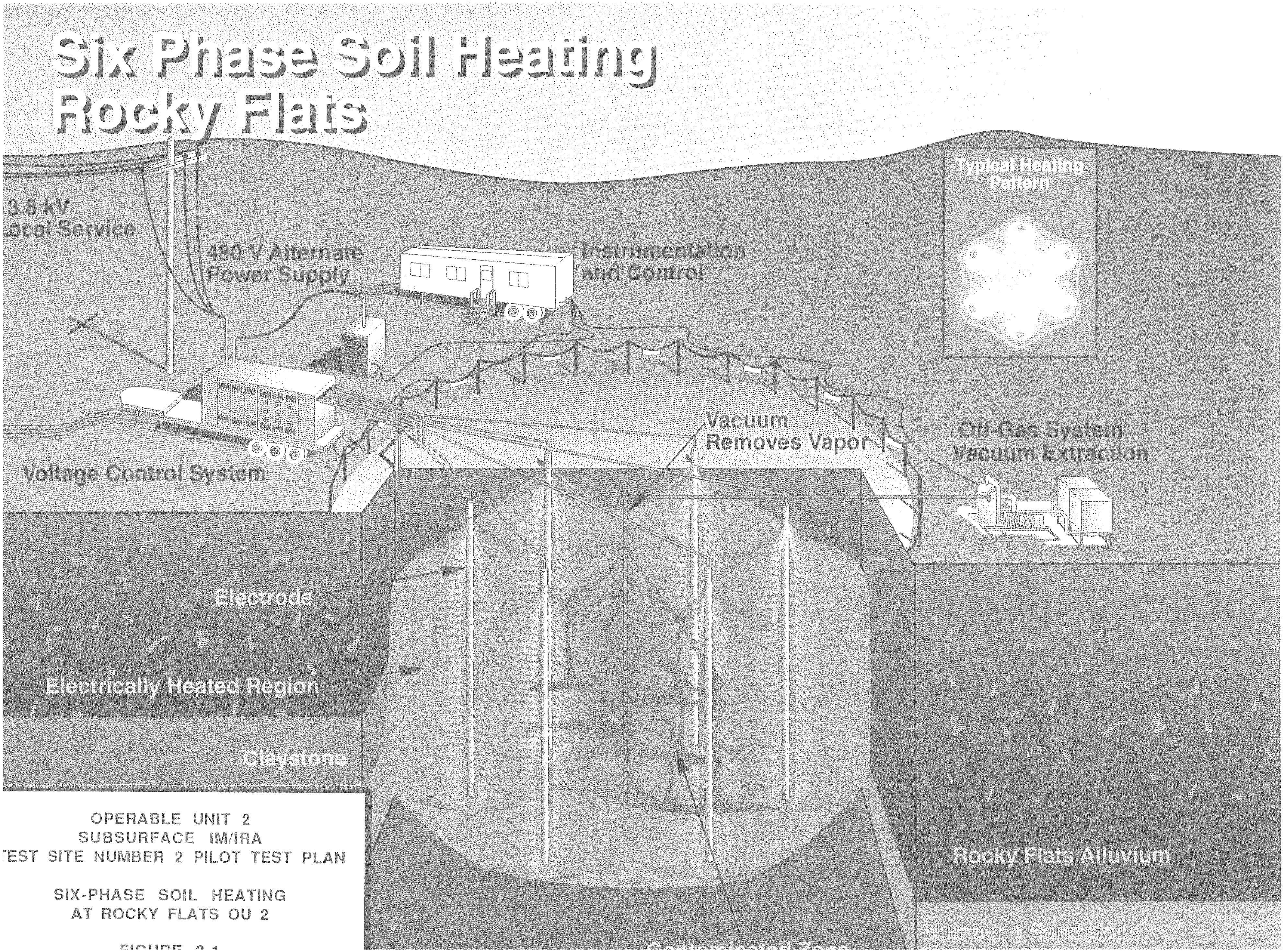
SECTION 3

PILOT STUDY EQUIPMENT

The following section summarizes the SPSH configuration and off-gas treatment system to be implemented for Test Site No. 2. This section also describes some of the design parameters that will be considered for the SPSH pilot test. Detailed information on equipment designs and installation will be included in the Implementation Plan and are not included in this Test Plan. A description of how the Observational Approach will be used in the installation and operation of the test equipment is also included.

Figure 3-1 shows the conceptual design of SPSH applied to IHSS 110. Pilot Test No. 2 will use an innovative multiple array SPSH approach to treat VOC contaminated soil at IHSS 110. Multiple arrays of six electrodes each will be installed along the length of the trench. Some of the electrodes will be re-used as electrodes for neighboring arrays as shown in Figure 3-2 to minimize the number of electrodes required. The SPSH arrays will be operated sequentially, starting at the west end of the trench and working toward the east. The transformer supplying power to the SPSH system, the off-gas treatment unit, and the electrode wetting system will be switched between arrays as the treatment zone is moved along the trench.

The components of SPSH systems are typically "off-the-shelf" items. However, design of such a system is site-specific. Design specifications such as the number of vents, spacing, location, and construction; electrode spacing, depth, location, and diameter; and operational settings for power, water addition, and vent pressure are determined by a combination of design formulas, computer simulations, and practical experience.



OPERABLE UNIT 2
SUBSURFACE IM/IRA
TEST SITE NUMBER 2 PILOT TEST PLAN

SIX-PHASE SOIL HEATING
AT ROCKY FLATS OU 2

FIGURE 2-1

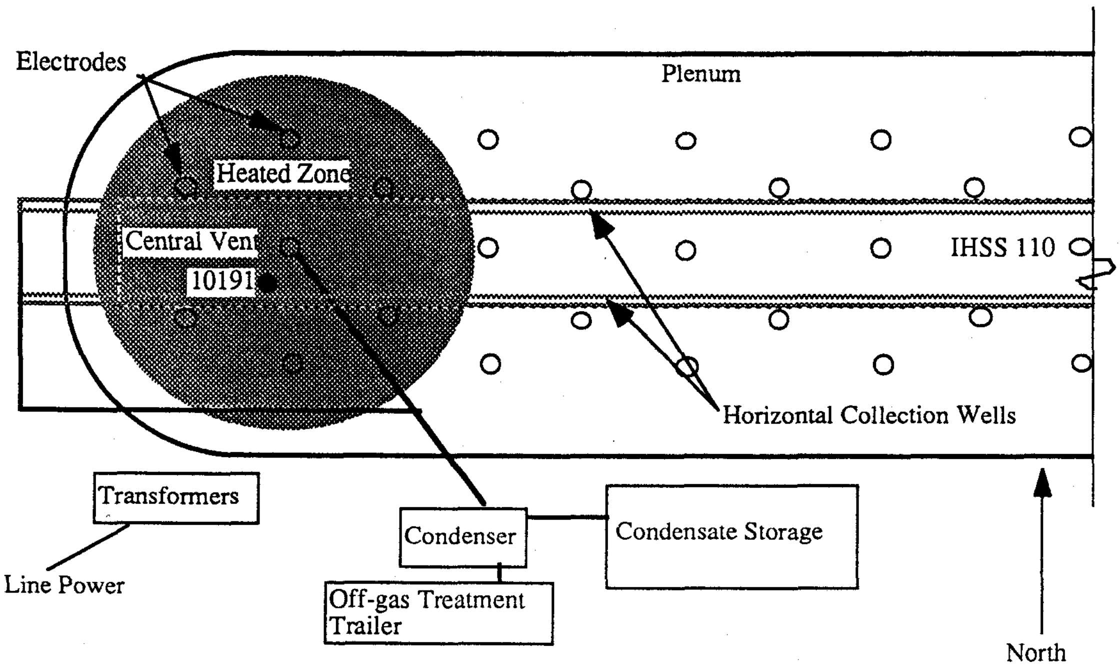


Figure 3-2: SPSH Configuration

3.1 POWER SYSTEM/ELECTRODES

The configuration for SPSH at IHSS 110 is depicted in Figure 3-2. 13.8 kVA line power will be supplied to the transformer system which converts the power into six-phase AC power at voltages appropriate for uniform heating (expected to be less than 1500 Volts line-to-neutral). Each of the six electrodes will be connected to a separate electrical phase.

The electrodes will be installed along the length of the trench in 30' diameter patterns, using casing hammer well installation methods. Electrodes will be made of standard well construction materials modified somewhat to incorporate an electrode moistening capability and temperature sensors. The casing hammer installation method will be needed to insure accurate placement of the electrodes since large cobbles are frequently encountered in the Rocky Flats Alluvium soil. With standard auger drilling techniques, it is possible that electrode placement wells could be deflected or stopped as large cobbles are encountered. Installation methods and electrode designs will be covered in detail in the Implementation Plan, discussed in Section 8.

The depth of the electrode array will be governed by the geology and the extent of contamination encountered during drilling with the maximum electrode depth not to exceed 20 feet (discussed in detail in Section 4). Electrodes will be pre-assembled to the degree possible, then inserted into the casing or open hole, depending on the stability of the borehole. If the electrodes are assembled within a casing, the casing will be removed before packing. The electrodes will consist of steel casing with graphite packed between the casing and the surrounding soil to improve electrical contact (Gauglitz, et al. 1994).

During electrical heating, the greatest energy dissipation occurs near the electrodes where current fluxes are highest. As a consequence, the soil near the electrodes has a tendency to dry first. Because drying reduces the ability of the soil to conduct electricity, it is necessary to avoid excessive drying near the electrodes. This issue has been resolved by using an electrode moistening system to maintain conduction in the soil near the electrode. Clean water will be added to the soil surrounding the active electrodes at flowrates between 0.02 and 0.08 gpm per electrode. Flowrates will be varied to maintain electrical conductivity of the soil surrounding the electrodes.

3.2 VENTING

Contaminants will be drawn from the soil by an applied vacuum into a surface plenum, the central vent of the active array (which also connects to the electrical neutral of the six-phase power system), and two horizontal vents. Materials and construction details of the venting system are contained in the Implementation Plan.

3.2.1 Surface Plenum

The surface plenum is the principal method for collecting contaminants from the heated soil. It is also necessary to insure collection of contaminated gases so that they are not released to the atmosphere. The plenum will be constructed by securing an engineered barrier over a gravel layer covering the soil surface. The plenum will cover the entire IHSS 110 trench, healed into the soil around its perimeter (see Figure 3-3). An insulating layer will cover the plenum to reduce condensation as steam is drawn out of the soil. A vacuum will be applied to the plenum throughout the test and will be manually regulated independently from the vertical and horizontal vent wells.

3.2.2 Vertical/Horizontal Vents

The central vent is a vertical extraction well connected to the transformer neutral. It will be screened between approximately 10 and 20 feet below the surface to assist in removal of contaminants. The precise location of the screened interval will be determined during installation based on the geography encountered during drilling. The central vent of the active array will be maintained at negative pressure during heating to ensure capture of contaminants in the lower regions of the heated zone that are not effectively captured by the surface plenum.

The horizontal vents will start at the soil surface near the east end of the IHSS 110 trench, descend to approximately 10 feet below the surface for the length of the trench, dip down to provide a drainage region at the West end of the trench, then regain the surface. A packer will be installed in the horizontal vents to provide control of venting location along the vent.

The horizontal vents will be used as either extraction or injection vents depending on observed venting requirements. During vacuum operation, condensation will accumulate in the horizontal vents; therefore, they will be constructed so that liquid will drain to a region where it can be periodically pumped off and collected in storage tanks along with the condensate collected from the other vents. Section 3.4 discusses the treatment and management of this condensate. The vents will be installed parallel to the trench and screened the entire length of the trench.

3.2.3 Expected Flowrates

The contaminated air and steam will be drawn from the vents using a vacuum blower capable of an absolute pressure of 15 inches Hg. TCE concentrations should be less than 20,000 ppmv, which is substantially below the 80,000 ppmv lower explosive limit for TCE; PCE and CCl_4 are considered inflammable (based on MSDS).

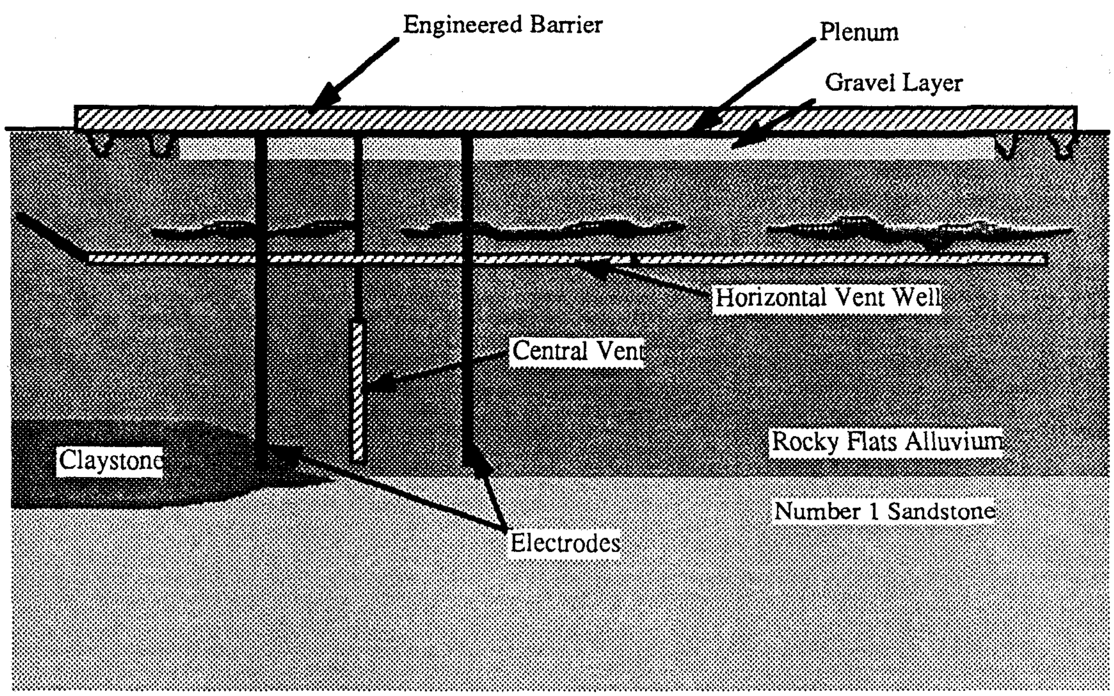


Figure 3-3: Venting System for a Typical Pilot Test Electrode Array.

3.3 OFF-GAS TREATMENT

As resistive heating increases the soil temperature, air and water vapor will be drawn into the venting system. This flow stream will be processed through an off-gas treatment system consisting of a thermal oxidation unit, condenser, air stripper, blowers, HEPA filters, and caustic scrubber. See "OU 2 Subsurface IM/IRA Soil Vapor Extraction Pilot Test Off-gas Treatment Alternatives Evaluation" report (EG&G 1994a) for more detail.

Thermal oxidation unit system testing will be conducted to verify its ability to meet specified destruction efficiencies. Flow stream temperatures and residence time data will be collected during the system testing. Additional details will be provided in the Implementation Plan described in Section 8.

3.4 RESIDUALS MANAGEMENT EQUIPMENT

To accommodate a peak condensate flow of up to 3,600 gal/day, which may last for a few days at a time, a condenser/water knockout box at the surface will remove most of the water prior to entering the off-gas treatment system. The remaining contaminated off-gas will be routed through a thermal oxidation unit and HCl scrubber before being discharged to the atmosphere.

The condensate from the condenser/knockout box will be collected and stored in a temporary holding tank. This water will be air-stripped, with the resulting contaminated air stream being fed back into the thermal oxidation unit. The air-stripped condensate will be temporarily stored and transferred on a regular basis by tanker truck to the OU 2 Surface Water Field Treatment Unit (FTU) for processing or will be treated by the Test Site No. 2 off-gas treatment system to equivalent standards as FTU treatment for surface discharge. The water to be trucked off for treatment is expected to meet FTU acceptance criteria (EG&G 1994b).

The HCl generated by the off-gas treatment system will be neutralized with NaOH. The brine solution generated by the neutralization process will be transported by tanker truck to the Building 374 Evaporation Treatment facility. The brine solution is expected to meet the Evaporator Treatment facility acceptance criteria.

3.5 OBSERVATIONAL APPROACH

Due to the uncertainties associated with the expected hydrogeology and nature and extent of contamination within the OU 2 subsurface, DOE has incorporated the EPA Observational Approach guidance in the planning of the Subsurface IM/IRA. The Observational Approach provides a means of building the required degree of flexibility into the planning and implementation of an environmental restoration project to overcome potential deviations in expected site conditions, and to better ensure project success. These goals are achieved by planning for reasonably conceivable deviations in expected site conditions and using new site data as they become available throughout the course of the project to modify the IM/IRA as appropriate. The use of this approach should also streamline the IM/IRA, and ultimately reduce the cost and time required for implementation.

The SPSH system performance specifications and pilot test procedures presented in this Test Plan have been developed to offer as much flexibility in design and implementation of the IM/IRA as possible. Specifications for the electrode installation, for example, have been prepared to accommodate the likely range in soil stratigraphy below IHSS 110. Similarly, rather than specifying the exact depths and screened intervals for the extraction vent, the Test Plan provides guidance for field sizing based on the actual geology of the soil boring.

Table 3-1 presents reasonable deviations that might be encountered during implementation of the proposed SPSH-SVE system at IHSS 110. The table also indicates the mechanisms that will be used to identify the potential deviations and presents contingency plans that will be implemented in the event that a deviation actually occurs.

Additional information on the EPA Observational Approach and its application to the Subsurface IM/IRA is presented in EPA Office of Solid Waste and Emergency Response Directive No. 9355.3-06 (EPA 1989) and the Subsurface IM/IRAP (EG&G 1992b).

Table 3-1 Observational/Streamlined Approach Six-Phase Soil Heating Enhanced SVE at IHSS 110

Expected Conditions	Potential Deviations	Mechanisms to Identify Deviations	Contingency
Single claystone lens partially extends beneath electrode array	a) Claystone fully underlays trench b) No claystone found c) Multiple lenses found	Soil boring observations	a) shorter treatment depth extending to claystone b) & c) No change required
Metal inclusions in trench are minimal and present no impact	Metal inclusions are present and are likely to impact operations.	Low resistances measured between electrodes prior to operation.	Re-evaluate electrode placement
NAPL not encountered during drilling.	NAPL encountered during drilling.	Soil boring observations	Evaluate impact on lower hydrostratigraphic units and continue drilling if possible. Notify regulators of course of action.
Perched saturated zone not encountered during drilling	Perched saturated zone encountered during drilling	Soil boring observations	Evaluate possible impact on lower hydrostatigraphic units and adjust electrode depths as necessary.
Electrode and vent installation as designed	Difficulties encountered during drilling for installation	Direct observation	Re-evaluate location of electrode or vent
Horizontal vent operational	Horizontal vent operational problems	Direct observation	Evaluate effectiveness of vent and correct problem if required.
Off-gas treatment system functioning as designed	Off-gas treatment system malfunction	Direct observation	SPSH power shut-off; evaluate & correct problem before resuming operations
Continuous operation	a) Power shut-off b) Operations shut-down due to inclement weather	Direct observation	SPSH power shut-off; evaluate & correct problem before resuming operations
Surface voltage differences measured during systems testing are small	Systems testing identifies surface voltages exceeding acceptable limits	Measure voltage differences between surface objects.	SPSH power shut-off. Ground locations showing voltage differences; resume operations.

61

Table 3-1 Continued

Expected Conditions	Potential Deviations	Mechanisms to Identify Deviations	Contingency
Minor variations in soil permeability	Significant soil permeability variations are present in treatment zone	Pressure measurements in vent piping indicate unexpected differences between flowrates from vents.	Adjust vent valving to control flowrates
RFA permeability between 10^{-3} & 10^{-6} cm/sec	a)RFA perm. > 10^{-3} cm/sec b)RFA perm. < 10^{-6}	Observation of off-gas flowrate	a) Decrease vent vacuum to maintain efficient operation of off-gas treatment unit. b) Potential reconfiguration of venting system.
Significant contamination exists in treatment zone	Minimal contamination exists in treatment zone	VOC concentration in off-gas during steaming conditions	Move to next array setting
Radionuclide particulates not present in extracted vapor	Radionuclide particles are present in extracted vapor	Analysis of HEPA filter material	Retain HEPA filters
Total VOC concentrations in off-gas <20,000 ppm	Total VOC concentrations in off-gas >20,000 ppm	Sampling & analysis of vapor stream	Reduce power to SPSH array, reduce vacuum to vents, dilute flow stream.
Soil sufficiently conductive to heat soil	Soil conductivity too low to heat soil	Measure soil resistivity based on operating resistances	Re-wet soil
Condensate will be managed through treatment at OU 1 FTU or direct discharge	Condensate storage capacity exceeded	Direct observation	Add additional storage capacity, treat water at alternate facility, or shut-down test
Contaminant levels significantly reduced after heating	Contaminant remains after cool down.	VOC concentrations in off-gas and soils	Re-wet soil and continue heating

62

SECTION 4

EXPERIMENTAL DESIGN AND PROCEDURES

This section presents an overview, and the guidelines and procedures that will be followed during the SPSH pilot test operations. A more detailed discussion will be provided in the Operation and Maintenance Plan, described in Section 8. The identified procedures may be modified to respond to changing field conditions. Any deviation from these established procedures will be properly documented in a field logbook using the Scientific Notebook Method. Revised procedures will be implemented through the use of Document Modification Requests (DMRs), Manual 3-21000-ADM Procedure 05.07, Rev. 1.

