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FINAL
PHASE III RFI/RI WORK PLAN

REVISION 1

ROCKY FLATS PLANT

881 HILLSIDE AREA

(OPERABLE UNIT NO. 1)

U S DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

March 1991

VOLUME I

ADMIN RECORD

FINAL PHASE III RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION

WORK PLAN

REVISION 1

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881 HILLSIDE AREA
(OPERABLE UNIT NO 1)

ENVIRONMENTAL RESTORATION PROGRAM

U S Department of Energy
Rocky Flats Office
Golden, Colorado

MARCH 1991

Editorial Note **Sidebars in this Revised RFI/RI Work Plan text denote changes from the Final Phase III RFI/RI Work Plan dated October, 1990 Text changes made in response to an EPA or CDH comment (Attachment 1 0) are denoted by solid dots in the right hand margin**

This document presents the work plan for the Phase III Resource Conservation and Recovery Act (RCRA) Facility Investigation/Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial investigation (RFI/RI), of the 881 Hillside Area [Operable Unit Number 1 (OU No 1)] at the Rocky Flats Plant An initial (Phase I) field program was completed during 1987, and a draft RI report was submitted to the U S Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH) in July, 1987 (Rockwell International, 1987a) Based on results of that investigation, a second phase of field work was conducted at the 881 Hillside in the fall of 1987 A draft Phase II RI was submitted to EPA and CDH in March 1988 (Rockwell International, 1988a), and in October 1988 the DOE received written comments on the draft Phase II RI This Phase III RFI/RI Work Plan presents site-specific plans for further field work to characterize contaminant sources and the extent of soils, surface water, and ground-water contamination Also included are plans for human health and environmental risk assessments and a RCRA Corrective Measures Study/CERCLA Feasibility Study (CMS/FS) This work plan is based on results presented in the draft RI reports as well as subsequent surface water and ground-water sampling and analysis

A draft Phase III RFI/RI Work Plan was submitted to EPA and CDH in February 1990 (EG&G, 1990a), and a final Phase III Work Plan was submitted to EPA and CDH in October 1990 which incorporated EPA and CDH May 1990 comments on the draft plan (EG&G, 1990b) This February 1991 document is Revision 1 of the Final Phase III RFI/RI Work Plan and incorporates agency comments on the October 1990 submittal Although not required by the Inter-agency Agreement (IAG), Revision 1 was prepared so that final agency comments are reflected in a single document prior to implementation of the Phase III scope of work This better assures that the RFI/RI and CMS/FS are conducted in accordance with a plan to which all parties are in agreement It is noted that this plan has also been modified for reasons not associated with specific agencies' comments These changes have been made to "update" the plan with respect to the current understanding of the site, other operable unit study activities that impact OU No 1, and regulatory issues Major changes are as follows

- Revised geological characterization based on the on-going site-wide geological characterization program
- Addition of a concise site conceptual model
- Discussion of all Rocky Flats Plant treatability study programs
- Reference to a more extensive surface soil sampling program to assess the mobility of plutonium in the soil/water environment
- Elaboration and modification to the discussion of applicable or relevant and appropriate requirements (ARARs)

Sites at the 881 Hillside Area were selected as High Priority Sites as a result of Plant-wide characterization activities which showed elevated concentrations of volatile organic compounds in ground water upgradient from Woman Creek (DOE, 1987a) The Phase I and Phase II RIs indicated that the unconfined ground-water flow system is contaminated The most pronounced organic contamination is in the eastern portion of the 881 Hillside Area, with tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,1-dichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, and carbon tetrachloride reaching several thousand micrograms per liter in many samples Organic contamination in the western portion of the 881 Hillside area occurs at much lower concentrations Concentrations of metals and inorganics above estimated background levels are considered to represent possible contamination for the purposes of planning the Phase III RFI/RI The eastern portion of the study area showed the highest concentrations of inorganic constituents, with total dissolved solids of approximately 2000 milligrams per liter, and numerous occurrences of nickel, strontium, selenium, zinc, copper, and uranium above background in most wells Other metals exceeded background less frequently and by a smaller margin in this area and elsewhere at OU No 1

Phase I and Phase II soils investigations indicated tetrachloroethene, trichloroethene, and 1,1,1-trichloroethane contamination in some soil samples In addition, toluene was detected in soil sample during the French Drain Geotechnical Investigation Prevalent occurrences of methylene chloride, acetone, and phthalates in soil samples have raised questions of laboratory contamination which prevent definitive conclusions about the actual presence of these contaminants in soils Plutonium and americium were detected above background in soil samples that include the ground surface Windblown radionuclide-bearing dust from the 903 Pad Area is the suspected source of these radionuclides Plans for additional characterization of waste sources and soils are described herein

Tetrachloroethene and trichloroethene are the principal volatile organic compounds which have been detected in surface water samples from a few stations, although the concentrations and frequency of occurrence are low Low concentrations of methylene chloride, acetone, and toluene in the surface water occur at many sampling stations The furthest downgradient surface water samples do not show organic contamination Numerous metals and other inorganic compounds were occasionally above background Gross alpha, gross beta, uranium, and plutonium exceeded background in many of the samples

Proposed sampling and analysis for the RFI/RI, presented in Section 5 0, will support source characterization and better definition of the nature and extent of soil, ground-water, and surface water contamination Fifty-four boreholes will be drilled and twenty monitor wells will be installed for the purposes of source characterization An additional seventeen monitoring wells will be installed to determine the nature and extent of contamination, and to support hydraulic testing for better characterization and prediction of contaminant movement

Based on the Phase I and II results, an interim measures/interim remedial action (IM/IRA) is being implemented at OU No 1 The IM/IRA focuses on the collection of contaminated alluvial ground water, and treatment of the ground water to remove organic and inorganic contaminants

Surface soil scrapes, and soil samples for vertical profile analysis will be collected to better characterize the distribution of radionuclides, and to complement an investigation of surface soils over an 800 acre area which is planned for Operable Unit No 2, east of the 881 Hillside Area Three new sediment sampling stations will be established to enable characterization of sediments that are more directly associated with the 881 Hillside than sediment samples analyzed in previous investigations

A baseline risk assessment plan is provided in Sections 4 1 6 and 6 0 The baseline risk assessment includes both a public health evaluation and environmental evaluation Section 4 1 6 focuses on the public health evaluation including contaminant identification, exposure assessment, toxicity assessment, and risk characterization This section also briefly discusses the environmental evaluation, however, the details are provided in Section 6 0, the Environmental Evaluation Plan This plan was prepared to provide a framework for addressing environmental effects as a result of exposure to contaminants from the 881 Hillside Area The plan presents a three-stage approach for conducting the environmental evaluation The sequential approach was designed to ensure that all procedures to be performed are appropriate, necessary, and sufficient to adequately characterize the nature and extent of the environmental impacts resulting from contaminants at 881 Hillside

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GLOSSARY OF ACRONYMS

ACRONYM	MEANING
AEC	Atomic Energy Commission
ALAD	Amino-lerulinic acid dehydrase
ARARs	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
BCFs	Bioconcentration Factors
CAD	Corrective Action Decision
CCl_4	Carbon Tetrachloride
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLP	Contract Laboratory Program
CFR	Code of Federal Regulations
$CHCl_3$	Chloroform
cm/s	Centimeters per second
CMS/FS	Corrective Measures Study/Feasibility Study
CWA	Clean Water Act
DQO	Data Quality Objectives
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
dpm/g	Disintegrations per Minute per Gram
DOE	Department of Energy
DRCOG	Denver Regional Council of Governments
EPA	Environmental Protection Agency
ER	Environmental Restoration Program
ERDA	Energy Research and Development Administration
FFACO	Federal Facility Agreement and Consent Order
FR	Federal Register
FS	Feasibility Study
FSP	Field Sampling Plan
ft/ft	Foot Per Foot
ft/yr	Foot Per Year

GLOSSARY OF ACRONYMS

(Continued)

ACRONYM	MEANING
GFAA	Graphite Furnace Absorption Spectroscopy
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
GPM	Gallons Per Minute
HEAST	Health Effects Assessment Summary Tables
HSL	Hazardous Substance List
HSP	Health and Safety Plan
IHSS	Individual Hazardous Substance Site
IAG	Inter-Agency Agreement - the Federal Facility Agreement & Consent Order (FFACO)
ICP	Inductively Coupled Argon Plasma Emission Spectroscopy
IM/IRA	Interim Measures/Interim Remedial Action
IRIS	Integrated Risk Information System
Kg	Kilograms
m	Meter
MATC	Maximum Allowable Tissue Concentrations
mCi/m^2	micoCurie per Square Meter
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDA	Minimum Detectable Activity
mg	Milligrams
mg/kg	Milligrams Per Kilogram
mg/l	Milligrams Per Liter
ml	Milliliters
mm	Millimeters
NCP	National Contingency Plan
nm	Nanometers
NPDES	National Pollutant Discharge Elimination System
OSWER	Office of Solid Waste and Emergency Response
PCE	Tetrachloroethene
pCi/g	picoCuries per Gram
pCi/l	picoCuries per Liter
QA/QC	Quality Assurance/Quality Control
QAPjP	Quality Assurance Project Plan
RAAMP	Radioactive Ambient Air Monitoring Program

GLOSSARY OF ACRONYMS

(Continued)

ACRONYM	MEANING
RAID	Superfund Risk Assessment Information Directory
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act of 1976
RfD	Reference Dose
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI	Remedial Investigation
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedures
SW	Surface Water Monitoring Station
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TBC	To Be Considered
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
TDS	Total Dissolved Solids
TOSCO	The Oil Shale Company
TSP	Treatability Studies Plan
μCi	Microcuries
μg/ℓ	Micrograms Per Liter
μg/kg	Micrograms Per Kilogram
μm	Micrometers

This document presents the work plan for the Phase III Resource Conservation and Recovery Act (RCRA) Facility Investigation/Comprehensive Environmental Response, Compensation Liability Act (CERCLA) Remedial Investigation (RFI/RI) of the 881 Hillside Area [Operable Unit No 1 (OU No 1)] at the Rocky Flats Plant It addresses characterization of contaminant sources as well as the nature and extent of contamination in soils, ground water, and surface water The work plan also presents the tasks that must be completed in the performance of the RCRA Corrective Measure Study/CERCLA Feasibility Study (CMS/FS)

This investigation is part of a comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions currently in progress at the Rocky Flats Plant These investigations are pursuant to the U S Department of Energy (DOE) Environmental Restoration (ER) Program [formerly known as the Comprehensive Environmental Assessment and Response Program (CEARP)], a Compliance Agreement between DOE, the U S Environmental Protection Agency (EPA) and the State of Colorado Department of Health (CDH) dated July 31, 1986, and the Federal Facility Agreement and Consent Order (FFACO) [known as the Inter-Agency Agreement (IAG)] The program developed by DOE, EPA, and CDH in response to the agreements addresses RCRA and CERCLA issues and has been integrated with the ER Program In accordance with the IAG, the CERCLA terms "Remedial Investigation" and "Feasibility Study" in this document are considered equivalent to the RCRA terms "RCRA Facility Investigation" and "Corrective Measures Study"

1 1 ENVIRONMENTAL RESTORATION PROGRAM

The ER Program is designed to investigate and clean up contaminated sites at DOE facilities The ER Program is being implemented in five phases Phase 1 (Installation Assessment) includes preliminary assessments and site inspections to assess potential environmental concerns Phase 2 (Remedial Investigations) includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites and to evaluate potential contaminant migration pathways Phase 3 (Feasibility Studies) evaluates remedial alternatives and develops remedial action plans to mitigate environmental problems identified as needing correction in Phase 2 Phase 4 (Remedial Design/Remedial Action) includes design and implementation of site-specific remedial actions selected on the basis of Phase 3 feasibility studies Phase 5 (Compliance and Verification) implements monitoring and performance assessments of remedial actions, and verifies and documents the adequacy of remedial actions carried out under Phase 4 Phase 1 has already been completed at Rocky Flats Plant (DOE, 1986), and Phases 2, 3, and 4 are currently in progress for OU No 1

Phase 2 activities at OU No 1 include a Phase I and a Phase II RI An initial (Phase I) field program was completed at the 881 Hillside Area in 1987, and a draft Phase I RI report was submitted to EPA and CDH in July 1987 (Rockwell International, 1987a) Based on results of that investigation, a second phase of field work was conducted at the 881 Hillside in the fall of 1987 A draft Phase II RI was submitted to EPA and CDH in March 1988 (Rockwell International, 1988a), and in October 1988 the DOE received written comments on the draft Phase II RI A draft Phase III RFI/RI Work Plan was submitted to EPA and CDH in February 1990 (EG&G, 1990a), and a final Phase III Work Plan was submitted to EPA and CDH in October 1990 which incorporated EPA and CDH May 1990 comments on the draft plan (EG&G, 1990b) This February 1991 document is Revision 1 of the Final Phase III RFI/RI Work Plan and incorporates agency comments on the October 1990 submittal Although not required by the Inter-agency Agreement (IAG), Revision 1 was prepared so that final agency comments are reflected in a single document prior to implementation of the Phase III scope of work This better assures that the RFI/RI and CMS/FS are conducted in accordance with a plan to which all parties are in agreement It is noted that this plan has also been modified for reasons not associated with specific agencies' comments These changes have been made to "update" the plan with respect to the current understanding of the site, other operable unit study activities that impact OU No 1, and regulatory issues Major changes are as follows

- Revised geological characterization based on the on-going site-wide geological characterization program
- Addition of a concise site conceptual model
- Discussion of all Rocky Flats Plant treatability study programs
- Reference to a more extensive surface soil sampling program to assess the mobility of plutonium in the soil/water environment
- Elaboration and modification to the discussion of applicable or relevant and appropriate requirements (ARARs)

ER Program Phase 3 activities at OU No 1 include submittal of a draft FS report to EPA and CDH in March 1988 (Rockwell International, 1988b) This document was submitted with the draft Phase II RI report, and EPA comments on the Feasibility Study (FS) were received with the Phase II RI comments Written responses to the March 1988 RI/FS were prepared and forwarded to EPA in February 1989 (Rockwell International, 1989a) An Interim Measure/Interim Remedial Action Plan (IM/IRAP) has also been developed to collect and treat contaminated alluvial ground water at OU No 1 (DOE, 1990a) The plan was released for public comment during October and November 1989 and finalized in January 1990 Construction of the interim remedial action was started in January 1990 A final remedial action will be proposed based on Phase I, II, and III investigations

1.2 WORK PLAN OVERVIEW

This Phase III RFI/RI Work Plan for the 881 Hillside Area presents results of the Phase I and Phase II RIs, defines data quality objectives and data needs based on that investigation, specifies RI/FS tasks, and presents a Field Sampling Plan (FSP) This section (1 0 Introduction) presents site locations and descriptions, and Section 2 0 presents results of the previous RIs Included in Section 2 0 are Phase I and Phase II characterization results for site geology and hydrology as well as the nature and extent of contamination in soils, ground water, surface water, and sediments Section 3 0 discusses data quality objectives for the Phase III investigation Section 4 0 specifies RI/FS tasks to be performed, and Section 5 0 presents the FSP to meet Remedial Investigation/Feasibility Study (RI/FS) objectives The Environmental Evaluation Work Plan (EEW) for OU No 1 is presented in Section 6 0, and the Applicable or Relevant and Appropriate Requirements (ARARs) are presented in Section 7 0 The proposed schedule for conducting the RFI/RI is presented in Section 8 0 Written responses to EPA and CDH comments on the October 1990 Final Phase III RFI/RI Work Plan are presented in Attachment 1 0

1 3 BACKGROUND AND PHYSICAL SETTING

1 3 1 Background

The Rocky Flats Plant is a government-owned, contractor-operated facility, which is part of the nationwide nuclear weapons production complex The Plant was operated for the U S Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975 At that time, responsibility for the Plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the DOE in 1977 Dow Chemical U S A , an operating unit of the Dow Chemical Company, was the prime operating contractor of the facility from 1951 until June 30, 1975 Rockwell International was the prime contractor responsible for operating the Rocky Flats Plant from July 1, 1975, until December 31, 1989 EG&G Rocky Flats, Inc , became the prime contractor at the Rocky Flats Plant on January 1, 1990, and currently operates the Plant

1 3 1 1 Plant Operations

The primary mission of the Rocky Flats Plant is to fabricate nuclear weapon components from plutonium, uranium, and other non-radioactive metals (principally beryllium and stainless steel) Parts made at the Plant are shipped elsewhere for assembly In addition, the Plant reprocesses components after they are removed from obsolete weapons for recovery of plutonium

Both radioactive and nonradioactive wastes are generated in the production process Current waste handling practices involve on-site and off-site recycling of hazardous materials, on-site storage of hazardous and radioactive mixed wastes, and off-site disposal of solid radioactive materials at another DOE facility However, both storage and disposal of hazardous and radioactive wastes occurred on site in the past Preliminary assessments under the ER Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination

1 3 1 2 **Previous Investigations**

Various studies have been conducted at the Rocky Flats Plant to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment The investigations performed prior to 1986 are summarized in Rockwell International (1986a) and include

- Detailed descriptions of the regional geology (Malde, 1955, Spencer, 1961, Scott, 1960, 1963, 1970, 1972 and 1975, Van Horn, 1972 and 1976, DOE, 1980, Dames and Moore, 1981, and Robson, et al , 1981a and 1981b)
- Several drilling programs beginning in 1960 that resulted in the construction of approximately 60 monitor wells by 1982
- An investigation of surface and ground-water flow systems by the U S Geological Survey (Hurr, 1976)
- Environmental, ecological, and public health studies which culminated in an environmental impact statement (DOE, 1980)
- A summary report on ground-water hydrology using data from 1960 to 1985 (Hydro-Search, Inc , 1985)
- A preliminary electromagnetic survey of the Plant perimeter (Hydro-Search, Inc , 1986)
- A soil gas survey of the Plant perimeter and buffer zone (Tracer Research, Inc , 1986)
- Routine environmental monitoring programs addressing air, surface water, ground water, and soils (Rockwell International, 1975 through 1985, and 1986b) Additional information on routine environmental programs is also presented in post-1986 annual environmental monitoring reports (Rockwell International, 1987b, 1989b, and EG&G, 1990c)

In 1986, two major investigations were completed at the Plant The first was the ER Program Phase 1 installation assessment (DOE, 1986) which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported A number of sites were identified that could potentially have adverse impacts on the environment These sites were designated as Solid Waste Management Units (SWMUs) by Rockwell International (1987c) and were divided into three categories

1) Hazardous waste management units that will continue to operate and need a RCRA operating permit

2) Hazardous waste management units that will be closed under RCRA interim status

3) Inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or CERCLA.

The IAG redefines the SWMUs within the second and third categories as Individual Hazardous Substance Sites (IHSSs) This term is used hereinafter, however, no RCRA or CERCLA regulatory distinction in the use of the terms "site", "unit", or "IHSS" is intended in this document

The second major investigation completed at the Plant in 1986 involved a hydrogeologic and hydrochemical characterization of the entire Plant site Plans for this study were presented in Rockwell International (1986c and 1986d), and study results were reported in Rockwell International (1986e) Investigation results indicated four areas to be significant contributors to environmental contamination, with each area containing several sites The areas are the 881 Hillside Area, the 903 Pad Area, the Mound Area, and the East Trenches Area

Sites at the 881 Hillside Area were selected as High Priority Sites because of the elevated concentrations of volatile organic compounds detected in the ground water, the relatively permeable soils, and the proximity of the area to a surface water drainage RFI/RI activities to date at the 881 Hillside Area are discussed in more detail in Section 2 0

Two other Plant-wide studies have been conducted since the Phase II RI which affect further RFI/RI activities at OU No 1 The first, a draft Geologic Characterization Report for the Rocky Flats Plant (EG&G, 1990d) was completed in January 1990, based on re-evaluation of log data and other geologic information This study supersedes all previous geologic investigations with the exception of Hurr (1976) The second study of note was the draft Background Geochemical Characterization Report (EG&G, 1990e) This revised report summarizes background data for ground water, surface water, sediments, and geologic materials and identifies preliminary statistical boundaries of background variability

1 3 1 3 Current Investigations and Studies

OU No 1 is located between two other operable units where current studies are likely to provide data that will support the determination of the nature and extent of contamination at OU No 1 These operable units are to the northeast, OU No 2 (903 Pad, Mound, and East Trenches Areas), and to the south OU No 5 (Woman Creek) The RFI/RI Phase II Work Plan for OU No 2 was conditonally approved by the regulatory agencies, and field investigations are scheduled to begin in the spring of 1991 The draft RFI/RI Report for OU No 2 will be submitted in March 1993, well after the OU No 1 RFI/RI Report (draft report scheduled to be submitted in July 1992) However, this will likely permit partial utilization of the OU No 2 findings for the OU No 1 RFI/RI The OU No 5 RFI/RI Work Plan is scheduled to be submitted to the regulatory agencies in April 1991, and the RFI/RI Report will be submitted in late 1993 This will also permit partial utilization of data collected for this OU

In addition to these adjacent RFI/RIs, two interim measures/interim remedial actions (IM/IRAs) for contaminated surface water at OU No 2 will be conducted during the course of the OU No 2 RFI/RI These IM/IRAs will provide valuable data on the treatability fo water contaminated with organics and radionuclides which will support the detailed evaluation of alternatives for the OU No 1 CMS/FS There is also a site-wide routine sampling program being conducted at Rocky Flats Surface water stations around the Plant are being sampled monthly for site-wide characterization of surface waters

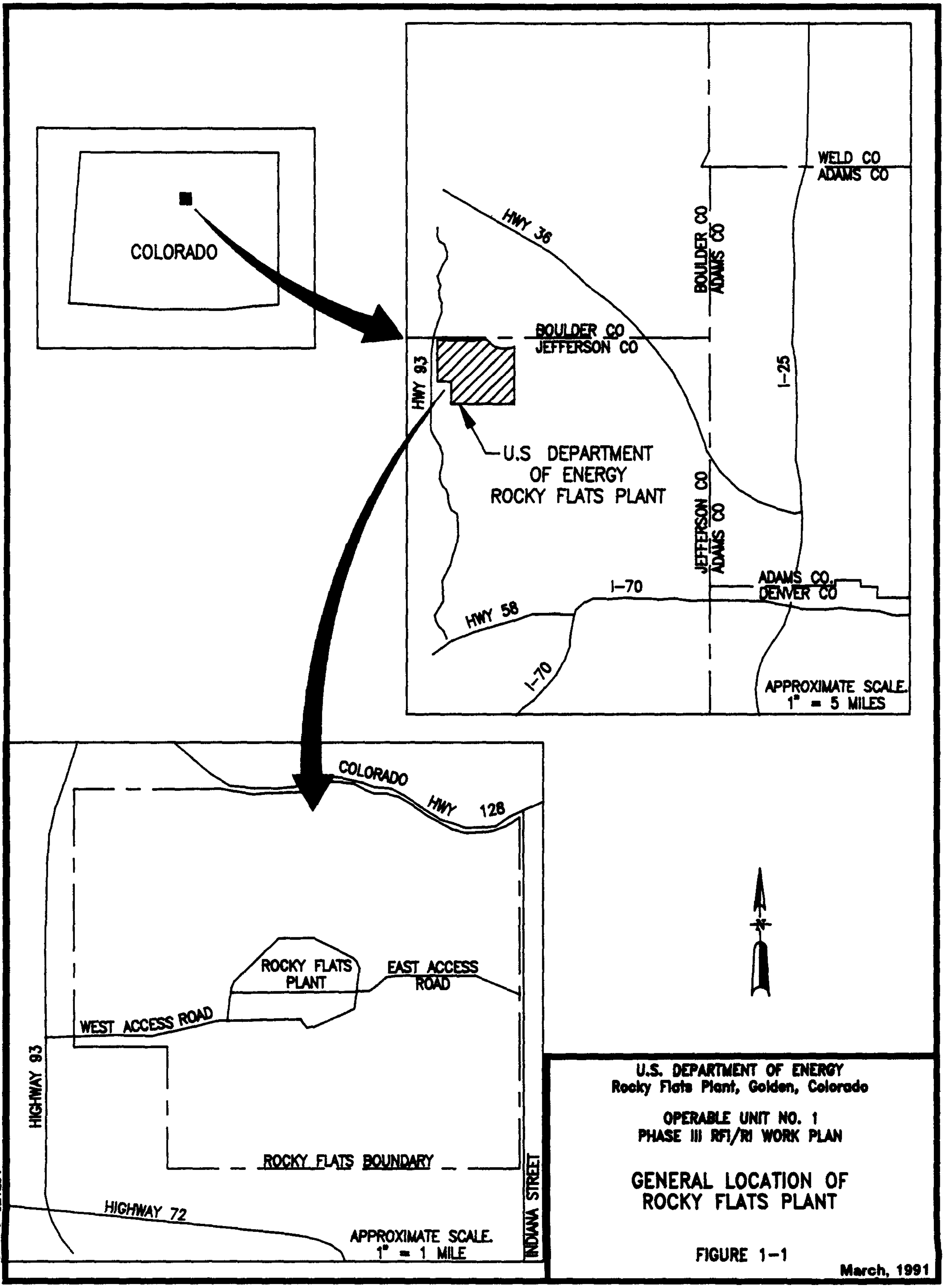
Lastly, the IAG site-wide activities will augment the RFI/RI and CMS/FS for OU No 1 In particular, the site-wide treatability studies will support the deteailed evaluation of alternatives for the OU No 1 CMS/FS (see Section 4 1 7 for additional information regarding treatability studies activities), and the Historical Release Report may provide additional information on the nature of the wastes disposed at OU No 1 The draft Historical Release Report is scheduled to be submitted to the regulatory agencies in January 1992

1 3 2 Physical Setting

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1) Other surrounding cities include Boulder, Westminster, and Arvada, which are located less then ten miles to the northwest, east, and southeast, respectively The Plant consists of approximately 6,550 acres of federally owned land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal Meridian Major buildings are located within the Plant security area of approximately 400 acres The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 1-2)

1 3 2 1 Topography

The natural environment of the Plant and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains The Plant is directly east of the north-south trending Front Range, and is located about 16 miles east of the Continental Divide, at an elevation of approximately 6,000 feet above mean sea level (msl) Rocky Flats Plant is located on a broad, eastward sloping plain of coalescing alluvial fans developed along the Front Range The fans extend about five miles in an eastward direction from their origin at Coal Creek Canyon and terminate on the east at a break in slope to low rolling hills The operational area at the Plant is located near the eastern edge of the fans on a terrace between stream-cut valleys (North Walnut Creek and Woman Creek)



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

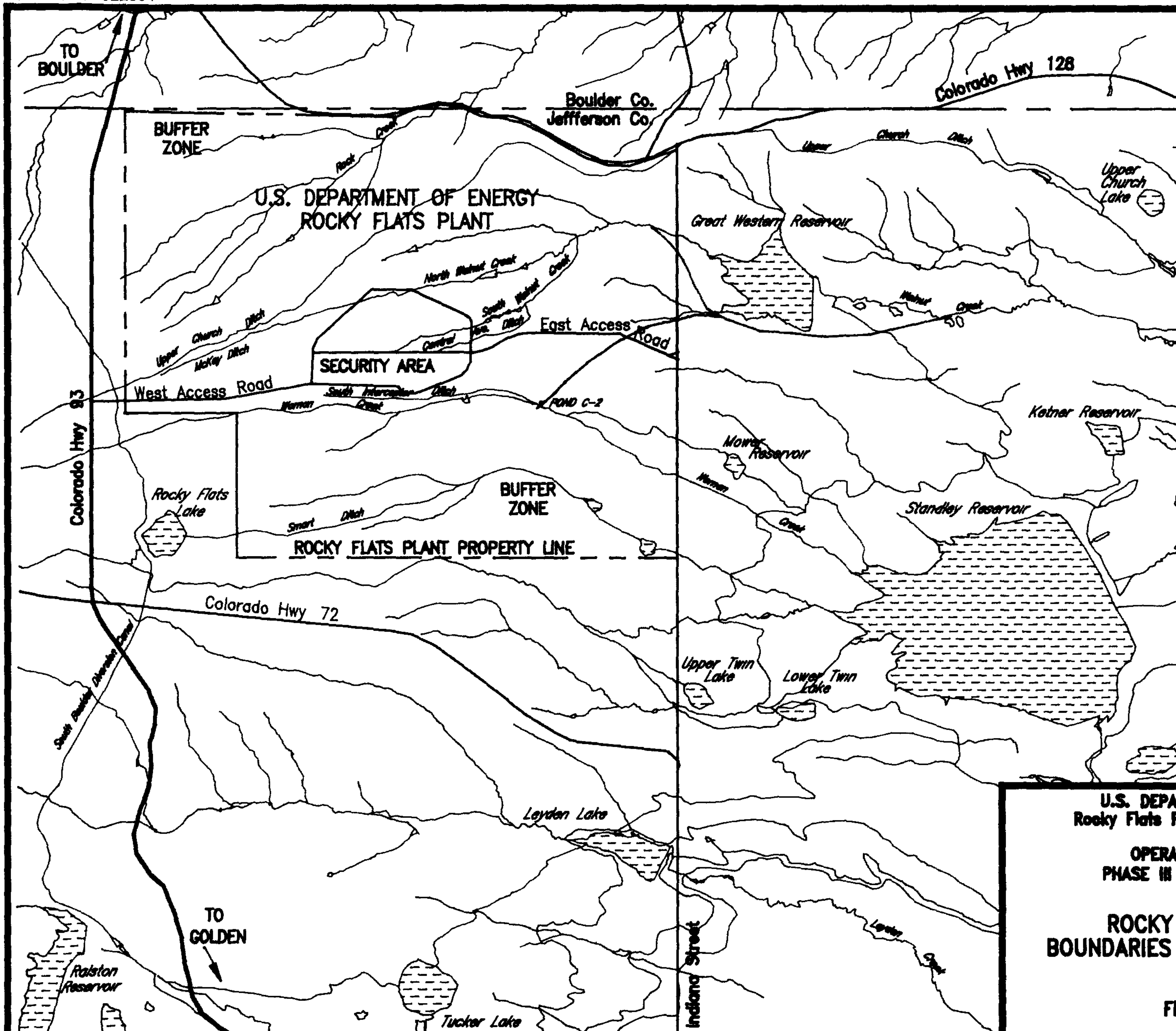
OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

GENERAL LOCATION OF
ROCKY FLATS PLANT

FIGURE 1-1

March, 1991

R33091 PJ-022591



EXPLANATION

BROOMFIELD DIVERSION CANAL

POND C-2 DIVERSION PIPE (8" PVC)

N

SCALE 1" = 1 MILE

0 1/2 1 MILE

(after U.S.G.S. Quads., Louisville, 1979 Golden, 1980; Lafayette, 1979 and Arvada, 1980)

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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

ROCKY FLATS PLANT
BOUNDARIES AND BUFFER ZONE

FIGURE 1-2

March, 1991

1 3 2 2 Surface Water Hydrology

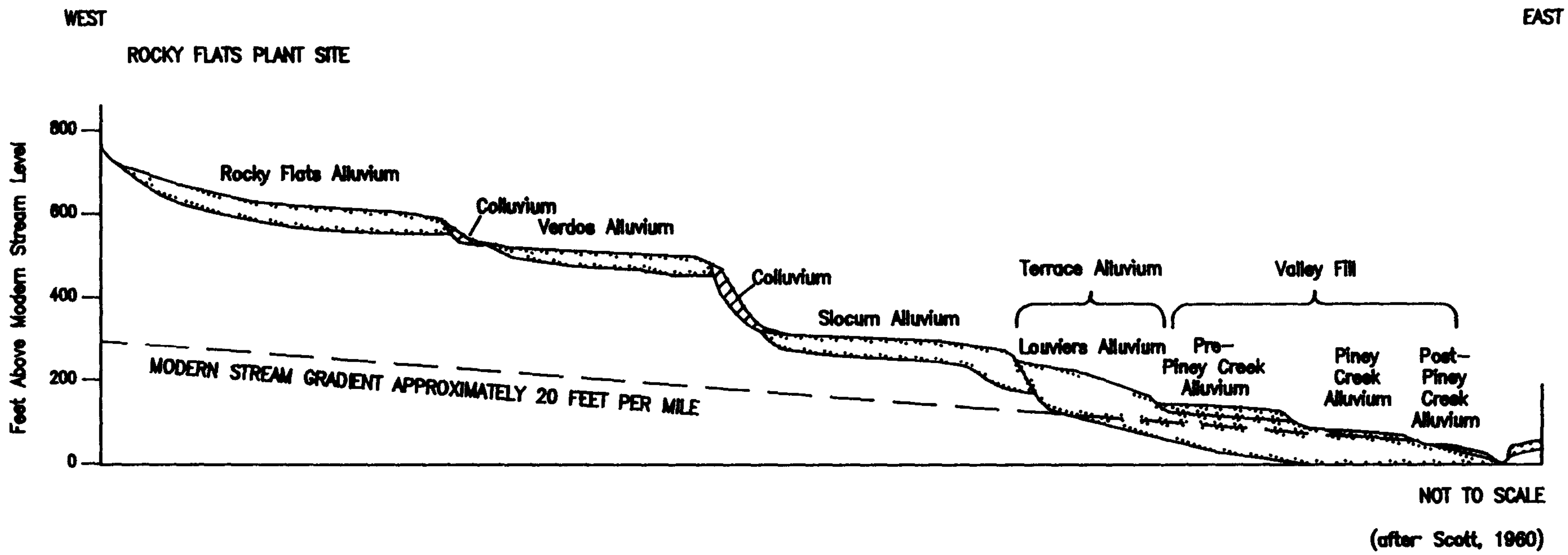
Three intermittent streams drain the Rocky Flats Plant with flow generally from west to east These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 1-2) Rock Creek drains the northwestern corner of the Plant and flows northeast through the buffer zone to its off-site confluence with Coal Creek An east-west trending interfluve separates the Walnut and Woman Creek drainages North and South Walnut Creeks and an unnamed tributary drain the northern portion of the Plant security area These three forks of Walnut Creek join in the buffer zone and flow toward Great Western Reservoir which is approximately one mile east of the confluence This flow is, however, routed around Great Western Reservoir by the Broomfield Diversion Canal, operated by the City of Broomfield Woman Creek drains the southern Rocky Flats Plant buffer zone flowing eastward to Standley Reservoir The South Interceptor Ditch lies between the Plant and Woman Creek The South Interceptor Ditch collects runoff from the southern Plant security area and diverts it to Pond C-2, where it is treated and monitored in accordance with the Plant National Pollutant Discharge Elimination System (NPDES) permit Treated water from Pond C-2 is then diverted to the Walnut Creek watershed where it is released to the Broomfield Diversion Canal

1 3 2 3 Regional and Local Hydrogeology

Geologic units beneath the Rocky Flats Plant consist of unconsolidated surficial units (Rocky Flats Alluvium, various terrace alluvia, valley fill alluvium, and colluvium) (Figure 1-3), underlain by Cretaceous bedrock (Arapahoe Formation, Laramie Formation, and Fox Hills Sandstone) (Figure 1-4) Figure 1-5 presents a generalized stratigraphic section of the Denver Basin bedrock, and Figure 1-6 shows a stratigraphic section for the Rocky Flats Plant including unconsolidated deposits Ground water occurs under unconfined conditions in both surficial and shallow bedrock units In addition, confined ground-water flow occurs in deeper bedrock sandstones

Rocky Flats Alluvium

The Quaternary Rocky Flats Alluvium is the oldest and topographically highest alluvial deposit at the Rocky Flats Plant (Scott, 1965) The Rocky Flats Alluvium is a series of coalescing alluvial fans deposited by braided streams (Hurr, 1976) It consists of a topsoil layer underlain by up to 100 feet of varying amounts of silt, clay, sand, and gravel The erosional surface (pediment) on which the alluvium was deposited slopes gently eastward truncating the Fox Hills Sandstone, the Laramie Formation, and the Arapahoe Formation at the Rocky Flats Plant



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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE COLORADO

FIGURE 1-3

March, 1991

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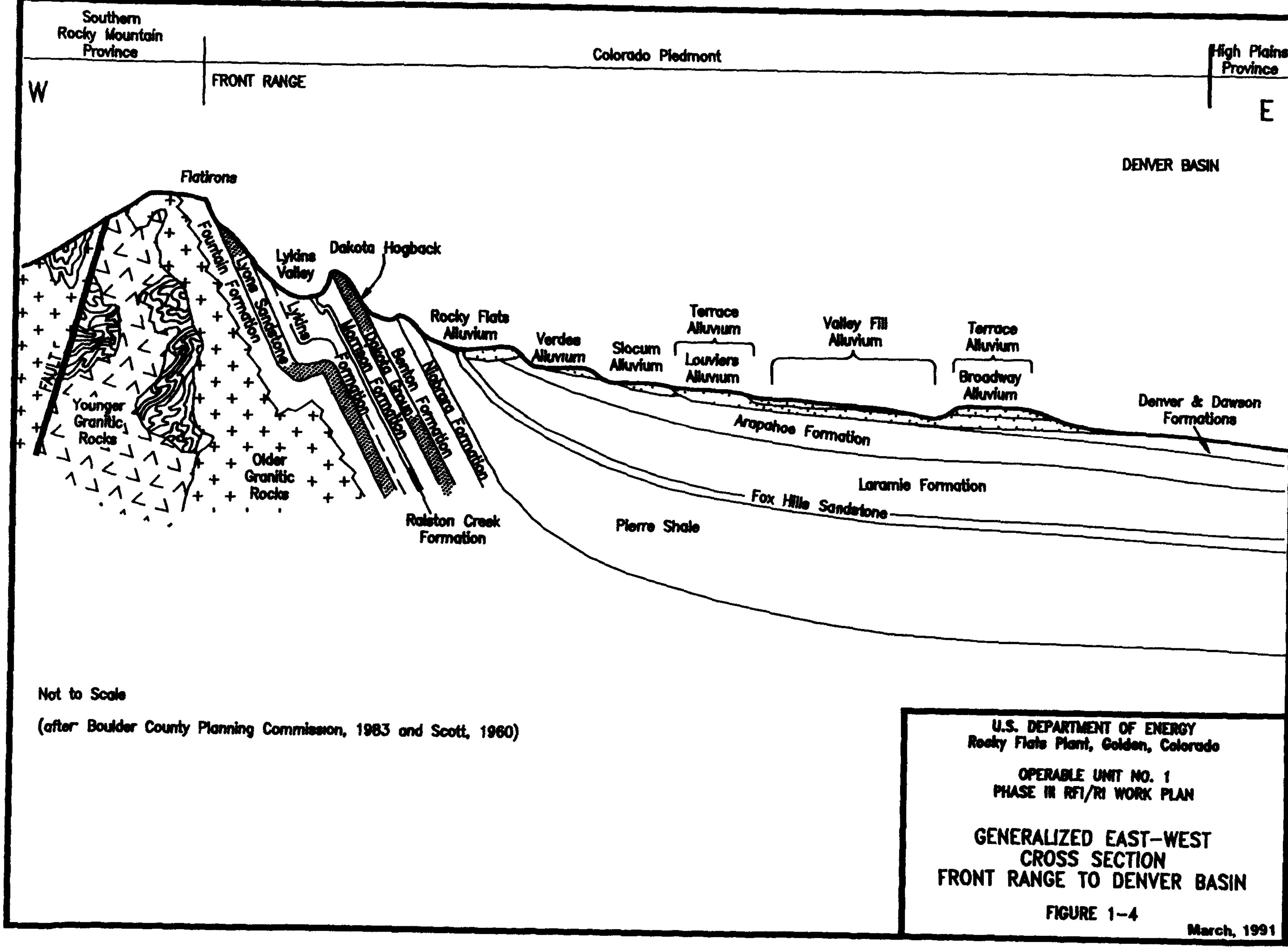
R33093.PJ-021291



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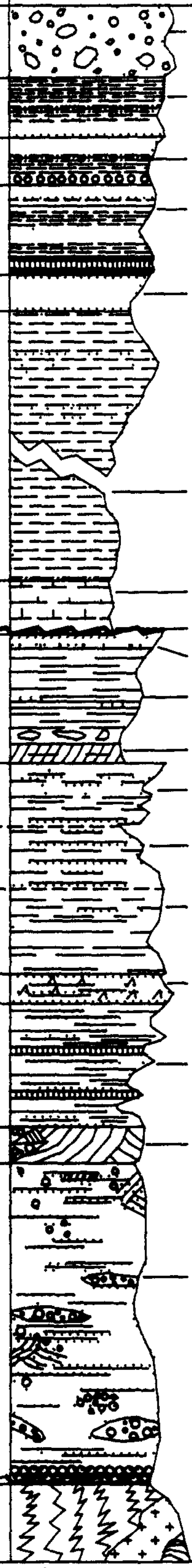
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

GENERALIZED EAST-WEST
CROSS SECTION
FRONT RANGE TO DENVER BASIN

FIGURE 1-4

March, 1991



AGE	FORMATION	Thickness (feet)	SUMMARY DESCRIPTION
TERTIARY	Green Mountain	600	Boulder conglomerate with occasional thin siltstone lenses
TERTIARY	Denver	870'	Yellowish-brown to grayish-olive fluvial tuffaceous claystone, siltstone and sandstone interbedded with conglomerate and olive-gray mudflows
UPPER CRETACEOUS	Arapahoe	270'	Yellowish-gray to yellowish-brown sandstone, siltstone, and claystone, discontinuous conglomerate at base
UPPER CRETACEOUS	Laramie	500'	Gray fine-to-medium-grained sandstone and silty clays, thin coal beds in lower part
UPPER CRETACEOUS	Fox Hills	60'	Tan, fine-to-medium-grained sandstone and sandy shale
UPPER CRETACEOUS	Pierre	± 8000'	Dark gray, silty shale and few thin, silty sandstones
UPPER CRETACEOUS	Niobrara	350'	Dark gray, very calcareous shale "Foraminifera" abundant (Smoky Hills Member) Light gray, dense, fossiliferous limestone (Fort Hays Member)
UPPER CRETACEOUS	Benton	420'	Brown, sandy, fossiliferous limestone Dark gray shale with bentonite streaks, thin limestones in middle part, few cone-in-cone concretions in lower part Dark gray, brittle silty shale (Mowry)
LOWER CRETACEOUS	Dakota Group: So Platte	270'	Light gray, fine-to-medium-grained sandstone, several dark gray shales in middle part
LOWER CRETACEOUS	Dakota Group: Lytle	100'	Light gray, fine-to-coarse-grained, locally conglomeratic sandstone, frequent red and green siltstone interbeds
Jurassic	Morrison	365'	Gray to greenish-gray to red shale and siltstone, thin limestones in middle part, lenticular sandstones in upper and lower part
Jurassic	Ralston Creek	110'	Light tan siltstone and light red, silty shale, gypsiferous, sandstone at base and locally conglomeratic
TRIASSIC? / PERMIAN	Lykins	400'	Red siltstone with two laminated limestones in lower part
PERMIAN	Lyons	120'	Grayish-white, fine-to-medium-grained cross-bedded sandstone, conglomeratic lenses frequent
PENNSYLVANIAN	Fountain	1000'	Red, fine-to-coarse-grained sandstone and conglomerate, arkosic, thin, lenticular red siltstones frequent throughout
PRECAMBRIAN			Gneiss, schist, and small granitic intrusions

(modified from LeRoy and Weimer 1971)

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

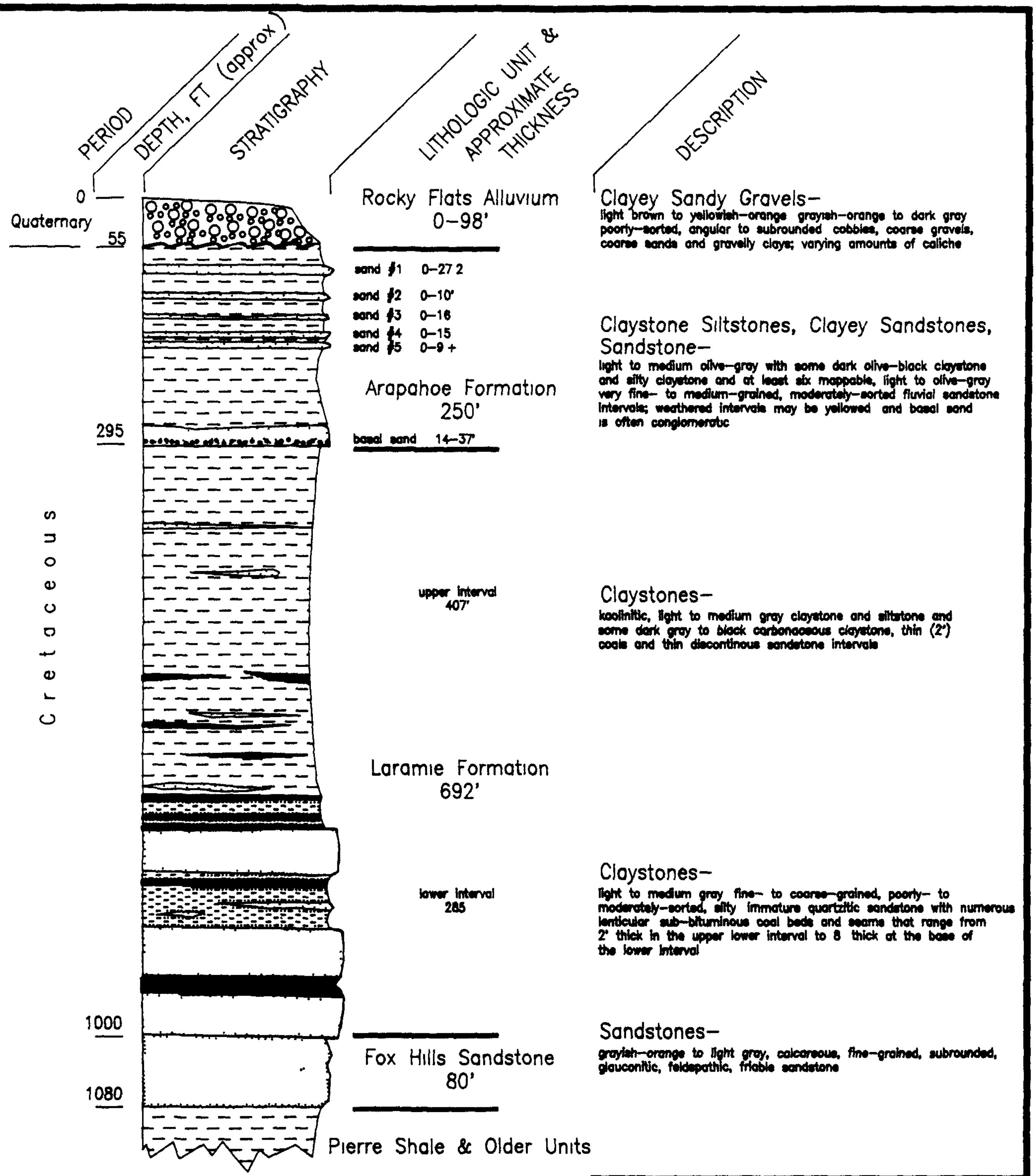
OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

GENERALIZED STRATIGRAPHIC SECTION FOR DENVER BASIN

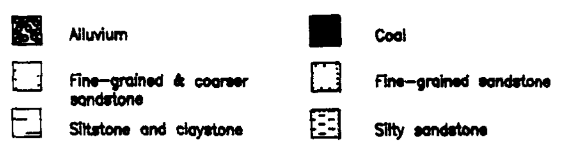
FIGURE 1-5

March, 1991

R33094 PJ-021291



EXPLANATION



EG&G, 1991c

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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

LOCAL STRATIGRAPHIC SECTION OF THE ROCKY FLATS PLANT

FIGURE 1-6

March, 1991

R33095 PJ-021291

After deposition of the Rocky Flats Alluvium, eastward flowing streams began dissecting the deposit by headward erosion and lateral planation All of the alluvium was removed by erosion in the Woman Creek drainage south of OU No 1 and in the South Walnut Creek drainage to the north The result is a terrace of Rocky Flats Alluvium extending eastward from the Plant between the two drainages

Unconfined ground-water flow occurs in the Rocky Flats Alluvium which is relatively permeable Recharge to the alluvium is from precipitation, snowmelt, and water losses from ditches, streams, and ponds that are cut into the alluvium General water movement in the Rocky Flats Alluvium is from west to east and towards the drainages Ground-water flow is also controlled by pediment drainages in the top of bedrock Ground-water levels in the Rocky Flats Alluvium rise in response to recharge during the spring and decline during the remainder of the year Discharge from the alluvium occurs at seeps in the colluvium that covers the contact between the alluvium and bedrock along the edges of the valleys Most seeps flow intermittently The Rocky Flats Alluvium thins, due to erosion, east of the Plant boundary and does not directly supply water to wells located downgradient of Rocky Flats Plant

Other Alluvial Deposits

Various other alluvial deposits occur topographically below the Rocky Flats Alluvium in the Plant drainages Colluvium (slope wash) mantles the valley side slopes between the Rocky Flats Alluvium and the valley bottoms In addition, remnants of younger terrace deposits including the Verdos, Slocum, and Louviers Alluvia occur occasionally along the valley side slopes Recent valley fill alluvium occurs in the active stream channels

Unconfined ground-water flow occurs in these surficial units Recharge is from precipitation, percolation from streams during periods of surface water runoff, and by seeps discharging from the Rocky Flats Alluvium Discharge is by evapotranspiration and by seepage into other geologic formations and streams The direction of ground-water flow is generally downslope through colluvial materials and then along the course of the stream in valley fill materials During periods of high surface water flow, water is lost to bank storage in the valley fill alluvium and returns to the stream after the runoff subsides

Arapahoe Formation

The Arapahoe Formation underlies surficial materials beneath most of the Plant except beneath the western portion of the Plant From approximately the middle of the west buffer zone and west almost to Highway 93, the Laramie Formation unconformably underlies the Rocky Flats Alluvium The Arapahoe formation is a fluvial deposit composed of overbank and channel deposits It consists predominantly of claystones and siltstones with some silty sandstones beneath the Plant Total formation thickness varies up to 270 feet (Robson, et al , 1981a), and the unit is nearly flat-lying beneath the central and eastern portions of the Plant (EG&G 1990d and 1990f) The sandstone bodies within the claystone are generally composed of very fine-grained sand and silt Their hydraulic conductivities are equivalent to, or less than, those of the overlying Rocky Flats Alluvium Geologic characterization of the Arapahoe Formation beneath Rocky Flats indicates that the unit is composed of fluvial deposits (EG&G, 1990d) The Arapahoe Formation beneath the Plant contains more claystone and siltstone than typically described for other areas within the Denver Basin