Systems Operations (SO) testing will be followed by three phases of pilot test operations:

- baseline SVE operations,
- SPSH operations, and
- cool down SVE operations

SO testing will ensure that the SPSH and off-gas treatment systems are operating as designed prior to any testing. The baseline SVE and SPSH pilot tests will provide information on the effectiveness, implementability, and cost of remediating soils at OU 2 using SPSH. Criteria that will be used to evaluate the SVE and SPSH data are discussed briefly in Section 5 of this Test Plan and in more detail in the Sampling and Analysis Plan.

The baseline SVE testing will provide the performance data required to extrapolate remediation costs using SVE alone. Based on computer modeling predictions and preliminary results from Test Site No. 1, this phase should require 3 to 14 days. During this period, the off-gas treatment equipment will be tested to ensure performance during the more demanding heating phase of the pilot test.

63

The SPSH part of the pilot test should require between 20 and 45 days per array setting along the length of the trench. The duration of testing will depend on the electrical resistivity and water content of the heated region, and off-gas contaminant extraction rates. Heating will continue until sufficient vadose water is removed to increase soil resistivity beyond SPSH transformer system limits or until contaminant removal rates drop below baseline removal rates established for standard SVE. If significant contamination remains subsequent to heating, rewetting and continued heating will be evaluated. At the end of the heating phase for one array, power will be switched to the next array/treatment region. Conventional SVE will continue through all previously heated regions for the duration of testing or until the soil has cooled significantly. The cool down phase of testing should take between 2 and 3 months.

Soil boring data collected from the IHSS 110 trench indicate that the majority of the VOC contamination exists within the upper 5 to 10 feet of the vadose zone in the Rocky Flats Alluvial formation. Contamination exists in the groundwater beneath the trench, but is believed to result from other contamination sources. The pilot test performed at Test Site No. 2 will, therefore, be conducted within the vadose zone or perched saturated regions only. The limited possibility of contamination at greater depths does not justify the added technical complications of heating in the saturated zone. No dewatering is planned as part of the Test Site No. 2 operations. This pilot test is not intended to evaluate the effectiveness of SPSH on removal of contamination within the saturated zone.

4.1 SYSTEM OPERATIONS (SO) TESTING

SO testing procedures will be initiated following connection of the aboveground equipment, to verify the proper installation and operation of the SPSH and off-gas treatment systems and to gather operating information. All information gathered during the pilot operations will be maintained in a field logbook and as electronic computer files.

The first step of the SO testing will involve inspection of all components of the system. This inspection will include, but not be limited to, the following equipment:

- Piping - visually examine for cracks, loose connections, and possible leaks.

54

- Valves - verify proper operation.

- Blowers - follow manufacturer's inspection procedures (i.e., check oil, belts, etc.).

- Condenser/Knockdown Drum/Demister - follow manufacturer's inspection procedures.

- Thermal Oxidation unit - follow manufacturer's inspection procedures.

- HEPA Filters - inspect filters for debris or blockage.

- SPSH Power Supply - verify proper wiring connections to line power and electrodes and proper settings.

- Alarms/Automatic Shutdowns - check for proper operation at design settings, follow manufacturer's inspection procedures.

- Monitoring Equipment/Instrumentation - follow manufacturer's inspection and calibration procedures.

Electrical safety tests will be performed following the off-gas treatment system SO check. These tests include surface and instrumentation voltage checks and will be described in detail in the Health and Safety Plan. System operations testing will also include measurements of initial electrical resistances of the soil between electrodes, to be used for calculating initial voltage settings for the heating phase of the test. Prior to starting the test, proper operation of the data acquisition system and the measurement instruments will be confirmed. All instruments necessary for measuring the removal of contaminants will be tested and any required repairs will be performed before initiating the baseline SVE test.

65

4.2 BASELINE SOIL VAPOR EXTRACTION TEST

This phase of the pilot test represents baseline, non-heated SVE operation. Few, if any, process changes will be made once operation begins in order to simplify comparisons between the baseline test and the SPSH pilot test. As a consequence, the preliminary conventional SVE test will not necessarily be optimized for greatest efficiency. Un-heated SVE testing will only occur at the first array setting at the west end of IHSS 110.

4.2.1 Test Design

The important design parameters for this test include the vacuum achieved by the off-gas system, and the split of off-gas flow between the vertical, horizontal, and surface plenum vents. The distribution of flow between vents will be selected to optimize air flow through the contaminated soil regions with the vacuum system operating near its maximum achievable vacuum. The flowrate split between vents will be applied in the SPSH pilot test. The baseline SVE test will provide an opportunity to thoroughly test the performance of the off-gas treatment system prior to any heating. Following the test of baseline SVE performance, soil heating will commence.

4.2.2 Test Operation and Monitoring

The preliminary non-heated SVE test will begin by starting the off-gas treatment system and vacuum blower. Gas samples for off-site analysis will be taken from the vacuum line every twelve hours during the preliminary SVE test. Gas samples from each of the PT wells (PT-15-210-20, PT-22-210-20, PT-23.5-210-15, PT-15-270-10, are PT-25-90-5) should be taken every other day beginning on the second day of the SVE test.

This phase of testing will proceed until the future performance on SVE can be estimated based on the data collected. Previous testing of SVE in IHSS 110 suggests that sufficient data for assessing the performance of SVE can be collected in two weeks.

4.3 SIX-PHASE SOIL HEATING TEST

4.3.1 Test Design

The heating phase of the pilot test will be initiated following completion of the baseline SVE test. During this phase of the test, the SPSH transformers will supply power sequentially to array settings along the length of IHSS 110. This phase of the test should produce elevated off-gas VOC concentrations and increasing soil temperatures throughout the region being heated. Increased off-gas flowrates should be observed as relative permeability of the soil to gas flow increases, and the water present in the soil begins to boil.

4.3.2 System Start-Up

The pilot test will begin by starting the off-gas treatment system. The off-gas treatment system will run until gas flowrates achieve steady-state conditions. The SPSH power transformers and control system will then be energized and the SPSH power system will begin the power-up programming. All heating will be stepped up in a controlled fashion so that the capacity of the off-gas treatment system is not exceeded. The off-gas treatment system will be operated to meet Colorado regulatory air discharge requirements. The SPSH system will be monitored at all times during the initial phase of the pilot test.

4.3.3 Operation During Pilot Test

Once the initial heating steps have been completed. The changes in soil temperature will progress more slowly. As a result, operator monitoring and oversight of the pilot test during evening hours will be primarily via telecommunications. It is anticipated that the operations subcontractor response time to system malfunctions outside of normal working hours will be within 1-2 hours.

Operation of one array will continue until off-gas VOC concentration or maximum heating duration criteria are met (described in detail in the Operations and Maintenance plan). SPSH power and the off-gas treatment system will be powered down for change-over to the next array. Electrical

57

wiring and off-gas treatment valving will be switched, and operations will resume after brief SO testing at the next array.

Based on previous pilot test experience, the SPSH system will be in operation 24 hours a day, over an estimated 20 to 45 day period for each array setting, not including preliminary baseline SVE testing for the first array, and problem resolution. Soil resistivity and off-gas VOC concentration results from the monitoring program and the baseline SVE testing will better define the duration of the test . Heating will continue until sufficient vadose water is removed to increase the soil resistivity beyond SPSH transformer system limits or until contaminant removal rates drop below baseline removal rates established for standard SVE. If significant contamination remains subsequent to heating, rewetting and continued heating will be evaluated.

4.3.4 Electrical System Monitoring

The SPSH electrical system consists of the SPSH power transformers, electrodes, and the electrode wetting system. With the exception of the wetting system, these components will require minimal attention during the actual pilot test. Periodic checks will be performed to ensure that all operational parameters are within range and the power level is adjusted to remain in compliance with the recommended power curves. Other monitoring of the electrical system will include checking the electrode wetting system tank and refilling when necessary and monitoring voltage between selected surface locations using a hand held multimeter.

4.3.5 Gas Sampling and Equipment Monitoring

Off-gas treatment system temperatures, pressure, humidity, and gas flow measurements will be taken to monitor the overall system performance. The type and frequency of measurement will be outlined in the Sampling and Analysis Plan, described in Section 8. Special attention will be given to ensure that contaminant levels do not exceed 10% of the lower explosive limit (LEL is 80,000 for trichloroethylene [TCE] @25°C, 78,000 @ 100°C; perchloroethylene [PCE] and carbon tetrachloride [CCl_4] are inflammable).

56

4.3.6 Condensate Management

As the system progresses through initial heating into steady state operation, water vapor will be condensed from the off-gas. A condenser and water knockout system will separate contaminants from water vapor in the off-gas and reduce the moisture content before the off-gas goes to the thermal oxidation unit. The off-gas treatment system is described in more detail in Section 3.3.

Condensate samples will be collected throughout the test to evaluate VOC contaminant levels. Water samples will be taken once a day from the condensate storage and from the air stripped condensate to ensure regulatory/acceptance criteria are met prior to discharge to the OU 2 Surface Water Field Treatment Unit or surface discharge. Analytical sampling methods will be covered in the Sampling and Analysis Plan.

4.3.7 Shut Down Operations

Heating operations at each array setting will be considered complete when sufficient data has been collected to address the criteria for success outlined in Section 1 and in the Operations and Maintenance Plan. This is expected to occur under the following conditions:

- remediation appears to be complete based on off-gas concentration monitoring;
- marked reduction in heating efficiency is observed due to high soil resistivity.

Following heating along the entire length of IHSS 110, shut down of electrical heating will occur. Monitoring of temperature, gaseous emissions, condensate, and pressures will continue for up to 2 months during the cool down phase. The off-gas treatment system will continue operation during this period. The conditions for shutdown are discussed in more detail in the Operations and Maintenance Plan.

4.3.8 Normal Shut-Down Procedures

Normal shut down of the pilot test will occur under the conditions outlined in this section and at the determination of the test technical lead engineer, or operator designated alternate. Under these normal conditions, procedures for the SPSH system will include recording the event and taking the following actions:

- Set electrode voltage to lowest setting;
- Open vacuum switch on power supply;
- Turn off electrode water addition system;
- Shut off breaker supplying SPSH transformers;
- Write test end date and time information in field logbook;
- Follow Operation and Maintenance Plan for post-heating and monitoring.

4.3.9 Emergency Shut-Down Procedures

In the event of an emergency shut-down the Health and Safety Plan will be invoked and the following actions will take place:

- Select "Emergency Off" from power supply control display;
- Turn off electrode water addition system;
- Shut down the off-gas treatment system;
- Make notifications in accordance with SOP and safety plan;
- Record findings and conditions requiring emergency shutdown.

The Health and Safety Plan will include a list of potential failure mode scenarios related to site and worker safety which will dictate the emergency termination of the SPSH operation and the initiation of emergency planning.

4.4 RESPONSE TO SYSTEM ANOMALIES

4.4.1 Loss of SPSH Power Control

A loss of primary SPSH power control will be regarded as a significant situation and will invoke emergency shut down procedures and postpone electrical heating. System operators will respond to the system power control loss by immediately correcting the anomaly. Less significant power

60

control failure could be addressed under normal shut down procedures. The power supply system will be equipped with external support and communications to allow system diagnostics by the instrument manufacturer to evaluate control problems.

4.4.2 Off-Gas Treatment System Failure

A failure of the off-gas treatment system vacuum blower will be indicated by an unexpected rise in vent pressure or dramatic changes in off-gas monitoring parameters. In this event, a central alarm beacon, located on the top of the trailer, will activate, thus alerting operators outside of the trailer. In almost all cases, the control loops will cut power to the blowers and SPSH power supply, thus ceasing operations. These stand-down conditions will remain in place until the off-gas treatment system operation can be restored. No heating will occur under stand-down conditions.

4.4.3 Monitoring Failure

The monitoring of soil temperatures, pressures, gas concentrations, and physical characteristics are critical to the successful implementation of the pilot test. Therefore, redundancy has been built into the monitoring system to ensure data collection in spite of minor monitoring equipment failure. For example, the loss of a single thermocouple will not shutdown the SPSH operation, but the failure or loss of multiple monitoring locations or devices will warrant temporary interruption of the pilot test. The loss of monitoring capability and the need for system shut down will be determined by the field operations engineer.

4.4.4 Loss of Power

A power failure of the site supplied line power would cause a complete loss of power to the soil heating system because no backup power source exists. A loss of power would be handled in the same fashion as an emergency shut down of the SPSH. Under these conditions, the off-gas treatment system would also experience power loss. An alternate power supply, such as a diesel generator, will be activated if power loss to the off-gas treatment system continues for more than 5 days. Should a power interruption occur, the monitoring equipment will be supported temporarily by an emergency back-up system.

4.4.5 Water Storage Overflow

If the amount of condensate collected from the off-gas stream exceeds 90% of the capacity of the holding tanks, an automatic emergency shut down would occur of both the SPSH and off-gas treatment systems. The test would not be restarted until the holding tanks were pumped to allow for further condensate accumulation.

4.5 COOL DOWN OPERATIONS

4.5.1 Test Design

The final phase of the pilot test will consist of conventional SVE operations as the soil cools to ambient conditions. Few, if any, process changes will be made from the baseline SVE phase of the test. The purpose of this phase is to ensure that contaminants still off-gassing from the soil are collected and treated in the off-gas treatment system.

4.5.2 Test Operation and Monitoring

The cool down operations and monitoring will be similar to the SPSH phase of testing with the exception that power will no longer be supplied to the soil. Response to off-normal off-gas treatment system occurrences remains as described above. Soil Vapor Extraction during the cool down phase should continue for approximately 2 months after heating of the last array setting, or until soil temperatures decay to ambient conditions.

4.6 MODELING

Two modeling programs will be used to predict the performance of SPSH at IHSS 110; one to predict electrical power dissipation and root-mean-squared (RMS) voltage gradients in the soil for safety analysis, and the other to predict the response of the subsurface hydrogeology to electrical heating.

The soil heating patterns shown in Figure 4-1 were calculated by a rigorous electric field solution in a computer code called TEMPEST (Trent & Eyler 1993). TEMPEST predictions have been used to fine-tune a semi-analytical model of electrical heating as a function of water content, temperature, soil type, and location within the heated zone. This model was incorporated into a modified version of the TOUGH2 code (Transport Of Unsaturated Groundwater and Heat), a thermal, porous media code capable of predicting the movement of air and water in soils (Pruess 1987 & 1990).

The modified TOUGH2 model will be used to size electrodes and array diameter, design vent placement, and calculate venting rates given vent pressures.

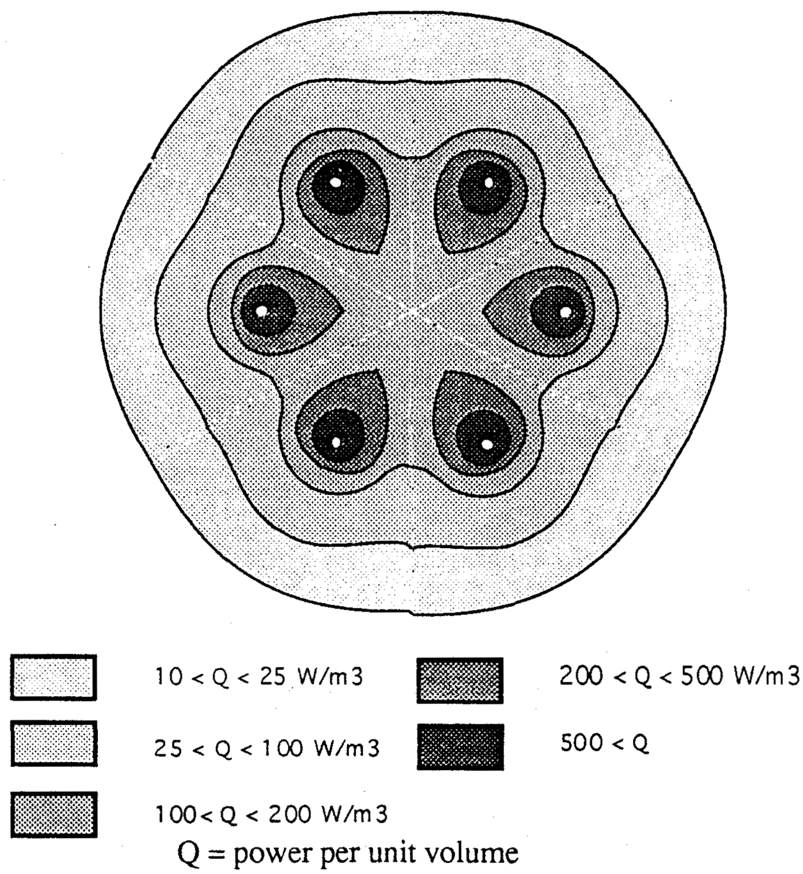


Figure 4-1: Predicted Soil Heating from SPSH

SECTION 5

DATA COLLECTION

Technical data will be collected to measure the performance of the SPSH pilot test against its objectives. Two primary data sets will be collected to evaluate the technical performance of the test: comparison of off-gas concentrations observed during SPSH operations to those observed during conventional SVE operation; and comparison of pre- and post-test soil VOC concentrations.

A relative increase in the mass removal rate of VOCs during heating, as compared to SVE alone, will prove, in part, accelerated removal from OU 2 soils. An increased removal rate is the result of increased contaminant concentration in the extracted air and increased gas flow through the contaminated zones. Contaminant mass removal rates will be evaluated by measuring contaminant concentrations and flowrate of the vapor streams withdrawn from the soil. Nevertheless, this is insufficient to prove accelerated remediation of soils, because contaminants may come from outside the heated zone, making interpretation of the off-gas concentration data difficult. For this reason, pre- and post-test coring of soils, combined with volume averaging of contaminant concentrations, will be used as a more accurate measure of the mass removed from the heated zone.

Monitoring performance of the SPSH pilot test will require collecting *in-situ* and surface equipment data indicating sub-surface pressures and temperatures, VOC contamination levels from soil and soil gas, and off-gas vent pressures and flowrates over the test duration.

- Soil gas pressures will indicate direction of flow in the soil. This information will be used to control the venting and heating to ensure collection of contaminants.

- Soil temperatures will be used to evaluate heating performance; both the magnitude and extent of temperature increases.

- Changes in soil gas contamination levels as well as differences in pre- and post-test soil sample contamination levels will indicate the extent of remediation that has taken place.

64

5.1 PRE-TEST DATA FOR PERFORMANCE EVALUATION

Pre-test data will be collected for each array of electrodes installed at IHSS 110. The following sub-section describes the data collection process for a single array. Additional details will be provided in the Implementation Plan and the Sampling and Analysis Plan.Soil samples will be collected for pre-test site characterization from three wells per array. One of these sets of soil samples will be collected during installation of the central vent. The other two sets will be collected during installation of monitoring wells (T-10-270 and T-15-90)[1]. The monitoring wells will be grouted and used to monitor *in-situ* temperatures at 5 elevations during the test. These two grouted wells are necessary to validate the effectiveness of the SPSH technology. It is crucial to have cored observation wells located away from the electrodes and central vent where they are representative of the bulk soil. After the test is completed, post-test soil samples will be collected from wells drilled within 3 feet of the pre-test sampling locations.

General drilling specifications for the SPSH electrode boreholes, the monitoring well boreholes, and the central and horizontal vent boreholes are listed in Tables 5-1 and 5-2. The labels listed in the tables designate the different types of wells; the standard convention (#year) will be used once the proper label for each well is known.

Table 5-1. Pre-Test Characterization - Electrodes

Label	Description	Borehole Diameter (inches)	Sampled (yes/no)
E-0	electrode,temperature	11	no
E-60	electrode,temperature	11	no
E-120	electrode,temperature	11	no
E-180	electrode,temperature	11	no
E-240	electrode,temperature	11	no
E-300	electrode,temperature	11	no

[1]Instrument and well numbering scheme is based on cylindrical coordinates. The letters indicate the instrument type (E=electrode, T=thermocouple, P=pressure sensor). The numbers represent; the radius from the array center (in feet), angle (ccw measured from North), depth from surface (in feet).

Table 5-2. Pre-Test Characterization - Vent /Monitoring Locations

Label	Description	Borehole Diameter (inches)	Sampled (yes/no)
Central Vent	central vent	8	yes
T-10-270	temperature @ 5, 10, 15, 20, 25 feet, grouted	8	yes
T-15-90	temperature @ 5, 10, 15, 20, 25 feet, grouted	8	yes
Horizontal Vent 1	horizontal vent, screened	8	no
Horizontal Vent 2	horizontal vent, screened	8	no
PT-15-210-20	pressure, temp, gas conc, screened	2	no
PT-22-210-20	pressure, temp, gas conc, screened	2	no
PT-23-210-15	pressure, temp, gas conc, screened	2	no
PT-15-270-10	pressure, temp, gas conc, screened	2	no
PT-25-90-5	pressure, temp, gas conc, screened	2	no

The pilot test will be conducted using the Observational Approach. VOCs in oil are believed to exist primarily at a depth of 5 to 10 feet in the shallow trench at IHSS 110. If sufficient contamination at greater depths is encountered during electrode installation, the electrodes will be extended to a maximum depth of 20 feet. This maximum depth is set by seasonal water table fluctuations and defines the vadose zone treatment area. The possibility of contamination at greater depths does not justify the added technical complication of heating in the saturated zone for this pilot test study. If a perched saturated zone is encountered at depths less than 20 feet, an evaluation on the potential impact to lower hydrostratigraphic units will be made and electrode depth adjusted accordingly.

uu

Continuous cores from each of the specified wells will be taken with a split spoon sampler driven in front of the well casing. Typical soil sample sizes, such as two inch diameter cores, will be sufficient for soil characterization. Cores will be immediately containerized, labeled, and stored until they are sent to a laboratory for analysis.