The Arapahoe Formation is recharged by ground-water movement from overlying surficial deposits and infiltration from streams The main recharge areas are under the Rocky Flats Alluvium, although some recharge from the colluvium and valley fill alluvium likely occurs along the stream valleys Recharge is greatest during the spring and early summer when rainfall and stream flow are at a maximum and water levels in the Rocky Flats Alluvium are high Ground-water movement in the Arapahoe Formation is generally toward the east, although flow within individual sandstones is controlled locally by the channel geometries Regionally, ground-water flow in the Arapahoe Formation is toward the South Platte River in the center of the Denver Basin (Robson, et al , 1981a)

Laramie Formation and Fox Hills Sandstone

The Laramie Formation underlies the Arapahoe Formation and is composed of two units a thick upper unit composed predominantly of claystone and a lower unit which contains coal and sandstone The upper Laramie Formation is greater than 700 feet thick and is of very low hydraulic conductivity, therefore, the U S Geologic Survey (Hurr, 1976) concludes that Plant operations will not impact any units below the upper claystone unit of the Laramie Formation

The lower sandstone unit of the Laramie Formation and the underlying Fox Hills Sandstone comprise a regionally important aquifer in the Denver Basin known as the Laramie-Fox Hills Aquifer (Robson, 1983) Near the center of the basin the aquifer thickness ranges from 200 to 300 feet These units subcrop beneath the Rocky Flats Alluvium west of the Plant and can be seen in clay pits excavated through the Rocky Flats Alluvium The steeply dipping beds (approximately 50°) of these units located west of the Plant flatten to the east (less than 2° dip) (EG&G, 1990d and 1990f) (see Figure 1-4) Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water flow and leakage along the Front Range (Robson, et al , 1981b)

1 3 2 4 Meteorology

The area surrounding the Rocky Flats Plant has a semiarid climate characteristic of much of the central Rocky Mountain region Approximately forty percent of the 15-inch annual precipitation falls during the spring season, much of it as wet snow Thunderstorms (June to August) account for an additional thirty percent of the annual precipitation Autumn and winter are drier seasons, accounting for nineteen and eleven percent of the annual precipitation, respectively Snowfall averages 85 inches per year, falling from October through May (DOE, 1980)

Special attention has been focused on dispersion meteorology surrounding the Plant due to the remote possibility that significant atmospheric releases might affect the Denver metropolitan area Studies of air flow and dispersion characteristics (e g , Hodgin, 1983 and 1984) indicate that drainage flows (winds coming down off the mountains to the west) turn and move toward the north and northeast along the South Platte River valley and pass to the west and north of Brighton, Colorado (DOE, 1986)

1 3 2 5 Surrounding Land Use and Population Density

The Rocky Flats Plant is located in a rural area Approximately 50 percent of the area within ten miles of the Rocky Flats Plant is in Jefferson County The remainder is located in Boulder County (40 percent) and Adams County (10 percent) According to the 1973 Colorado Land Use Map, 75 percent of this land was unused or was used for agriculture Since that time, portions of this land have been converted to housing, with several new housing subdivisions being started within a few miles of the buffer zone

A recent demographic study shows that approximately 2 2 million people lived within 50 miles of the Rocky Flats Plant in 1989 (DOE, 1990b) Approximately 9,100 people lived within five miles of the Plant in 1989 (DOE 1990b) The most populated sector was to the southeast, toward the center of Denver Recent population estimates registered by the Denver Regional Council of Governments (DRCOG) for the eight-county Denver metro region have shown distinct patterns of growth between the first and second halves of the decade Between 1980 and 1985, the population of the eight-county region increased by 197,890, a 2 4 percent annual growth rate Between 1985 and 1989 a population gain of 71,575 was recorded, representing a 1 0 percent annual increase (the national average) The 1989 population showed an increase of 2,225 (or 0 1 percent) from the same date in 1988 (DRCOG, 1989)

There are eight public schools within six miles of the Rocky Flats Plant The nearest educational facility is the Witt Elementary School, which is approximately 2 7 miles east of the Plant buffer zone The closest hospital is Centennial Peaks Hospital located approximately seven miles northeast The closest park and recreational area is the Standley Lake area, which is approximately five miles southeast of the Plant Boating, picnicking, and limited overnight camping are permitted Several other small parks exist in communities within ten miles The closest major park, Golden Gate Canyon State Park, located approximately 15 miles to the southwest, provides 8,400 acres of general camping and outdoor recreation Other national and state parks are located in the mountains west of the Rocky Flats Plant, but all are more than 15 miles away

Some of the land adjacent to the Plant is zoned for industrial development Industrial facilities within five miles include the TOSCO laboratory (40-acre site located two miles south), the Great Western Inorganics Plant (two miles south), the Frontier Forest Products yard (two miles south), the Idealite Lightweight Aggregate Plant (2 4 miles northwest), and the Jefferson County Airport and Industrial Park (990-acre site located 4 8 miles northeast)

Several ranches are located within ten miles of the Plant, primarily in Jefferson and Boulder Counties They are operated to produce crops, raise beef cattle, supply milk, and breed and train horses According to the 1987 Colorado Agricultural Statistics, 20,758 acres of crops were planted in Jefferson County (total land area of approximately 475,000 acres) and 68,760 acres of crops were planted in Boulder County (total land area of 405,760 acres) Crops consisted of winter wheat, corn, barley, dry beans, sugar beets, hay, and oats Livestock consisted of 5,314 head of cattle, 113 hogs, and 346 sheep in Jefferson County, and 19,578 head of cattle, 2,216 hogs, and 12,133 sheep in Boulder County (Post, 1989)

1 3 2 6 Ecology

A variety of vegetation thrives within the Plant boundary Included are species of flora representative of tall-grass prairie, short-grass plains, lower montane, and foothill ravine regions None of these vegetative species are on the endangered species list It is evident that the vegetative cover along the Front Range of the Rocky Mountains has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years Since the acquisition of the Rocky Flats Plant property, vegetative recovery has occurred, as evidenced by the presence of disturbance-sensitive grasses species like big bluestem (Andropogon gerardii) and sideoats grama (Bouteloua curtipendula) No vegetative stresses attributable to hazardous waste contamination have been identified (DOE, 1980)

The animal life inhabiting the Rocky Flats Plant and its buffer zone consists of species associated with western prairie regions The most common large mammal is the mule deer (Odocoileus lemionus), with an estimated 100 to 125 permanent residents There are a number of small carnivores, such as the coyote (Canis latrans), red fox (Vulpes fulva), striped skunk (Mephitis mephitis), and long-tailed weasel (Mustela frenata) A profusion of small herbivores consisting of species such as the pocket gopher (Thomomys sp and Perognathus sp), white-tailed jackrabbit (Lepus townsendii), and the meadow vole (Microtus pennsylvanicus) can be found throughout the Plant and buffer zone (DOE, 1980)

Commonly observed birds include western meadowlarks (Sturnella neglecta), horned larks (Eremophila alpestris), mourning doves (Zenaidura macroura), and vesper sparrow (Pooecetes gramineus) A variety of ducks, killdeer (Charadrius vociferus), and red-winged black birds (Agelaius phoeniceus) are seen in areas adjacent to ponds Mallards (Anas platyrhynochos) and other ducks (Anas sp) frequently nest and rear young on several of the ponds Common birds of prey in the area include marsh hawks (Circus cyaneus), red-tailed hawks (Buteo jamaicensis), ferruginous hawks (Buteo regalis), rough-legged hawk (Buteo lagopus), and great horned owls (Bubo virginianus) (DOE, 1980)

Bull snakes (Pituophis melanoleucus) and rattlesnakes (Crotalus sp) are the most frequently observed reptiles Eastern yellow-bellied racers (Coluber constrictor) have also been seen The eastern short-horned lizard (Phrynosoma douglassi brevirostre) has been reported on the site, but these and other lizards are not commonly observed The western painted turtle (Chrysemys picta) and the western plains garter snake (Thamnophis radix) are found in and around many of the ponds (DOE, 1980)

The bald eagle and the black-footed ferret are the two endangered species which were identified as potentially present at Rocky Flats Plant by the U S Fish and Wildlife Service Bald eagles are occasional visitors to the area primarily during migration times However, eagle sightings are rare and little suitable habitat exists at the Plant No bald eagle nests have been found on the Plant site Prairie dogs provide the food source and habitat for black-footed ferrets Since there are no prairie dog towns in or near the 881 Hillside Area, ferrets probably do not exist at OU No 1 Subsequent to a field visit on June 15, 1988, the U S Fish and Wildlife Service has concurred with these findings (Rockwell International, 1988c)

Plans for evaluating the vegetation and biota with respect to OU No 1 contaminants are presented in Section 6 0

1 4 881 HILLSIDE SITE LOCATIONS AND DESCRIPTIONS

This RFI/RI Work Plan addresses the 881 Hillside Area located on the south side of the Rocky Flats Plant security area These sites were designated high priority sites because of their suspected relationship to ground-water contamination (DOE, 1987a) Several sites are included in the area because of their physical proximity to each other Figure 1-7 shows the location of the 881 Hillside Area and presents the IHSS locations within the area

There are 12 sites designated as IHSSs located within OU No 1 These sites are

- Oil Sludge Pit Site (IHSS Ref No 102)
- Chemical Burial Site (IHSS Ref No 103)
- Liquid Dumping Site (IHSS Ref No 104)
- Out-of-service Fuel Oil Tank Sites (IHSS Ref Nos 105 1 and 105 2)
- Outfall Site (IHSS Ref No 106)

- Hillside Oil Leak Site (IHSS Ref No 107)
- Multiple Solvent Spill Sites (IHSS Ref Nos 119 1 and 119 2)
- Radioactive Site - 800 Area Site #1 (IHSS Ref No 130)
- Sanitary Waste Line Leak Site (IHSS Ref No 145)
- Building 885 Drum Storage Site (IHSS Ref No 177)

The site descriptions presented in the following sections are taken from the Rocky Flats Plant CEARP Phase I Report (DOE, 1986), the RCRA Part B Operating Permit Application (Rockwell International, 1987c), and the Phase II Remedial Investigation Report for High Priority Sites (Rockwell International, 1988a) The following descriptions also include a more recent review of historical aerial photography

1 4 1 Oil Sludge Pit Site (IHSS Ref No 102)

Approximately 30 to 50 drums of oil sludge were emptied into a pit south of Building 881 in the late 1950s, and the pit was later covered (Rockwell International, 1987c) Based on interviews with Plant personnel, the sludge was reportedly collected during cleaning of the two No 6 fuel oil tanks south of Building 881 (IHSS Ref Nos 105 1 and 105 2) in 1958 (Rockwell International, 1987c) However, the pit appears to have been in existence in 1955 based on aerial photography of the area In the 1955 photos, the oil sludge pit is located approximately 500 feet south of Building 881 and measures approximately 40 feet by 70 feet in dimension The pit appears to contain oily liquids, and seepage from the pit is evident Also apparent on the 1955 photo is a small pond adjacent to Woman Creek Drainage from the Oil Sludge Pit Site appears directed toward this pond The oil sludge pit was covered after its use (Rockwell International, 1987c), and the pit and seepage are no longer visible on 1959 aerial photographs

1 4 2 Chemical Burial Site (IHSS Ref No 103)

An area south of Building 881 was reportedly used to bury unknown chemicals (DOE, 1986) The exact location, dates of use, and contents of the site are unknown This site was originally thought to be located in the same area as the Oil Sludge Pit Site (Rockwell International, 1987c) However, a pit apparently filled with liquid is evident approximately 150 feet southeast of Building 881 on 1963 aerial photographs This pit is roughly circular on the photos and measures approximately 50 feet in diameter

1 4 3 Liquid Dumping Site (IHSS Ref No 104)

An area east of Building 881 was reportedly used for disposal of unknown liquids and for disposing empty drums prior to 1969 (DOE, 1986) A pit was reported with plan dimensions of approximately 50 by 50 feet based on 1965 aerial photographs (Rockwell International, 1987c) However, further review of these historical aerial photos indicates the identified "pit" may be a shadow on the photo The Liquid Dumping Pit Site is likely the same location as the Chemical Burial Site, however, the area originally identified as the Liquid Dumping Pit will also undergo additional investigation to verify its absence

1 4.4 Out-of Service Fuel Tank Sites (IHSS Ref Nos 105.1 and 105.2)

Two out-of-service No 6 fuel oil tanks are located immediately south of Building 881 (Figure 1-8) These tanks were used from 1958 through 1976 They were filled with asbestos-containing material and then with concrete subsequent to their use (presumably in 1976), (Rockwell International, 1987c) These tanks tested tight when they were pressure tested in 1973 (Rockwell International, 1987c)

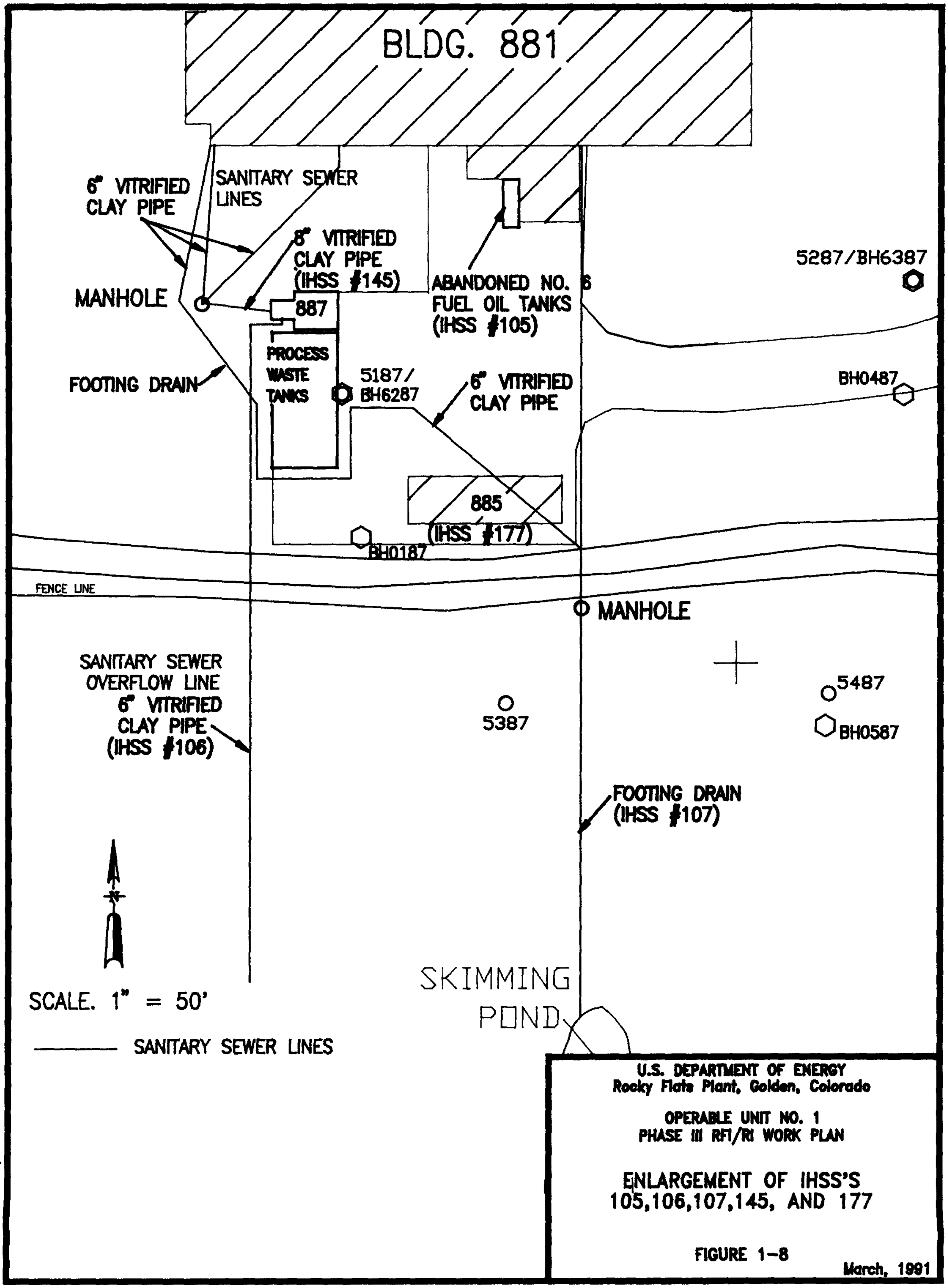
1 4 5 Outfall Site (IHSS Ref No 106)

A six-inch diameter vitrified clay pipe outfall existed south of Building 881 which discharged water in December 1977 Previous reports indicated that this was a cleanout pipe for an overflow line from the Building 881 cooling tower (Rockwell International, 1987c) However, review of construction drawings during the Phase II RI indicated that the pipe is an overflow line from the sanitary sewer sump in Building 887 (Figure 1-8)

1 4 6 Hillside Oil Leak Site (IHSS Ref No 107)

In May 1973, an oil leak was discovered on the hillside south of Building 881 The source of the oil was believed to be the two No 6 fuel oil tanks (IHSSs 105 1 and 105 2) south of the building, however, pressure testing of the tanks and associated lines in 1973 did not reveal any leaks (Rockwell International, 1987c) The oil spill was contained with straw, and the straw and soil were removed and disposed of in the Present Landfill north of the Plant (Rockwell International, 1987c)

It was later discovered that the oil had emerged through the Building 881 footing drain outfall (Figure 1-8) A ditch and concrete skimming pond were built below the footing drain outfall to contain the oil (Owen and Steward, 1973) These structures are still present, although no oil has been observed in the outfall since 1973 (Rockwell International, 1987c)



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

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

ENLARGEMENT OF IHSS'S
105,106,107,145, AND 177

FIGURE 1-8

March, 1991

R33124.PJ-022591/50

1 4 7 Multiple Solvent Spill Site (IHSS Ref Nos 119 1 and 119.2)

Beginning in 1967, two areas east of Building 881 and along the southern perimeter road were used as barrel storage areas The barrels contained unknown quantities and types of solvents and wastes The two facilities were expanded between 1967 and 1971, with major expansion occurring in 1969 Barrel storage in these areas was discontinued, and all barrels were removed by 1972 The exact types and quantities of solvents stored at this facility are unknown (Rockwell International, 1987c) IHSS 119 1 is the larger western barrel storage area, and IHSS 119 2 is the eastern barrel storage area The site boundaries shown on Figure 1-7 represent the extent of soil disturbance associated with the sites Actual barrel storage areas within each site are also shown

1 4 8 Radioactive Site - 800 Area #1 (IHSS Ref No 130)

An area east of Building 881 and northwest of IHSS 119 1 was used between 1969 and 1972 to dispose of soil and asphalt contaminated with low levels of plutonium The materials at this site were derived from three sources on the Plant site

In September 1969 approximately 320 tons [250 cubic yards (Illsley, 1978)] of plutonium-contaminated soil and asphalt were removed from the west side of Building 776 and placed on the 881 Hillside (Owen and Steward, 1973) The soil and asphalt were contaminated during the May 11, 1969, fire in building 776, and had an estimated average plutonium activity of 7 4 disintegrations per minute per gram (dpm/g) [3 36 picoCuries per gram (pCi/g)] The total plutonium concentration of this material was estimated to be 14 milligrams (mg) [864 microCuries (μCi)] (Putzier, 1970) Material from the 1969 fire was buried under one to two feet of fill dirt (Owen and Steward, 1973)

In August 1970, a section of the Central Avenue roadway between Eighth and Tenth Streets was removed and placed on the 881 Hillside at IHSS 130 (Owen and Steward, 1973) This stretch of road was radioactively contaminated in June 1968 by a leaking drum in transit from the 903 Drum Storage Site to Building 774 (Owen and Steward, 1973) The exact quantity and radioactivity of the material removed from Central Avenue are unknown

The third episode of soil disposal at IHSS 130 occurred in 1972 (Owen and Steward, 1973) Approximately 60 cubic yards of plutonium-contaminated soil were removed from around the Building 774 process waste tanks and placed on the 881 Hillside (Owen and Steward, 1973) The soil was placed on top of previously deposited soils at IHSS 130 and covered with approximately three feet of fill dirt (Illsley, 1978) The estimated total long-lived alpha activity of this soil is less than 250 dpm/g (Illsley, 1978)

1 4 9 Sanitary Waste Line Leak Site (IHSS Ref No 145)

The four-inch, cement-asbestos sanitary sewer line located south of Building 881 leaked in January 1981 An earthen dike was constructed to prevent the spill from entering the South Interceptor Ditch, and the line was repaired The line conveyed sanitary wastes to the sanitary treatment plant and did not carry hazardous or radioactive materials Conveyance of laundry wastewater, which may have contained low levels of radioactive materials, was discontinued in 1973 (Rockwell International, 1987c) Recent review of Building 881 construction drawings indicates that the only sanitary waste lines presently located south of the building are the six-inch overflow line from Building 887 (IHSS 106) and an eight-inch vitrified clay pipe which runs east-west into Building 887 (Figure 1-8) Presumably, the four-inch, cement-asbestos sewer line was replaced subsequent to the waste line leak

1 4 10 Building 885 Drum Storage Site (IHSS Ref No 177)

Building 885, immediately south of Building 881, is currently used for satellite collection and 90-day accumulation of RCRA regulated wastes (Figure 1-7) The building will be closed under RCRA Interim Status (40 CFR 265) Complete information on this site is provided in the RCRA Interim Status Closure Plan which is appended to the revised Post-Closure Care Permit Application for hazardous and radioactive mixed wastes at the Rocky Flats Plant (Rockwell International, 1988d) Any ground-water contamination from this site will be addressed by the remedial action for Operable Unit No 10

2 1 881 HILLSIDE AREA PREVIOUS INVESTIGATIONS

Previous environmental investigations performed at the 881 Hillside Area include the Phase I and Phase II Remedial Investigations (Rockwell International, 1987a and 1988a) and the French Drain Geotechnical Investigation in support of the IM/IRA (EG&G, 1991a) Each of these programs is described below

2 1 1 Phase I and Phase II Remedial Investigations

Remedial investigations were performed in two phases at the 881 Hillside Area The first phase of investigations began in March 1987, in accordance with the plans presented in DOE (1987a and 1987b) The second phase of field work was performed subsequent to submittal of the draft 881 Hillside Area Phase I RI Report and meetings with CDH and EPA to plan further work based on Phase I results

Objectives of the remedial investigations were to

- Verify waste source locations
- Characterize waste sources
- Characterize site geology and hydrology
- Determine the presence and extent of ground-water, surface water, and soil contamination
- Provide data to estimate the potential for contaminant migration via the ground-water, surface water, and air pathways
- Support feasibility studies of alternative remedial actions

The Phase I and Phase II field programs consisted of

- Preparation of detailed topographic site maps
- Radiometric and organic vapor screening surveys
- Geophysical surveys using electromagnetometry, resistivity, magnetometry, and metal detection
- Soil gas sampling using the Petrex method
- Drilling, sampling, and chemical analyses of subsurface soils from 17 Phase I boreholes and 6 Phase II boreholes (Figure 2-1 and Table 2-1)
- Installation of 4 alluvial wells and 3 bedrock wells during Phase I drilling and 11 alluvial wells and 1 bedrock well during Phase II drilling (Figure 2-1)

TABLE 2 1
881 HILLSIDE AREA
MONITORING WELL DATA

Well Number	Geologic Strata of Complete	Ground Surface Elev (ft)	Top of Casing Elev (ft)	Depth to Top of Screen	Depth to Bottom of Screen	Total Depth (ft)	Depth to Bedrock (ft)	Bedrock Elevation	Northing Coordinate (ft) - RFP	Easting Coordinate (ft) - RFP	State Northing (ft)	State Easting (ft)
0187	Qaf	5992 35	5994 23	3 38	11 83	12 08	11 87	5980 48	35145 60	20540.59	748127 4287	2083652.9398
5187	Qrf	5963 30	5965 21	3 58	13 84	14 08	13 50	5949 80	35120 00	20738.10	748102 4865	2083850 4816
5287	Qrf	5967 60	5969 61	3 50	20 25	20 50	20 00	5947 60	35161 94	20954 54	748145 1309	2084066 7281
0974		5924 60	5926 25	0 00	0 00	20 10	0 00	0 00	35042 78	21670 91	748028 3697	2084783 3009
1074		5925 40	5925 91	0 00	0 00	9 96	0 00	0 00	35002 37	21592.52	747987 7153	2084705 0632
6386	Qc	5900 40	5902 04	3 80	15 25	15 50	14 80	5885 60	35155 84	22641 51	748144 5996	2085753 2740
6986	Qc	5921 19	5922 64	3 00	14 00	14 00	13 30	5907 89	34786 10	21168 07	747788.0554	2084271 8950
0287	Qc	5930 56	5932 63	3 22	9 08	9 32	8 75	5921 81	34725 76	20819 75	747708 6194	2083933 4097
0487	Qc	5909 79	5911 81	3 51	19 47	19 70	19 50	5890 29	34957 41	21774 11	747943 3600	2084886 7577
0687	Qc	5904 53	5906 42	3 56	6 88	7 06	6 50	5898 03	35016 02	22021 30	748002 7765	2085133 6830
4387	Qc	5924 92	5926 49	3 50	12 25	12 50	12 00	5912 92	35043 82	21675 56	748029 4259	2084787 9460
4487	Qc	5949 53	5951 26	1 50	3 50	3 70	3 20	5946 33	35317 96	22323 69	748305 6314	2085435 0051
4787	Qc	5882 72	5884 83	3 50	7 25	7 50	7 00	5875 72	34792.68	21789 41	747778 7224	2084902.5941
4887	Qc	5909 94	5911 53	3 50	10 05	10 30	9 80	5900 14	34844 28	21578.31	747829 6141	2084691 3770
4987	Qc	5912.68	5914 48	1 80	4 75	5 00	4 50	5908.18	35004 54	21891 49	747990 8687	2085003 9476
5087	Qc	5933 21	5935 05	3 50	13 50	13 70	13 20	5920 01	35133 80	22222.15	748121 1820	2085334 0958
5387	Qc	5959 82	5961 84	3 50	9 05	9 30	8.80	5951 02	35002.12	20799 60	747984 8454	2083912.3575
5487	Qaf/Qc	5955 85	5957 72	1 33	4 53	4 68	4 20	5951 65	35001 45	20919 36	747984 5675	2084032.0807
B302089	Qc	5907 50	5909 55	3 85	13 30	15 00	13 50	5894 00	33804 66	20373 64	746786 2956	2083490 4539
B301889	Qc	5866 80	5868 83	13 16	22 60	24 45	22 30	5844 50	34321 96	22207 35	747309 5078	2085321 9781
5986R	Qc	5919 90	5921 66	20 10	27 30	28 60	29 50	5890 40	34769 30	21146 63	747753 2293	2084260.0565
6886	Qvf	5880 75	5883 77	1 50	3 50	3 50	2 80	5877 95	34172.96	20466 13	747174 5774	2083570 0100
5587	Qt	5858 08	5860 13	3 35	7 35	7 50	7 00	5851 08	34633 09	21805 12	747619 2290	2084918 8244
5886	Qvf	5888 89	5891 37	1 50	3 50	3 50	3 00	5885 89	34102.78	20319 54	747104 3846	2083423 4220

KEY TO GEOLOGIC STRATA Qaf-Artificial Fill, Qrf-Rocky Flats Alluvium, Qc-Colluvium, Qvf-Valley Fill Alluvium, Qt-Terrace Alluvium, Kcl-Bedrock Weathered Claystone, Kss(u)-Bedrock Unweathered Sandstone, Kss(w)-Bedrock Weathered Sandstone, Kst(w)-Bedrock Weathered Siltstone, AL-undifferentiated Alluvium

TABLE 2-1
881 HILLSIDE AREA
MONITORING WELL DATA

Well Number	Geologic Strata of Complete	Ground Surface Elev (ft)	Top of Casing Elev (ft)	Depth to Top of Screen	Depth to Bottom of Screen	Total Depth (ft)	Depth to Bedrock (ft)	Bedrock Elevation	Northing Coordinate (ft) - RFP	Easting Coordinate (ft) - RFP	State Northing (ft)	State Easting (ft)
6486	Qvf	5834 48	5836 46	3 41	9 00	9 00	8 80	5825 68	34683 82	22497 26	747685 5186	2085601 1100
6886	Qvf	5880 75	5883 77	1 50	3 50	3 50	2 80	5877 95	34172.96	20466 13	747174 5774	2083570 0100
0974		5924 60	5926 25	0 00	0 00	20 10	0 00	0 00	35042.78	21670 91	748028 3697	2084783 3009
B301889	Qc	5866 80	5868 83	13 16	22 60	24 45	22 30	5844 50	34321 96	22207 35	747309 5078	2085321 9781
5986	Kss(w)	5914 32	5915 3	19 00	28 00	28 00	7 50	5906 82	34770 41	21153 12	747772.0500	2084256 9680
6286	Kss(w)	5897 54	5898 75	25 22	35 19	35 19	22 00	5875 54	35154 34	22613 19	748156 0499	2085717 0180
0587BR	Kss(u)	5927 76	5930 16	42 00	51 25	51 50	12 20	5915 56	35095 27	21736 48	748081 0586	2084848.6844
0387BR	Kss(u)	5930 58	5932.44	102 80	107 75	108 00	20 00	5910 58	34723 33	20847 58	747706 2876	2083961 2436
4587BR	Kss(u)	5949 42	5951 00	89 50	101 05	101 30	4 00	5945 42	35325 47	22340 05	748313 1987	2085451 3360
0887BR	Kss(u)	5919 70	5921 68	84 00	89 02	89 34	8 70	5911 00	34774 29	21180 72	747758.1749	2084294 2980
B304789	Kcl	5867 50	5869 56	27 90	37 57	39 14	22 90	5844 60	34321 35	22184 13	747308 8221	2085298.7662

KEY TO GEOLOGIC STRATA Qaf-Artificial Fill, Qrf-Rocky Flats Alluvium, Qc-Colluvium, Qvf-Valley Fill Alluvium, Qt-Terrace Alluvium, Kcl-Bedrock Weathered Claystone, Kss(u)-Bedrock Unweathered Sandstone, Kss(w)-Bedrock Weathered Sandstone, Kst(w)-Bedrock Weathered Siltstone, AL-undifferentiated Alluvium

- Packer testing of cored bedrock wells
- Slug testing on all new wells containing sufficient water for testing
- Single hole pumping tests of wells 2-87 and 4-87
- Quarterly sampling and analysis of ground water from all 1986 wells (up to five quarters of data) and 1987 wells (in general, two samples for Phase I wells and one sample for Phase II wells) in the study area in addition to older wells which had shown contamination in the past
- Surface water sampling and analysis from stations along Woman Creek and the South Interceptor Ditch, as well as from seeps and springs located in the area
- Bedload sediment sampling and analysis in Woman Creek

2 1 2 French Drain Geotechnical Investigation

An interim remedial action is proposed at the 881 Hillside Area to collect, treat, and discharge the treated alluvial ground water Alluvial ground water will be collected by a french drain across the hillside and pumped to a water treatment plant at the top of the hillside A geotechnical and geochemical soils investigation was performed at the 881 Hillside Area in order to evaluate the site characteristics along the proposed french drain alignment, a possible french drain extension, and associated influent and effluent lines (Figure 2-2)

A series of 36 borings on approximately 10 foot centers were taken along the entire length of the influent/effluent lines, the french drain alignment, and the potential french drain extension Six additional boreholes were drilled as offsets to the 100-foot centered boreholes to obtain geotechnical samples of the colluvium This was required because most of the core from the central boreholes was used for geochemical sampling, leaving little for additional geotechnical sampling

Objectives of the french drain geotechnical investigation included

- Geotechnical soil and bedrock samples and testing (in situ and laboratory) to assist in the design of the french drain system and evaluate the slope stability of the 881 Hillside
- Accurate lithologic logs, including depth to bedrock and location of subcropping bedrock sandstone units
- Geologic data for generating geologic cross sections
- Samples for chemical analyses that added to the 881 Hillside database to determine
  a Appropriateness of proposed french drain location
  b Appropriate level of health and safety protection for french drain construction
  c Disposition of excavated soils

- Hydraulic conductivities of each five-foot depth interval in bedrock and discrete conductivities of any subcropping sandstones that were encountered

The French Drain Geotechnical Investigation consisted of

- Drilling, sampling, and chemical analyses of subsurface soils from 37 boreholes

- Packer testing of 28 cored bedrock boreholes

- Installation of four alluvial piezometers along the proposed French Drain Extension

- Sampling for geotechnical testing in 42 boreholes of both the surficial and bedrock units (EG&G, 1991a)

2 2 SITE PHYSICAL CHARACTERISTICS

A site-specific conceptual model of the 881 Hillside Area has been developed based on previous investigations This model describes contaminant sources and pathways through which contaminant transport may occur from these areas

2 2 1 Geology

Geologic materials at OU No 1 consist of surficial materials (colluvium, Rocky Flats Alluvium, and valley fill alluvium) overlying the Cretaceous Arapahoe Formation Geologic interpretations presented herein are based on information from Hurr (1976) and the Draft Geologic Characterization Report (EG&G, 1990d) These interpretations are subject to change or modification based upon information gathered during the Phase III RFI/RI

2 2 1 1 Surficial Geology

Surficial materials at the 881 Hillside Area consist of the Rocky Flats Alluvium, colluvium, valley fill alluvium, and artificial fill unconformably overlying bedrock In addition, there are a few isolated exposures of claystone bedrock Figure 2-3 presents the distribution of surficial materials The study area is located on the south-facing hillside which slopes down from the Rocky Flats terrace toward Woman Creek on the south side of the Plant Rocky Flats Alluvium caps the top of the slope, and colluvium covers the hillside Artificial fill and disturbed materials are present around Building 881 and south of the building to the South Interceptor Ditch Artificial fill overlies colluvium at IHSS 130, and surficial materials are disturbed in the vicinity of IHSSs 119 1 and 119 2 Valley fill alluvium is present along the drainage of Woman Creek south of the 881 Hillside Area, and terrace alluvium occurs on the north side of the Woman Creek valley fill alluvium

Rocky Flats Alluvium

The Quaternary Rocky Flats Alluvium is the oldest and topographically highest alluvial deposit at the Rocky Flats Plant (Scott, 1965) The Rocky Flats Alluvium is a series of coalescing alluvial fans deposited by braided streams (Hurr, 1976) The erosional surface (pediment) on which the alluvium was deposited slopes gently eastward truncating the Fox Hills Sandstone, the Laramie Formation, and the Arapahoe Formation at the Rocky Flats Plant

After deposition of the Rocky Flats Alluvium, eastward flowing streams began dissecting the deposit by headward erosion and lateral planation All of the alluvium was removed by erosion in the Woman Creek drainage south of the 881 Hillside Area and in the South Walnut Creek drainage to the north The result is a terrace of Rocky Flats Alluvium extending eastward from the Plant between the two drainages This terrace forms the crest of the 881 Hillside Area

Colluvium

Colluvial materials are present on the hillside below the Rocky Flats terrace east of Building 881 and extend south to the Woman Creek drainage (Figure 2-2) These materials are deposited by slope wash and downslope creep of Rocky Flats Alluvium and bedrock Colluvium ranges from two feet (BH16-87) to twenty-two (well 62-86) feet in thickness

Colluvial materials on the 881 Hillside have been disturbed by construction of Building 881, various excavation activities associated with the IHSSs, and construction of the South Interceptor Ditch These areas are shown as disturbed ground on Figure 2-2 Within IHSSs 119 1 and 119 2, shallow excavation took place to construct roadways and to provide level drum storage areas Colluvium is also disturbed south of Building 881 in the vicinity of IHSSs 106 and 107 This area was excavated during construction of the skimming pond in 1972 Finally, colluvium was excavated along the South Interceptor Ditch during its construction from 1979 to 1981

Colluvium is undisturbed on the hillside south of IHSSs 130, 119 1, and 119 2 and south of the perimeter road The colluvium is thickest in the north-south trending swales draining the 881 Hillside (wells 4-87 and 6-87) and thinnest over the intervening ridges (wells 48-87, 49-87, and 50-87) Colluvium consists predominantly of clay with common occurrences of sandy clay and gravel layers

Gravel layers are present in colluvial materials both unconformably overlying bedrock and near the surface These gravels are likely deposited in a south (downslope) direction by creep and slope wash erosion of the Rocky Flats Alluvium and can be expected to be elongated in the north-south direction with a rather limited extent in the east-west direction The gravel layers range from 1 3 feet (wells 43-87, 62-86, and 69-86) to 5 5 feet (well 59-86) in thickness Colluvial gravel deposits can be correlated between some of the wells and boreholes For example, the basal gravel in well 59-86 can be traced to wells 69-86 and 8-87 Sand and gravel layers in well 43-87 can also be correlated with sand and gravel layers in well 4-87 (Figure 2-4)

Terrace Alluvium

A Quaternary terrace alluvium is present on the north side of the Woman Creek valley fill alluvium This terrace is approximately five to ten feet above the present stream level indicating that it is probably Holocene in age (Scott, 1960) The thickness of the deposit ranges from approximately three (well 58-86) to seven (well 55-87) feet The terrace alluvium is composed of very poorly sorted gravelly sand

Valley Fill Alluvium

The most recent alluvial deposit in the 881 Hillside Area is the valley fill alluvium along Woman Creek This alluvium is derived from reworked and redeposited older alluviums and bedrock Alluvium thickness ranges from approximately six feet (well 68-86) to nine feet (well 64-86) The unconsolidated valley fill alluvium generally consists of poorly sorted, angular to subrounded granite and quartzite cobbles, pebbles, and gravels in a silty, sand matrix.

Fill

There are two types of fill on the 881 Hillside (Figure 2-2) derived from separate sources The first is natural fill material derived from excavation of the Building 881 foundation, and the second is artificial fill placed at IHSS 130 (Section 1 4 8)

Material excavated for the Building 881 foundation was spread over a large area generally south of the building The very poorly sorted and unconsolidated natural fill was derived from Rocky Flat Alluvium, colluvium, and claystone bedrock It is predominantly composed of sandy clay with some gravelly zones

Soils placed at IHSS 130 comprise the second type of fill It consists of clayey sand with subangular quartzite cobbles Asphalt was also encountered from 0 to 2 75 feet in BH11-87 The artificial fill at IHSS 130 overlies natural colluvial materials In borehole BH11-87, approximately five feet of fill are present, with fill thickness increasing to approximately ten feet in BH10-87 The artificial fill at IHSS 130 was unsaturated during the Phase II RI drilling program

2 2 1 2 Bedrock Geology

The Cretaceous Arapahoe Formation underlies surficial materials at the 881 Hillside Area The bedrock beneath the 881 Hillside consists of claystones with interbedded lenticular sandstones, siltstones, and occasional minor lignite deposits The bedrock sediments were deposited by meandering and braided streams flowing generally from west to east off the Front Range (Weimer, 1973) Sandstones were deposited in stream channels and as overbank splays, claystones were deposited in back swamp and floodplain areas Leaf fossils, organic matter, and lignite beds were encountered within the claystones during drilling at the 881 Hillside Contacts between various lithologies are both gradational and sharp Based on results of the high resolution seismic reflection study at Rocky Flats Plant, bedrock in the 881 Hillside Area is dipping less than two degrees to the east (EG&G, 1990f) The seismic investigation along with the geologic characterization provide strong evidence that some sandstones at the Plant are quite continuous Further work defining the geometrics and distribution of individual sandstone bodies at the Plant is ongoing

Claystones

Arapahoe Formation claystone was the most frequently encountered lithology immediately below the alluvium/bedrock contact Claystones are generally thinly bedded and contain occasional laminae and interbeds of fine-grained sand and silt (wells 3-87, 45-87, and 47-87) Intervals of carbonaceous material and fossils (mainly plant fragments and leaves) are also common in the claystones

Weathered bedrock was encountered directly beneath surficial materials in all of the boreholes and wells, and weathering appears to have altered between approximately two (borehole BH16-87) and 60 feet (well 62-86) of bedrock Claystone in the weathered zone are generally consolidated, while sandstones in the weathered zone are typically friable Iron oxide staining and concretions along with caliche are characteristic of the zone The weathered claystone is also characterized by mild fracturing typically exhibiting a fracture density of three to seven iron oxide-filled, healed fractures per foot Unweathered claystones may typically exhibit a fracture density of zero to three iron oxide-filled to manganese oxide-filled, healed fractures per foot This fracture density information was obtained from borehole logs of the French Drain Geotechnical Investigation (EG&G, 1991a) and will be provided in the Phase III RFI/RI report As a result, the weathered claystone has slightly higher hydraulic conductivities than unweathered claystone In well 5-87 and abandoned hole 7-87A, claystone was mildly fractured from the alluvium/ bedrock contact to depths of approximately 46 and 26 feet, respectively A 45 degree fracture was also identified in weathered claystone in well 8-87 at a depth of approximately 54 feet

Unweathered bedrock occurs between 37 7 (well 8-87) and 56 feet (well 3-87) below ground surface The unweathered claystones are typically darker gray than weathered claystone and have little mottling They are also more consolidated than weathered claystones and exhibit little to no fracturing

Sandstones

Arapahoe Formation sandstones were encountered beneath the 881 Hillside in holes 59-86, 62-86, 3-87, 5-87, 6-87A, 7-87A, 8-87, and 45-87 These sandstones are generally composed of poorly to moderately sorted, subrounded to rounded, very fine- to medium-grained, poorly to moderately well cemented quartz sand with up to 10% lithic fragments The thickness of individual sandstone beds ranged from approximately five feet (well 5-87) to twelve feet (well 8-87)

Sandstones encountered in holes 5-87, 6-87A, 7-87A, and 8-87 are weathered Weathered sandstones ranged from olive gray to moderate yellowish brown in color with brown, orange, and yellow iron oxide staining Weathered sandstones were described as being friable and brittle Unweathered sandstones are lithologically similar to the weathered sandstones and were found in wells 45-87 and 3-87, at 89 5 feet and 103 feet, respectively Unweathered sandstones are generally medium dark gray to pale olive in color with infrequent staining of brown and yellows The deeper unweathered sandstones are generally more consolidated than weathered sandstone The orientation, geometry, and extent of bedrock sandstones at the 881 Hillside are not well defined at this time

A saturated lignite bed was encountered from approximately 85 to 88 feet below ground surface in well 8-87 and between approximately 87 8 to 88 1 feet below ground surface in well 3-87 Very carbonaceous-rich claystones occur frequently in this stratigraphic horizon Based on a two degree dip of the bedrock, the two lignite layers correlate and are presumably continuous

2 2 2 Ground-water Hydrology

Unconfined ground-water flow occurs in surficial materials and subcropping sandstones In addition, subcropping claystone may be saturated in some locations Confined ground-water flow occurs in lower sandstone units The majority of the wells that have been installed in weathered claystone throughout the Plant monitor the unconfined flow system Due to low hydraulic conductivities, water recovery is low

2 2 2 1 Unconfined Flow System

Recharge/Discharge Conditions

Ground water is present in the Rocky Flats Alluvium, colluvium, valley fill alluvium, and subcropping sandstones under unconfined conditions Recharge to the water table occurs as infiltration of incident precipitation and as seepage from ditches and creeks In addition, retention ponds along Woman Creek likely recharge the valley fill alluvium

The shallow ground-water flow system is quite dynamic, with large water level changes occurring in response to precipitation events and stream and ditch flow Alluvial water levels are highest during the spring and early summer months of May and June Water levels generally decline during late summer and fall, at which time some wells go dry The shallow ground-water flow system supports ephemeral flow in the creeks

Alluvial ground water discharges to seeps, surface water drainages, colluvium and bedrock at the 881 Hillside Area Seeps occur on the Hillside where colluvial materials are thin Ground water in valley fill materials discharges to Woman Creek

There is a strong downward gradient between ground water in surficial materials and bedrock Calculated vertical gradients range from approximately 0 3 to 3 7 ft/ft indicating a hydraulic potential for downward flow (Table 2-2) These values were calculated using the methods of Kasef (1986) It should be noted these vertical gradients only indicate the potential for downward flow Actual downward flow rates are controlled by the thickness and vertical hydraulic conductivity of the intervening layers as well as the vertical gradient

Ground-Water Flow Directions

Figures 2-5, 2-6, 2-7, and 2-8 depict the water table in surficial materials in January, May, August, and October 1989, respectively Ground water flows from the Rocky Flats Alluvium at the top of the 881 Hillside generally southeast through colluvial materials toward Woman Creek At the Rocky Flats pediment edges, ground water emerges as seeps and springs at the contact between the alluvium and claystone bedrock (contact seeps), is consumed by evapotranspiration, or flows through colluvial materials following topography toward the valley fill and terrace alluviums Flow through colluvial materials appears to primarily occur in the gravel within the colluvium Available water level data for well 47-87 indicate that ground water is below the base of the South Interceptor Ditch (Figure 2-5), although there could be discharge to the ditch during wet periods Once ground water reaches the valley, it either flows down-valley in the alluvium (easterly), is consumed by evapotranspiration, or discharges to Woman Creek During the driest portions of the year, evapotranspiration can result in no flow in either the colluvium or the valley fill alluvium

TABLE 2-2

VERTICAL GRADIENTS CALCULATED FOR WELL PAIRS AT THE 881 HILLSIDE

Well No	Ground Elevation (ft AMSL)	Potentiometric Surface Elevation (ft AMSL)	Date of Water Level	Depth Upper Zone Base (ft)	Elevation Upper Zone Base (ft)	Depth Top of Lower Zone (ft)	Elevation Top of Lower Zone (ft)	Differential Head (ft)	Separator Thickness (ft)	Downward Vertical Gradient (ft/ft)
2 87	5930 56	5921 13	10/05/87	8 75	5921 81	---	---			
3-87BR	5930 58	5842 24	10/05/87	---	---	103 1	5827.48	86 89	94 33	0 92
43 87	5924 92	5918 39	01/11/88	12 0	5912 92	---	---			
5 87BR	5927 76	5883 96	01/11/88	---	---	45 7	5882 06	34 43	30 86	1 12
44 87	5949 53	5947 26	12/18/87	3 2	5946 33	---	---			
45 87BR	5949 42	5859 60	12/18/87	—	---	89 5	5859 92	87 66	86.41	1 01
69 86	5915 42	5914 60	02/04/88	13 3	5902 12	---				
59 86	5914 32	5889 63	02/04/88	---	---	19 0	5895 32	24 97	6 8	3 67
59 86	5914 32	5898 63	02/04/88	26 5	5887 82	---	---			
8 87BR	5919 70	5874 10	02/04/88	---	---	85 0	5834 70	15 53	53 12	0 29

Ground-Water Flow Rates

Hydraulic conductivity values were calculated for surficial materials based on results of drawdown-recovery tests performed on 1986 wells during the initial site characterization (Rockwell International, 1986e) and on results of baildown/recovery and single well pumping tests performed on select 1986 and 1987 wells during remedial investigations (Rockwell International, 1987a, 1988a, and 1989a) Ground-water flow velocities are presented below based on site-specific hydraulic conductivity values and gradients However, these flow rates represent extremely conservative estimates, as a conservative estimate of effective porosity (0 1) was used in the calculations As site-specific effective porosity values are developed for OU No 1, ground-water flow rate calculations will be revised

Hydraulic conductivity values are available for three wells completed in colluvium at the 881 Hillside, two are completed in gravel layers (wells 69-86 and 4-87) and one is completed in sandy clay (well 2-87) (Table 2-3) The test results indicate hydraulic conductivities of 9×10^{-4} centimeters per second (cm/s) and 7×10^{-5} cm/s for the gravel layers and 4×10^{-5} cm/s for the sandy clay Using the maximum hydraulic conductivity value of 9×10^{-4} cm/s, a gradient of 0 15 for colluvial gravel at the hillside, and an assumed effective porosity of 0 1, the maximum possible ground-water velocity through colluvial gravel is approximately 1,400 feet per year (ft/yr) Using the geometric mean hydraulic conductivity of 1×10^{-4} cm/s, a gradient of 0 15, and an effective porosity of 0 1, the mean ground-water velocity through colluvium is approximately 155 ft/yr Volatile organic contaminants from IHSSs 119 1 and 130, based on chemical data presented in Section 2 3, have not yet reached well 47-87 due to attenuation mechanisms in the area (That well was usually dry, but the samples that were obtained did not contain volatile organic concentrations above detection limit) There is one report of PCE [8J micrograms per liter ($\mu g/\ell$) - estimated below detection limit and flagged "A" (accepted with qualifications)] at well 64-86 However, this one value is considered insufficient to demonstrate contamination at that easterly location Those data will be verified in Phase III, but current evidence suggests that organic contaminants in ground water from IHSS 119 1 have moved less than 200 feet in 15 to 18 years (11 to 13 ft/yr) This represents an estimate of organic contaminant migration rate, including the effects of retardation and attenuation, not ground-water flow rate

Once ground water reaches the creek drainage, it travels within the alluvium east toward the property boundary at Indiana Street Flow in the alluvium occurs in response to infiltration events, and the saturated thickness decreases following the event by down-valley flow and evapotranspiration High evaporative losses have been noted repeatedly in investigations of the valley fill alluvium Hurr (1976) notes that as much as 0 25 cubic feet per second (ft^3/s) were lost to evapotranspiration along Woman Creek during the period July to September, 1974 In addition, both Rockwell International (1987c) and the DOE (1980) comment on evapotranspirative losses from the valley fill alluvium, based on water level records

TABLE 2-3

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS IN SURFICIAL MATERIALS

COLLUVIUM

Well No	Drawdown-Recovery Tests (cm/s)	Slug Tests (cm/s)
69-86	9×10^{-4}	2×10^{-4}
2-87	4×10^{-5}	3×10^{-5}
4-87	7×10^{-5}	---
Geometric Mean	$1\ 4 \times 10^{-4}$	$7\ 7 \times 10^{5}$