All sampling will be consistent with Rocky Flats Plant Environmental Restoration requirements. The specific SOPs and other detailed procedures not covered by existing SOPs will be detailed in the Sampling and Analysis Plan described in Section 8.

5.1.1 Soil Analysis for TCE/PCE/CCl_4

Laboratory analysis for TCE/PCE/CCl_4 and oil co-contaminants will be performed. Duplicate samples will be taken every foot from the surface to 10' (unless cores do not permit this frequency of sampling), then every five feet from 10' to 20'.

5.1.2 Analysis for Moisture Content

A set of duplicate samples for moisture determination will be taken from the core every foot from the surface to 10', then every 5 feet from 10' to 20'. These samples will be placed in capped vials and the moisture content obtained by weighing the samples before and after complete drying. ASTM procedures will be followed for this analysis.

5.1.3 General Core Analysis

Core logging will be completed following sampling, with data reported for the content of clay, sand, gravel, carbonate, and other important minerals.

5.2 ON-LINE SAMPLING AND TEST MONITORING

A comprehensive monitoring program has been developed to quantify changes in the subsurface due to electrical heating, to measure the rate of contaminant removal as the test proceeds, to record the power input to the soil, and evaluate the performance of the six-phase power supply. The on-line sampling plan is covered in more detail in the Sampling and Analysis Plan. The following sections provide an overview of the SPSH on-line monitoring program for this pilot test.

5.2.1 *In-Situ* Pressure and Temperature Monitoring

During the operation of the first array, subsurface pressures and temperatures will be recorded using an automated data acquisition system. This data will consist of 10 temperature data points collected from the monitoring wells; temperature, pressure and soil gas VOC concentrations from 6 Geo-Probes; and thermocouples located on the electrodes to assist in power control of the SPSH system. These locations are listed in Tables 5-1 and 5-2 and illustrated in Figure 5-1 for the first array. Using the observational approach, subsequent arrays will be implemented in approximately the same manner along the length of the trench.

68

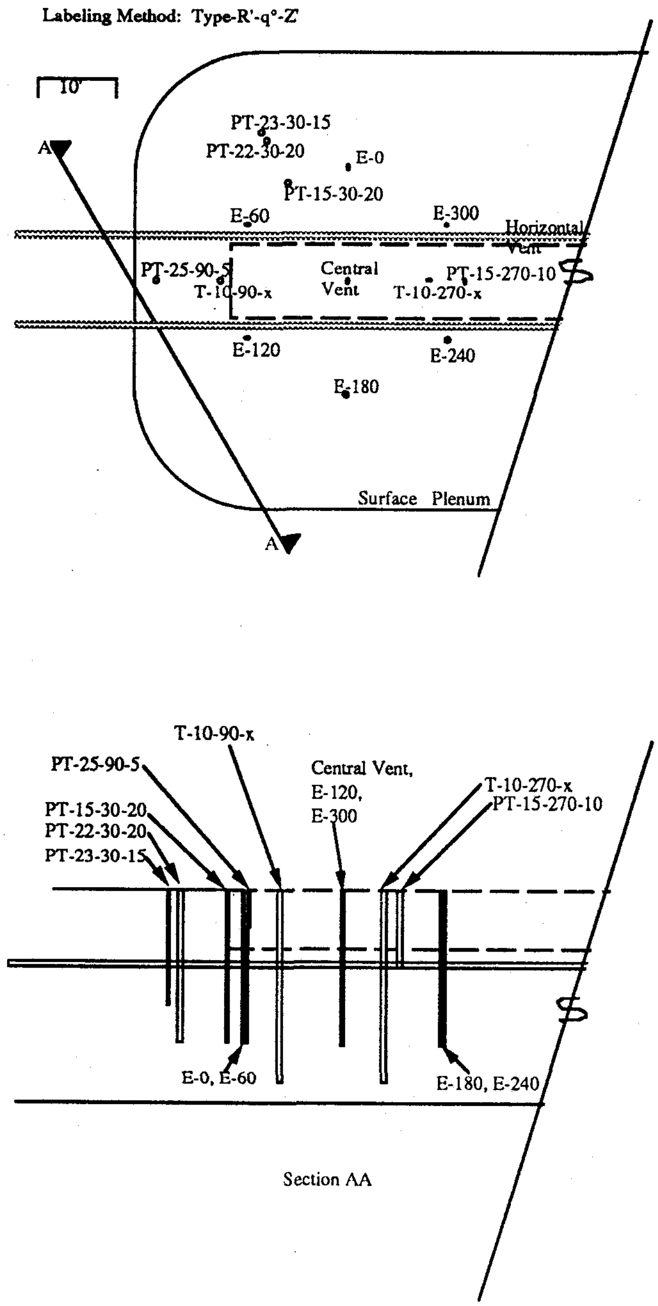


Figure 5-1: *In-Situ* Instrumentation Locations for the First Array (subsequent array configurations will be similar)

Each of the observation wells (T-10-270 and T-15-90) will have five thermocouples positioned at five foot intervals (designated T-10-270-5, T-10-270-10, T-10-270-15, T-10-270-20, T-10-270-25 and T-15-90-5, T-15-90-10, T-15-90-15, T-15-90-20, T-15-90-25). Geo-Probes will be used for measuring pressures, temperatures, and for taking occasional soil gas samples at locations PT-15-210-20, PT-22-210-20, PT-23-210-15, PT-10-270-15, are PT-25-90-5 (see Tables 5-1 & 5-2). The PT wells will not be cored because their installation does not facilitate core sampling.

5.2.2 Off-Gas Treatment System Monitoring

In addition to off-gas temperature and pressure, the data collection system will record the total amount of air and water leaving the soil through the off-gas collection system. These quantities will be determined by measuring the condensate mass flowrate (which can be measured using a flow totalizer, with time base at least every 6 hours) and the mass flowrate of the air leaving the condenser. The total mass flowrate leaving the soil can then be deduced. This measurement will require temperature, pressure, and humidity measurements of the off-gas stream as well as some measurement of mass or volumetric flowrate, such as differential pressures measured across an orifice meter. The precise locations and specifications of these instruments will be presented in the Process and Instrumentation Diagram (P&ID) for the off-gas treatment system. The computer system used to control the off-gas treatment unit will record data from these instruments.

5.2.3 Off-Gas and Condensate Contamination Sampling

Gas samples from the off-gas stream and from the soil will be used to monitor the performance of the pilot test. Off-gas VOC concentration samples will be used to show changes in contaminant removal due to soil heating and to measure total VOC mass removed.

Off-gas contamination analysis will be performed using both an on-line Flame Ionizing Detector (FID) system as well as discrete sampling for off-site analysis. The sampling for off-site analysis will be taken every twelve hours during the Baseline SVE phase of the demonstration and daily during the heating operations. These samples will be analyzed for TCE, PCE, and CCl_4 using standard gas-chromatography techniques and methodologies.

Subsurface gas samples will be taken from the Geo-Probes (wells PT-15-210-20, PT-22-210-20, PT-23-210-15, PT-15-270-10, are PT-25-90-5) after installation, and at weekly intervals until heating begins. During heating, it is not possible to get a representative sample because the steam present in the soil will condense during the sampling procedure. Sampling will resume on a weekly basis after the soil has cooled sufficiently (<50°C) to allow accurate sampling. This data provides a backup indication of how the site is being remediated. Soil gas VOC concentration should slightly decrease during the initial SVE phase of testing, should increase during heating and decrease as the VOC mass is removed and the soil cools during the cool down phase of testing.

To collect gas samples from the Geo-Probes, these wells must be temporarily attached to a vacuum system with air drawn from the well. Electric power to the SPSH array will be shut off during this sampling activity with safety requirements and procedures specified in the Health and Safety Plan. A small volume of air will be removed from these wells; approximately three times the volume of the well and process lines will flush the well and provide a measure of the VOC contamination. It is expected that the VOC concentration will change over time as VOCs are stripped from the soil.

Liquid condensate from the off-gas treatment system will be sampled for contaminant concentration. This measurement will be performed at least daily to give contaminant mass balance data as well as provide for appropriate control of condensate air stripping. Analytical methods are described in detail in the Sampling and Analysis Plan.

5.2.4 Power System Monitoring

The output voltages for application to the soil electrodes are remotely controlled via computer link or a manual override station installed on the power supply skid. Remote control of the power supply invokes automated link - tap changing as required by the system operational power curve limits. This computer control system also records RMS voltage, current, and power measurements for each electrode.

5.3 POST-TEST CHARACTERIZATION

The post-test soil sampling wells will be drilled adjacent to those wells cored prior to the test, preferably within three feet. The post test wells will be cored, sampled, and the soils analyzed with the same techniques used for the pre-test wells. Samples will be taken at the same elevation as in the adjacent pre-test wells to allow direct comparison of pre- and post-test results.

Extra care will be taken when soil samples are collected from the heated zone before it has cooled down. The contaminants can quickly volatilize from the hot samples, resulting in an underprediction of post-test VOC concentrations in the sub-surface. Analytical methods and specific samples to be collected will be covered in the Sampling and Analysis Plan.

5.4 DATA FOR MODELING

Soil analytical data is required for the electrical and vadose zone modeling needed to design the SPSH system. This data will be obtained through laboratory analysis of existing well core samples generated under the OU 2 RI/FS drilling program. The data that will be collected are: absolute and relative permeabilities (to both gas and liquid flow), capillary pressure and electrical conductivity vs. water content. Additional properties, such as grain density, specific heat, and thermal conductivity, will be assumed, based on soil particle composition.

5.5 COST DATA

Cost data will be collected during the SPSH pilot test to enable estimation of cost effectiveness for future applications of the SPSH technology at other OU 2 VOC contaminated sites. This data will enable a cost comparison between SPSH and other technologies that could meet the remediation needs at a given site. The data to be collected and summarized in the final pilot test report include the costs for equipment, labor, consumables, set-up expenses and analytical charges.

- Equipment costs include the design, procurement, fabrication and delivery of the system and components, including the electrodes, venting system, transformer, blowers, monitoring equipment and associated off-gas treatment system.

- Labor costs include mobilization and demobilization, implementation and operation of the system, maintenance, monitoring and support personnel, and preparation of supporting documentation. The labor costs for both subcontractor and contractor time will be provided.

- Consumable costs include chemicals, personnel protective equipment, maintenance, supplies and electrical power.

- Set-up expenses include preparation of the test site and completion and delivery of the supporting documents.

- Analytical charges include those for evaluation and monitoring of both the SPSH-SVE and off-gas treatment systems.

- A unit cost analysis by analyte (i.e., $/lb TCE removed, etc.) will be included.

SECTION 6

DATA ANALYSIS AND INTERPRETATION

Soil gas VOC concentrations and gas flowrate through the soil are expected to increase as the soil is heated, allowing faster removal of contaminants from IHSS 110. This will be shown by observing changes in off-gas concentrations and flowrates, and comparing VOC concentrations in pre- and post-test soil samples. The following sections describe how the data will be interpreted to assess the performance of the SPSH pilot test and to evaluate the ability of the SPSH technology to meet the pilot test objectives.

6.1 PRESENTATION OF DATA

Field data will be reported in a concise manner during the three modes of SPSH testing (baseline, SPSH, and cool down), thereby facilitating subsequent data interpretation.

Subsurface temperatures will be plotted as a function of depth for each well, T-10-270 and T-15-90, at least every 3 days during the test. These plots will be used to assess the extent and magnitude of subsurface heating.

Contaminant concentrations measured in the off-gas stream from the first heated array will be plotted through time. The curve observed during baseline (w/o heating) operations will be extrapolated to predict the total contaminant mass removed and treatment time expected without heating. This will be compared to the actual amount of contaminant collected during the SPSH treatment of the first array (baseline and heating phases).

Pre-test soil contaminant concentrations will be plotted as a function of depth for wells T-10-270 and T-15-90, and the central vent and compared with post test data collected at the same locations. This comparison will provide data to calculate removal efficiencies for the SPSH pilot test. The soil VOC removal data will also be used to estimate a total mass of contaminant removed from the soil. This will be compared to the amount of contaminant collected and destroyed in the off-gas treatment system. If more contaminant was collected from the off-gas than was estimated to have

74

been removed based on soil samples, it is likely that contaminants may have entered the off-gas treatment system from outside the heated region.

A comparison between water collected in the off-gas treatment system and water removed from the soil (based on soil sample water content measurements) will also be used as an indication of whether all of the steam and volatilized VOCs were collected by the off-gas treatment system.

The phase voltage and amperage will vary as the soil dries, and in particular, will vary depending on the local water content near the electrodes. An important result will be the relationship between the rate of water moistening at the electrodes and the phase voltage and amperage. This result will allow an evaluation of whether electrode moistening is effective for RFA soils.

Finally, a correlation will be made between water removal and contaminant removal from the soil. Data from previous demonstrations indicate that this has a strong positive correlation (Gauglitz, et. al. 1994).

6.2 EFFECTS OF TEMPERATURE

A benefit of increasing the soil temperature is that it increases the concentration of contaminants in the soil gas extracted from the soil through SVE vents. Increasing the soil temperature from 20 to 80°C will increase the vapor pressure and thus the concentration of PCE, TCE, and CCl_4 by more than an order of magnitude in the extracted air (see Figure 6-1). This effect is further explained in the discussion of Henry's Law included in Appendix A. If the volatility of the VOCs is not inhibited by the non-volatile co-contaminant, a concurrent order of magnitude increase in the mass removal rate would occur due to the temperature increase.

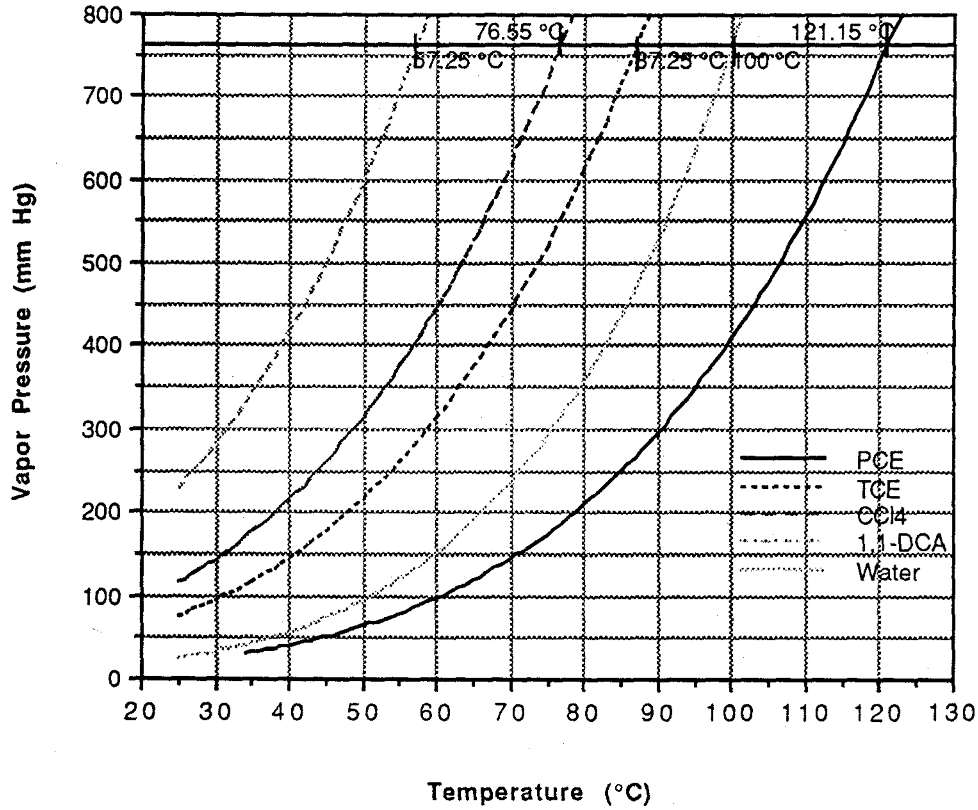


Figure 6-1: Vapor Pressure for Contaminants as a Function of Temperature.

6.3 EFFECT OF SOIL DRYING

Vapor transport through the low permeability RFA could be quite slow under wet conditions. However, when the soil dries, this flowrate can be enhanced more than an order of magnitude. The enhancement results from removal of liquid from the pore space that inhibits the flow of gas. The change in relative permeability during soil drying will be evaluated by correlating the increasing gas flow as a function of differential pressure.

6.4 EFFECT OF STEAMING

The creation of steam in the heated zone has a dramatic effect on the speed and extent of contaminant cleanup. The *in-situ* steam generation increases flow past contaminants for a given vent vacuum. This provides a greater gas volume for removal of the contaminant and increases the rate of remediation. Steam is created in the entire heated region, regardless of the permeability of the soil to gas flow (due to tight soil or presence of a NAPL). Finally, during heating, the water films covering the soil particles within the NAPL contaminated regions will boil. The resulting steam is forced through the NAPL, effectively steam stripping it. This effect will be described by correlating the measured change in soil water content due to heating with a measured change in soil VOC contamination.

6.5 EFFECT OF MULTIPLE ARRAYS

The multiple SPSH array settings along IHSS 110 will have overlapping heated regions. This overlay will influence the performance of SPSH. Since neighboring arrays share 2 electrodes, the soil region surrounding these electrodes will be already heated and substantially dried at the start of SPSH at the next array. Pre-heating part of the adjacent treatment zone will result in lower power requirements to treat the adjacent array. Pre-heating and drying may also result in an imbalance of resistivity seen by the SPSH transformers. As sequential arrays are treated, SVE without SPSH will continue at the already heated arrays. Extraction of soil gas while these arrays are cooling takes advantage of the elevated temperatures and elevated off-gas concentrations.

77

6.6 MODELING

The detailed description of the cores taken from IHSS 110 will be used to generate a realistic, multi-layered model of the subsurface. Calculation of voltages and currents will be compared with actual field data, and the geologic and soil parameters will be adjusted to give the best match with the field data. Once adjusted, the model will be used to predict the change in power, temperature, and pressure with time for future SPSH applications. Comparison of the predicted response against the field data, and particularly discrepancies, will suggest major changes (i.e. heterogeneities in the soil, non-uniform drying, etc) in the subsurface. These differences will be interpreted and incorporated into future model applications.

6.7 ANALYTICAL DATA QUALITY OBJECTIVES

Analytical data quality objectives (DQOs) are related to the objectives of the sampling and analysis program. The primary objectives of the sampling and analysis program include:

- measuring the instantaneous VOC contaminant mass recovery rate of the baseline non-heated SVE and heated SPSH phases of testing,
- evaluating how the VOC mass recovery rate changes with time and system configuration, including effects of the multiple array design,
- measuring the soil VOC concentrations before and after pilot testing.

Secondary objectives include:

- measuring the effectiveness of the off-gas treatment equipment,
- characterizing the condensate and scrubber brine solution waste streams,
- characterizing the soil samples collected during the drilling for vapor extraction wells and electrodes.

Data Quality Objectives (DQOs) associated with tolerances on field measuring equipment (pressure gauges, temperature indicators, etc.) will be described in the Sampling and Analysis Plan. Data Quality Objectives associated with the sampling and analysis program are presented in this document.

78

Data Quality Objectives express quantitative and qualitative statements describing the quality and quantity of data required for the SPSH-SVE system operation and testing. Development of DQOs is performed as a three stage process:

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses/needs
- Stage 3 - Design a data collection program

6.7.1 Identifying Decision Types

The Subsurface IM/IRAP (EG&G 1992b) and Section 1 of this document identify the goals of the IM/IRA and the critical decisions to be made during implementation of the IM/IRA. Specifically, analytical data will be used to determine success or failure of the SPSH-SVE pilot test, to evaluate the effectiveness of the off-gas treatment system, and to determine whether recovered condensate and scrubber brine solution meet the acceptance criteria for the OU 2 Field Treatment Unit and Building 374 Treatment Facility (374 Evaporator) facilities at RFP.

6.7.2 Identifying Data Uses/Needs

Data uses and needs are comprised of the following specific elements:

- Data uses
- Data types
- Data quality needs
- Data quantity needs
- Analysis options
- Precision, accuracy, representativeness, completeness and comparability (PARCC) parameters. This information will be covered in detail in the Sampling and Analysis Plan. A summary of the data uses and needs to fulfill the pilot test objectives is presented in this Test Plan in Table 6-1.

79

Table 6-1: Data Needs to Fulfill Pilot Test Objectives

	Off-gas	HEPA Filters	Soil	Condensate	On-Line Monitoring Instruments
Data Uses:	To identify contaminant mass recovery rate and effectiveness of off-gas treatment equipment	To verify that alpha emitting radionuclides are not present in exhaust gas.	To establish pre-treatment (baseline) contaminant concentrations	Characterize condensate and and assess applicable FP treatment facilities.	Control of SPSH and off-gas treatment systems
Data Types:	Chemical type and concentration; Collection and analysis of samples of extracted soil gas and treated soil gas.	Field measurement of exhaust gas sample filter media for alpha activity.	Chemical type and concentration. Collection of discrete and composite soil samples during drilling.	Chemical type and concentration - collected from grab samples from water storage tank.	Physical state variables collected during operation
Analytical Parameters:	PCE, TCE, CCl_4, 1,1-DCA	Alpha activity	VOCs and Radionuclides[a]	EPA target Compound List (VOCs) Target Analyte List[b] and Radionuclides[c]	Temperture, pressure, and flowrate measurements.
Data Quality Needs:	Level II	Level II	Level III or IV	Level III or IV	Level II
Analysis Options:	Field or laboratory quality gas chromatograph with photoionization and electron capture detector (or detector with equivalent performance)	Benchtop laboratory alpha detector.	See footnote [d]	See footnote [d]	See footnote [a]
MDL:	20 ppb V for all analytes	≥ 20% detection efficiency (of Alpha present)			
Precision:	Laboratory replicate with < 20% RPD	NA			
Accuracy:	Initial 3 point calibration curve covering the range of the instrument detector with < 20% RSD.	Calibration check every 12 hours at the mid point of the calibration curve with	< 30% RPD from established response factor Laboratory method	blanks with < 1/2	

Table 6-1: Continued

	Off-gas	Exhaust Gas Sample Filter Media	Soil	Condensate	On-Line Monitoring Instruments
MDL	Daily calibration check against an Alpha standard with < 40% RPD.	See footnote [d]	See footnote [d]	See footnote [a]	
Representativeness:	Sampling and analyses conducted in accordance with procedures presented in the Sampling and Analysis Plan	Sampling and analyses conducted in accordance with procedures presented in the Sampling and Analysis Plan.			
Completeness:	Laboratory completeness > 70% Field data/sampling completeness > 80 % Overall data completeness > 70 %	Field Sampling > 70% Overall completeness > 70%	See footnote [d]	See footnote [d]	
Comparability:	NA. Non-standard analytical method.	NA. Non-standard analytical method.			

[a] See the Sampling and Analysis Plan for appropriate analytical methods.
[b] Includes 5 non-TAL constituents: cesium, lithium, molybdenum, strontium, and tin.
[c] Gross Alpha; Gross Beta; Strontium 89, 90; Plutonium 239, 240; Americium 241, Tritium and Total Uranium 233/234, 235, 238.
[d] See EG&G Rocky Flats General Radiochemistry and Routine Analytical Service Protocol (GRRASP) (EG&G 1990) and Rocky Flats Site-Wide Quality Assurance Project Plan (EG&G 1991)

NA = Not Applicable
ppbV = Parts per billion (volume basis)
RPD = Relative Percent Deviation
RSD = Relative Standard Deviation (n-l)
MDL = Method Detection Limit

SECTION 7

FINAL REPORT AND SCHEDULE

7.1 OUTLINE OF FINAL REPORT

The Final Pilot Test Report will be based on the suggested outline presented in the "Guide for Conducting Treatability Studies under CERCLA" (EPA 1992).

1. Introduction
    - 1.1 Site description
        - 1.1.1 SIte name and location
        - 1.1.2 History of operations
        - 1.1.3 Prior removal and remediation activities
    - 1.2 Waste stream description
        - 1.2.1 Waste matrices
        - 1.2.2 Pollutants/chemicals
    - 1.3 Treatment technology description
        - 1.3.1 Treatment process and scale
        - 1.3.2 Operating features
    - 1.4 Previous treatability studies at the site
2. Conclusions and Recommendations
    - 2.1 Conclusions
    - 2.2 Recommendations
3. Treatability Study Approach
    - 3.1 Test objectives and rationale
    - 3.2 Experimental design and procedures
    - 3.3 Equipment and materials
    - 3.4 Sampling and analysis
        - 3.4.1 Waste stream
        - 3.4.2 Treatment process
    - 3.5 Data management

87

3.6 Deviations from the Work Plan

4. Results and Discussion

4.1 Data analysis and interpretation

4.1.1 Analysis of waste stream characteristics

4.1.2 Analysis of treatability study data

4.1.3 Comparison to test objectives

4.2 Quality assurance/quality control

4.3 Costs/schedule for performing the treatability study

4.4 Key contacts

References

Appendices

A. Data summaries

B. Key contacts

7.2 SCHEDULE OF EVENTS

A Gantt chart of the activities associated with Pilot Test 2 is included in Appendix B of this Test Plan. The logic ties and durations of activities are subject to change based on changes made in the implementation and operation of the SPSH-SVE and off-gas treatment systems. All changes will be made according to the contingencies presented in the Observational Approach Matrix presented in Table 3-1.

SECTION 8

SUPPLEMENTAL DOCUMENTS

The following supplemental documents will be prepared before the SPSH pilot test operations. Documents marked with a '*' will be submitted for regulatory approval. These documents present the details for the implementation and safe operation of the SPSH/SVE and off-gas treatment systems.

- Technical Memorandum Number 4* - presents a conceptual model of the subsurface geology and contamination (IHSS 110) based on currently available date. Evaluates data needs for additional contaminant characterization.

- Implementation Plan* - will outline the technical details and presents designs for construction of the SPSH-SVE system and associated off-gas treatment system. The plan will include installation of monitoring wells and monitoring equipment. In addition, an outline of existing applicable SOPs will be provided and a description of procedures not covered under existing SOPs.

- Health and Safety Plan* - will evaluate the health and safety issues associated with the addition of SPSH and the new off-gas treatment system at IHSS 110.

- Project Management Plan - will provide the details of the project with respect to the Work Breakdown Structure, the organizational structure and the schedule. A detail of the roles and responsibilities of applicable personnel within each organization will be presented.

- Operations and Maintenance Plan - will present specific operational details for the SPSH-SVE and off-gas treatment systems, from a post-construction perspective. Specifics for system maintenance will be provided. The Plan will address residuals management from a daily operating perspective and will provide emergency notification contact names and phone numbers.

- Data Management Plan - will provide the details for management of all data generated through both field activities and laboratory analyses. The plan will describe the requirements for reporting, validation, and introduction of data into the RFEDs system.

- Sampling and Analysis Plan* - will address the sampling and analysis requirements for the test. The plan will consist of a Field Sampling Plan and a Quality Assurance Addendum to the Rocky Flats Site-Wide Quality Assurance Project Plan.

- Waste Management Plan - will provide the details for management of waste and residuals generated by the SPSH-SVE and off-gas treatment systems. This plan will include the Waste Stream Residue Identification and Characterization (WSRIC) document.

- Technical Memorandum Number 2* - presents an evaluation of existing off-gas treatment technologies and recommends, based upon a set of criteria, an appropriate off-gas system for the SPSH-SVE system.

85

SECTION 9

PERMITTING, REGULATORY REQUIREMENTS, AND PATENTS

9.1 REGULATORY AGENCY OPERATIONAL PERMITS

The following operational permit is relevant to the SPSH demonstration at IHSS 110:

- Colorado Department of Health (CDH), Air Pollution Emissions Notice (APEN) application made by EG&G for air discharge notification related to off-gas treatment system;

9.2 PATENTS

Patent No.4,957,393 for the invention of SPSH and additional patents are pending.

REFERENCES

Cohen, R.M., and J.W. Mercer. 1993. DNAPL Site Evaluation, C.K. Smoley, CRC Press, Inc., Boca Raton, Florida.

DOE. 1992. Final Historical Release Report for the Rocky Flats Plant USDOE. Department of Energy. Golden Colorado ER Program. June.

DOE. 1993. Preliminary Draft, Phase II RFI/RI Report 903 Pad, Mound, and east Trench Area Operable Unit Number 2. December.

EG&G. 1992b. Subsurface Interim Measures/Interim Remedial Action Plan/ Environmental Assessment and Decision Document, Operable Unit No. 2.

EG&G. 1993a. Interim Report Groundwater Recharge Study. Rocky Flats Site, Golden, Colorado. October.

EG&G. 1993b. Soil Vapor Survey Field Report Summary: IHSS's 110, 112, 113, 111.1 and 109. Rocky Flats Plant, Golden, Colorado. December.

EG&G. 1994a. Technical Memorandum No. 2, OU 2 Subsurface IM/IRA, Soil Vapor Extraction Pilot Test, Off-gas Treatment Alternatives Evaluation.

EG&G. 1994b. Phase I Preliminary Plan for Future Utilization of Existing Water Treatment Facilities at Rocky Flats Plant, Draft. May 31, 1994.

EPA (U.S. Environmental Protection Agency). 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final. EPA 540G-89 004.

EPA. 1989. Remedial Investigation/Feasibility Study Streamlining. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Directive No. 9355.3-06.

EPA. 1991. Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction; Interim Guidance. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/2-91/019a.

EPA. 1992. Guide for Conducting Treatability Studies under CERCLA. Final. Risk Reduction Engineering Laboratory Office of Research and Development and Office of Emergency and Remedial Response Office of Solid Waste and Emergency Response, U.S.E.P.A., Washington, DC. EPA/540/R-92/071a

Gauglitz, P.A., J.S. Roberts, T.M. Bergsman, S.M. Caley, W.O. Heath, M.C. Miller, R.W. Moss, and R. Schalla. 1994. "Six-Phase Soil Heating Accelerates VOC Extraction from Clay Soil". Proceedings of Spectrum '94: International Nuclear and Hazardous Waste Management, Atlanta, Georgia, August 14-18.

Gossett, J.M., 1985. Anaerobic Degradation of C1 and C2 Chlorinated Hydrocarbons, Report AD-A165-005, Air Force Engineering and Services Center Report.

Gust, Art, 1994. Personal Communication, Geologist, WCFS. May.

Illsley, C.T. 1983. Environmental Inventory - Updated Information on Burial Sites at Rocky Flats, EA-321-83-240. 28 January 1983.

Mackay, D., and W.Y. Shiu, 1981. "A Critical Review of Henry's Law Constant for Chemicals of Environmental Interest," J. Phys. Chem. Ref. Data, 10(4), pp. 1175-1199.

O'Melia, B. 1994. Personal Communication, Field Engineer, Test Site No. 1, WCFS. May.

Owen, J.B. and L.M. Steward. 1973. Environmental Inventory - A Historical Summation of Environmental Incidents Affecting Soils at or Near the U.S. Atomic Energy Commission Rocky Flats Plant; Dow Chemical Company, Rocky Flats Division.

88

Pedersen, T.A., and J.T. Curtis, 1991. Soil Vapor Extraction Technology Reference Handbook, EPA/540/2-91/003.

Pruess, K, 1987. "TOUGH User's Guide". LBL-20700, Lawrence Berkeley Laboratory, University of California, Berkeley, California.

Pruess, K., 1990. "TOUGH2 - A General-Purpose Numerical Simulator for Multiphase Fluid and Heat Flow", LBL-29400, Lawrence Berkeley Laboratory, University of California, Berkeley, California.

Reid, R.C., Prausnitz, J.M., and T.K. Sherwood, 1977. The Properties of Gases and Liquids, McGraw-Hill, New York.

Rockwell International. 1987. Draft Remedial Investigation Report for 903 Pad, Mound, and East Trenches Areas, U. S. Department of Energy, Rocky Flats Plant, Golden, Colorado. 31 December 1987.

Trent, D.S., Eyler, L.L., 1993. "TEMPEST: A Computer Program for Three-Dimensional Time-Dependent Computational Fluid Dynamics", PNL-8857, Pacific Northwest Laboratory, Richland, Washington.

Yaws, C., Yang, H-C, X. Pan, 1991. Henry's Law Constants for 362 Organic Compounds in Water, Chem. Engineering, pp. 179-185,.

APPENDIX A

DISCUSSION OF HENRY'S LAW

Henry's law is commonly used to represent the relationship between gas and liquid phase concentrations;

$$y_i P = x_i H_i \qquad [1]$$

where the contaminant mole fractions in the gas and liquid are given by Y_i and X_i respectively; P is the total system pressure, and H_i is Henry's constant for the contaminant. Henry's constant depends strongly on temperature. The necessary temperature relationship can be obtained from the more general equation for vapor liquid equilibria given below (Reid et al. 1977).

$$y_i P = x_i \gamma_i P_i^{sat} \qquad [2]$$

where γ_i is the activity coefficient, and P_i^{sat} is the pure contaminant vapor pressure. A gas-phase fugacity coefficient of 1 has been assumed, indicating an ideal gas; this is typically a very good assumption. Comparing Eqs. [1] and [2] gives the following relationship for Henry's constant.

$$H_i = \gamma_i P_i^{sat} \qquad [3]$$

The important observation is that the temperature dependence arises from both the activity coefficient and the vapor pressure. Good data for vapor pressure are available in the literature (shown in Figure A-1, based on data from Reid et al. 1977). However, exceedingly little data are available for the effect of temperature on the activity coefficient, or equivalent Henry's constant data. Simple models for the activity coefficient, such as the "two-suffix Margules" equation, suggest a rather strong temperature dependence for the activity coefficient (Reid et al. 1977).

However, comparison of Eq. [3] with the data of Gossett (1985), shows that the activity coefficient is essentially independent of temperature for at least a small temperature range. Figure 6-1 gives Gossett's Henry's constant data for PCE and TCE. Also shown are temperature extrapolations based on Eq. [3], assuming that the activity coefficient is independent of temperature, and that Antoine's equation approximates the vapor pressure for PCE and TCE (Reid et al. 1977). The extrapolation appears to agree well with the limited data. Yaws et al. (1991), and Mackay and Shiu (1981) give additional Henry's constant data for PCE and TCE at ambient temperature.

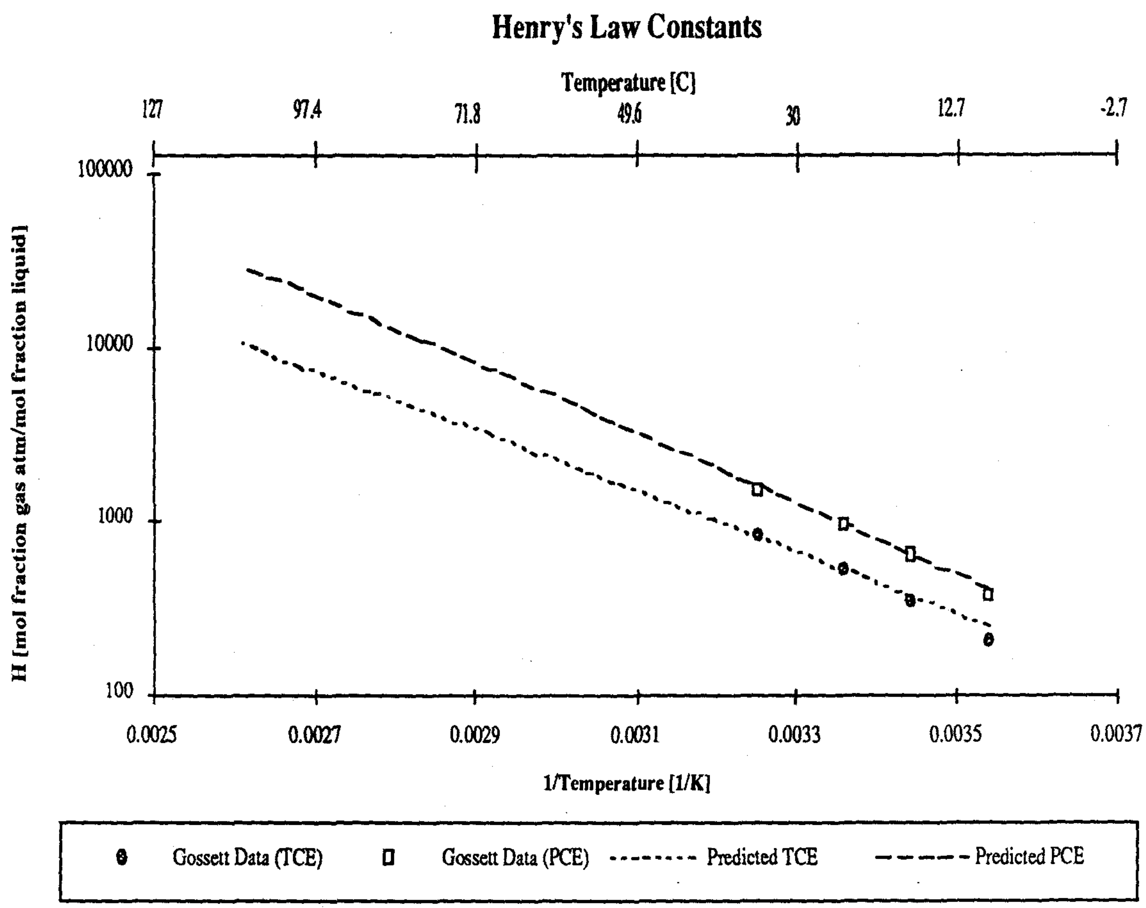
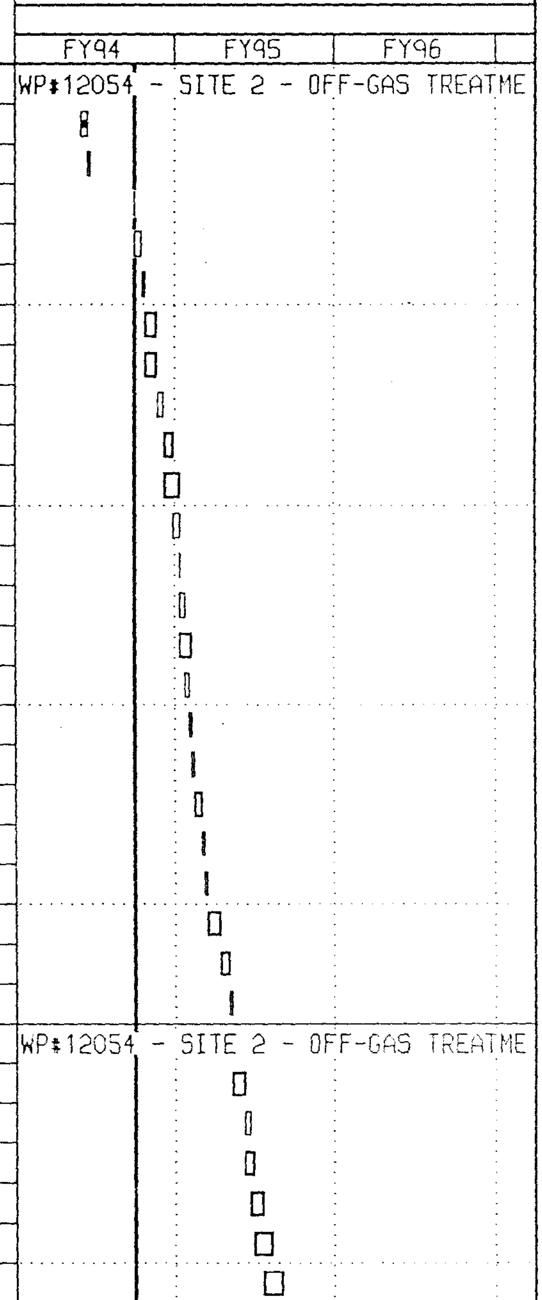


Figure A-1: Henry's Law Constant verses Temperature

APPENDIX B

SCHEDULE OF ACTIVITIES FOR PILOT TEST SITE NO. 2.

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR
BB54A00010	DEVELOP OFF-GAS TREATMENT PRELIM DESING BASIS	1MAR94A	14MAR94A	10	0
BB54A00015	IDENTIFY/EVALUATE OFF-GAS TREATMENT SYST OPTIONS	15MAR94A	21MAR94A	5	0
BB54A00020	OFF-GAS TREATMENT BASIS OF DESIGN	1JUL94	1JUL94	10	1
BB54A00021	DEVELOP ACCEPTANCE CRITERIA FOR WASTE STREAMS	1JUL94	15JUL94	10	10
BB54A00025	OFF-GAS TREATMENT BASIS OF DESIGN REVIEW	18JUL94	22JUL94	5	5
BB54A00030	OFF-GAS TREATMENT PROCESS DESIGN SPECS (P&ID)	25JUL94	19AUG94	20	20
BB54A00031	OFF-GAS TRAILER SPECS	25JUL94	19AUG94	20	20
BB54A00035	OFF-GAS TREATMENT PRELIM DESIGN (P&ID) REVIEW	22AUG94	2SEP94	10	10
BB54A00040	SOLICIT BIDDERS FOR OFF-GAS TREATMENT	6SEP94	26SEP94	15	15
BB54A00050	OFF-GAS TREATMENT FINAL DESING	6SEP94	10OCT94	25	25
BB54A00045	REVIEW OFF-GAS TREATMENT POTENTIAL BIDDERS	27SEP94	10OCT94	10	10
BB54A00055	ESTABLISH OFF-GAS TREATMENT SHORT BIDDERS LIST	11OCT94	12OCT94	2	2
BB54A00060	OFF-GAS TREATMENT FINAL DESIGN REVIEW	11OCT94	24OCT94	10	10
BB54A00065	PREPARE SOW OFF-GAS TREATMENT VENDOR	11OCT94	7NOV94	20	20
BB54A00070	OFF-GAS TREATMENT COMMENT INCORPORATION	25OCT94	31OCT94	5	5
BB54A00075	ISSUE FINAL DESING OFF-GAS TREATMENT	1NOV94	7NOV94	5	5
BB54A00080	REVIEW DRAFT SOW OFF-GAS TREATMENT	8NOV94	14NOV94	5	5
BB54A00085	PREPARE FINAL SOW OFF-GAS TREATMENT VENDOR	15NOV94	30NOV94	10	10
BB54A00090	REVIEW FINAL SOW OFF-GAS TREATMENT	1DEC94	7DEC94	5	5
BB54A00095	DOE REVIEW FINAL SOW OFF-GAS TREATMENT	8DEC94	14DEC94	5	5
BB54A00100	OFF-GAS TREATMENT CONTRACT SOLICITATION	15DEC94	12JAN95	15	15
BB54A00105	OFF-GAS TREATMENT CONTRACT BID EVALUATION	13JAN95	2FEB95	15	15
BB54A00110	OFF-GAS TREATMENT CONTRACT AWARD	3FEB95	7FEB95	3	3
BB54A00115	OFF-GAS TREATMENT DETAIL DESIGN	8FEB95	7MAR95	20	20
BB54A00120	OFF-GAS TREATMENT DETAIL DESIGN REVIEW	8MAR95	21MAR95	10	10
BB54A00125	OFF-GAS TREATMENT PERMIT PREPARATION	8MAR95	28MAR95	15	15
BB54A00130	OFF-GAS TREATMENT PROCUREMENT	22MAR95	19APR95	20	20
BB54A00135	OFF-GAS TREATMENT EPA/CDH PERMIT REVIEW	29MAR95	10MAY95	30	30
BB54A00140	OFF-GAS TREATMENT FABRICATION	20APR95	1JUN95	30	30



Plot Date 6JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

(c) Primavera Systems, Inc.