WOMAN CREEK VALLEY FILL

Well No	Drawdown-Recovery Tests (cm/s)	Slug Tests (cm/s)
56-86	4×10^{-4}	---
65-86	3×10^{3}	---
68-86	1×10^{-3}	---
70-86	3×10^{-4}	---
Geometric Mean	$7\ 7 \times 10^{-4}$	

Based on evaluation of drawdown/recovery tests, the Woman Creek valley fill alluvium has a geometric mean hydraulic conductivity of 7 7 x 10^{-4} cm/s (797 ft/yr) and a maximum conductivity of 3 x 10^{-3} cm/s (3,104 ft/yr) (Table 2-3) Using a hydraulic gradient of 0 021 and an assumed effective porosity of 0 1, the resulting ground-water flow velocity ranges from 167 to 652 ft/yr using the geometric mean and maximum hydraulic conductivity values

The inference that the ground water flows only three quarters of the year is based on water level data from wells completed in Woman Creek alluvium Six of the nine wells completed in the Woman Creek alluvium have been dry during at least some portion of the year since their installation The Phase II RI report (Rockwell International, 1988a) presents water level data which show that the valley fill alluvium is dry at wells 1-86, 64-86, and 66-86 from about June to October (three months) Because the alluvium is not saturated for the full year, a dissolved constituent travels only a portion of this distance each year Thus, a solute particle would travel approximately 125 to 489 feet in valley fill alluvium during a year based on the average and maximum hydraulic conductivity values Section 5 0 discusses additional hydraulic testing to estimate hydraulic conductivities as well as dispersion coefficients

The claystone within the bedrock is also considered part of the unconfined ground-water flow system even though limited flow occurs in this unit Packer tests were performed in four wells drilled in 1987 for the Phase II RI/FS and in 24 boreholes for the French Drain Geotechnical Investigation The results of these packer tests are presented in Tables 2-4 and 2-5

Most of the packer tests performed for the French Drain Geotechnical Investigation showed no water loss in the weathered claystones and therefore the hydraulic conductivity values are given as less than results (EG&G, 1991a) These values were used in the calculation of the geometric mean in two ways In one calculation, the values indicating no water loss were taken as actual values and included in the calculation In the other instance, the values reported with a less than sign preceeding them were replaced with the value 1 0 x 10^{7} cm/s which is believed to be a representative value for the hydraulic conductivity of the weathered claystone Hydraulic conductivity values for weathered claystones estimated from packer tests showed a range of 2 3 x 10^{-3} cm/s to 3 6 x 10^{7} cm/s, with a geometric mean range of 2 1 x 10^{-6} cm/s to 3 4 x 10^{7} cm/s

The hydraulic conductivity values for unweathered claystone are given in Table 2-5 The values ranged from 3 x 10^{-6} cm/s to 1 x 10^{-8} cm/s with a geometric mean of 9 5 x 10^{-6} cm/s The geometric mean of hydraulic conductivity for unweathered claystone is one to two orders of magnitude less than the value for weathered claystone

TABLE 2-4

RESULTS OF PACKER TESTS IN WEATHERED CLAYSTONES

Borehole No *	Hydraulic Conductivity (cm/s)
5-87BR	2 x 10^{-6}
	1 x 10^{-6}
	2 x 10^{7}
8-87BR	7 x 10^{7}
B300190	<1 5 x 10^{-6}
B300290	2 2 x 10^{-3}
	2 3 x 10^{-3}
B300390	N/A
B300490	N/A
B300590	<2 8 x 10^{-6}
	<3 7 x 10^{-6}
	<4 5 x 10^{-6}
B300690	<3 3 x 10^{-6}
	<3 7 x 10^{-6}
	8 4 x 10^{7}
B300790	<5 0 x 10^{-6}
	<8 4 x 10^{-6}
	<4 8 x 10^{-6}
B300890	<5 9 x 10^{-6}
	<3 4 x 10^{-6}
	2 0 x 10^{-6}
B300990	<2 6 x 10^{-6}
	<1 3 x 10^{-6}
	<2 0 x 10^{-6}
B30190	6 4 x 10^{-6}
	N/A
B301190	<6 6 x 10^{-6}
	<5 3 x 10^{-6}
	<3 5 x 10^{-6}
B301290	<1 5 x 10^{-6}
	<1 0 x 10^{-6}
	1 1 x 10^{-4}
B301390	3 5 x 10^{-6}
	1 7 x 10^{-6}
	3 5 x 10^{-6}
	<5 0 x 10^{7}
B301490	<4 9 x 10^{-6}
	<6 0 x 10^{-6}
	<2 3 x 10^{-6}
B301590	8 5 x 10^{-4}
	4 2 x 10^{-6}
	2 3 x 10^{-6}
	8 0 x 10^{-6}
B301690	<6 6 x 10^{7}
	<4 3 x 10^{7}
	4 4 x 10^{7}
B301790	<1 3 x 10^{-6}
	<5 8 x 10^{7}
	<4 8 x 10^{7}
	<4 1 x 10^{7}
B301890	<8 3 x 10^{7}
	3 9 x 10^{-6}
	<4 5 x 10^{7}
	<4 5 x 10^{7}
B301990	<7 4 x 10^{7}
	<5 4 x 10^{7}
	<5 6 x 10^{7}
	<5 3 x 10^{7}
B302090	<7 2 x 10^{7}
	<5 5 x 10^{7}
	<5 2 x 10^{7}
	<4 5 x 10^{7}
B302190	<6 2 x 10^{7}
	<4 2 x 10^{7}
	<3 6 x 10^{7}
B302290	<7 4 x 10^{7}
	<5 4 x 10^{7}
	<4 5 x 10^{7}

TABLE 2-4 (Continued)

RESULTS OF PACKER TESTS IN WEATHERED CLAYSTONES

Borehole No *	Hydraulic Conductivity (cm/s)
B303790	<8 2 x 10^{7}
	<6 6 x 10^{7}
	<5 4 x 10^{7}
B303890	<1 2 x 10^{-6}
	<1 0 x 10^{-6}

Gemetric Mean

1) Values reported as less than values taken as actual values 2 1 x 10^{-6} cm/s

2) Values reported as less than values replaced with 1 x 10^{7} cm/s 3 4 x 10^{7} cm/s

* French Drain Geotechnical Investigation boreholes begin with B, 881 Hillside RI boreholes begin with a number

TABLE 2-5

RESULTS OF PACKER TESTS IN UNWEATHERED CLAYSTONE

Borehole No		Hydraulic Conductivity (cm/s)
3-87		1×10^{-8}
		3×10^{7}
		2×10^{-8}
		5×10^{-8}
		4×10^{-8}
		$4 5 \times 10^{7}$
8-87	with lignite	9×10^{-8}
	with lignite	1×10^{-8}
45-87		2×10^{7}
		3×10^{-6}
		2×10^{-8}
		9×10^{7}
	Geometric Mean	$9 5 \times 10^{-8}$

2 2 2 2 Confined Flow System

The greatest potential for ground-water flow in the Arapahoe Formation occurs in the sandstones contained within the claystones Ground-water recharge to sandstones occurs as infiltration from alluvial ground water where sandstones subcrop beneath the alluvium and by leakage from claystones overlying the sandstones

Following Robson, et al (1981a), flow within individual sandstones is assumed to be from west to east, but the geometry of the bedrock ground-water flow path is not fully understood at this time due to its dependence upon the continuity of the sandstones and their hydraulic interconnection Evaluation of the lateral extent and degree of interconnection of the sandstone units is a primary goal of an ongoing program of profiling the Arapahoe Formation through drilling and the high resolution seismic reflection studies

Hydraulic conductivity values for sandstones were estimated from drawdown-recovery tests performed in 1986, slug tests performed in 1987, and packer tests performed in 1986 and 1987 (Rockwell International, 1988a) Drawdown-recovery test results for wells 59-86, 62-86, 3-87, and 5-87 in weathered sandstone were 2 x 10^{-4} cm/s, 1 x 10^{-5} cm/s, 2 x 10^{-6} cm/s, and 8 x 10^{-5} cm/s, with a geometric mean of 2 4 x 10^{5} cm/s (Table 2-6) The variability of results for sandstones is reasonable given their variable silt content Slug and packer tests typically yielded lower hydraulic conductivity values sandstone in wells 62-86 and 5-87 had values of 6 x 10^{-6} cm/s to 7 x 10^{-8} cm/s based on slug tests, and sandstone in wells 59-86, 62-86, 3-87 and 5-87 had values of 4 4 x 10^{7} cm/s, 5 x 10^{-8}, 7 8 x 10^{7}, and 2 x 10^{7} cm/s based on packer tests

2 2 3 Surface Water Hydrology

2 2 3 1 Woman Creek

Woman Creek is located south of the 881 Hillside Area with its headwaters in largely undisturbed Rocky Flats Alluvium (Figure 1-2) Runoff from the southern part of the Plant is collected in the South Interceptor Ditch located due north of the creek and delivered to Pond C-2 Pond C-1 (upstream of C-2) receives stream flow from Woman Creek The discharge from Pond C-1 is diverted around Pond C-2 into the Woman Creek channel downstream Water in Pond C-2 is treated and discharged to Woman Creek in accordance with the Plant NPDES permit (discharge point 007) It is then pumped from the Woman Creek drainage northeast through an eight-inch diameter PVC pipe (Pond C-2 diversion pipe) to join the Broomfield Diversion Canal located in the Walnut Creek drainage basin

Flow in Woman Creek and the South Interceptor Ditch is intermittent, appearing and disappearing along various reaches During the 1986 initial site characterization, measurable flow occurred at less than one-half of the ten

TABLE 2-6

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS OF BEDROCK UNWEATHERED SANDSTONE

Well No	Drawdown-Recovery Tests (cm/s)	Slug Tests (cm/s)	Packer Tests (cm/s)
59-86BR	2×10^{-4}	---	$4 4 \times 10^{7}$
62-86BR	1×10^{-5}	6×10^{-6}	5×10^{-8}
3-87BR	2×10^{-6}	---	$7 8 \times 10^{7}$
5-87BR	8×10^{-6}	7×10^{-5}	2×10^{7}
Geometric Mean	$2 4 \times 10^{-5}$	$2 0 \times 10^{5}$	$2 4 \times 10^{7}$

stations located along Woman Creek and the South Interceptor Ditch (Rockwell International, 1986e) All recorded flows, measured at the time of quarterly sampling events, were less than ten gallons per minute During the 1986 and 1987 investigations, there was no surface flow in Woman Creek downstream of Pond C-2 The intermittent surface water flow observed for Woman Creek and the South Interceptor Ditch is indicative of frequent interaction with the shallow ground-water system

2 2 4 Surficial Soils

Surficial soils of OU No 1 are predominantly moderately deep to deep well-drained clay loams of moderate to low permeability The area is drained by Woman Creek and soils along the flood plain and low terraces have formed in stratified loamy alluvium The higher gently sloping soils are formed from Rocky Flats Alluvium and colluvium where gravels and cobbles are common The hillsides in the area are formed from cobbly, gravelly, and loamy alluvium (mixed sources) or claystone Runoff is generally rapid and erosion hazard can be severe on the steeper slopes Numerous soil series occur in the area, however, all belong in the Arguistoll great group with the exception of some entisoils in the drainages (Figure 2-9 and Table 2-7) Arguistolls are generally characterized as well-drained soils with mollic (dark) epipedons, argillic "B" horizons, and calcic "C" horizons They exist in ustic moisture regimes (limited moisture, but adequate for plant growth during growing season) The two predominant subgroups are Torrertic and Aridic, with the Torrertic Arguistolls having more pronounced shrinking and swelling capability (U S Department of Agriculture, 1980)

2 3 NATURE AND EXTENT OF CONTAMINATION

2 3 1 Background Characterization

In order to facilitate the interpretation of chemical results in non-background areas, a background characterization program has been implemented to define the spatial and temporal variability of naturally occurring constituents A plan was completed in January 1989 (Rockwell International, 1989c), field work was conducted, and a draft Background Geochemical Characterization Report was prepared and submitted to the regulatory agencies in December 1989 (Rockwell International, 1989d) The report was recently finalized for submittal in December 1990 (EG&G, 1990e) The document summarizes the background data for ground water, surface water, sediments, and geologic materials, and identifies preliminary statistical boundaries of background variability Spatial variations in the chemistry of geologic materials and water were addressed by placing sample locations throughout background areas at the Plant The goal of evaluating temporal variations in water chemistry has not yet been achieved because at least two years of quarterly data are needed Revision of the background report will continue as additional background data are collected

TABLE 2-7

SOIL TYPES AT THE 881 HILLSIDE AREA

Series	Family	Phase	Min-Max Slope (%)	Infiltration Rate	Soil Type*
Denver	Torrertic Arguistolls	clay loam	5-9	slow	27
Denver-Kutch	Torrertic Arguistolls	clay loam	5-9	slow	29
Denver-Kutch-Midway	Torrertic Arguistolls	clay loam	9-25	slow	31
Flatirons	Aridic Paleustols	sandy loam	0-3	slow	45
Haverson	Ustic Torrifluvents	loam	0-3	moderate	60
Leyden-Primen-Standley	Aridic Arguistolls	cobbly clay loam	15-50	slow	80
Midway	Ustic Torriorthents	clay loam	9-30	slow	98
Nederland	Aridic Arguistolls	sandy loam	15-50	moderate	100
Nunn	Aridic Arguistolls	clay loam	0-2	slow	102
Nunn	Aridic Arguistolls	clay loam	2-5	slow	103
Standley-Nunn	Aridic Arguistolls	gravelly clay loam	0-5	slow	149
Willowman-Leyden	Aridic Arguistolls	clay loam	9-30	moderate	174

* Soil Type number corresponds to soil type exhibited in Figure 2-9

The boundaries of background variability were quantified through the calculation of tolerance intervals assuming a normal distribution Assumptions and statistical analyses of the background tolerance intervals are presented in Rockwell International (1989d) The upper limit of the tolerance interval or the maximum detected value for each parameter analyzed in background ground-water, surface water, sediment, and geologic samples are provided in Tables 2-8 through 2-11, respectively Maximum detected values are provided where there were insufficient data to calculate tolerance intervals This condition resulted from either an insufficient number of samples, or an insufficient number of detectable concentrations for a given analyte Background samples initially were not analyzed for EPA Contract Laboratory Program (CLP) Target Compound List (TCL) organics, because the background areas are outside of potentially contaminated areas However, as of first quarter 1990, ground-water and surficial water samples are being collected in background areas for volatile organic analysis

To assess the presence of inorganic contamination at the 881 Hillside Area, site-specific chemical data are compared to the background tolerance intervals or the maximum detected value if a tolerance interval could not be calculated A constituent concentration that is greater than the upper limit of the one-sided 95% tolerance interval at the 95% confidence level will be considered to preliminarily represent contamination Although not statistically significant, site specific chemical concentrations above the maximum detected background value are considered a very preliminary indication of contamination in the following assessment

2 3 2 Borehole Samples

Phases I and II of the RI for OU No 1 focused on source characterization of preliminarily identified past waste disposal sites Soil samples were collected from boreholes drilled in Rocky Flats Alluvium, colluvium, and weathered claystone in 1987 in order to characterize the IHSSs Figure 2-1 shows Phase I and II RI borehole sampling locations These soil samples were analyzed for the parameters listed in Table 2-12 Table 2-13 lists 881 Hillside borehole sampling information including sample depths, material sampled, and target IHSSs Soil sampling results are presented in Appendix A

A 1990 IM/IRA investigation included a geotechnical investigation along the proposed french drain and influent and effluent lines (EG&G, 1991a) Soils were discretely sampled for analysis of volatile organic compounds (VOCs) and composite sampled for metal, radionuclide, semivolatile, and pesticide/PCB analysis The presence of toluene in the soil samples from numerous intervals of the french drain boreholes represents the most significant indication of VOCs in the immediate vicinity of the french drain Toluene was not detected in Phase I or II investigations Soil sampling results for the french drain investigation are presented in Appendix B, and borehole locations are shown in Figure 2-2

TABLE 2-8

BACKGROUND GROUND-WATER QUARTER 2 1989
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Dissolved Metals							
Aluminum	mg/l	ND	ND	ND	ND	ND	0 327*
Antimony	mg/l	ND	ND	ND	ND	ND	ND
Arsenic	mg/l	ND	ND	ND	ND	ND	0 0186*
Barium	mg/l	ND	ND	ND	ND	ND	ND
Beryllium	mg/l	ND	ND	ND	ND	ND	ND
Cadmium	mg/l	ND	ND	ND	ND	ND	ND
Calcium	mg/l	85	76 8*	138	73 4*	65.7*	64 6
Cesium	mg/l	ND	ND	ND	ND	ND	ND
Chromium	mg/l	ND	ND	ND	ND	0 0122*	ND
Cobalt	mg/l	ND	ND	ND	ND	ND	ND
Copper	mg/l	ND	ND	ND	ND	ND	ND
Iron	mg/l	0 266*	ND	0 94*	ND	ND	ND
Lead	mg/l	ND	ND	ND	ND	ND	ND
Lithium	mg/l	ND	0 172*	0 028	031*	0 0106*	ND
Magnesium	mg/l	5 79*	15 3*	26 57	45 3*	9 41*	ND
Manganese	mg/l	0 365	0 088*	0 686*	0.126*	0 292*	0 0182*
Mercury	mg/l	ND	ND	0 003*	008*	ND	ND
Molybdenum	mg/l	0 0136*	ND	ND	0 015*	0 015*	0 112*
Nickel	mg/l	0 0432*	ND	ND	ND	ND	ND
Potassium	mg/l	7 73*	ND	ND	ND	ND	21 89*
Selenium	mg/l	ND	ND	0 0114*	ND	ND	0 041*
Silver	mg/l	ND	ND	ND	ND	ND	ND
Sodium	mg/l	13 4	98 7*	88	36 9*	25 6*	599
Strontium	mg/l	0 159*	ND	ND	ND	ND	0 451*
Thallium	mg/l	ND	ND	ND	0 01*	ND	ND
Tin	mg/l	ND	ND	ND	ND	ND	
Vanadium	mg/l	ND	ND	ND	ND	ND	ND
Zinc	mg/l	0 141*	ND	0.0212*	0 107*	ND	0 564

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TABLE 2-8 (Continued)

BACKGROUND GROUND-WATER QUARTER 2 1989
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Other							
Total Dissolved Solids	mg/l	352	520*	947	320*	170*	1761
Carbonate	mg/l	ND	ND	ND	ND	ND	49
Bicarbonate	mg/l	436	470*	719	400*	140*	412
Chloride	mg/l	15 6	20*	40 29	11*	15*	607
Sulfate	mg/l	45 1	86*	150	44*	16*	950
Nitrate	mg/l	2 98	0 18*	0 69*	0 58*	1 6*	0 610
Cyanide	mg/l	0038*	ND	ND	0 0036*	ND	ND
pH	----	8 6 (5 98)	7 4* (7 1)**	8 68 (6 12)	8 2* (7 4)**	7 5* (7 2)**	10 57 (7 43)
Dissolved Radionuclides							
Gross Alpha	pCi/l	12.543	27*	13 515	12*	7*	13*
Gross Beta	pCi/l	14.570	12*	18 530	7*	2*	15*
Uranium 233, 234	pCi/l	1.647	11*	6 481	5 8*	1 1*	12 936
Uranium 235	pCi/l	0.000	0 3*	0 232	0 2*	0*	0 135
Uranium 238	pCi/l	0.195	7 7*	5 084	3 2	0 6*	3 3507
Strontium 89, 90	pCi/l	0.552	0.1*	0 878	0 1	-0 1*	0 2*
Plutonium 239, 240	pCi/l	0.009	0*	0 012	0 03	0 01*	0 000
Americium 241	pCi/l	0.000	0*	0 012	0	0 01*	0 019
Cesium 137	pCi/l	0 603	0 2*	0 776	0 4	0 3*	0 7*
Tritium	pCi/l	309	100*	505	100	100*	731

* - Maximum Detected Value
** - Minimum Detected Value
ND - Not Detected at Contract Required Detection Limit
() - Tolerance Internal Lower Limit for Two-Sided Parameter

TABLE 2-9

BACKGROUND SURFACE WATER (QUARTERS 1 and 2)
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Round 1 (7 samples) Total	Round 1 (7 samples) Dissolved	Round 2 (7 samples) Total	Round 2 (7 samples) Dissolved
Metals					
Aluminum	mg/l	0 916*	0 485*	8 444	0 454*
Antimony	mg/l	ND	ND	ND	ND
Arsenic	mg/l	ND	ND	ND	ND
Barium	mg/l	ND	ND	0 294*	ND
Beryllium	mg/l	ND	ND	ND	ND
Cadmium	mg/l	ND	ND	ND	ND
Calcium	mg/l	85 01	99 14	105 03	93 27
Cesium	mg/l	1 00*	ND	ND	ND
Chromium	mg/l	ND	ND	0 0115*	ND
Cobalt	mg/l	ND	ND		ND ND
Copper	mg/l	ND	ND	ND	ND
Iron	mg/l	31 17	4 69*	12 070	0 453*
Lead	mg/l	ND	0 0055*	0 0308*	0 0131*
Lithium	mg/l	ND	ND	0 0192*	0 0166*
Magnesium	mg/l	12 48	11.98	17 578	15 74
Manganese	mg/l	0 636	0 826	1 101	0 232
Mercury	mg/l	0.001	0.002	0 004*	0 0004*
Molybdenum	mg/l	ND	ND	0 026	0 032
Nickel	mg/l	ND	ND	ND	ND
Potassium	mg/l	ND	ND	ND	ND
Selenium	mg/l	ND	ND	ND	ND
Silver	mg/l	.001*	0 0125*	ND	ND
Sodium	mg/l	47.36	44 81	42.651	43 22
Strontium	mg/l	0.382	0 35	ND	ND
Thallium	mg/l	ND	ND	ND	ND
Tin	mg/l	ND	ND	ND	ND
Vanadium	mg/l	ND	ND	ND	ND
Zinc	mg/l	027	032	0 0892*	0 0228*

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TABLE 2-9 (Continued)

BACKGROUND SURFACE WATER (QUARTERS 1 and 2)
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Round 1 (9 samples) Total	Round 1 (9 samples) Dissolved	Round 2 (7 samples) Total	Round 2 (7 samples) Dissolved
Other					
Total Dissolved Solids	mg/l	329 52	NA	365 15	NA
Carbonate	mg/l	ND	NA	ND	NA
Bicarbonate	mg/l	389.72	NA	344 21	NA
Chloride	mg/l	89.11	NA	82.56	NA
Sulfate	mg/l	50.20	NA	65 30	NA
Nitrate	mg/l	2 45	NA	2 1*	NA
Cyanide	mg/l	ND	NA	0 0043*	NA
pH	----	9.02 (5 89)	NA	8 3 (6 44)	NA
Radionuclides					
Gross Alpha	pCi/l	266	5 805	106	NA
Gross Beta	pCi/l	213	9 335	79	NA
Uranium 233, 234	pCi/l	1 250	3.684	1 326	NA
Uranium 235	pCi/l	0 106	0.364	0 000	NA
Uranium 238	pCi/l	0.937	2 311	0 977	NA
Strontium 89, 90	pCi/l	2.160	1 452	1 243	NA
Plutonium 239, 240	pCi/l	1 066	0 017	0 112	NA
Americium 241	pCi/l	0 111	0.014	0 014	NA
Cesium 137	pCi/l	12 788	0.591	1 059	NA
Tritium	pCi/l	266	NA	863	NA

mg/l - milligrams per liter
pCi/l - picoCuries per liter
NA - Not Analyzed
ND - Not Detected
* - Maximum Detected Value
() - Tolerance Interval Lower Limit for Two-Sided Parameter

TABLE 2-10

BACKGROUND SEDIMENT
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Upper Limit (9 Samples)
Total Metals		
Aluminum	mg/kg	24789
Antimony	mg/kg	ND
Arsenic	mg/kg	13 0*
Barium	mg/kg	182*
Beryllium	mg/kg	ND
Cadmium	mg/kg	ND
Calcium	mg/kg	72551
Cesium	mg/kg	ND
Chromium	mg/kg	43 38
Cobalt	mg/kg	ND
Copper	mg/kg	22 0*
Iron	mg/kg	28308
Lead	mg/kg	39 502
Lithium	mg/kg	ND
Magnesium	mg/kg	4110*
Manganese	mg/kg	372 20
Mercury	mg/kg	ND
Molybdenum	mg/kg	ND
Nickel	mg/kg	29 9*
Potassium	mg/kg	ND
Selenium	mg/kg	ND
Silver	mg/kg	6 8*
Sodium	mg/kg	ND
Strontium	mg/kg	175*
Thallium	mg/kg	ND
Tin	mg/kg	ND
Vanadium	mg/kg	50.2*
Zinc	mg/kg	92 688

TABLE 2 10 (Continued)

BACKGROUND SEDIMENT
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Upper Limit (9 Samples)
Other		
Nitrate	mg/kg	ND
pH	----	9 03 (8 77)
Total Radionuclides		
Gross Alpha	pCi/g	60
Gross Beta	pCi/g	50
Uranium 233, 234	pCi/g	1.669
Uranium 235	pCi/g	0 176
Uranium 238	pCi/g	1 755
Strontium 89, 90	pCi/g	1 390
Plutonium 239, 240	pCi/g	0 096
Americium 241	pCi/g	0 029
Cesium 137	pCi/g	1 578
Tritium	pCi/g	0 408

mg/kg - milligrams per kilogram
pCi/g - picoCuries per gram
ND - Not Detected
* - Maximum Detected Value
() - Tolerance Interval Lower Limit for Two-Sided Parameter

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TABLE 2-11

BACKGROUND GEOLOGIC MATERIALS
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
Total Metals					
Aluminum	mg/kg	25312	21663	13495	10300*
Antimony	mg/kg	ND	ND	16 2*	ND
Arsenic	mg/kg	15.86	7 7	15 05	3 6*
Barium	mg/kg	155 8	345 8	240 1	165*
Beryllium	mg/kg	11 27	17 75	11 8	2 2*
Cadmium	mg/kg	3 2*	1 8*	ND	ND
Calcium	mg/kg	43079	20811	10183	5940*
Cesium	mg/kg	ND	274*	ND	ND
Chromium	mg/kg	37 9	26 8	16 57	10.7*
Cobalt	mg/kg	18 2*	15 9*	29 7*	20.5*
Copper	mg/kg	20 03	26 7	30 62	19 6*
Iron	mg/kg	22916	29991	41295	12300*
Lead	mg/kg	18 04	26 4	34 5	13.4*
Lithium	mg/kg	44 4	32 1	33 37	7 0*
Magnesium	mg/kg	4425	6151	4896	2520*
Manganese	mg/kg	422.9	545 1	656	305*
Mercury	mg/kg	0 58*	0 44*	0 35*	0 27*
Molybdenum	mg/kg	38 65	32 78	33 68	11 2*
Nickel	mg/kg	43.27	35 4	56 95	14 3*
Potassium	mg/kg	3336	2789	1400*	ND
Selenium	mg/kg	ND	ND	ND	ND
Silver	mg/kg	40 9*	33 5*	18 7*	12 7*
Sodium	mg/kg	ND	3680*	ND	ND
Strontium	mg/kg	226*	111 1	144 42	69 2*
Thallium	mg/kg	ND	ND	ND	ND
Tin	mg/kg	338*	441*	274*	268*
Vanadium	mg/kg	54 67	58 2	47 7	22 2*
Zinc	mg/kg	52 64	98 1	106 7	79 9*

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TABLE 2-11 (Continued)

BACKGROUND GEOLOGIC MATERIALS
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
Other					
Sulfide	mg/kg	13*	5*	5*	2*
Nitrate	mg/kg	4 3*	4 274	2 0*	1 9*
pH	----	9 64 (6 06)	9 48 (6 96)	10 14 (7.04)	9 2* (8 0)**
Total Radionuclides					
Gross Alpha	pCi/g	37 108	51 710	52 302	37
Gross Beta	pCi/g	36 886	35 135	35 743	29
Uranium 233, 234	pCi/g	1 491	1 759	1 985	0 8
Uranium 235	pCi/g	0.087	0 169	0 258	0 1
Uranium 238	pCi/g	1 353	1 675	1 643	1 0
Strontium 89, 90	pCi/g	0 768	0 776	0 786	0 4
Plutonium 239, 240	pCi/g	0 017	0 023	0 020	0 01
Americium 241	pCi/g	0 018	NR	NR	NR
Cesium 137	pCi/g	0 082	0 113	ND	0 0
Tritium	pCi/g	0 410	0 299	0 322	0 39

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

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TABLE 2-12

PHASE I AND PHASE II RI
SOIL SAMPLING

METALS

Hazardous Substances List - Metals

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Tin
- Vanadium
- Zinc

Other Metals

- Chromium (hexavalent)
- Chromium (trivalent)
- Lithium
- Strontium

ORGANICS

Hazardous Substances List -- Volatiles

- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- trans-1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene

TABLE 2-12 (Continued)

PHASE I AND PHASE II RI
SOIL SAMPLING

ORGANICS (CONT.)

Hazardous Substances List - Volatiles (Continued)

- 2-Chloroethyl Vinyl Ether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes

Hazardous Substances List -- Semi-Volatiles

- N-Nitrosodimethylamine
- Phenol
- Aniline
- bis(2-Chloroethyl)ether
- 2-Chlorophenol
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- Benzyl Alcohol
- 1,2-Dichlorobenzene
- 2-Methylphenol
- bis(2-Chloroisopropyl)ether
- 4-Methylphenol
- N-Nitroso-Dipropylamine
- Hexachloroethane
- Nitrobenzene
- Isophorone
- 2-Nitrophenol
- 2,4-Dimethylphenol
- Benzoic Acid
- bis(2-Chloroethoxy)methane
- 2,4-Dichlorophenol
- 1,2,4-Trichlorobenzene
- Naphtalene
- 4-Chloroaniline
- Hexachlorobutadiene
- 4-Chloro-3-methylphenol(para-chloro-meta-cresol)
- 2-Methylnaphthalene
- Hexachlorocyclopentadiene
- 2,4,6-Trichlorophenol
- 2,4,5-Trichlorophenol
- 2-Chloronaphthalene
- 2-Nitroaniline
- Dimethyl Phthalate
- Acenaphthylene
- 3-Nitroaniline
- Acenaphthene
- 2,4-Dinitrophenol
- 4-Nitrophenol
- Dibenzofuran
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- Diethylphthalate
- 4-Chlorophenyl Phenyl ether
- Fluorene
- 4-Nitroaniline
- 4,6-Dinitro-2-methylphenol

TABLE 2-12 (Continued)

PHASE I AND PHASE II RI
SOIL SAMPLING

ORGANICS (CONT.)

Hazardous Substances List -- Semi-Volatiles (Continued)

- N-nitrosodiphenylamine
- 4-Bromophenyl Phenyl ether
- Hexachlorobenzene
- Pentachlorophenol
- Phenanthrene
- Anthracene
- Di-n-butylphthalate
- Fluoranthene
- Benzidine
- Pyrene
- Butyl Benzyl Phthalate
- 3,3'-Dichlorobenzidine
- Benzo(a)anthracene
- bis(2-ethylhexyl)phthalate
- Chrysene
- Di-n-octyl Phthalate
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenz(a,h)anthracene
- Benzo(g,h,i)perylene

Hazardous Substances List -- Pesticides/PCBS

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

Other Organics

- Oil and Grease

TABLE 2-12 (Continued)

PHASE I AND PHASE II RI
SOIL SAMPLING

RADIONUCLIDES	Gross Alpha
	Gross Beta
	Uranium 233+234, 235 and 238
	Americium 241
	Plutonium 239+240
	Strontium 89 + 90
	Cesium 137
	Tritium
OTHER	pH

TABLE 2-13

REMEDIAL INVESTIGATION
BOREHOLE SAMPLE INFORMATION
881 HILLSIDE BOREHOLES

Borehole Number	SAMPLE INFORMATION Number	Date	Depth Increment (ft)	Sample Type	Material Sampled	IHSS No
BH0187	BH018701WT	06/04/87	0 20 - 1 40	WT	AF	145
BH0187	BH018704WS	06/04/87	4 50 - 5 70	CT,DH	KACS	
BH0187	BH018710WS	06/04/87	10 00 - 11 50	BR,DH	KACS	
BH0287	BH02870012	05/27/87	0.00 - 11 80	CO,FS	QC	106, 107
BH0287	BH02871214	05/27/87	11.80 - 14 30	CO	QC	
BH0287	BH028714CT	05/27/87	12 00 - 14.30	CT	KACS	
BH0287	BH02871420	05/27/87	14 30 - 20 40	CO	KACS	
BH0287	BH028718BR	05/27/87	17 90 - 18 60	BR	KACS	
BH0387	BH03870009	05/19/87	0 00 - 8 75	CO	QC	130
BH0387	BH03870204	05/19/87	2 00 - 4 00	CO	QC	
BH0387	BH038702WT	05/19/87	2 45 - 3 90	WT	QC	
BH0387	BH038709CT	05/19/87	7 15 - 8 75	CT	QC	
BH0387	BH038712BR	05/19/87	11 75 - 13 25	BR	KACS	
BH0487	BH04870010	06/05/87	0 00 - 10 00	CO	AF	105 1, 105 2
BH0487	BH048710WT	06/05/87	10 30 - 12 80	WT	AF	
BH0487	BH048715CT	06/05/87	15 30 - 15 70	CT	AF	
BH0487	BH048719BR	06/05/87	19 30 - 20 30	BR	KACS	
BH0587	BH05870005	05/19/87	0 00 - 4 50	CO	QC	103, 107
BH0587	BH058705CT	05/19/87	2 00 - 4 50	CT	QC	
BH0587	BH058708BR	05/19/87	7 50 - 9 30	BR	KACS	
BH0687	BH06870010	05/20/87	0 00 - 10 00	CO	QC	102
BH0687	BH06871020	05/20/87	10 00 - 20 00	CO	QC	
BH0687	BH068726CT	05/20/87	24 10 - 25 50	CT	QC	
BH0687	BH068730BR	05/20/87	27 00 - 30 00	BR	KACS	

Sample Type Codes
BR - Bedrock CO Composite CT - Contact DH - Direct Hit, Encountered Contaminant Defined in Appendix A
FS - Field Screen WT - Water Table QRF Rocky Flats Alluvium QC - Colluvium KACS - Weathered Claystone
AF - Artificial Fill

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TABLE 2-13 (Continued)

REMEDIAL INVESTIGATION
BOREHOLE SAMPLE INFORMATION
881 HILLSIDE BOREHOLES

Borehole Number	SAMPLE INFORMATION Number	Date	Depth Increment (ft)	Sample Type	Material Sampled	IHSS No.
BH0787	BH078705CT	05/26/87	4 30 - 4 80	CT, FS	QC	104, 130
BH0787	BH07870510	05/26/87	5 00 - 10 00	CO	KACS	
BH0787	BH078708BR	05/26/87	7 80 - 9 68	BR	KACS	
BH0787	BH078710WS	05/26/87	9 68 - 10 35	FS	KACS	
BH0787	BH07871013	05/26/87	10 35 - 13 00	CO	KACS	
BH0887	BH08870007	06/03/87	0 00 - 6 10	CO	QC	119 1
BH0887	BH088707CT	06/03/87	6 10 - 7 00	CT	QC	
BH0887	BH088710BR	06/03/87	10 20 - 12 10	BR	KACS	
BH0987	BH09870010	05/29/87	0 00 - 10 00	CO	QC	119 1
BH0987	BH098706WT	05/29/87	6 03 - 6 60	WT	QC	
BH0987	BH098711CT	05/29/87	10 08 - 11 30	CT	QC	
BH0987	BH098714BR	05/29/87	14 30 - 14 75	BR	KACS	
BH1087	BH10980010	06/01/87	0 00 - 10 00	CO	AF	130
BH1087	BH10871020	06/01/87	10 00 - 18 95	CO	QC	
BH1087	BH108720CT	06/01/87	18 95 - 20 00	CT	QC	
BH1087	BH108723BR	06/01/87	23 00 - 25 40	BR	KACS	
BH1187	BH11870010	06/02/87	0 00 - 10 00	CO	AF/QC	130
BH1187	BH118711CT	06/02/87	8 70 - 10 70	CT,FS	QC	
BH1187	BH118714WT	06/02/87	13 90 - 17 00	WT,BR	KACS	
BH1287	BH128702CT	05/27/87	0 00 - 2 25	CT	QC	119 1
BH1287	BH128705BR	05/27/87	5 25 - 6 50	BR	KACS	

Sample Type Codes: BR - Bedrock CO - Composite CT - Contact DH - Direct Hit, Encountered Contaminant Defined in Appendix A
FS - Field Screen WT - Water Table QRF - Rocky Flats Alluvium QC Colluvium KACS - Weathered Claystone
AF - Artificial Fill

TABLE 2-13 (Continued)

REMEDIAL INVESTIGATION
BOREHOLE SAMPLE INFORMATION
881 HILLSIDE BOREHOLES

Borehole Number	SAMPLE INFORMATION Number	Date	Depth Increment (ft)	Sample Type	Material Sampled	IHSS No
BH1387	BH13870010	05/29/87	0 00 - 10 10	CO	QC	130
BH1387	BH138711CT	05/29/87	10 10 - 11 56	CT,FS	QC	
BH1387	BH138714BR	05/29/87	14 56 - 16 20	BR	KACS	
BH1487	BH148703W1	05/28/87	2 00 - 2 90	DH	QC	119 1
BH1487	BH148706CT	05/28/87	5 50 - 6 50	CT	QC	
BH1487	BH148708W2	05/28/87	7 75 - 8 00	DH,BR	KACS	
BH1487	BH148709BR	05/28/87	6 50 - 9 00	BR	KACS	
BH1587	BH15870005	06/03/87	0 00 - 5 00	CO	QRF	119 1
BH1587	BH15870510	06/03/87	5 00 - 10 0	CO	QRF	
BH1587	BH158726BR	06/03/87	24 10 - 25 80	BR	KACS	
BH1687	BH168702CT	06/02/87	0 00 - 1 80	CT	QC	119 2
BH1687	BH16870206	06/02/87	2 00 - 6 00	CO	KACS	
BH1687	BH168706BR	06/02/87	6 00 - 6.50	BR	KACS	
BH1787	BH17870005	06/03/87	0 00 - 3 90	CO	QC	119 2
BH1787	BH178705CT	06/03/87	3 90 - 5 25	CT	QC	
BH1787	BH178708BR	06/03/87	8 25 - 8 70	BR	KACS	
BH1787	BH178708BR	06/03/87	8 7 - 9 5	BR	KACS	
BH5787	BH578704DH	10/07/87	4 00 - 5 80	DH	QC	119 1
BH5787	BH578708DH	10/07/87	8 00 - 10 00	DH	QC	
BH5787	BH578710UC	10/07/87	10 00 - 12 00	CT, DH	QC	
BH5787	BH578712CT	10/07/87	12 00 - 14 00	CT, DH	KACS	
BH5787	BH578714BR	10/08/87	14 00 - 16 00	BR, DH	KACS	
BH5787	BH578716DH	10/08/87	16 00 18 00	BR, DH	KACS	

Sample Type Codes
BR - Bedrock CO - Composite CT - Contact DH - Direct Hit, Encountered Contaminant Defined in Appendix A
FS - Field Screen WT Water Table QRF - Rocky Flats Alluvium QC - Colluvium KACS - Weathered Claystone
AF - Artificial Fill

TABLE 2-13 (Continued)

REMEDIAL INVESTIGATION
BOREHOLE SAMPLE INFORMATION
881 HILLSIDE BOREHOLES

Borehole Number	SAMPLE INFORMATION Number	Date	Depth Increment (ft)	Sample Type	Material Sampled	IHSS No
BH5787	BH578718DH	10/08/87	18 00 - 20 00	BR, DH	KACS	119 1
BH5787	BH578720DH	10/08/87	20.00 - 22 00	BR, DH	KACS	
BH5787	BH578722DH	10/08/87	22 00 - 24 00	BR, DH	KACS	
BH5787	BH578724DH	10/08/87	24 00 - 26 00	BR, DH	KACS	
BH5787	BH578726DH	10/08/87	26 00 - 28 00	BR, DH	KACS	
BH5887	BH588700UC	10/08/87	0 00 - 1 70	CT, DH	QC	119 2
BH5887	BH588702CT	10/08/87	2 00 - 3 90	CT, DH	QC	
BH5887	BH588704BR	10/08/87	4 00 - 7 00	BR	KACS	
BH5987	BH598704UC	10/05/87	2 00 - 3 50	UC	QC	119 2
BH5987	BH598707CT	10/05/87	4 00 - 7 20	CT	KACS	
BH5987	BH598709BR	10/05/87	7 00 - 9 80	BR	KACS	
BH6187	BH618707DH	10/12/87	6 50 - 9 00	DH	QC	119 2
BH6187	BH618709CT	10/13/87	9 00 - 11 50	CT	KACS	
BH6187	BH618712BR	10/13/87	11 50 - 14 00	BR	KACS	
BH6287	BH62870008	10/21/87	0 00 - 8 00	CO	QC	105 1, 105 2
BH6287	BH628712CT	10/21/87	12 50 - 14 00	CT	KACS	
BH6287	BH628714BR	10/21/87	14 00 - 16 00	BR	KACS	
BH6387	BH63870008	10/16/87	0 00 - 8 00	CO	AR/QRF	
BH6387	BH638712DH	10/16/87	12 00 - 13 70	DH	QRF	105 1, 105 2
BH6387	BH638718UC	10/19/87	18 00 - 18 40	CT	QRF	
BH6387	BH638722CT	10/19/87	22 00 - 22 50	CT	KACS	
BH6387	BH638724BR	10/19/87	24 50 - 26 00	BR	KACS	

Sample Type Codes
BR - Bedrock CO - Composite CT - Contact DH - Direct Hit, Encountered Contaminant Defined in Appendix A
FS - Field Screen WT - Water Table QRF - Rocky Flats Alluvium QC - Colluvium KACS - Weathered Claystone
AF - Artificial Fill

2 3 2 1 <u>Organic Compounds</u>

Prior analyses of organic constituents in soils at the 881 Hillside have provided qualitative data indicating the presence of methylene chloride, acetone, and phthalates in most samples, and tetrachloroethylene (PCE), trichloroethene (TCE), 1,1,1-trichloromethane (1,1,1-TCA) at a few boreholes (Rockwell International, 1988a) These data were rejected during data validation primarily due to small sample size, and there are remaining uncertainties regarding laboratory contamination of methylene chloride, acetone and phthalates Thus, the Phase I and Phase II RIs cannot provide quantitative definition of organic contaminants in the soils These data do, however, provide a qualitative indication of the spatial distribution of organic contamination in the soils and the relative magnitude of the contamination Future analyses will provide quantitative data

With respect to the Phase I and Phase II RIs, methylene chloride and acetone were in many of the laboratory blanks, however, the use of an inappropriately small sample aliquot for soil analysis prevents conclusions as to whether these organics are contaminants of the soil The phthalate contamination may have resulted from sample handling although no testing has been performed to verify this hypothesis, and some phthalate levels are high The available data cannot prove or disprove laboratory contamination for these samples Other evidence that supports the contention of laboratory artifact includes the absence or infrequent occurrence of methylene chloride and acetone in ground water These contaminants are very mobile and soluble VOCs in the ground water of the 881 Hillside are concentrated in two areas which are close to IHSSs and upgradient of the french drain The principal ground-water contaminants are PCE, TCE, carbon tetrachloride (CCl_4), and their degradation products Toluene is not a characteristic ground-water contaminant at the 881 Hillside Area, the highest of the three "detectable" toluene results in the 1988 Rockwell International RI/FS study was 2J $\mu g/\ell$ ("J" signifies that the analyte was estimated below detection limit)

Toluene, methylene chloride, and acetone were the only VOCs detected in the boreholes drilled during the french drain investigation (Table 2-14) Toluene is the most significant contaminant of this group because it occurs at multiple intervals in the majority of boreholes at concentrations ranging up to 1200 $\mu g/kg$ (at B303390) Methylene chloride and acetone, in contrast, typically occur at relatively low concentrations (less than five times the detection limit) and are present in laboratory blanks, and therefore may not indicate actual soil contamination, but a laboratory containment Higher concentrations in boreholes B300190 and B300290 may represent true contamination according to CLP criteria for evaluating low levels of these compounds Trichloroethane was reported at 1J $\mu g/kg$ for only one sample in one borehole (B301090) and is therefore not considered a contaminant of concern

The distribution of toluene in the french drain boreholes does not show horizontal or vertical gradients over the depths sampled (up to approximately 20 feet) (Table 2-15) However, several of the samples with the highest concentrations (>400 $\mu g/l$) were collected within the top four feet of soil, along the proposed french

BLE 2-14

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	2 Chloro ethylvinyl ether	4 Methyl 2 penta none	2 Hexa none	Chloro-benzene	Ethyl-benzene	Toluene	Total Xylenes
B300190	B3001900006	02/02/90	0 00 6 00						9	
B300190	B30019000060	02/02/90	0 00 6 00		3 J				11	
B300190	B3001900002	02/02/90	0 00 1 20						61	
B300190	B3001900204	02/02/90	2 00 3 80						640	
B300190	B3001900406	02/02/90	4 00 6 00						79	
B300190	B30019004060	02/02/90	4 00 6 00						150	
B300190	B3001900608	02/05/90	6 00 8 00						120	
B300190	B3001900810	02/05/90	8 00 9 90						13 B	
B300290	B3002900002	02/05/90	0 00 1 00						93	
B300290	B3002900204	02/05/90	2 00 3 10						33	
B300290	B3002900406	02/05/90	4 00 5 90						58 B	
B300290	B3002900608	02/05/90	6 00 7 50						140	
B300290	B3002900810	02/05/90	8 00 10 00						57	
B300390	B3003900203	02/07/90	2 00 2 90						99	
B300390	B3003900305	02/07/90	3 00 4 70						140	
B300390	B3003900507	02/07/90	5 00 6 30						130	
B300390	B3003900810	02/07/90	8 00 10 00						270	
B300490	B3004900002	02/09/90	0 00 1 00						860	
B300490	B3004900204	02/09/90	2 00 3 80						180	
B300490	B3004900406	02/09/90	4 00 5 40						150	
B300490	B3004900607	02/09/90	6 00 7 00						110	
B300490	B3004900709	02/09/90	7 00 8 50						160	
B300590	B3005900003	02/09/90	0 00 0 40						190	
B300590	B3005900305	02/09/90	3 00 4 20						41	
B300690	B3006900002	02/09/90	0 00 1 80						110	
B300690	B3006900203	02/09/90	2 00 2 60						200	
B300790	B3007900002	02/09/90	0 00 0 50						410	
B300790	B30079000020	02/09/90	0 00 0 50						190	
B300790	B3007900204	02/09/90	2 00 3 90						210	

* Rejected data excluded
B - Present in Blank   J Quantitation approximate based on QC review   E Exceeds calibration range, dilute/reanalyze

TABLE (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Methylene Chloride	Acetone	Carbon Disulfide	Chloro form	2 Butanone	Trans-1,3 Dichloro-propene	Trichloro-ethene
B300890	B3008900002	02/12/90	0 00 1 00	6 B						
B300890	B3008900204	02/12/90	2 00 3 40	18 B						
B300890	B3008900406	02/12/90	4 00 5 80	21 B						
B300890	B3008900608	02/12/90	6 00 8 00							
B300890	B3008900810	02/12/90	8 00 10 00	11						
B300890	B3008901012	02/12/90	10 00 12 00	2 JB						
B300990	B3009900002	02/12/90	0 00 1 70	2	6					
B300990	B3009900204	02/12/90	2 00 3 70	3 JB						
B300990	B3009900406	02/12/90	4 00 5 70	2 JB						
B300990	B3009900608	02/12/90	6 00 8 00	3 JB						
B300990	B3009900810	02/12/90	8 00 10 00	2 JB						
B300990	B3009901012	02/12/90	10 00 11 00	2 JB						
B301090	B3010900607	02/12/90	6 00 6 60	9 B	39 B			29		
B301090	B3010900708	02/12/90	7 50 8 00	9 B	27 B					1 J
B301090	B3010900810	02/12/90	8 00 9 20							
B301090	B3010901314	02/12/90	12 50 - 13 60							
B301090	B3010901415	02/16/90	14 00 15 00	3 J				3 J		
B301090	B3010901517	02/16/90	15 00 16 30	3 J				3 J		
B301090	B3010901719	02/16/90	17 00 19 00	3 J	3 J			4 J		
B301090	B3010901921	02/16/90	19 00 21 00	3 J				3 J	5 J	
B301190	B3011900002	02/22/90	0 00 2 00							
B301190	B3011900002D	02/22/90	0 00 2 00							
B301190	B3011900204	02/22/90	2 00 3 50	10 B	26 B					
B301190	B3011900406	02/22/90	4 00 6 00	10 B	21 B					
B301190	B3011900608	02/22/90	6 00 8 00	6 B	6 JB		3 JB			
B301190	B3011900810	02/22/90	8 00 10 00	7 B	17 B					
B301190	B3011901012	02/22/90	10 00 12 00	5 JB	5 JB		3 JB			
B301190	B3011901214	02/22/90	12 00 14 00	6 B	7 JB		3 JB			
B301190	B3011901416	02/22/90	14 00 15 10	12 B	6 JB		3 JB			

* Rejected data excluded
B - Present in Blank J Quantitation approximate based on QC review E Exceeds calibration range, dilute/reanalyze