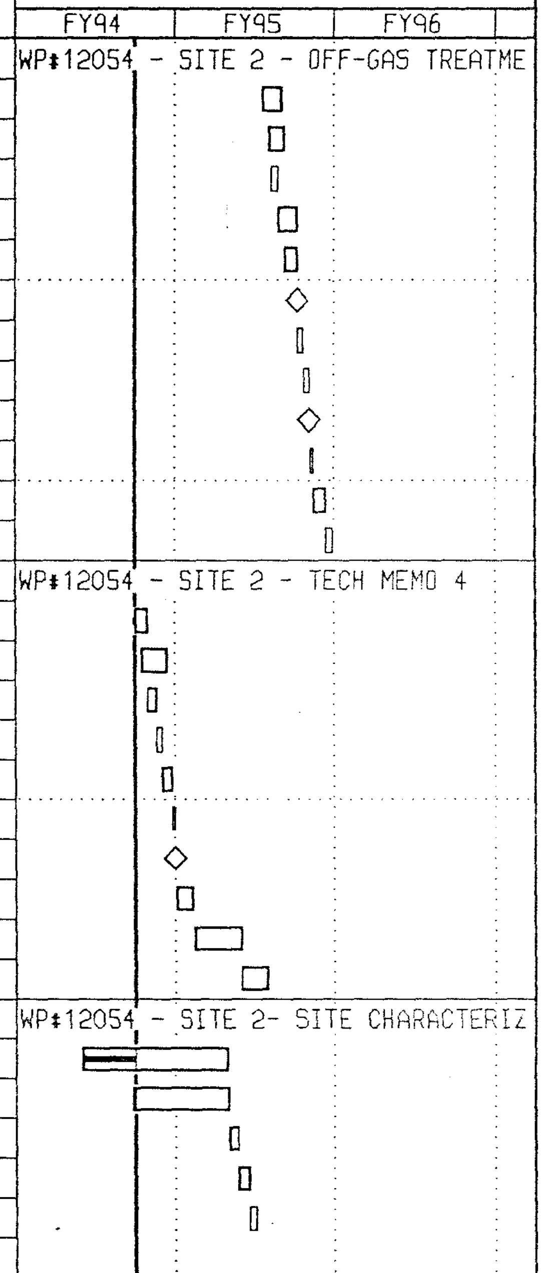
OU2N Sheet 1 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date	Revision	Checked	Approved

94

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR
	WP#12054 - SITE 2 - OFF-GAS TREATME				
BB54A00145	OFF-GAS TREATMENT IWCP PREPARATION	20APR95	1JUN95	30	30
BB54A00150	OFF-GAS TREATMENT EG&G SOURCE INSPECTION	4MAY95	8JUN95	25	25
BB54A00155	OFF-GAS TREATMENT PERMIT REVISION	11MAY95	24MAY95	10	10
BB54A00160	OFF-GAS TREATMENT EPA/CDH REVIEW REVISED PERMIT	25MAY95	7JUL95	30	30
BB54A00165	OFF-GAS TREATMENT SYSTEM TEST BURN	9JUN95	7JUL95	20	20
BB54M00170	OFF GAS TREATMENT EPA/CDH PERMIT APPROVAL		7JUL95	0	0
BB54A00175	OFF-GAS TREATMENT SYSTEM TEST BURN DATA ANALYSIS	10JUL95	21JUL95	10	10
BB54A00185	OFF-GAS TRTMTN TEST BURN DATA EVAL EPA/CDH RVW.	24JUL95	4AUG95	10	10
BB54M00195	OFF-GAS TREATMENT TEST BURN FINAL DATA RPT APPRL		4AUG95	0	0
BB54A00200	OFF-GAS TREATMENT UNIT DELIVERY	7AUG95	11AUG95	5	5
BB54A00205	OFF-GAS TREATMENT WC SETUP & INSTALLATION	14AUG95	11SEP95	20	20
BB54A00210	CONDUCT SYSTEM REVIEW OFF-GAS TREATMENT	12SEP95	25SEP95	10	10
	WP#12054 - SITE 2 - TECH MEMO 4				
BB54A00215	PREPARE FIRST DRAFT TM-4	30JUN94A	28JUL94	20	19
BB54A00421	GEOTECH LAB TEST ON CORE SAMPLES	15JUL94	13SEP94	42	42
BB54A00220	PNL/EG&G REVIEW TM-4 FIRST DRAFT	29JUL94	18AUG94	15	15
BB54A00225	INCORPORATE PNL/EG&G COMMENTS TM-4 FIRST DRAFT	19AUG94	1SEP94	10	10
BB54A00230	EPA/CDH REVIEW TM-4 SECOND DRAFT	2SEP94	23SEP94	15	15
BB54A00235	INCORPORATE EPA/CDH COMMENTS SECOND DRAFT TM-4	26SEP94	30SEP94	5	5
BB54M00240	TM-4 APPROVAL		30SEP94	0	0
BB54A00245	MODIFY WORK PLAN FOR ADDITIONAL CHARACTERIZATION	3OCT94	11NOV94	30	30
BB54A00250	SAMPLING FOR ADDITIONAL CHARACTERIZATION	14NOV94	1MAR95	70	70
BB54A00255	ADD'L CHARACTERIZATION GEOTECH/ANALYTICAL LAB	2MAR95	1MAY95	42	42
	WP#12054 - SITE 2- SITE CHARACTERIZ				
BB54A00260	DESIGN SOIL COLUMN EXPERIMENTS	1MAR94A	30JAN95	228	142
BB54A00265	CONDUCT SOIL COLUMN EXPERIMENTS (PNL)	24JUN94A	31JAN95	148	143
BB54A00270	ANALYZE EXPERIMENTAL DATA	1FEB95	23FEB95	17	17
BB54A00275	SUMMARY REPORT ON EXPERIMENTAL DATA	24FEB95	20MAR95	17	17
BB54A00280	PNL PRESENTATION OF RESULTS	21MAR95	3APR95	10	10



Plot Date 5JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

OU2N

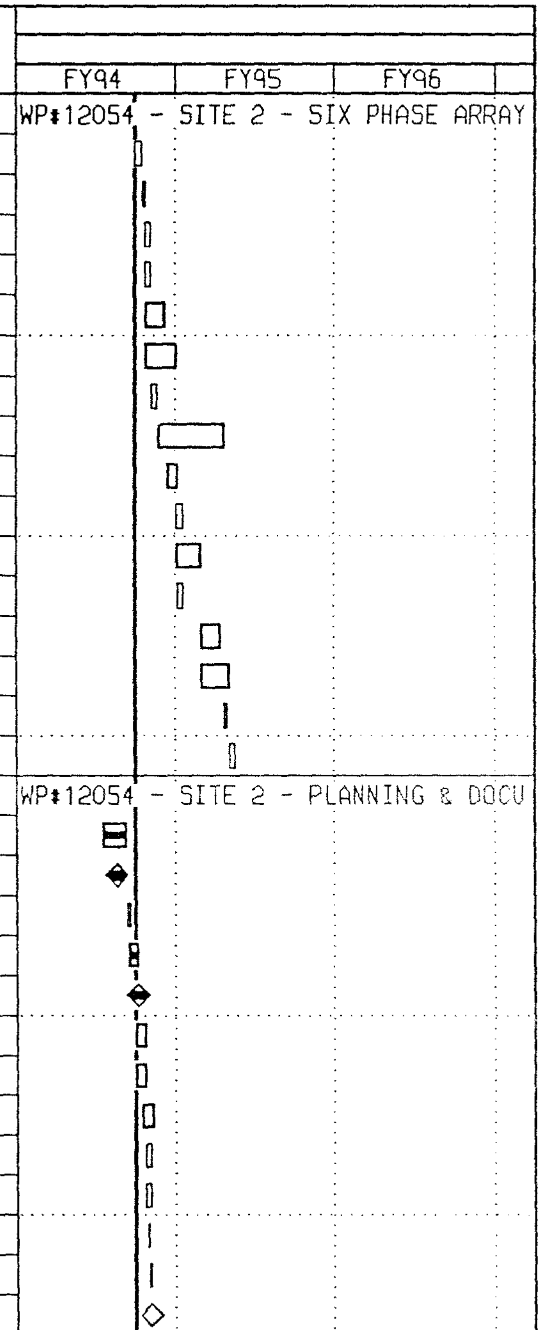
Sheet 2 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date	Revision	Checked	Approved

95

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR
BB54A00285	SIX PHASE HEATING BASIS OF DESIGN	1JUL94	15JUL94	10	10
BB54A00290	SIX PHASE HEATING BASIS OF DESIGN REVIEW	18JUL94	22JUL94	5	5
BB54A00295	THERMOCOUPLE DESIGN & TESTING	25JUL94	5AUG94	10	10
BB54A00300	WETTING SYSTEM DESIGN	25JUL94	5AUG94	10	10
BB54A00310	ELECTRICAL SAFETY DESIGN	25JUL94	6SEP94	31	31
BB54A00315	SITE SPECIFIC PS CONFIGURATION	25JUL94	3OCT94	50	50
BB54A00320	DESIGN ELECTRODES	8AUG94	19AUG94	10	10
BB54A00325	PNL PROCURE ELECTRODES	22AUG94	19JAN95	100	100
BB54A00305	SITE DESIGN SIMULATION TOUGH 2	14SEP94	4OCT94	15	15
BB54A00355	SOIL TEST THERMOCOUPLE	4OCT94	17OCT94	10	10
BB54A00360	DESIGN INSTRUMENTATION AND CONTROL SYSTEM	4OCT94	28NOV94	38	38
BB54A00306	VENTING SYSTEM DESIGN	5OCT94	18OCT94	10	10
BB54A00335	DEVELOP AND APPROVE SITE DESIGN DOCUMENT	29NOV94	10JAN95	25	25
BB54A00385	INSTRUMENTATION AND CONTROL SYSTEM PROCUREMENT	29NOV94	31JAN95	40	40
BB54A00400	SHIP ELECTRODE SYSTEM	20JAN95	26JAN95	5	5
BB54A00405	INSTRUMENTATION AND CONTROL SYSTEM DELIVERY	1FEB95	14FEB95	10	10
BB54A00410	PREPARE FIRST DRAFT SITE 2 TEST PLAN	18APR94A	10JUN94A	39	0
BB54M00415	SITE 2 TEST PLAN PRESENTATION FOR THE EPA	19MAY94A		0	0
BB54A00420	EG&G/DOE REVIEW SITE 2 TEST PLAN	13JUN94A	17JUN94A	5	0
BB54A00425	INCORP EG&G/DOE COMMENTS SITE 2 TEST PLAN	16JUN94A	5JUL94A	12	0
BB54M00435	TEST PLAN DELIVERY TO EPA/CDH		6JUL94A	0	0
BB54A00430	PREPARE DRAFT PROJ. MANAGEMENT PLAN (PMP)	1JUL94	22JUL94	15	15
BB54A00445	EPA/CDH REVIEW SITE 2 TEST PLAN SECOND DRAFT	1JUL94	22JUL94	15	15
BB54A00479	SITE 2 SOW PREP FOR IMP CONTRACTOR	15JUL94	11AUG94	20	20
BB54A00450	EG&G REVIEW OF PMP	25JUL94	5AUG94	10	10
BB54A00455	DOE REVIEW OF PMP	25JUL94	5AUG94	10	10
BB54A00440	PUBLIC PRESENTATION SITE 2 TEST PLAN	29JUL94	29JUL94	1	1
BB54A00460	INCORPORATE COMMENTS SITE 2 TEST PLAN SECOND DRA	1AUG94	5AUG94	5	5
BB54M00465	EG&G/DOE PMP APPROVAL		5AUG94	0	0



Plot Date 6JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

(c) Primavera Systems, Inc.

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

OU2N

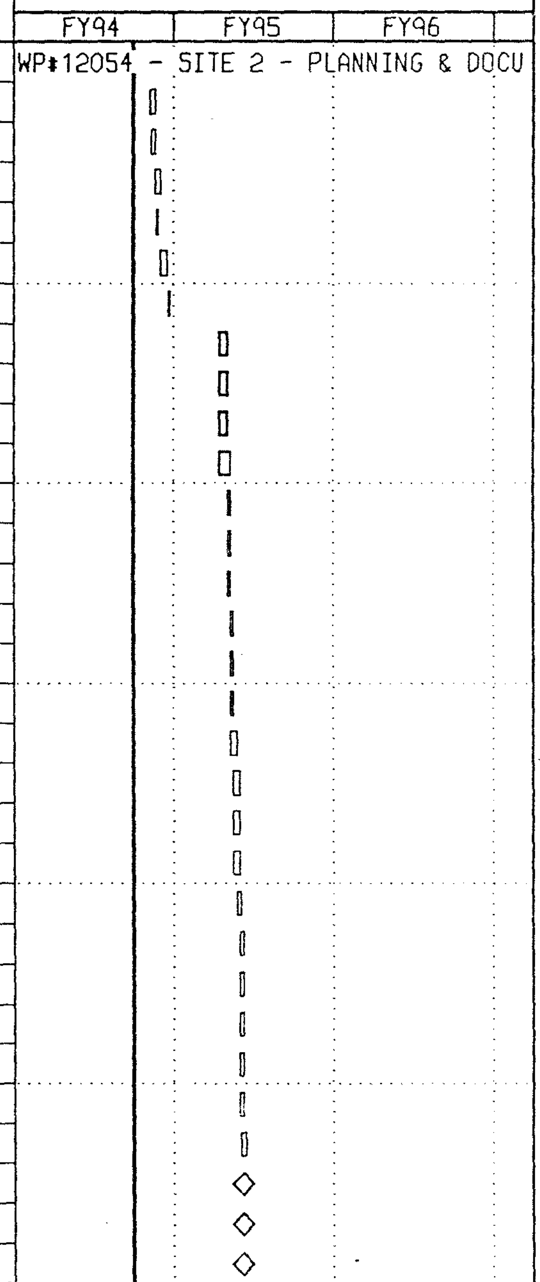
Sheet 3 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date	Revision	Checked	Approved

96

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR
	WP#12054 - SITE 2 - PLANNING & DOCU				
BB54A00470	EPA/CDH FINAL APPROVAL SITE 2 TEST PLAN	8AUG94	19AUG94	10	10
BB54A00480	SITE 2 SOW - RFP FOR IMP CONTR	12AUG94	18AUG94	5	5
BB54A00481	SITE 2 IMP CONTR PROPOSAL TO EG&G	19AUG94	1SEP94	10	10
BB54A00475	SITE 2 TEST PLAN DISTRIBUTION	22AUG94	26AUG94	5	5
BB54A00482	SITE 2 IMP CONTR TECH EVAL	2SEP94	16SEP94	10	10
BB54A00483	SITE 2 IMP CONTR AWARD	19SEP94	21SEP94	3	3
BB54A00485	PREPARE DRAFT SITE 2 IMPLEMENTATION PLAN	11JAN95	31JAN95	15	15
BB54A00486	PREPARE DRAFT SITE 2 WASTE MANAGEMENT PLAN	11JAN95	31JAN95	15	15
BB54A00487	PREPARE DRAFT SITE 2 SAP	11JAN95	31JAN95	15	15
BB54A00490	PREPARE DRAFT SITE 2 H&S PLAN	11JAN95	8FEB95	21	21
BB54A00495	EG&G/DOE REVIEW DRAFT SITE 2 IMPLEMENTATION PLAN	1FEB95	7FEB95	5	5
BB54A00496	EG&G/DOE REVIEW DRAFT SITE 2 SAP	1FEB95	7FEB95	5	5
BB54A00500	EG&G REVIEW DRAFT SITE 2 WASTE MANAGEMENT PLAN	1FEB95	7FEB95	5	5
BB54A00505	INCORP EG&G/DOE COMMENTS DRAFT SITE 2 IMPL. PLAN	8FEB95	14FEB95	5	5
BB54A00506	INCORPORATE EG&G/DOE COMMENTS SAP	8FEB95	14FEB95	5	5
BB54A00510	INCORP EG&G CMMNTS DRAFT SITE 2 WASTE MGMT PLAN	8FEB95	14FEB95	5	5
BB54A00515	EG&G REVIEW DRAFT SITE 2 H&S PLAN	9FEB95	22FEB95	10	10
BB54A00520	EPA/CDH REVIEW DRAFT SITE 2 IMPLEMENTATION PLAN	15FEB95	28FEB95	10	10
BB54A00521	EPA/CDH REVIEW SITE2 SAP	15FEB95	28FEB95	10	10
BB54A00525	DOE REVIEW DRAFT SITE 2 WASTE MANAGEMENT PLAN	15FEB95	28FEB95	10	10
BB54A00530	INCORP EG&G COMMENTS DRAFT SITE 2 H&S PLAN	23FEB95	1MAR95	5	5
BB54A00535	INCOR. EPA/CDH COMMENTS DRAFT SITE 2 IMPL. PLANT	1MAR95	7MAR95	5	5
BB54A00536	INCORP EPA/CDH COMMENTS SITE 2 SAP	1MAR95	7MAR95	5	5
BB54A00540	SITE 2 IMPLEMENTATION PLAN DISTRIBUTION	1MAR95	7MAR95	5	5
BB54A00545	INCOR. DOE COMMENTS DRAFT SITE 2 WASTE MGMT PLAN	1MAR95	7MAR95	5	5
BB54A00550	SITE 2 WASTE MANAGEMENT PLAN DISTRIBUTION	1MAR95	7MAR95	5	5
BB54A00555	DOE REVIEW DRAFT SITE 2 H&S PLAN	2MAR95	15MAR95	10	10
BB54A00560	EPA/CDH APPROVAL SITE 2 IMPLEMENTATION PLAN		7MAR95	0	0
BB54A00565	EG&G/DOE APPROVAL SITE 2 WASTE MANAGEMENT PLAN		7MAR95	0	0
BB54M00561	EPA/CDH APPROVAL SITE 2 SAP	8MAR95	7MAR95	0	0



Plot Date 6JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

(c) Primavera Systems, Inc.

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

OU2N

Sheet 4 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date	Revision	Checked	Approved

97

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR	FY94 / FY95 / FY96
						WP#12054 - SITE 2 - PLANNING & DOCU
BB54A00541	SITE 2 SAP DISTRIBUTION	8MAR95	14MAR95	5	5	
BB54A00570	PREPARE DRAFT SITE 2 O&M PLAN	15MAR95	10MAY95	40	40	
BB54A00575	PREPARE DRAFT SITE 2 DM PLAN	15MAR95	10MAY95	40	40	
BB54A00580	INCORP DOE COMMENTS DRAFT SITE 2 H&S PLAN	16MAR95	22MAR95	5	5	
BB54A00585	EG&G DOE APPROVAL H&S PLAN	23MAR95	27MAR95	3	3	
BB54A00590	SITE 2 H&S PLAN DISTRIBUTION	28MAR95	3APR95	5	5	
BB54A00595	EG&G REVIEW DRAFT SITE 2 O&M PLAN	11MAY95	17MAY95	5	5	
BB54A00600	EG&G REVIEW DRAFT SITE 2 DM PLAN	11MAY95	24MAY95	10	10	
BB54A00605	INCORPARATE EG&G COMMENTS DRAFT SITE 2 O&M PLAN	18MAY95	24MAY95	5	5	
BB54A00610	DOE REVIEW DRAFT SITE 2 O&M PLAN	25MAY95	1JUN95	5	5	
BB54A00615	INCORP EG&G COMMENTS DRAFT SITE 2 DM PLAN	25MAY95	1JUN95	5	5	
BB54A00620	INCORPORATE DOE COMMENTS DRAFT SITE 2 O&M PLAN	2JUN95	8JUN95	5	5	
BB54A00625	SITE 2 O&M PLAN DISTRIBUTION	2JUN95	8JUN95	5	5	
BB54A00630	DOE REVIEW DRAFT SITE 2 DM PLAN	2JUN95	15JUN95	10	10	
BB54M00635	EG&G/DOE APPROVAL SITE 2 O&M PLAN		8JUN95	0	0	
BB54A00640	INCORP DOE COMMENTS DRAFT SITE 2 DM PLAN	16JUN95	22JUN95	5	5	
BB54A00645	EG&G/DOE APPROVAL SITE 2 DM PLAN	23JUN95	27JUN95	3	3	
BB54A00650	SITE 2 DM PLAN DISTRIBUTION	28JUN95	5JUL95	5	5	
BB54M00655	AS-BUILTS TO PM FILES		24JAN96	0	0	
BB54A00660	DOE REVIEW OF AS-BUILTS	25JAN96	7FEB96	10	10	
BB54M00665	DOE APPROVAL OF AS-BUILTS		7FEB96	0	0	
						WP#12054 - SITE 2 - OPERATING CONTR
BB54A00670	SITE 2 SOW/SOLE SOURCE PREP FOR OPERATING CONTR	7AUG95	1SEP95	20	20	
BB54A00675	SITE 2 SOW OPERATING CONTRACTOR RFP	5SEP95	11SEP95	5	5	
BB54A00680	SITE 2 OPERATING CONTRACTOR PROPOSAL TO EG&G	12SEP95	25SEP95	10	10	
BB54A00685	SITE 2 OPERATING CONTRACT TECHNICAL EVALUATION	26SEP95	9OCT95	10	10	
BB54A00690	SITE 2 OPERATING CONTRACTOR CONTRACT AWARD	10OCT95	12OCT95	3	3	
						WP#12054 - SITE 2 - PERMANENT POWER
BB54A00695	PERM POWER DESIGN REQUEST	26APR94A	2MAY94A	5	0	
BB54A00700	PERM POWER DESIGN	3MAY94A	23MAY94A	15	0	

Plot Date 6JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

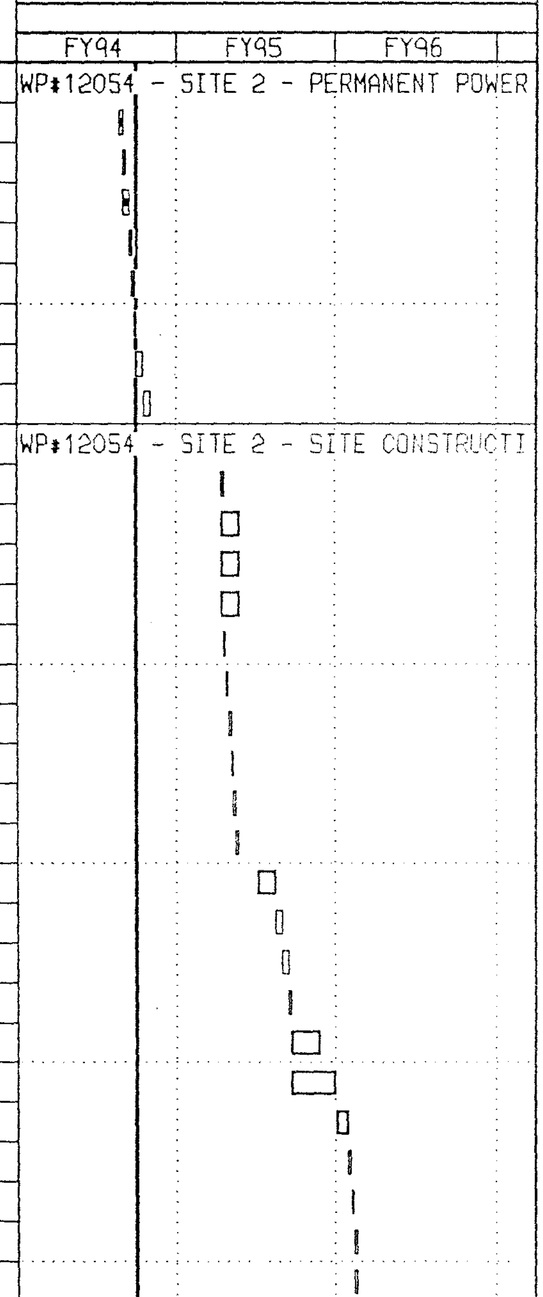
DU2N

Sheet 5 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date	Revision	Checked	Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR
WP#12054 - SITE 2 - PERMANENT POWER					
BB54A00705	PERM POWER DESIGN REVIEW	24MAY94A	31MAY94A	5	0
BB54A00710	INCORPORATE PERM POWER DESIGN REVIEW COMMENTS	1JUN94A	7JUN94A	5	0
BB54A00715	PREPARE STATEMENT OF WORK PERM POWER	1JUN94A	14JUN94A	10	0
BB54A00720	PERM POWER STATEMENT OF WORK REVIEW	15JUN94A	21JUN94A	5	0
BB54A00725	INCORPORATE PERM POWER S.O.W. COMMENTS	22JUN94A	28JUN94A	5	0
BB54A00730	PERM POWER S.O.W. APPROVAL	29JUN94A	30JUN94A	2	0
BB54A00745	PERM POWER CONTRACT AWARD	1JUL94A	15JUL94	10	10
BB54A00750	PERM POWER SUBCONTRACTOR MOBILIZATION	18JUL94	2AUG94	12	12
WP#12054 - SITE 2 - SITE CONSTRUCTI					
BB54A00755	40 HOUR OSHA HAZ WASTE TRAINING	11JAN95	17JAN95	5	5
BB54A00760	IWCP WORK PACKAGE DEVELOPMENT/APPROVAL	11JAN95	21FEB95	30	30
BB54A00765	EXCAVATION PERMIT/RWP	11JAN95	21FEB95	30	30
BB54A00770	PRE-CONSTRUCTION REVIEW SIX PHASE HEATING	11JAN95	21FEB95	30	30
BB54A00775	8 HOUR HAZ WASTE SUPERVISORY TRAINING	18JAN95	20JAN95	3	3
BB54A00780	GENERAL EMPLOYEE TRAINING	23JAN95	27JAN95	5	5
BB54A00785	RAD WORKER TRAINING	30JAN95	3FEB95	5	5
BB54A00790	HEALTH & SAFETY TRAINING	6FEB95	8FEB95	3	3
BB54A00795	QUALITY ASSURANCE TRAINING	9FEB95	13FEB95	3	3
BB54A00800	RESPIRATOR TRAINING	14FEB95	20FEB95	5	5
BB54A00805	SCHEDULE RESERVE	4APR95	16MAY95	30	30
BB54A00810	GRADING & LAYOUT	17MAY95	31MAY95	10	10
BB54A00815	SUPPORT STRUCTURES & POWER HOOKUP	1JUN95	14JUN95	10	10
BB54A00820	DRILLING CONTRACTOR MOBILIZATION	15JUN95	21JUN95	5	5
BB54A00825	PRETEST SAMPLING & ANALYSIS	22JUN95	24AUG95	45	45
BB54A00830	DRILL & INSTALL ELECTRODES & SUBSURFACE INST	22JUN95	29SEP95	70	70
BB54A00835	INSTALLATION OF ADDITIONAL VENTING	2OCT95	27OCT95	20	20
BB54A00840	CONSTRUCT TRENCH	30OCT95	3NOV95	5	5
BB54A00845	CAP INSTALLATION & FENCING	6NOV95	10NOV95	5	5
BB54A00850	SET UP PT MONITORING EQUIPMENT	13NOV95	17NOV95	5	5
BB54A00855	SET UP DRIP SYSTEM	13NOV95	17NOV95	5	5



Plot Date 6JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

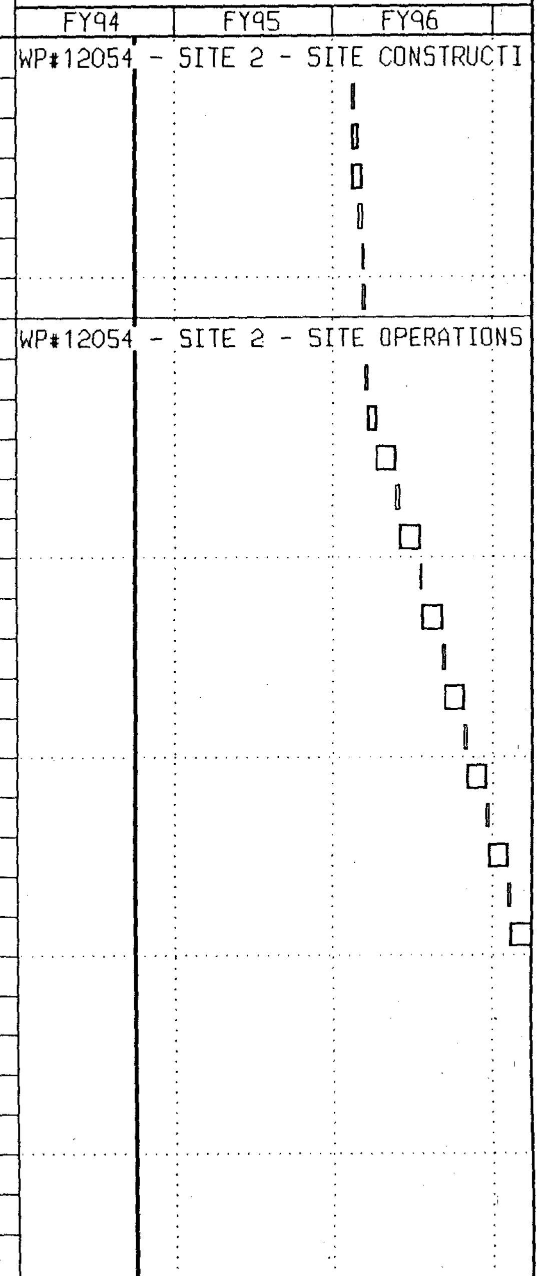
OU2N

Sheet 6 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date | Revision | Checked | Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR
	WP#12054 - SITE 2 - SITE CONSTRUCTI				
BB54A00860	SET UP WATER & EFFLUENT STORAGE	13NOV95	17NOV95	5	5
BB54A00865	SET UP ELECTRODES & POWER SYSTEM	13NOV95	28NOV95	10	10
BB54A00870	SET UP VENT PIPING	13NOV95	5DEC95	15	15
BB54A00875	CONDUCT GROUNDING CHECK	29NOV95	5DEC95	5	5
BB54A00880	POWER SYSTEM TESTING	6DEC95	8DEC95	3	3
BB54A00885	SVE SYSTEM TESTING	6DEC95	12DEC95	5	5
	WP#12054 - SITE 2 - SITE OPERATIONS				
BB54A00890	SYSTEM OPERATIONAL TEST	13DEC95	19DEC95	5	5
BB54A00895	ONSITE OPERATIONS - VENTING	20DEC95	6JAN96	10	10
BB54A00900	1ST HEATING ARRAY OPERATION	7JAN96	20FEB96	45	45
BB54A00901	SAMPLING & ANALYSIS - 1ST ARRAY	21FEB96	1MAR96	10	10
BB54A00902	2ND HEATING ARRAY OPERATION	2MAR96	16APR96	45	45
BB54A00903	MOBILIZATION TO 3RD ARRAY	17APR96	21APR96	5	5
BB54A00904	3RD HEATING ARRAY OPERATIONS	22APR96	6JUN96	45	45
BB54A00905	MOBILIZATION TO 4TH ARRAY	7JUN96	11JUN96	5	5
BB54A00906	4TH HEATING ARRAY OPS	12JUN96	27JUL96	45	45
BB54A00907	MOBILIZATION TO 5TH ARRAY	28JUL96	1AUG96	5	5
BB54A00908	5TH HEATING ARRAY OPS	2AUG96	16SEP96	45	45
BB54A00909	MOBILIZATION TO 6TH ARRAY	17SEP96	21SEP96	5	5
BB54A00910	6TH HEATING ARRAY OPS	22SEP96	5NOV96	45	45
BB54A00911	MOBILIZATION TO 7TH ARRAY	6NOV96	10NOV96	5	5
BB54A00912	7TH HEATING ARRAY OPS	11NOV96	4JAN97	45	45
BB54A00913	MOBILIZATION TO 8TH ARRAY	5JAN97	9JAN97	5	5
BB54A00914	8TH HEATING ARRAY OPS	10JAN97	23FEB97	45	45
BB54A00915	POST-TEST SAMPLING & ANALYSIS	24FEB97	10APR97	45	45
BB54A00916	COOL-DOWN/VENTING	11APR97	30APR97	20	20
BB54M00915	COMPLETION OF SITE 2 PILOT TEST		30APR97	0	0
BB54A00920	DISCONNECT & PACK PNL EQUIPMENT	1MAY97	14MAY97	10	10
BB54A00930	DEMOBILIZE	15MAY97	28MAY97	10	10



Plot Date 6JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

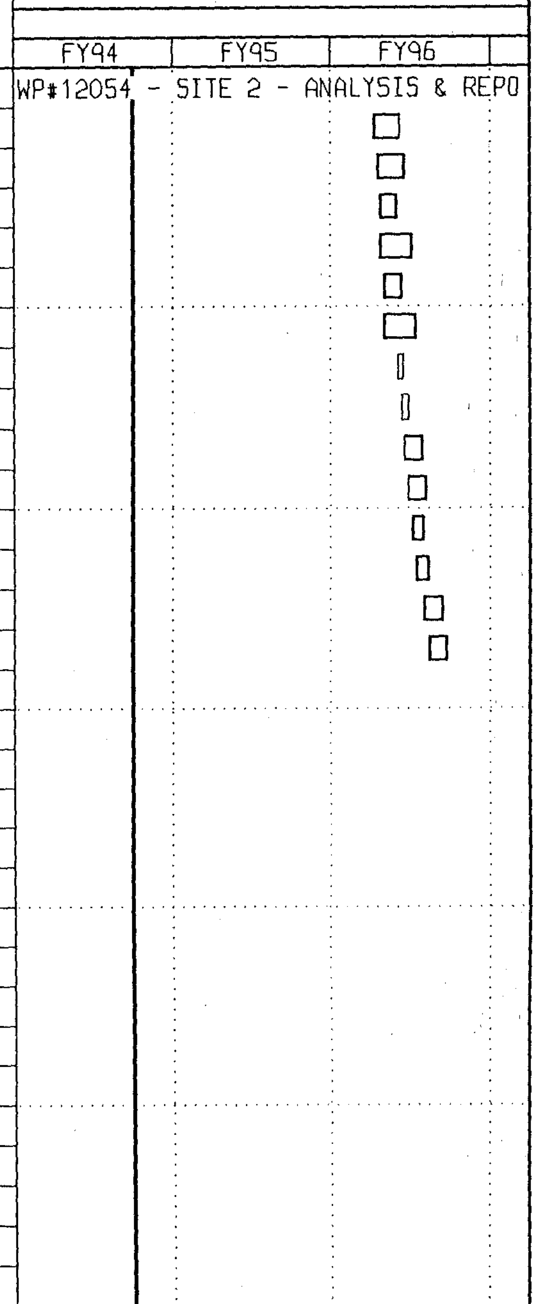
OU2N

Sheet 7 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date	Revision	Checked	Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR	REM DUR
BB54A00935	ANALYSIS OF EXTRACTED SOIL GAS VENT TEST	8JAN96	8MAR96	45	45
BB54A00945	ANALYSIS OF EXTRACTED SOIL GAS HEATING TESTS	17JAN96	19MAR96	45	45
BB54A00940	DRAFT DATA INCORP INTO EG&G RFEDS VENT TEST	22JAN96	1MAR96	30	30
BB54A00950	DATA VALIDATION OF SOIL GAS SAMPLES VENT TEST	22JAN96	4APR96	53	53
BB54A00955	DRAFT DATA INCORP INTO RFEDS HEATING TESTS	31JAN96	12MAR96	30	30
BB54A00960	DATA VAL OF SOIL GAS SAMPLES HEATING TESTS	31JAN96	15APR96	53	53
BB54A00965	DOWNLOAD OF NON-VALID DATA FROM RFEDS VENT TEST	4MAR96	15MAR96	10	10
BB54A00970	DOWNLOAD OF NON-VAL FROM RFEDS HEATING TESTS	13MAR96	26MAR96	10	10
BB54A00975	COMPILE DRAFT DATA FOR VENT TEST	18MAR96	29APR96	30	30
BB54A00980	COMPILE NON-VALID DATA HEATING TESTS	27MAR96	8MAY96	30	30
BB54A00985	UPLOAD VALIDATION DATA INTO RFEDS VENT TEST	5APR96	2MAY96	20	20
BB54A00990	UPLOAD VALIDATED DATA RFEDS HEATING TESTS	16APR96	13MAY96	20	20
BB54A00995	COMPILE VALID DATA VENT TEST	3MAY96	14JUN96	30	30
BB54A00996	COMPILE VALID DATA HEATING TESTS	14MAY96	25JUN96	30	30
BB54A01000	ANALYSIS OF COOLDOWN SAMPLES	1MAY97	3JUL97	45	45
BB54A01005	DRAFT DATA INCORP IN RFEDS - COOLDOWN	7JUL97	15AUG97	30	30
BB54A01015	DOWNLOAD NON-VAL DATA COOLDOWN	18AUG97	29AUG97	10	10
BB54A01010	DATA VALIDATION COOLDOWN SAMPLES	18AUG97	30OCT97	53	53
BB54A01025	COMPILE NON-VALID DATA COOLDOWN SAMPLES	2SEP97	13OCT97	30	30
BB54A01020	UPLOAD VALID DATA COOLDOWN SAMPLES	31OCT97	1DEC97	20	20
BB54A01030	COMPILE VALID DATA COOLDOWN SAMPLES	2DEC97	20JAN98	30	30
BB54A01500	PREPARE FIRST SITE 2 DRAFT REPORT	21JAN98	3MAR98	30	30
BB54M01600	SUBMIT DRAFT SITE 2 PILOT TEST REPT TO EG&G/DOE		3MAR98	0	0
BB54A01650	SUBMIT FIRST DRAFT SITE 2 TO EG&G/DOE FOR REVIEW	4MAR98	10MAR98	5	5
BB54A01700	INCORP EG&G/DOE REVW COMMENTS SITE 2 PILOT TESTS	11MAR98	1APR98	15	15
BB54M01750	SUB DRAFT FINAL PILOT TEST REPORT SITE 2-CDH/EPA		1APR98	0	0
BB54A01800	EPA/CDH REVIEW SITE 2 FINAL DRAFT TEST REPORT	2APR98	29APR98	20	20
BB54A01850	INCORP EPA/CDH COMMNTS SITE 2 FINAL DRAFT REPORT	30APR98	13MAY98	10	10
BB54M01900	ISSUE FINAL SITE 2 TEST REPORT		13MAY98	0	0



Plot Date 6JUL94
Data Date 1JUL94
Project Start 1OCT91
Project Finish 17APR13

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

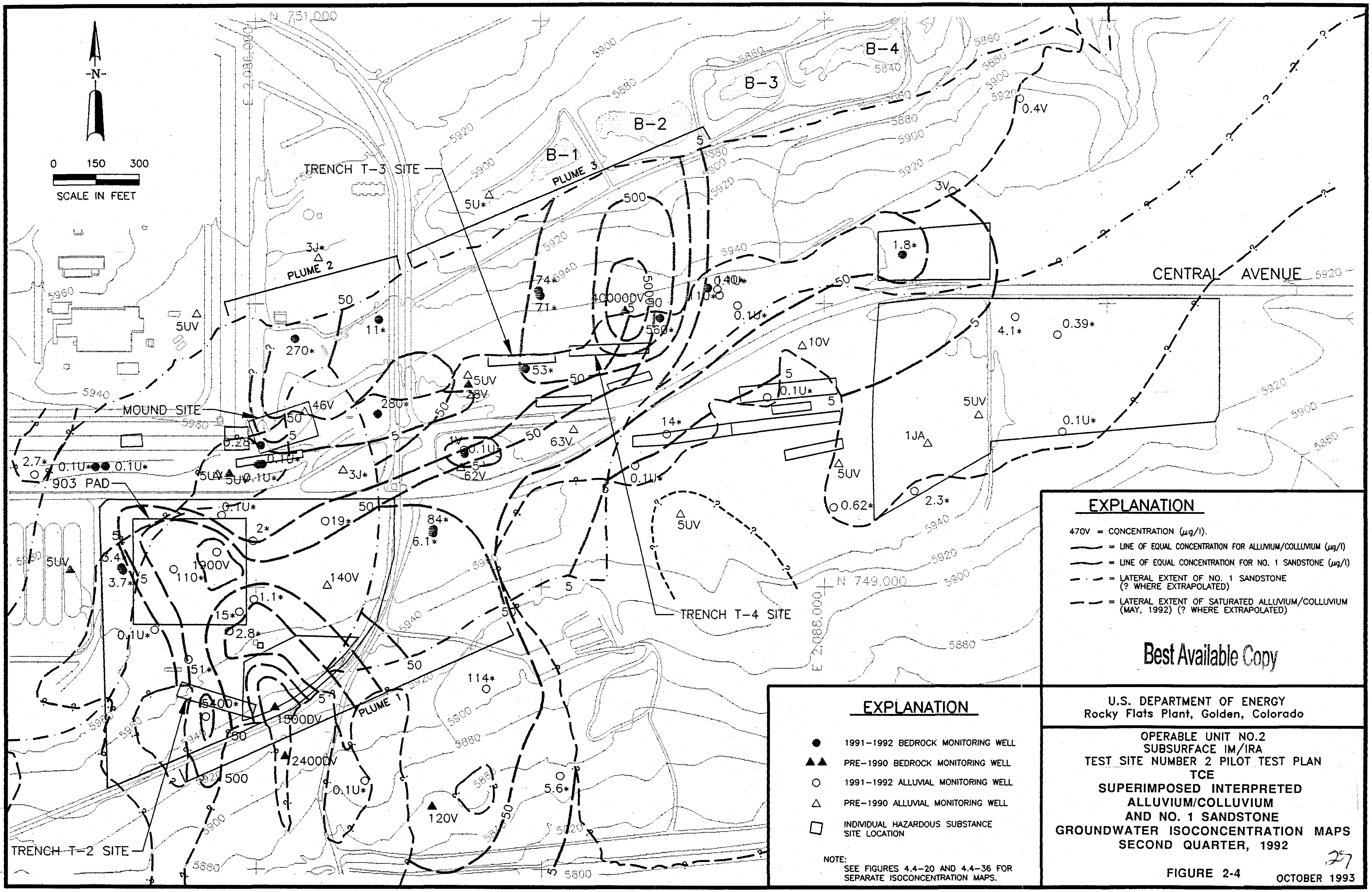
OU2N

Sheet 8 of 8

EG&G ROCKY FLATS, INC
OU2 - 903 PAD, MOUND, EAST TRENCHES
WORK PACKAGE 12054 - SITE 2

Date	Revision	Checked	Approved

101 | 101



EXPLANATION

470V = CONCENTRATION (µg/l).