TABLE (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)		2 Chloro ethylvinyl ether	4 Methyl 2 pentanone		2 Hexanone	Chloro-benzene		Ethyl-benzene	Toluene		Total Xylenes	
B300890	B3008900002	02/12/90	0 00	1 00								140			
B300890	B3008900204	02/12/90	2 00	3 40								220			
B300890	B3008900406	02/12/90	4 00	5 80								180			
B300890	B3008900608	02/12/90	6 00	8 00											
B300890	B3008900810	02/12/90	8 00	10 00								15			
B300890	B3008901012	02/12/90	10 00	12 00								190			
B300990	B3009900002	02/12/90	0 00	1 70								25			
B300990	B3009900204	02/12/90	2 00	3 70								270	E		
B300990	B3009900406	02/12/90	4 00	5 70								150			
B300990	B3009900608	02/12/90	6 00	8 00								270	E		
B300990	B3009900810	02/12/90	8 00	10 00								220			
B300990	B3009901012	02/12/90	10 00	11 00								40			
B301090	B3010900607	02/12/90	6 00	6 60		2	JB					460	E		
B301090	B3010900708	02/12/90	7 50	8 00		1	JB		1	J		220	E	1	J
B301090	B3010900810	02/12/90	8 00	9 20											
B301090	B3010901314	02/12/90	12 50	13 60											
B301090	B3010901415	02/16/90	14 00	15 00		1	J					240			
B301090	B3010901517	02/16/90	15 00	16 30		1	J					230			
B301090	B3010901719	02/16/90	17 00	19 00		2	J					160			
B301090	B3010901921	02/16/90	19 00	21 00								260			
B301190	B3011900002	02/22/90	0 00	2 00								150			
B301190	B3011900002D	02/22/90	0 00	2 00								220			
B301190	B3011900204	02/22/90	2 00	3 50								100			
B301190	B3011900406	02/22/90	4 00	6 00								160			
B301190	B3011900608	02/22/90	6 00	8 00								37			
B301190	B3011900810	02/22/90	8 00	10 00								57			
B301190	B3011901012	02/22/90	10 00	12 00								28			
B301190	B3011901214	02/22/90	12 00	14 00								77			
B301190	B3011901416	02/22/90	14 00	15 10								29			

* Rejected data excluded

B Present in Blank J - Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TAB[illegible]4 (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Methylene Chloride	Acetone	Carbon Disulfide	Chloro form	2-Butanone	Trans-1,3-Dichloro-propene	Trichloro-ethene
B301190	B3011901618	02/22/90	16 00 16 90	9 B	13 B					
B301190	B3011901820	02/22/90	18 00 18 70	13 B	8 JB		3 JB			
B301290	B3012900002	02/26/90	0 00 0 95	7 B	16 B					
B301290	B3012900204	02/26/90	2 00 3 60	6 JB	11 JB					
B301290	B3012900406	02/26/90	4 00 6 00	5 JB	12 B					
B301390	B3013900002	02/26/90	0 00 0 70							
B301390	B3013900204	02/26/90	2 00 4 00	5 JB	9 JB					
B301390	B3013900406	02/26/90	4 00 4 90	5 JB	10 JB					
B301390	B3013900608	02/26/90	6 00 6 80	7 B	12 B					
B301490	B3014900304	02/26/90	3 00 3 90	5 JB						
B301490	B3014900406	02/26/90	4 00 5 30	4 JB	5 JB					
B301490	B3014900608	02/26/90	6 00 8 00	5 JB	8 JB					
B301490	B3014900810	02/26/90	8 00 9 70	4 JB	6 JB					
B301490	B3014901012	02/26/90	10 00 11 90	5 JB	6 JB					
B301490	B3014901214	02/26/90	12 00 13 70	5 JB	8 JB					
B301490	B3014901416	02/26/90	14 00 15 60	5 JB	14 B					
B301490	B30149010120	02/26/90	10 00 11 90	13 B	17 JB					
B301590	B3015900002	03/19/90	0 00 2 00	6	5 J					
B301590	B3015900204	03/19/90	2 00 3 10							
B301590	B3015900406	03/19/90	4 00 4 70	5 J	6 J					
B301590	B3015900708	03/19/90	7 00 - 7 70	5 J	11					
B301590	B3015901012	03/19/90	10 00 11 00	3 J	7 J					
B301590	B3015901214	03/19/90	11 50 13 00	5 J	7 J			5 J		
B301690	B3016900002	03/19/90	0 00 2 00							
B301690	B3016900204	03/19/90	2 00 4 00							
B301690	B3016900406	03/19/90	4 00 6 00							
B301690	B3016900608	03/19/90	6 00 8 00	4 J						
B301690	B3016900810	03/19/90	8 00 10 00	4 J	3 J					
B301690	B3016901012	03/19/90	10 00 12 00	5 J						

* Rejected data excluded
B Present in Blank J - Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABL[illegible]4 (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	2 Chloro ethylvinyl ether	4 Methyl 2 penta none	2 Hexa none	Chloro benzene	Ethyl benzene	Toluene	Total Xylenes
B301190	B3011901618	02/22/90	16 00 16 90						84	
B301190	B3011901820	02/22/90	18 00 18 70						130	
B301290	B3012900002	02/26/90	0 00 0 95						130	
B301290	B3012900204	02/26/90	2 00 3 60						150	
B301290	B3012900406	02/26/90	4 00 6 00						130	
B301390	B3013900002	02/26/90	0 00 0 70						610	
B301390	B3013900204	02/26/90	2 00 4 00						120	
B301390	B3013900406	02/26/90	4 00 4 90						240	
B301390	B3013900608	02/26/90	6 00 6 80						130	
B301490	B3014900304	02/26/90	3 00 3 90						120	
B301490	B3014900406	02/26/90	4 00 5 30						67	
B301490	B3014900608	02/26/90	6 00 8 00						91	
B301490	B3014900810	02/26/90	8 00 9 70						26	
B301490	B3014901012	02/26/90	10 00 11 90						120	
B301490	B3014901214	02/26/90	12 00 13 70						66	
B301490	B3014901416	02/26/90	14 00 15 60						51	
B301490	B30149010120	02/26/90	10 00 11 90						170	
B301590	B3015900002	03/19/90	0 00 2 00						200	
B301590	B3015900204	03/19/90	2 00 3 10						230	
B301590	B3015900406	03/19/90	4 00 4 70						70	
B301590	B3015900708	03/19/90	7 00 7 70						200	
B301590	B3015901012	03/19/90	10 00 11 00						57	
B301590	B3015901214	03/19/90	11 50 13 00						270	
B301690	B3016900002	03/19/90	0 00 2 00						460	
B301690	B3016900204	03/19/90	2 00 4 00						160	
B301690	B3016900406	03/19/90	4 00 6 00						300	
B301690	B3016900608	03/19/90	6 00 8 00						230	
B301690	B3016900810	03/19/90	8 00 10 00						250	
B301690	B3016901012	03/19/90	10 00 12 00						200	

* Rejected data excluded

3 Present in Blank J Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABLE (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Methylene Chloride	Acetone	Carbon Disulfide	Chloro form	2 Butanone	Trans 1,3-Dichloro-propene	Trichloro-ethene
B301690	B3016901214	03/19/90	12 00 13 70							
B301690	B3016901416	03/19/90	14 90 15 90	5 J	2 J					
B301690	B3016901618	03/19/90	16 90 18 90	5 J	3 J					
B301690	B3016901820	03/19/90	18 90 19 90	5 J	2 J					
B301790	B3017900002	03/20/90	0 00 1 50							
B301790	B3017900204	03/20/90	2 00 2 50							
B301790	B3017900406	03/20/90	4 00 5 90							
B301790	B3017900608	03/20/90	6 00 8 00							
B301790	B3017900810	03/20/90	8 00 10 00							
B301790	B3017901012	03/20/90	10 00 12 00							
B301790	B3017901213	03/20/90	12 00 13 00							
B301790	B3017901315	03/20/90	13 00 15 00							
B301790	B30179004060	03/20/90	4 00 5 90							
B301890	B3018900002	03/20/90	0 00 1 00							
B301890	B3018900204	03/20/90	2 00 4 00							
B301890	B3018900406	03/20/90	4 00 6 00							
B301890	B3018900608	03/20/90	6 00 8 00							
B301890	B3018900810	03/20/90	8 00 10 00							
B301890	B3018901012	03/20/90	10 00 12 00							
B301890	B3018901214	03/20/90	12 00 14 00							
B301890	B3018901416	03/20/90	14 00 16 00							
B301890	B3018901618	03/20/90	16 00 18 00							
B301890	B3018901820	03/21/90	18 00 - 20 00	15 B	1 J					
B301990	B3019901416	03/22/90	14 30 16 30	7 B	7 J	2 J				
B301990	B3019901718	03/22/90	17 00 17 70	8 B	5 J	1 J				
B301990	B3019901819	03/22/90	17 70 18 70	11 B	7 JB					
B301990	B3019900002	03/21/90	0 00 1 60							
B301990	B3019900204	03/21/90	2 00 4 00							
B301990	B3019900406	03/21/90	4 00 6 00							

* Rejected data excluded
B - Present in Blank   J Quantitation approximate based on QC review   E Exceeds calibration range, dilute/reanalyze

TABLE 2-[illegible]ntinued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	2 Chloro ethylvinyl ether	4 Methyl 2 penta none	2 Hexa none	Chloro benzene	Ethyl-benzene	Toluene	Total Xylenes
B301690	B3016901214	03/19/90	12 00 13 70						99	
B301690	B3016901416	03/19/90	14 90 15 90						240	
B301690	B3016901618	03/19/90	16 90 18 90						220	
B301690	B3016901820	03/19/90	18 90 19 90						230	
B301790	B3017900002	03/20/90	0 00 1 50						7 J	
B301790	B3017900204	03/20/90	2 00 2 50						30 J	
B301790	B3017900406	03/20/90	4 00 5 90						23	
B301790	B3017900608	03/20/90	6 00 8 00						20	
B301790	B3017900810	03/20/90	8 00 10 00						11 J	
B301790	B3017901012	03/20/90	10 00 12 00						8 J	
B301790	B3017901213	03/20/90	12 00 13 00						6 J	
B301790	B3017901315	03/20/90	13 00 15 00						10 J	
B301790	B30179004060	03/20/90	4 00 5 90						15	
B301890	B3018900002	03/20/90	0 00 1 00						460 B	
B301890	B3018900204	03/20/90	2 00 4 00						280 B	
B301890	B3018900406	03/20/90	4 00 6 00						150 B	
B301890	B3018900608	03/20/90	6 00 8 00						180 B	
B301890	B3018900810	03/20/90	8 00 10 00						200 B	
B301890	B3018901012	03/20/90	10 00 12 00						240 B	
B301890	B3018901214	03/20/90	12 00 14 00						130 B	
B301890	B3018901416	03/20/90	14 00 16 00						9 J	
B301890	B3018901618	03/20/90	16 00 18 00						8 J	
B301890	B3018901820	03/21/90	18 00 20 00						27	
B301990	B3019901416	03/22/90	14 30 - 16 30						31	
B301990	B3019901718	03/22/90	17 00 17 70						40	
B301990	B3019901819	03/22/90	17 70 18 70						37	
B301990	B3019900002	03/21/90	0 00 1 60						52	
B301990	B3019900204	03/21/90	2 00 4 00						290	
B301990	B3019900406	03/21/90	4 00 6 00						98	

Rejected data excluded
Present in Blank J Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABLE (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Methylene Chloride	Acetone	Carbon Disulfide	Chloro form	2 Butanone	Trans 1,3 Dichloro-propene	Trichloro ethene
B301990	B3019900608	03/21/90	6 00 7 50							
B301990	B3019900608D	03/21/90	6 00 7 50							
B302090	B3020900002	03/22/90	0 00 0 70	10 B						
B302090	B3020900204	03/22/90	2 00 3 40	8 B	3 J					
B302090	B3020900406	03/22/90	4 00 5 10	13 B	18 B					
B302090	B3020900608	03/22/90	6 00 7 60	10 B	12 B					
B302090	B3020900810	03/22/90	8 00 9 60	8 B	2 J					
B302090	B3020901012	03/22/90	10 00 11 90	8 B						
B302090	B3020901214	03/22/90	12 00 13 00	8 B	17 B					
B302090	B3020901416	03/22/90	14 00 16 00	8 B	22 B	1 J				
B302090	B3020901618	03/22/90	16 00 17 20	15 B	24 B					
B302090	B3020901921	03/22/90	19 00 19 80	8 B	130 B	1 J				
B302190	B3021900204	06/25/90	2 00 4 00	2 JB		2 JB				
B302190	B3021900204D	06/25/90	2 00 4 00	1 JB	5 J					
B302190	B3021900406	06/25/90	4 00 6 00	2 JB		2 JB				
B302190	B3021900608	06/25/90	6 00 - 8 35	4 JB						
B302190	B3021900810	06/25/90	8 35 10 35	2 JB	2 J					
B302190	B3021901012	06/25/90	10 35 12 35	8 B	6 JB					
B302190	B3021901214	06/25/90	12 35 14 35	2 JB	4 JB					
B302190	B3021901416	06/25/90	14 35 16 30	8 B		2 J				
B302190	B3021901618	06/25/90	16 30 18 30	8 B	5 JB					
B302190	B3021901820	06/25/90	18 30 20 30	9 B	93 B			26		
B302190	B3021902022	06/25/90	20 30 22 70	7 B	67 B			13		
B302190	B3021902224	06/25/90	22 70 24 30	8 B	6 JB					
B302190	B3021902426	06/25/90	24 70 26 70	7 B	6 JB					
B302190	B3021902628	06/25/90	26 90 28 40	8 B	4 JB					
B302190	B3021900002	06/25/90	0 00 2 00	8 B	5 JB					
B302290	B3022900002	06/26/90	0 00 - 2 00							
B302290	B3022900204	06/26/90	2 00 4 00	6 B	2 J					

* Rejected data excluded
B Present in Blank J Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABLE (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	2 Chloro ethylvinyl ether	4 Methyl 2 penta none	2 Hexa none	Chloro-benzene	Ethyl-benzene	Toluene	Total Xylenes
B301990	B3019900608	03/21/90	6 00 7 50						260	
B301990	B3019900608D	03/21/90	6 00 7 50						330	
B302090	B3020900002	03/22/90	0 00 0 70						110	
B302090	B3020900204	03/22/90	2 00 3 40						150	
B302090	B3020900406	03/22/90	4 00 5 10						110	
B302090	B3020900608	03/22/90	6 00 7 60						110	
B302090	B3020900810	03/22/90	8 00 9 60						110	
B302090	B3020901012	03/22/90	10 00 11 90						150	
B302090	B3020901214	03/22/90	12 00 - 13 00						160	
B302090	B3020901416	03/22/90	14 00 - 16 00						190	
B302090	B3020901618	03/22/90	16 00 17 20						110	
B302090	B3020901921	03/22/90	19 00 - 19 80						150	
B302190	B3021900204	06/25/90	2 00 4 00						39 B	
B302190	B3021900204D	06/25/90	2 00 4 00						53 B	
B302190	B3021900406	06/25/90	4 00 - 6 00						24 B	
B302190	B3021900608	06/25/90	6 00 - 8 35						10	
B302190	B3021900810	06/25/90	8 35 10.35						42 B	
B302190	B3021901012	06/25/90	10 35 12 35		1 JB	2 JB			27 B	
B302190	B3021901214	06/25/90	12 35 - 14 35						44 B	
B302190	B3021901416	06/25/90	14 35 - 16 30						47 B	
B302190	B3021901618	06/25/90	16 30 18 30						78 B	
B302190	B3021901820	06/25/90	18 30 - 20 30						170 B	
B302190	B3021902022	06/25/90	20 30 22 70						67 B	
B302190	B3021902224	06/25/90	22 70 24 30						51 B	
B302190	B3021902426	06/25/90	24 70 - 26 70						60 B	
B302190	B3021902628	06/25/90	26 90 28 40						39 B	
B302190	B3021900002	06/25/90	0 00 2 00						21 B	
B302290	B3022900002	06/26/90	0 00 - 2 00						290 B	
B302290	B3022900204	06/26/90	2 00 4 00						100 B	

Rejected data excluded
Present in Blank J - Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABLE 2 (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Methylene Chloride	Acetone	Carbon Disulfide	Chloro-form	2-Butanone	Trans-1,3-Dichloro-propene	Trichloro-ethene
B302290	B3022900406	06/26/90	4 00 6 00	6 B		1 JB				
B302290	B3022900608	06/26/90	6 00 8 00							
B302290	B3022900810	06/26/90	8 00 - 10 00							
B302290	B3022900810D	06/26/90	8 00 - 10 00							
B302290	B3022901012	06/26/90	10 00 12 30					20		
B302290	B3022901214	06/26/90	12 30 14 50	7 B	92					
B303090	B3030900204	07/06/90	2 00 4 20	3 JB	9 JB					
B303190	B3031900204	07/09/90	2 00 4 00	3 JB	4 JB					
B303390	B3033900002	07/11/90	0 00 - 2 00	6 B	6 JB					
B303390	B3033900002D	07/11/90	0 00 - 2 00							
B303390	B3033900204	07/11/90	2 00 4 00	6 B	5 JB					
B303390	B3033900006	07/11/90	0 00 - 5 50	5 B	4 JB					
B303390	B3033900608	07/11/90	5 50 - 8 00	6 B	14 B					
B303490	B3034900002	07/11/90	0 00 - 2 00							
B303490	B3034900002D	07/11/90	0 00 2 00							
B303490	B3034900204	07/11/90	2 00 4 00	7 B	6 JB					
B303590	B3035900002	07/12/90	0 00 - 2 00							
B303590	B3035900204	07/12/90	2 00 - 4 00	5 JB	4 JB					
B303590	B3035900507	07/12/90	4 40 - 7 70	5 JB	13 B		63			
B303590	B3035900709	07/12/90	7 70 9 70	5 JB	9 JB		23			
B303590	B3035900911	07/12/90	9 70 11 70	9 B	5 JB					
B303590	B3035901213	07/12/90	11 70 - 13 50	6 B	4 JB					
B303590	B3035901618	07/12/90	16 10 17 80	6 B	6 JB					
P302390	P3023900507	06/27/90	5 50 6 20	14 B		1 J				
P302490	P3024900204	06/28/90	2 00 3 00	13 B	5 JB					
P302490	P3024900204D	06/28/90	2 00 3 00	15 B		1 J				
P302590	P3025900305	06/29/90	3 00 5 00	17 B	7 JB					
P302690	P3026900204	07/02/90	2 00 4 70	2 JB	3 JB					
P302790	P3027900204	07/02/90	2 00 - 3 70	2 JB	2 JB					

* Rejected data excluded
B - Present in Blank J - Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABLE (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	2 Chloro ethylvinyl ether	4 Methyl 2 penta none	2-Hexa-none	Chloro-benzene	Ethyl-benzene	Toluene		Total Xylenes
B302290	B3022900406	06/26/90	4 00 6 00						83	B	
B302290	B3022900608	06/26/90	6 00 8 00						420	B	
B302290	B3022900810	06/26/90	8 00 10 00						220	B	
B302290	B3022900810D	06/26/90	8 00 - 10 00						310	B	
B302290	B3022901012	06/26/90	10 00 12 30						410	B	
B302290	B3022901214	06/26/90	12 30 - 14 50						180	B	
B303090	B3030900204	07/06/90	2 00 4 20								
B303190	B3031900204	07/09/90	2 00 4 00						22		
B303390	B3033900002	07/11/90	0 00 2 00						170		
B303390	B3033900002D	07/11/90	0 00 - 2 00						1200		
B303390	B3033900204	07/11/90	2 00 - 4 00						89		
B303390	B3033900006	07/11/90	0 00 - 5 50						5		
B303390	B3033900608	07/11/90	5 50 - 8 00						5	J	
B303490	B3034900002	07/11/90	0 00 - 2 00						730		
B303490	B3034900002D	07/11/90	0 00 - 2 00						360		
B303490	B3034900204	07/11/90	2 00 4 00						120		
B303590	B3035900002	07/12/90	0 00 - 2 00						270		
B303590	B3035900204	07/12/90	2 00 - 4 00						160	B	
B303590	B3035900507	07/12/90	4 40 - 7 70		42				43		
B303590	B3035900709	07/12/90	7 70 - 9 70		23				13		
B303590	B3035900911	07/12/90	9 70 - 11 70						190	B	
B303590	B3035901213	07/12/90	11 70 - 13 50						110	B	
B303590	B3035901618	07/12/90	16 10 - 17 80						71	B	
P302390	P3023900507	06/27/90	5 50 - 6 20						15	B	
P302490	P3024900204	06/28/90	2 00 3 00						77	B	
P302490	P3024900204D	06/28/90	2 00 - 3 00						42	B	
P302590	P3025900305	06/29/90	3 00 - 5 00						77	B	
P302690	P3026900204	07/02/90	2 00 4 70						110		
P302790	P3027900204	07/02/90	2 00 - 3 70						100		

* Rejected data excluded
B - Present in Blank J - Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABLE (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Methylene Chloride	Acetone	Carbon Disulfide	Chloro-form	2-Butanone	Trans-1,3-Dichloro-propene	Trichloro-ethene
P302890	P3028900204	07/05/90	2 00 4 00	3 JB	2 JB					
P302990	B3029900204	07/06/90	2 00 4 00	4 JB	34 B					
P303290	B3032900204	07/10/90	2 00 4 00							
P303290	B3032900204D	07/10/90	2 00 - 4 00	3 JB	46 B					

* Rejected data excluded
B Present in Blank J Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

TABL[illegible]4 (Continued)

Volatile Organic Compounds* Present in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)		2 Chloro ethylvinyl ether	4 Methyl 2 penta none	2 Hexa none	Chloro-benzene	Ethyl-benzene	Toluene		Total Xylenes
P302890	P3028900204	07/05/90	2 00	4 00						9		
P302990	B3029900204	07/06/90	2 00	4 00						1	J	
P303290	B3032900204	07/10/90	2 00	4 00						23		
P303290	B3032900204D	07/10/90	2 00	4 00						190		

* Rejected data excluded

B Present in Blank J Quantitation approximate based on QC review E Exceeds calibration range, dilute/reanalyze

TABLE 2-15

Toluene Concentrations in French Drain Borehole Samples at Rocky Flats

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Sample Type	Toluene* Concentration (ug/g)	
B300190	B3001900006	02/02/90	0 00 - 6 00	CLAYEY SANDY SILT	9	
B300190	B3001900006D	02/02/90	0 00 - 6 00	CLAYEY SANDY SILT	11	
B300190	B3001900002	02/02/90	0 00 - 1 20	SANDY GRAVELLY CLAY	61	
B300190	B3001900204	02/02/90	2 00 - 3 80	SILTY SANDY CLAY	640	
B300190	B3001900406	02/02/90	4 00 - 6 00	CLAYEY SANDY SILT	79	
B300190	B3001900406D	02/02/90	4 00 - 6 00	CLAYEY SANDY SILT	150	
B300190	B3001900608	02/05/90	6 00 - 8 00	SILTY CLAYEY SANDSTONE	120	
B300190	B3001900810	02/05/90	8 00 - 9 90	SILTY CLAYEY SANDSTONE	13	B
B300290	B3002900002	02/05/90	0 00 - 1 00	GRAVELLY SANDY CLAY	93	
B300290	B3002900204	02/05/90	2 00 - 3 10	SANDY CLAY	33	
B300290	B3002900406	02/05/90	4 00 - 5 90	SILTY SANDY CLAY	58	B
B300290	B3002900608	02/05/90	6 00 - 7 50	SILTY SANDSTONE	140	
B300290	B3002900810	02/05/90	8 00 - 10 00	SILTY CLAYSTONE	57	
B300390	B3003900203	02/07/90	2 00 - 2 90	GRAVELLY SANDY CLAY	99	
B300390	B3003900305	02/07/90	3 00 - 4 70	SANDY CLAY	140	
B300390	B3003900507	02/07/90	5 00 - 6 30	SANDY CLAY	130	
B300390	B3003900810	02/07/90	8 00 - 10 00	SANDY CLAY	270	
B300490	B3004900002	02/09/90	0 00 - 1 00	SILTY SANDY CLAY	860	
B300490	B3004900204	02/09/90	2 00 - 3 80	SANDY CLAY	180	
B300490	B3004900406	02/09/90	4 00 - 5 40	SILTY CLAY	150	
B300490	B3004900607	02/09/90	6 00 - 7 00	SILTY CLAY	110	
B300490	B3004900709	02/09/90	7 00 - 8 50	CLAYSTONE	160	
B300590	B3005900003	02/09/90	0 00 - 0 40	SANDY GRAVELLY CLAY	190	
B300590	B3005900305	02/09/90	3 00 - 4 20	SANDY CLAY	41	
B300690	B3006900002	02/09/90	0 00 - 1 80	GRAVELLY SAND/CLAY	110	
B300690	B3006900203	02/09/90	2 00 - 2 60	GRAVELLY SAND/CLAY	200	
B300790	B3007900002	02/09/90	0 00 0 50	GRAVELLY SANDY CLAY	410	
B300790	B3007900002D	02/09/90	0 00 - 0 50	GRAVELLY SANDY CLAY	190	
B300790	B3007900204	02/09/90	2 00 - 3 90	SANDY CLAY	210	
B300890	B3008900002	02/12/90	0 00 1 00	GRAVELLY CLAY	140	
B300890	B3008900204	02/12/90	2 00 3 40	SILTY CLAY	220	
B300890	B3008900406	02/12/90	4 00 - 5 80	SILTY CLAY	180	
B300890	B3008900810	02/12/90	8 00 - 10 00	SILTY CLAY	15	
B300890	B3008901012	02/12/90	10 00 - 12 00	SILTY CLAY	190	
B300990	B3009900002	02/12/90	0 00 1 70	GRAVELLY SILTY CLAY	25	
B300990	B3009900204	02/12/90	2 00 - 3 70	GRAVELLY SILTY CLAY	270	E
B300990	B3009900406	02/12/90	4 00 - 5 70	GRAVELLY SANDY CLAY	150	
B300990	B3009900608	02/12/90	6 00 - 8 00	GRAVELLY SANDY CLAY	270	E
B300990	B3009900810	02/12/90	8 00 - 10 00	GRAVELLY SANDY CLAY	220	
B300990	B3009901012	02/12/90	10 00 - 11 00	GRAVELLY SANDY CLAY	40	
B301090	B3010900607	02/12/90	6 00 - 6 60	GRAVELLY SILTY SAND	460	E
B301090	B3010900708	02/12/90	7 50 - 8 00	GRAVELLY SILTY SAND	220	E
B301090	B3010901415	02/16/90	14 00 - 15 00	GRAVELLY CLAYEY SAND	240	
B301090	B3010901517	02/16/90	15 00 - 16 30	GRAVELLY CLAY	230	
B301090	B3010901719	02/16/90	17 00 - 19 00	CLAY	160	
B301090	B3010901921	02/16/90	19 00 - 21 00	CLAY	260	
B301190	B3011900002	02/22/90	0 00 2 00	SANDY CLAY	150	