= LINE OF EQUAL CONCENTRATION FOR ALLUVIUM/COLLUVIUM (µg/l)

= LINE OF EQUAL CONCENTRATION FOR NO. 1 SANDSTONE (µg/l)

= LATERAL EXTENT OF NO. 1 SANDSTONE (? WHERE EXTRAPOLATED)

= LATERAL EXTENT OF SATURATED ALLUVIUM/COLLUVIUM (MAY, 1992) (? WHERE EXTRAPOLATED)

Best Available Copy

EXPLANATION

● 1991-1992 BEDROCK MONITORING WELL

▲▲ PRE-1990 BEDROCK MONITORING WELL

○ 1991-1992 ALLUVIAL MONITORING WELL

△ PRE-1990 ALLUVIAL MONITORING WELL

□ INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION

NOTE:
SEE FIGURES 4.4-20 AND 4.4-36 FOR SEPARATE ISOCONCENTRATION MAPS.

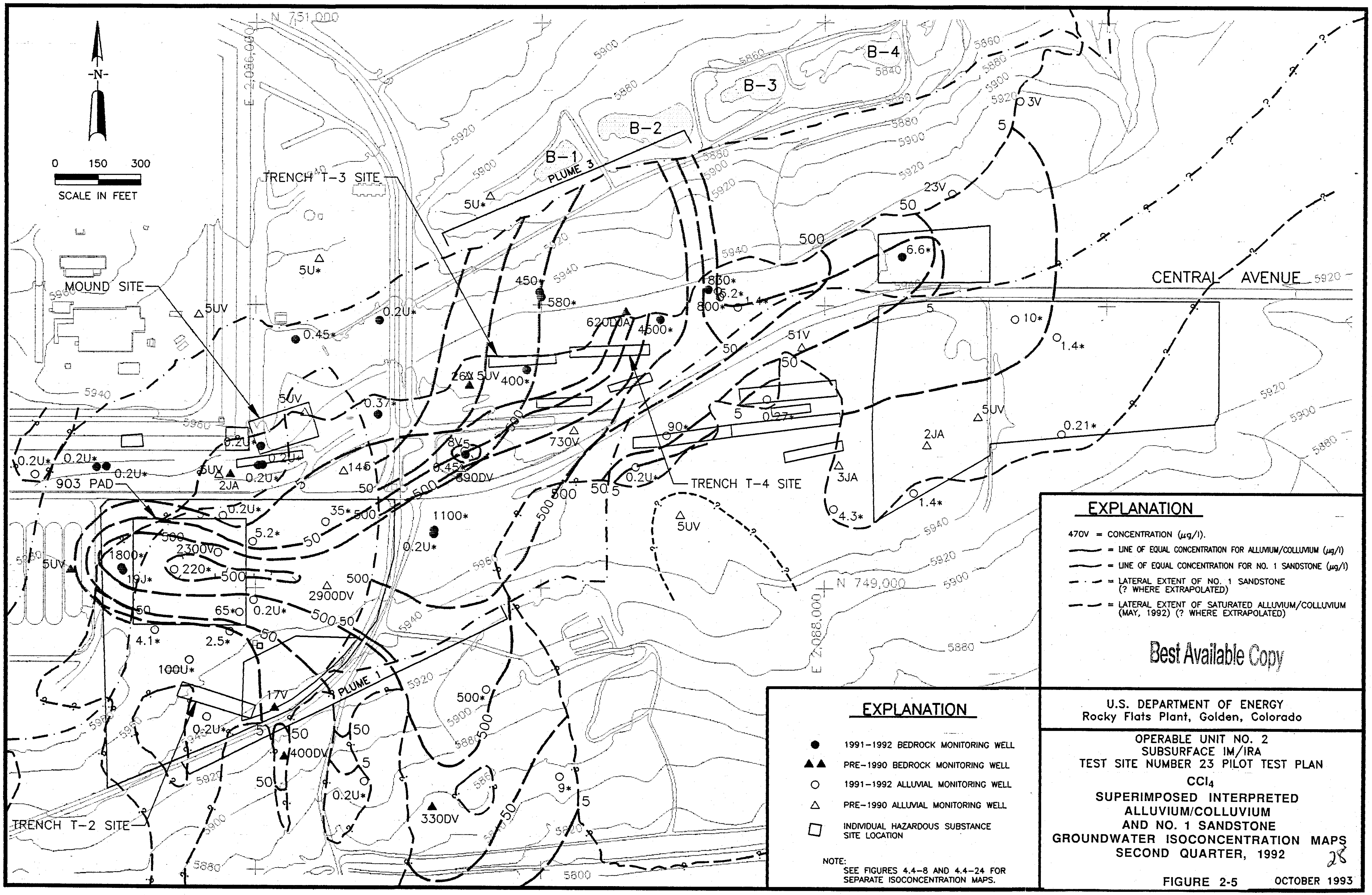
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO.2
SUBSURFACE IM/IRA
TEST SITE NUMBER 2 PILOT TEST PLAN
TCE
SUPERIMPOSED INTERPRETED
ALLUVIUM/COLLUVIUM
AND NO. 1 SANDSTONE
GROUNDWATER ISOCONCENTRATION MAPS
SECOND QUARTER, 1992

FIGURE 2-4

OCTOBER 1993

OU2R154A 1=300



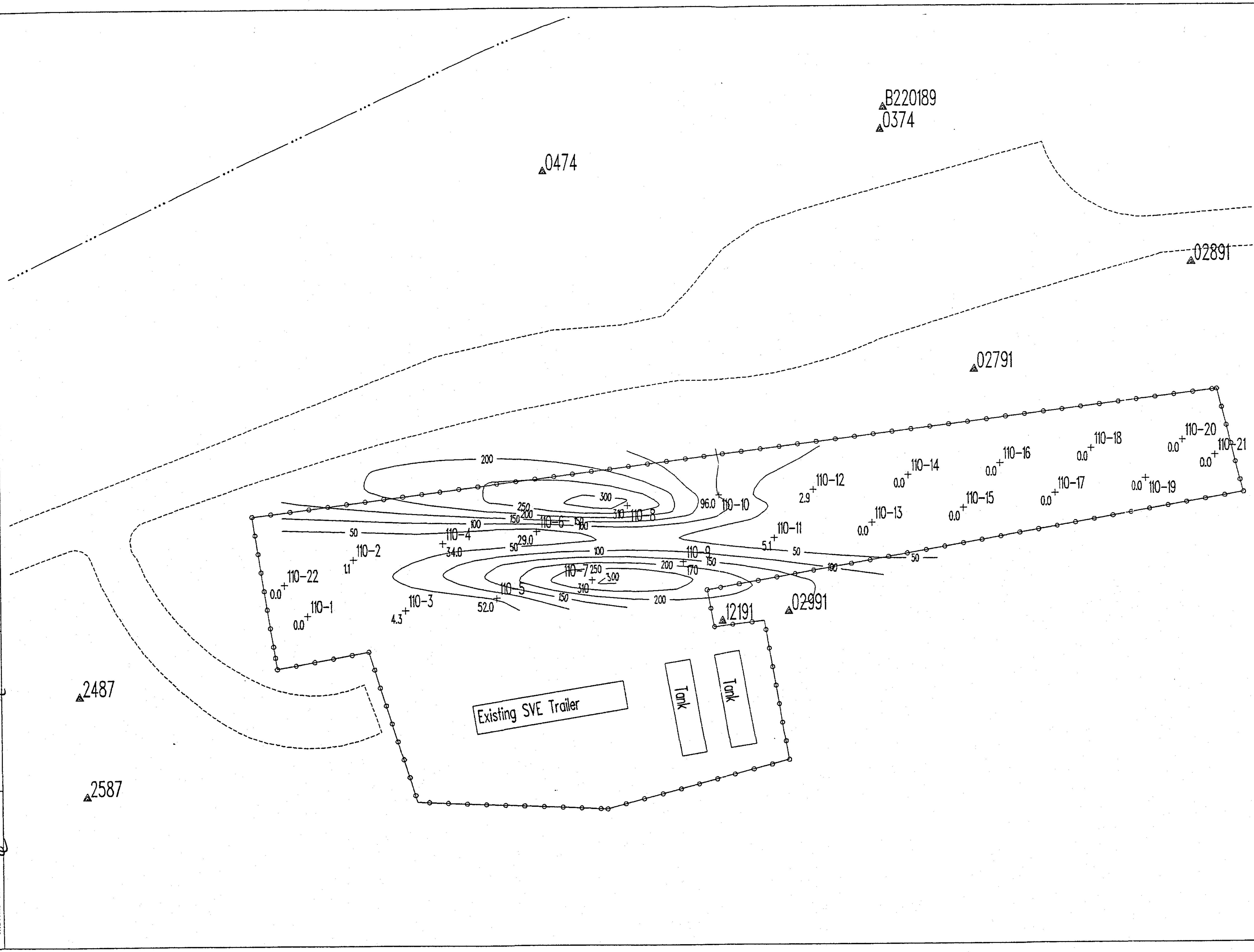
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
SUBSURFACE IM/IRA
TEST SITE NUMBER 23 PILOT TEST PLAN
CCl_4
SUPERIMPOSED INTERPRETED
ALLUVIUM/COLLUVIUM
AND NO. 1 SANDSTONE
GROUNDWATER ISOCONCENTRATION MAPS
SECOND QUARTER, 1992

FIGURE 2-5 OCTOBER 1993

28

0U2R152A 1=300



Soil Vapor Survey Sampling Locations PCE, (ug/L)

5 FOOT SAMPLE DEPTH

Boreholes

Edge of Road

Fence

Drainage

Contour Interval = 50 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

10 0 10 20 FEET

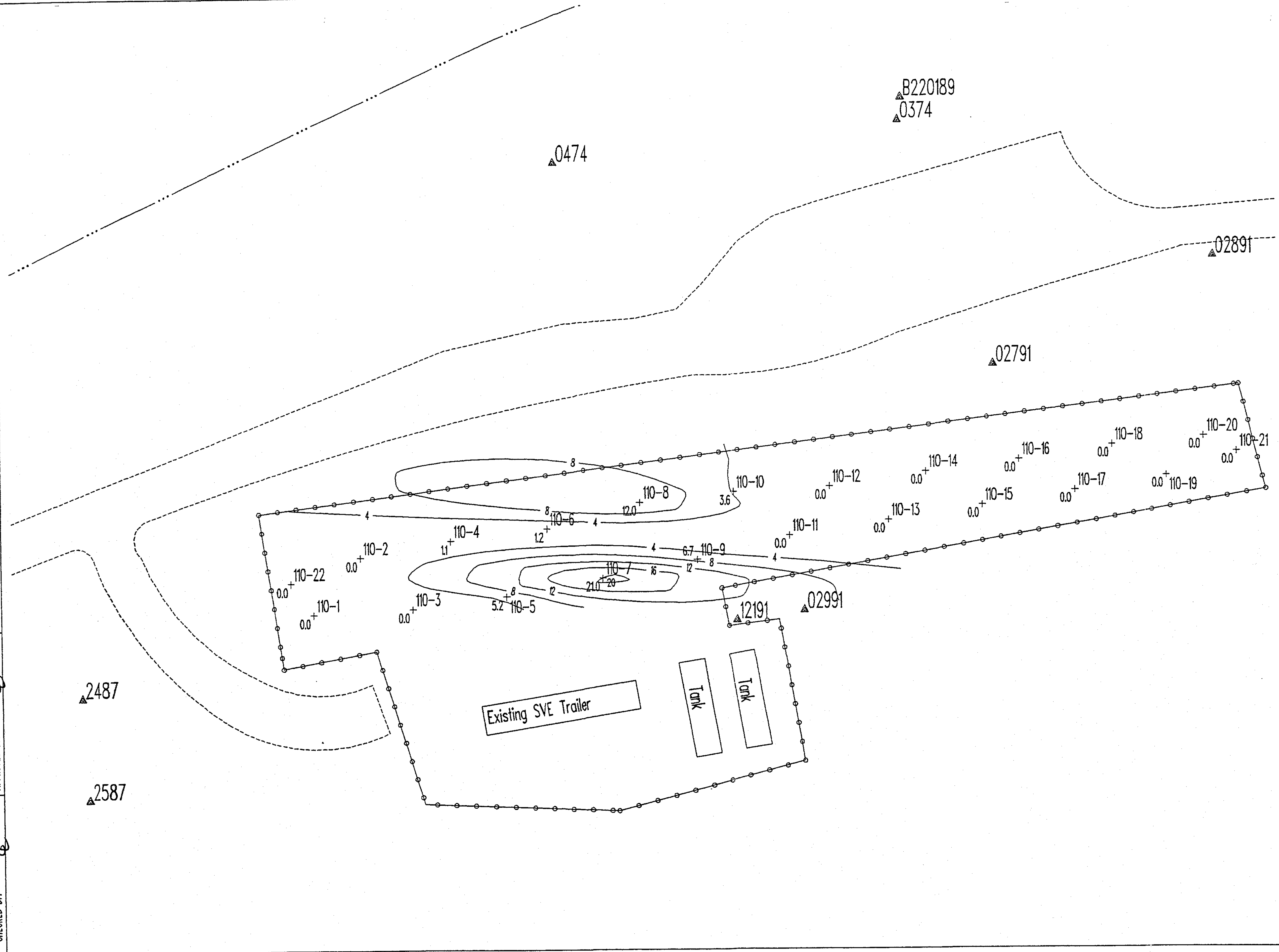
PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

IHSS 110 Tetrachloroethylene (PCE) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 5 FOOT DEPTH
FIGURE 2-6

CHECKED BY: | APPROVED BY: | DRAWN BY: DDJ/KJS | DATE: February 10, 1994 | FILENAME: /arc/data/soilvapor/ihss110S/svs1542.aml | REVISION NO: 2

Best Available Copy

39



Soil Vapor Survey Sampling Locations TCE, (ug/L)

5 FOOT SAMPLE DEPTH

0374 Boreholes

Edge of Road

Fence

Drainage

Contour Interval = 4 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

10 0 10 20 FEET

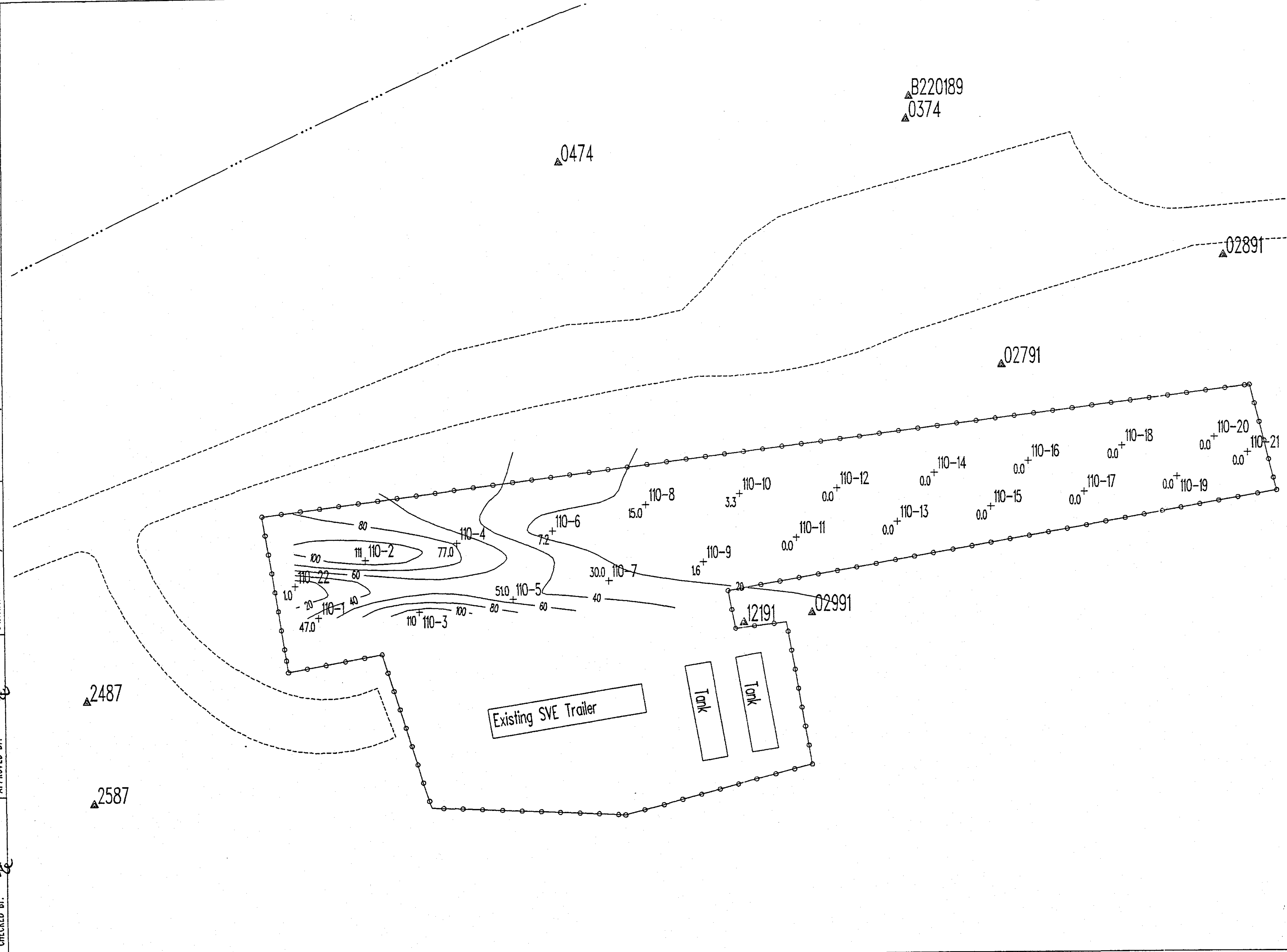
PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

IHSS 110 Trichloroethylene (TCE) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 5 FOOT DEPTH
FIGURE 2-7

REVISION NO: 2 | FILENAME: /arc/data/soilvapor/ihss110S/svs152.aml | DATE: February 10, 1994 | DRAWN BY: DDJ/KJS | APPROVED BY: | CHECKED BY:

Best Available Copy

30



NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

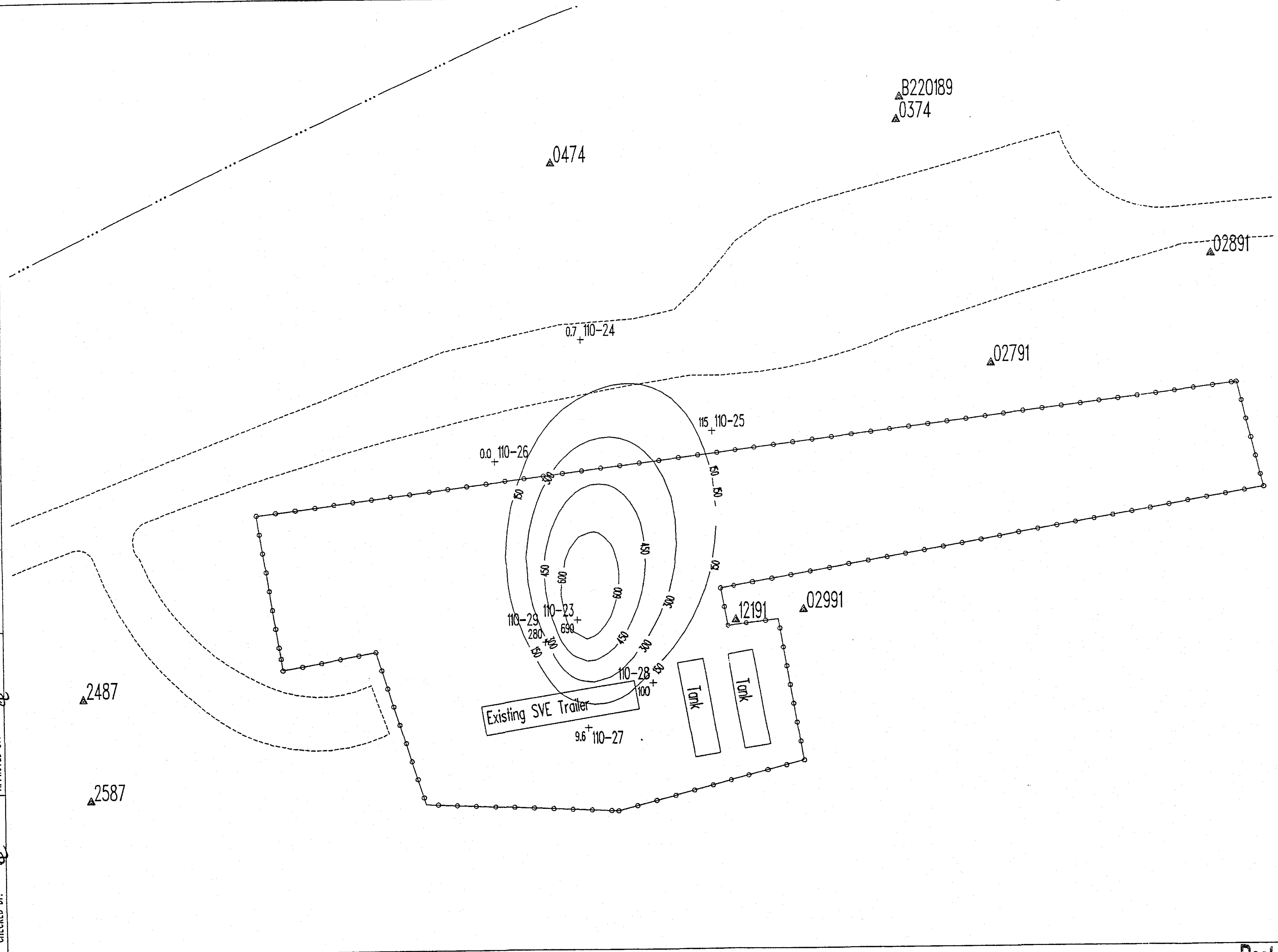
PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

IHSS 110 Carbon Tetrachloride (CCl_4)
SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 5 FOOT DEPTH
FIGURE 2-8

REVISION NO: 2 | FILENAME: /arc/data/soilvapor/ihss1105/svs1522.aml | DATE: February 10, 1994 | DRAWN BY: DDJ/KJS | APPROVED BY: | CHECKED BY:

Best Available Copy

31



0.0 110-23 Soil Vapor Survey Sampling Locations PCE, (ug/L)

10 FOOT SAMPLE DEPTH

0374 Boreholes

Edge of Road

Fence

Drainage

Contour Interval = 150 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

10 0 10 20 FEET

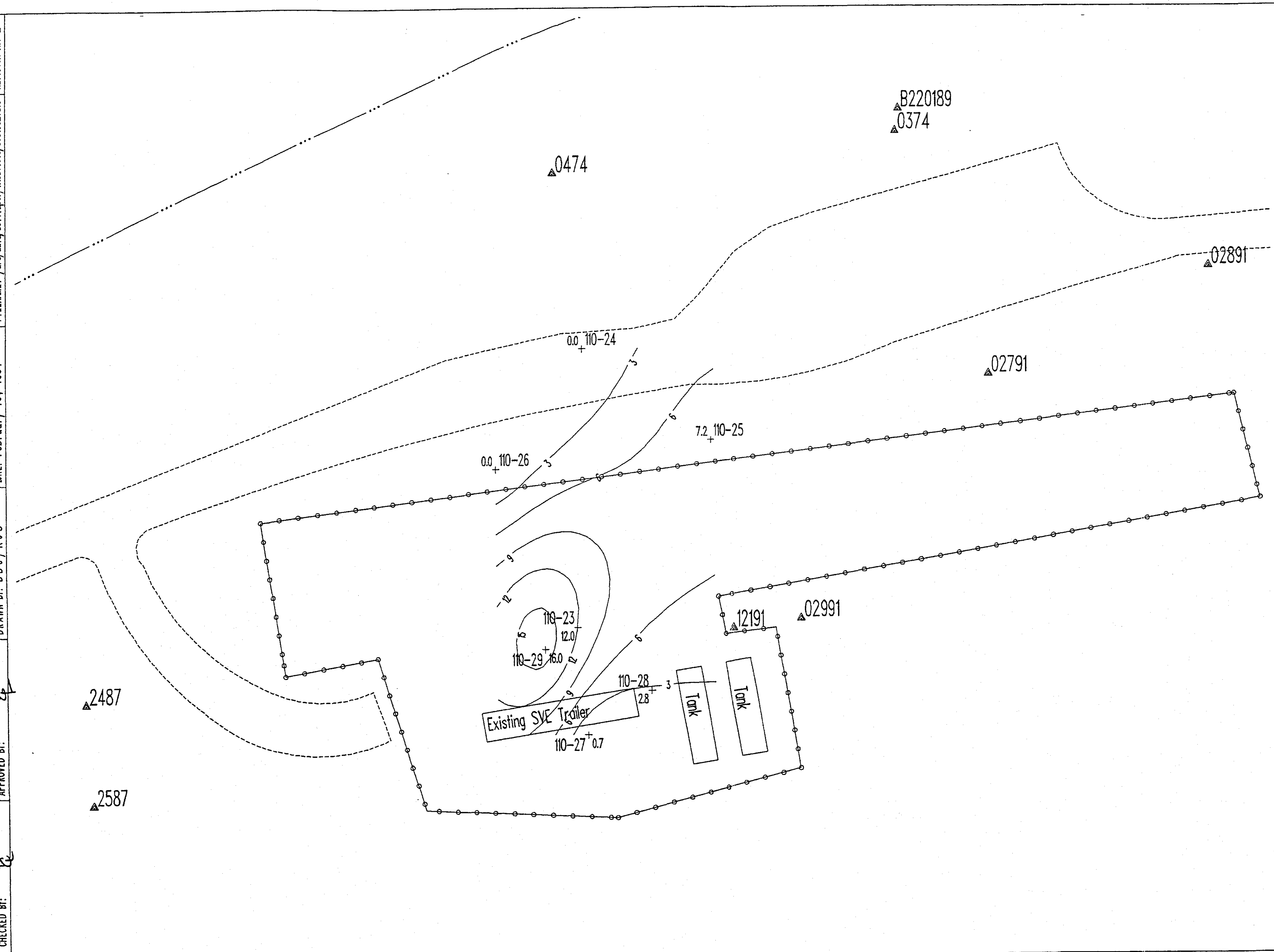
PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

IHSS 110 Tetrachloroethylene (PCE)
SOIL GAS ISOCONCENTRATION
CONTOUR MAP AT 10 FOOT DEPTH
FIGURE 2-9

CHECKED BY:	APPROVED BY:	DRAWN BY: DDJ/KJS	DATE: February 10, 1994	FILENAME: /arc/data/soilvapor/ihss1010/svs1742.aml	REVISION NO: 2

Best Available Copy

32



0.0 110-23 Soil Vapor Survey Sampling Locations TCE, (ug/L)

10 FOOT SAMPLE DEPTH

0374 Boreholes

Edge of Road

Fence

Drainage

Contour Interval = 3 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

10 0 10 20 FEET

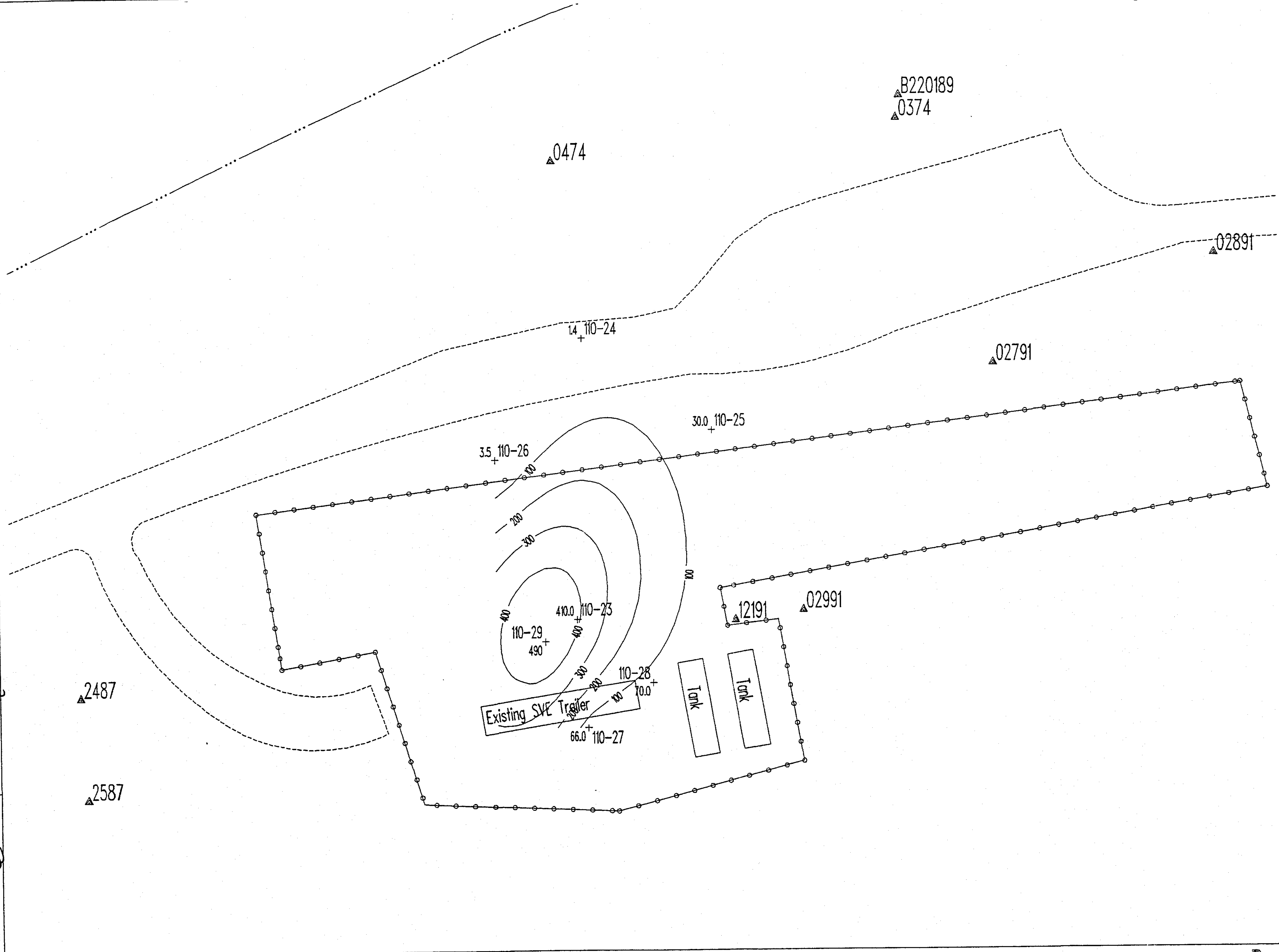
PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

IHSS 110 Trichloroethylene (TCE) SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 10 FOOT DEPTH
FIGURE 2-10

REVISION NO: 2	FILENAME: /arc/data/soilvapor/ihss1010/svs1732.arl	DATE: February 10, 1994	DRAWN BY: DDJ/KJS	APPROVED BY:	CHECKED BY:

Best Available Copy

33



0.0 110-23 Soil Vapor Survey Sampling Locations CCl_4, (ug/L)

10 FOOT SAMPLE DEPTH

0374 Boreholes

Edge of Road

Fence

Drainage

Contour Interval = 100 ug/L

NOTE: THE CONTOURS HAVE BEEN COMPUTER GENERATED FROM A LIMITED NUMBER OF POINTS AND MAY NOT REPRESENT ACTUAL FIELD CONCENTRATIONS.

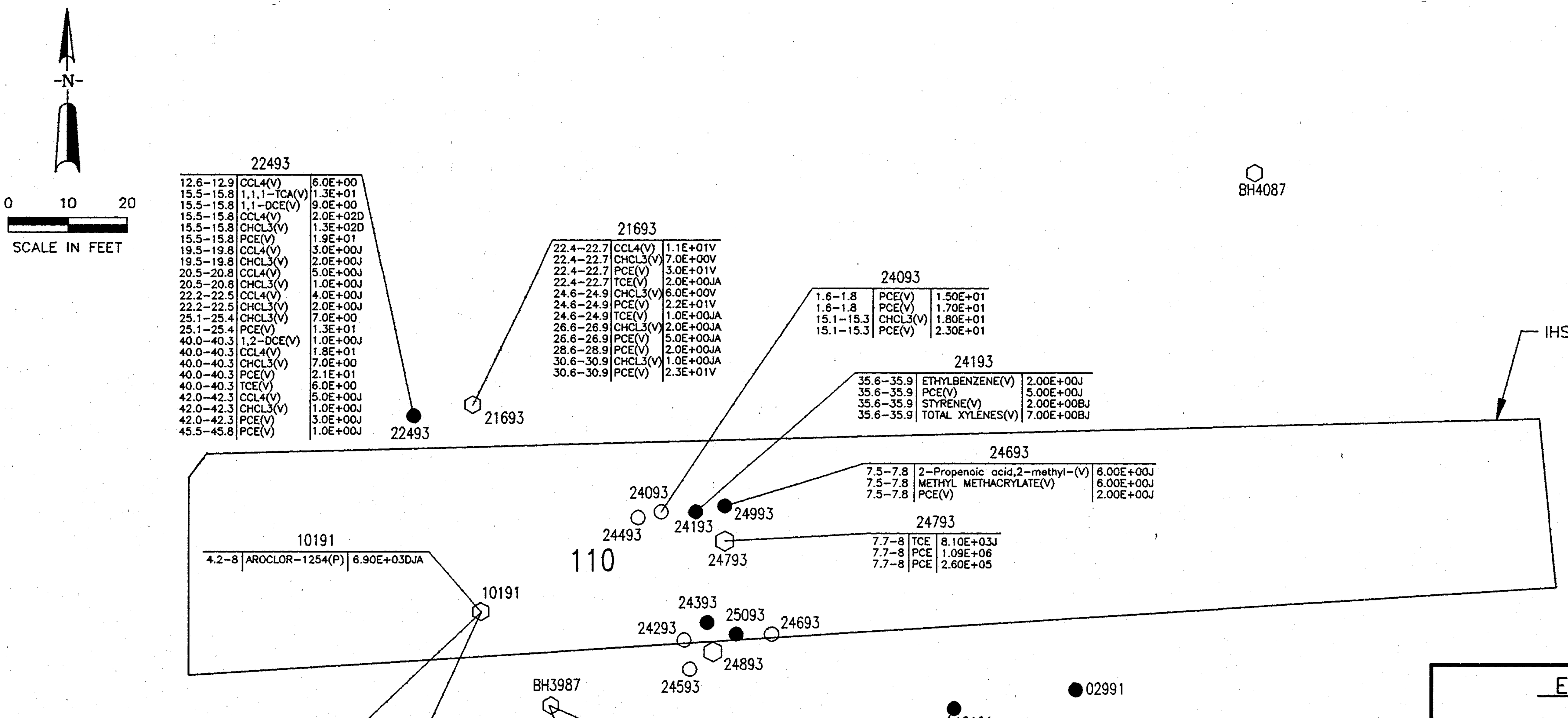
10 0 10 20 FEET

PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

IHSS 110 Carbon Tetrachloride (CCl_4)
SOIL GAS ISOCONCENTRATION CONTOUR MAP AT 10 FOOT DEPTH
FIGURE 2-11

CHECKED BY:	APPROVED BY:	DRAWN BY: DDJ/KJS	DATE: February 10, 1994	FILENAME: /arc/data/soilvapor/ihss11010/svs1722.aml	REVISION NO: 2

34



22493

12.6–12.9	CCL4(V)	6.0E+00
15.5–15.8	1,1,1–TCA(V)	1.3E+01
15.5–15.8	1,1–DCE(V)	9.0E+00
15.5–15.8	CCL4(V)	2.0E+02D
15.5–15.8	CHCL3(V)	1.3E+02D
15.5–15.8	PCE(V)	1.9E+01
19.5–19.8	CCL4(V)	3.0E+00J
19.5–19.8	CHCL3(V)	2.0E+00J
20.5–20.8	CCL4(V)	5.0E+00J
20.5–20.8	CHCL3(V)	1.0E+00J
22.2–22.5	CCL4(V)	4.0E+00J
22.2–22.5	CHCL3(V)	2.0E+00J
25.1–25.4	CHCL3(V)	7.0E+00
25.1–25.4	PCE(V)	1.3E+01
40.0–40.3	1,2–DCE(V)	1.0E+00J
40.0–40.3	CCL4(V)	1.8E+01
40.0–40.3	CHCL3(V)	7.0E+00
40.0–40.3	PCE(V)	2.1E+01
40.0–40.3	TCE(V)	6.0E+00
42.0–42.3	CCL4(V)	5.0E+00J
42.0–42.3	CHCL3(V)	1.0E+00J
42.0–42.3	PCE(V)	3.0E+00J
45.5–45.8	PCE(V)	1.0E+00J

21693

22.4–22.7	CCL4(V)	1.1E+01V
22.4–22.7	CHCL3(V)	7.0E+00V
22.4–22.7	PCE(V)	3.0E+01V
22.4–22.7	TCE(V)	2.0E+00JA
24.6–24.9	CHCL3(V)	6.0E+00V
24.6–24.9	PCE(V)	2.2E+01V
24.6–24.9	TCE(V)	1.0E+00JA
26.6–26.9	CHCL3(V)	2.0E+00JA
26.6–26.9	PCE(V)	5.0E+00JA
28.6–28.9	PCE(V)	2.0E+00JA
30.6–30.9	CHCL3(V)	1.0E+00JA
30.6–30.9	PCE(V)	2.3E+01V

24093

1.6–1.8	PCE(V)	1.50E+01
1.6–1.8	PCE(V)	1.70E+01
15.1–15.3	CHCL3(V)	1.80E+01
15.1–15.3	PCE(V)	2.30E+01

24193

35.6–35.9	ETHYLBENZENE(V)	2.00E+00J
35.6–35.9	PCE(V)	5.00E+00J
35.6–35.9	STYRENE(V)	2.00E+00BJ
35.6–35.9	TOTAL XYLENES(V)	7.00E+00BJ

24693

7.5–7.8	2–Propenoic acid,2–methyl–(V)	6.00E+00J
7.5–7.8	METHYL METHACRYLATE(V)	6.00E+00J
7.5–7.8	PCE(V)	2.00E+00J

24793

7.7–8	TCE	8.10E+03J
7.7–8	PCE	1.09E+06
7.7–8	PCE	2.60E+05

10191

4.2–8	AROCLOR–1254(P)	6.90E+03DJA

10191

2.8–3	1,1,1–TCA(V)	1.30E+04
2.8–3	CCL4(V)	2.80E+04
2.8–3	CHCL3(V)	8.80E+03
2.8–3	PCE(V)	1.30E+07D
2.8–3	TCE(V)	1.20E+05
6.3–6.5	1,1,1–TCA(V)	9.40E+03J
6.3–6.5	CCL4(V)	8.50E+04
6.3–6.5	PCE(V)	3.10E+05
7.8–8	1,1,1–TCA(V)	7.10E+03J
7.8–8	CCL4(V)	8.50E+04
7.8–8	PCE(V)	5.30E+05
9.9–10.1	1,1,1–TCA(V)	8.20E+03
9.9–10.1	CCL4(V)	1.40E+05
9.9–10.1	PCE(V)	5.20E+03J
10.5–10.7	1,1,1–TCA(V)	1.60E+03J
10.5–10.7	CCL4(V)	3.80E+04
10.5–10.7	PCE(V)	1.60E+03J
13.1–13.3	1,1,1–TCA(V)	6.10E+03J
13.1–13.3	CCL4(V)	1.20E+05
13.1–13.3	PCE(V)	4.70E+03J
15.9–16.1	1,1,1–TCA(V)	2.70E+04J
15.9–16.1	CCL4(V)	7.00E+05
29.8–30	CCL4(V)	4.00E+00J
29.8–30	CHCL3(V)	1.00E+02
29.8–30	PCE(V)	1.20E+02
29.8–30	TCE(V)	2.00E+00J
35.8–36	CCL4(V)	1.20E+01V
35.8–36	CHCL3(V)	2.10E+01JJA
35.8–36	PCE(V)	2.00E+00JA
49.8–50	1,1,1–TCA(V)	6.00E+00V
49.8–50	CCL4(V)	4.80E+01V
49.8–50	CHCL3(V)	1.10E+01V
49.8–50	PCE(V)	8.00E+00V

10191

4.2–8	2–METHYLNAPHTHALENE(SV)	8.10E+03DV
4.2–8	2–METHYLPHENOL(SV)	4.50E+02V
4.2–8	4–METHYLPHENOL(SV)	2.90E+03V
4.2–8	NAPHTHALENE(SV)	2.00E+03V
4.2–8	PHENANTHRENE(SV)	2.70E+03JA
8–14.1	HEXACHLOROBUTADIENE(SV)	1.70E+02JA
8–14.1	HEXACHLOROETHANE(SV)	1.10E+03V
14.1–20.1	HEXACHLOROETHANE(SV)	3.70E+02V

BH3987

0–2	1,2–DCA(V)	1.50E+01J
2–3.4	1,2–DCA(V)	1.40E+01J
12–14	1,2–DCA(V)	6.00E+00J

BH3987

0–2	N–Nitrosodiphenylamine(SV)	3.30E+01J

12191

27.9–28.1	PCE(V)	3.20E+01V

EXPLANATION

10291 ← LOCATION

2–8: SAMPLE INTERVAL (ft) | ANALYTE | ANALYTE CONCENTRATION (ug/kg) AND LAB AND VALIDATION QUALIFIERS

NOTE:
ALL ANALYTE CONCENTRATIONS ARE REPORTED IN ug/kg (parts per billion). ANALYTE ABBREVIATIONS AND LAB AND VALIDATION QUALIFIERS ARE PRESENTED ON FIGURE 2.4-3

EXPLANATION

24093 – 25093	SVE PILOT TEXT BOREHOLE AND WELLS
10191	RI BOREHOLE WITH NAPL
24793	SVE PILOT TEST BOREHOLE WITH NAPL

EXPLANATION

09491 ⬡	SOURCE BOREHOLE LOCATION
06591 ⬢	SOURCE BOREHOLE/MONITORING WELL LOCATION OPEN OR FILLED DEPENDING ON ALLUVIAL OR BEDROCK SCREENED INTERVAL
24493 ○	ALLUVIAL MONITORING WELL LOCATION
24393 ●	BEDROCK MONITORING WELL LOCATION
110	INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
(V)	VOLATILE ORGANIC COMPOUNDS
(SV)	SEMIVOLATILE ORGANIC COMPOUNDS
(P)	PESTICIDES/PCBs

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

OPERABLE UNIT 2
SUBSURFACE IM/IRA
TEST SITE NUMBER 2 PILOT TEST PLAN

VOCs, SVOCs AND PESTICIDES/PCBs
IHSS 110 (TRENCH T-3)
SUBSURFACE SOILS

FIGURE 2-12

JANUARY 1994

4045003A 1=20