* Rejected data excluded

B Present in Blank   J - Quantitation approximate based on QC review   E - Exceeds calibration range, dilute/reanalyze

TABLE 2-15 (Continued)

Toluene Concentrations in French Drain Borehole Samples at Rocky Flats (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Sample Type	Toluene* Concentration (ug/g)	
B301190	B30119000020	02/22/90	0 00 - 2 00	SANDY CLAY	220	
B301190	B3011900204	02/22/90	2 00 - 3 50	SANDY CLAY	100	
B301190	B3011900406	02/22/90	4 00 - 6 00	SANDY CLAY	160	
B301190	B3011900608	02/22/90	6 00 - 8 00	SAND AND CLAY	37	
B301190	B3011900810	02/22/90	8 00 - 10 00	SILTY CLAY AND SAND	57	
B301190	B3011901012	02/22/90	10 00 - 12 00	SILTY CLAY AND SAND	28	
B301190	B3011901214	02/22/90	12 00 - 14 00	SILTY CLAYEY SAND	77	
B301190	B3011901416	02/22/90	14 00 - 15 10	SILTY GRAVELLY SAND	29	
B301190	B3011901618	02/22/90	16 00 - 16 90	GRAVELLY SANDY CLAY	84	
B301190	B3011901820	02/22/90	18 00 - 18 70	GRAVELLY SANDY CLAY	130	
B301290	B3012900002	02/26/90	0 00 - 0 95	CLAYEY SILT	130	
B301290	B3012900204	02/26/90	2 00 - 3 60	SANDY CLAYEY SILT	150	
B301290	B3012900406	02/26/90	4 00 - 6 00	SANDY CLAYEY SILT	130	
B301390	B3013900002	02/26/90	0 00 0 70	CLAYEY SILT	610	
B301390	B3013900204	02/26/90	2 00 - 4 00	SANDY CLAY	120	
B301390	B3013900406	02/26/90	4 00 - 4 90	CLAYEY SAND	240	
B301390	B3013900608	02/26/90	6 00 - 6 80	SILTY CLAY	130	
B301490	B3014900304	02/26/90	3 00 - 3 90	SILTY CLAY	120	
B301490	B3014900406	02/26/90	4 00 - 5 30	SILTY CLAY	67	
B301490	B3014900608	02/26/90	6 00 - 8 00	SILTY SANDY CLAY	91	
B301490	B3014900810	02/26/90	8 00 - 9 70	SANDY CLAYEY SILT	26	
B301490	B3014901012	02/26/90	10 00 11 90	SILTY CLAY	120	
B301490	B3014901214	02/26/90	12 00 - 13 70	CLAY AND SAND	66	
B301490	B3014901416	02/26/90	14 00 - 15 60	SILTY CLAY	51	
B301490	B3014901012D	02/26/90	10 00 - 11 90	SILTY CLAY	170	
B301590	B3015900002	03/19/90	0 00 - 2 00	SILTY CLAY	200	
B301590	B3015900204	03/19/90	2 00 - 3 10	SILTY CLAY	230	
B301590	B3015900406	03/19/90	4 00 - 4 70	SILTY CLAY	70	
B301590	B3015900708	03/19/90	7 00 - 7 70	SILTY CLAY	200	
B301590	B3015901012	03/19/90	10 00 - 11 00	GRAVELLY CLAY	57	
B301590	B3015901214	03/19/90	11 50 13 00	CLAY	270	
B301690	B3016900002	03/19/90	0 00 - 2 00	SILTY CLAY	460	
B301690	B3016900204	03/19/90	2 00 4 00	SILTY CLAY	160	
B301690	B3016900406	03/19/90	4 00 - 6 00	SILTY CLAY	300	
B301690	B3016900608	03/19/90	6 00 - 8 00	CLAYEY SILT	230	
B301690	B3016900810	03/19/90	8 00 10 00	CLAYEY SILT	250	
B301690	B3016901012	03/19/90	10 00 - 12 00	SLITY CLAY	200	
B301690	B3016901214	03/19/90	12 00 - 13 70	CLAYEY SILT TO SILTY CLAY	99	
B301690	B3016901416	03/19/90	14 90 15 90	GRAVELLY SILTY CLAY	240	
B301690	B3016901618	03/19/90	16 90 18 90	GRAVELLY SILTY CLAY	220	
B301690	B3016901820	03/19/90	18 90 19 90	SLITY CLAY	230	
B301790	B3017900002	03/20/90	0 00 - 1 50	SILTY CLAY	7	J
B301790	B3017900204	03/20/90	2 00 - 2 50	SILTY CLAY	30	J
B301790	B3017900406	03/20/90	4 00 - 5 90	SILTY SANDY CLAY	23	
B301790	B3017900608	03/20/90	6 00 - 8 00	SILTY SANDY CLAY	20	
B301790	B3017900810	03/20/90	8 00 - 10 00	SILTY CLAY	11	J

* Rejected data excluded

B - Present in Blank J Quantitation approximate based on QC review E Exceeds calibration range, dilute/reanalyze

Toluene Concentrations in French Drain Borehole Samples at Rocky Flats (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Sample Type	Toluene* Concentration (ug/g)	
B301790	B3017901012	03/20/90	10 00 - 12 00	SILTY CLAY	8	J
B301790	B3017901213	03/20/90	12 00 - 13 00	SILTY CLAY	6	J
B301790	B3017901315	03/20/90	13 00 - 15 00	SILTY CLAY	10	J
B301790	B30179004060	03/20/90	4 00 - 5 90	SILTY SANDY CLAY	15	
B301890	B3018900002	03/20/90	0 00 - 1 00	SILTY CLAY	460	B
B301890	B3018900204	03/20/90	2 00 - 4 00	CLAY	280	B
B301890	B3018900406	03/20/90	4 00 - 6 00	SILTY SANDY CLAY	150	B
B301890	B3018900608	03/20/90	6 00 - 8 00	SILTY SANDY CLAY	180	B
B301890	B3018900810	03/20/90	8 00 - 10 00	SILTY CLAY	200	B
B301890	B3018901012	03/20/90	10 00 - 12 00	SILTY CLAY	240	B
B301890	B3018901214	03/20/90	12 00 - 14 00	SILTY SANDY CLAY	130	B
B301890	B3018901416	03/20/90	14 00 - 16 00	SILTY CLAY	9	J
B301890	B3018901618	03/20/90	16 00 - 18 00	SILTY CLAY	8	J
B301890	B3018901820	03/21/90	18 00 - 20 00	SILTY CLAY	27	
B301990	B3019900002	03/21/90	0 00 - 1 60	SILTY CLAY	52	
B301990	B3019900204	03/21/90	2 00 - 4 00	SILTY CLAY	290	
B301990	B3019900406	03/21/90	4 00 - 6 00	SILTY CLAY	98	
B301990	B3019900608	03/21/90	6 00 - 7 50	SILTY CLAY	260	
B301990	B30199006080	03/21/90	6 00 - 7 50	SILTY CLAY	330	
B301990	B3019901416	03/22/90	14 30 - 16 30	GRAVELLY SILTY CLAY	31	
B301990	B3019901718	03/22/90	17 00 - 17 70	SANDY CLAY	40	
B301990	B3019901819	03/22/90	17 70 - 18 70	SAND TO CLAYEY SAND	37	
B302090	B3020900002	03/22/90	0 00 - 0 70	CLAYEY SAND	110	
B302090	B3020900204	03/22/90	2 00 - 3 40	SILTY & GRAVELLY CLAY	150	
B302090	B3020900406	03/22/90	4 00 5 10	SILTY CLAY	110	
B302090	B3020900608	03/22/90	6 00 - 7 60	SILTY CLAY	110	
B302090	B3020900810	03/22/90	8 00 - 9 60	SILTY CLAY	110	
B302090	B3020901012	03/22/90	10 00 - 11 90	SILTY CLAY	150	
B302090	B3020901214	03/22/90	12 00 - 13 00	SILTY CLAY	160	
B302090	B3020901416	03/22/90	14 00 - 16 00	SILTY CLAY	190	
B302090	B3020901618	03/22/90	16 00 - 17 20	SILTY CLAY	110	
B302090	B3020901921	03/22/90	19 00 - 19 80	SILTY CLAY	150	
B302190	B3021900204	06/25/90	2 00 - 4 00	GRAVELLY SITLY SAND	39	B
B302190	B3021900204D	06/25/90	2 00 4 00	GRAVELLY SITLY SAND	53	B
B302190	B3021900406	06/25/90	4 00 6 00	SAND AND CLAY	24	B
B302190	B3021900608	06/25/90	6 00 - 8 35	SILTY CLAY	10	
B302190	B3021900810	06/25/90	8 35 - 10 35	SILTY CLAY	42	B
B302190	B3021901012	06/25/90	10 35 - 12 35	CLAY	27	B
B302190	B3021901214	06/25/90	12 35 - 14 35	SILTY CLAY	44	B
B302190	B3021901416	06/25/90	14 35 - 16 30	SILTY CLAY	47	B
B302190	B3021901618	06/25/90	16 30 - 18 30	SILTY CLAY AND TOPSOIL	78	B
B302190	B3021901820	06/25/90	18 30 - 20 30	SILTY CLAY	170	B
B302190	B3021902022	06/25/90	20 30 - 22 70	SILTY CLAY	67	B
B302190	B3021902224	06/25/90	22 70 - 24 30	SILTY CLAY	51	B
B302190	B3021902426	06/25/90	24 70 - 26 70	SILTY CLAY	60	B
B302190	B3021902628	06/25/90	26 90 - 28 40	SILTY CLAY	39	B

* Rejected data excluded

B Present in Blank   J - Quantitation approximate based on QC review   E - Exceeds calibration range, dilute/reanalyze

TABLE 2-15 (Continued)

Toluene Concentrations in French Drain Borehole Samples at Rocky Flats (Continued)

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Sample Type	Toluene* Concentration (ug/g)	
B302190	B3021900002	06/25/90	0 00 - 2 00	SILTY CLAY	21	B
B302290	B3022900002	06/26/90	0 00 - 2 00	GRAVELLY SILTY SAND	290	B
B302290	B3022900204	06/26/90	2 00 - 4 00	GRAVELLY SILTY SAND	100	B
B302290	B3022900406	06/26/90	4 00 - 6 00	SILTY CLAY	83	B
B302290	B3022900608	06/26/90	6 00 - 8 00	SILTY CLAY	420	B
B302290	B3022900810	06/26/90	8 00 - 10 00	SILTY CLAY	220	B
B302290	B30229008100	06/26/90	8 00 - 10 00	SILTY CLAY	310	B
B302290	B3022901012	06/26/90	10 00 - 12 30	SILTY CLAY	410	B
B302290	B3022901214	06/26/90	12 30 - 14 50	SILTY CLAY	180	B
B303190	B3031900204	07/09/90	2 00 - 4 00	SANDY SILTY CLAY	22	
B303390	B3033900002	07/11/90	0 00 - 2 00	SILTY SANDY CLAY	170	
B303390	B3033900002D	07/11/90	0 00 - 2 00	SILTY SANDY CLAY	1200	
B303390	B3033900204	07/11/90	2 00 4 00	SILTY SANDY CLAY	89	
B303390	B3033900006	07/11/90	0 00 - 5 50	SILTY SANDY CLAY	5	
B303390	B3033900608	07/11/90	5 50 - 8 00	SANDY SILTY CLAY	5	J
B303490	B3034900002	07/11/90	0 00 - 2 00	SILTY SANDY CLAY	730	
B303490	B3034900002D	07/11/90	0 00 - 2 00	SILTY SANDY CLAY	360	
B303490	B3034900204	07/11/90	2 00 - 4 00	SILTY CLAY	120	
B303590	B3035900002	07/12/90	0 00 - 2 00	SILTY CLAY	270	
B303590	B3035900204	07/12/90	2 00 - 4 00	SILTY CLAY	160	B
B303590	B3035900507	07/12/90	4 40 - 7 70	SILTY CLAY	43	
B303590	B3035900709	07/12/90	7 70 - 9 70	SILTY CLAY	13	
B303590	B3035900911	07/12/90	9 70 - 11 70	SILTY CLAYSTONE	190	B
B303590	B3035901213	07/12/90	11 70 - 13 50	SILTY CLAYSTONE	110	B
B303590	B3035901618	07/12/90	16 10 - 17 80	SILTY CLAYSTONE	71	B
P302390	P3023900507	06/27/90	5 50 - 6 20	GRAVELLY CLAY	15	B
P302490	P3024900204	06/28/90	2 00 - 3 00	SAND WITH GRAVEL	77	B
P302490	P3024900204D	06/28/90	2 00 - 3 00	SAND WITH GRAVEL	42	B
P302590	P3025900305	06/29/90	3 00 - 5 00		77	B
P302690	P3026900204	07/02/90	2 00 - 4 70	CLAYEY GRAVELLY SAND	110	
P302790	P3027900204	07/02/90	2 00 - 3 70	GRAVELLY SANDY CLAY	100	
P302890	P3028900204	07/05/90	2 00 - 4 00	SILTY CLAY	9	
P302990	B3029900204	07/06/90	2 00 - 4 00	SILTY CLAY	1	J
P303290	B3032900204	07/10/90	2 00 - 4 00	SILTY SANDY CLAY	23	
P303290	B3032900204D	07/10/90	2 00 4 00	SILTY SANDY CLAY	190	

* Rejected data excluded

B Present in Blank J Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

drain alignment High within-hole fluctuations generally indicate a random vertical distribution of toluene based on these data Field, trip, and laboratory blanks did not contain toluene, nor did rinsate blanks of the hollow stem auger used in drilling, and of the stainless steel cylinders used for sampling inside the coring device (field and trip blank data are provided in Appendix C of the IM/IRA implementation document) (EG&G, 1991a)

It has been hypothesized that Coherex is the source of the toluene observed during the French Drain Geotechnical Investigation Coherex has been used as a dust suppressant/soil stabilizer both before and during the Phase I and Phase II RI field activities of 1986 and 1987 The Material Safety Data Sheet (MSDS) for Coherex does not discuss toluene as a component but mentions petroleum distillates as a major constituent, so toluene may be a product of degradation Toluene may also have been used as a thinning agent to reduce the viscosity of the Coherex before application Several proposed tests to confirm Coherex as the toluene source are being discussed In addition, boreholes will be drilled and sampled to evaluate the extent of the toluene contamination downgradient of the 881 Hillside as discussed in Section 5 0

Two semi-volatile compounds were detected in french drain samples (EG&G, 1991a), although only bis(2-ethylhexyl)phthalate was a common constituent (Table 2-16) Bis(2-ethylhexyl)phthalate typically occurred at concentrations between 40-100 μg/kg, was estimated below the detection limit (flagged "J"), and was present in the blank (flagged "B") The maximum concentration was 1400 B μg/kg in B301590 The presence of this compound is consistent with previous investigations of the 881 Hillside, and similarly involves some uncertainty as to whether there is actual phthalate contamination or that the contamination is due to sample handling This latter possibility will be tested in the Phase III remedial investigation of the 881 Hillside, but does not directly influence plans for the interim action

Volatile chlorinated hydrocarbon contamination is apparently not extensive It occurred in soils from only 3 of the 23 RI boreholes [BH01-87 (IHSSs 107 and 177), BH57-87 (IHSS 119 1), and BH58-87 (IHSS 119 2)] The highest concentrations detected were tetrachloroethene (PCE) at 190 micrograms per kilogram (μg/kg) in BH01-87, trichloroethene (TCE) at 150 μg/kg in BH58-87, and 1,1,1-trichloroethane (1,1,1-TCA) at 110 μg/kg in BH58-87 Much lower concentrations (below or near detection limit) were reported for BH14-87 (TCE) BH12-87 (PCE), and BH61-87 (1,1,1-TCA)

Boreholes will be drilled and samples collected from all IHSSs for organic analysis during the Phase III RFI/RI An objective of this program will be to determine whether methylene chloride, acetone, and phthalates are soil contaminants Other objectives include verification of IHSS locations, assessment of the vertical and horizontal distribution of organic contamination including toluene, and identification of maximum concentrations of contaminants in suspended "hot spots"

Table 2-16

Semivolatile Organic Compound Concentrations* in French Drain Borehole Samples at Rocky Flats All Concentrations in ug/g

Borehole Number	Sample Number	Date Collected	Depth Increment (ft)	Pyrene		bis(2-Ethylhexyl) Phthalate	
B300190	B3001900006	02/02/90	0 00 - 6 00			61	J
B300890	B3008900004	02/12/90	0 00 - 3 40	40	J		
B300890	B3008900408	02/12/90	4 00 - 8 00			40	J
B301490	B3014900812	02/26/90	8 00 - 11 90			52	J
B301590	B3015900004	03/19/90	0 00 - 3 10			1400	B
B301590	B3015900408	03/19/90	4 00 - 7 70			1200	B
B301590	B3015900812	03/19/90	10 00 - 12 00			45	JB
B301690	B3016900408	03/19/90	4 00 - 8 00			43	JB
B301690	B3016900812	03/19/90	8 00 - 12 00			46	JB
B301690	B3016901216	03/19/90	12 00 - 15 90			40	JB
B301690	B3016901620	03/19/90	16 90 - 19 90			54	JB

* Rejected data excluded

B Present in Blank J - Quantitation approximate based on QC review E - Exceeds calibration range, dilute/reanalyze

2 3 2 2 **Metals**

In general, metal concentrations in soil samples from Rocky Flats Alluvium, colluvium, and claystone were within background levels Trace metals which occurred above background in these three materials include antimony (3%), arsenic (30%), mercury (6%), cadmium (61%), manganese (1%), and barium (7%) Parentheses indicate the percent of the samples exceeding the background range The metal data do not demonstrate gradients away from specific IHSSs These generally low concentrations of metals above background and their random spatial distribution does not suggest these metals represent contaminants The metals which do exceed background are typically very close to the estimated background levels Arsenic and cadmium are possible exceptions, reaching maxima of 24 milligrams per kilogram (mg/kg) and 6 4 mg/kg, respectively

2 3 2 3 **Radionuclides**

Radionuclides are analyzed by counting sub-atomic particle emissions, which is a random function Since radioactive disintegration is a statistical process and therefore has a probability distribution, results are reported as a measured value with an associated two standard deviation propagated error term following the measured value Computation of tolerance intervals for radionuclides did not account for the error term associated with each datum Techniques are under investigation to account for propagation of error resulting from computation For the purposes of this plan, the boundaries of the background variability for radionuclides will be the tolerance intervals as computed in the draft Background Geochemical Characterization Report Site radionuclide concentrations where the error term is larger than the measured value are below the minimum detectable activity (MDA) and are considered not statistically different from background Measured values which do exceed their associated counting errors are considered above background if they are greater than the upper limit of the tolerance interval Because this comparison does not account for the propagated error associated with the upper limit of the background tolerance interval, this yields conservative interpretation of the site data It is also noted that the upper limits of the tolerance intervals are similar in magnitude to the maximum concentration observed for the data set

Table 2-17 presents the percent of samples for each radionuclide detected above background at the surface and in the subsurface during the Phase I and II RIs However, samples were composited over varying depths so the reported values are not representative of a thin surface veneer alone Plutonium and americium were only detected above background in surface soils (the maximum concentrations of 0 91 ± 0 38 pCi/g and 0 15 ± 0 13 pCi/g, respectively, were diluted by compositing) This contamination is probably derived from the 903 Pad Area by wind dissemination of plutonium/americium contaminated dust More recently collected data for plutonium, uranium-238, and uranium-233 + 234 concentrations in surface scrape samples are presented in Table 2-18 (Lawton, 1989) Sample locations are shown in Figure 2-10 Plutonium concentrations were as high as 4 8 pCi/g in surface soils at the 881 Hillside Area These concentrations are typical of surface plutonium

TABLE 2-17

PERCENT OF SOIL SAMPLES WITH RADIONUCLIDES ABOVE BACKGROUND

Radionuclide	Percent of Surface Samples Above Background*	Percent of Subsurface Samples Above Background
Uranium (Total)	6	6
Plutonium-239 + 240	11	0
Americium-241	6	0
Cesium-137	17	7
Tritium	6	3

* This tabulation represents a minimum number of samples that had radionuclides above background because the surface soil samples were composited over intervals up to several feet in thickness

Notes

- Tabulation based on Phase I and Phase II RI soil sampling data
- Surface sample tabulation based on uppermost sample results from each borehole
- Subsurface sample tabulation based on all remaining borehole sample results
- Sample depths for all boreholes are provided in Table 2-13

TABLE 2-18

881 HILLSIDE 1988 SURFACE SCRAPE SAMPLING RESULTS

RADIONUCLIDE CONCENTRATION IN pCi/g

Sample No	Uranium-233 + 234	Uranium-238	Plutonium
881-1	0 56 ± 0 26	0 6 ± 0 15	4 3 ± 0 5
881-2	0 78 ± 0 26	0 86 ± 0 15	2 4 ± 0 2
881-3	0 82 ± 0 26	0 91 ± 0 15	4 8 ± 0 5
881-4	1 0 ± 0 3	0 97 ± 0 2	0 18 ± 0 006
881-5	0 86 ± 0 26	0 88 ± 0 15	0 59 ± 0 008
881-6	1 5 ± 0 3	5 5 ± 0 5	2 2 ± 0 2
881-7	0 74 ± 0 26	0 75 ± 0 15	0 63 ± 0 09
881-	0 86 ± 0 26	0 82 ± 0 15	1 8 ± 0 2
881-9	3 1 ± 0 3	1 0 ± 0 2	0 47 ± 0 006
881-	11 1 ± 0 3	0 98 ± 0 2	3 5 ± 0 4
881-11	1 0 ± 0 3	1 3 ± 0 2	2 6 ± 0 3
881-12	0 93 ± 0 26	1 4 ± 0	0 4 ± 0 06
881-13	0 94 ± 0 26	1 3 ± 0 2	0 16 ± 0 06
881-14	1 1 ± 0 3	1 0 ± 0 2	3 0 ± 0 4
881-15	2 0 ± 0 3	1 5 ± 0 16	0 01 ± 0 06
881-16	50 ± 190	1300 ± 100	0 3 ± 0 06
881-17	19 ± 74	590 ± 70	0 78 ± 0 19
881-18	60 ± 230	3000 ± 300	0 42 ± 0 08
881-19	10 ± 740	550 ± 602	0 09 ± 0 06

Data from Personal Communication, Richard Lawton, 1989 concentrations in this vicinity and to the east within the Plant boundary (Rockwell International, 1987b) High uranium concentrations occurred in Samples 16 through 19 Uranium which is used at the Rocky Flats Plant is depleted in uranium-233 and uranium-234, and therefore has a uranium-233 + 234 to uranium-238 activity ratio of less than one The ratio for natural uranium is greater than one The uranium isotope ratios for these surface soils indicate the uranium is depleted (low ratio) The contamination presumably resulted from drums that had leaked in the past or from past spills

Referring again to Table 2-17, uranium, cesium, and tritium occur infrequently above background in both surface and subsurface samples None of these results exceeded background by more than a factor of two above the upper tolerance interval, but the results do not represent the true surface concentrations because the samples were composited over depth The uranium-233 + 234 to uranium-238 activity ratios are greater than one for most of Samples 1 through 15 (Table 2-18) indicating the natural uranium, but Samples 6, 12, and 13 indicate possible mixing with depleted uranium

An independent assessment of criticality safety at Rocky Flats Plant conducted by Scientech, Inc , found no evidence of a criticality at the Rocky Flats Plant This study noted that the levels of cesium-137 activity in the Rocky Flats area are in the range of 0 3 to 0 6 pCi/g averaged over a soil depth of six centimeters based on a July 1989 aerial radiological survey of the Plant These values are consistent with world-wide fallout levels, and there is no indication of cesium 137 deposition due to Rocky Flats Plant operations (DOE, 1989)

2 3 3 Ground Water

Ground water at the 881 Hillside occurs in surficial materials (Rocky Flats Alluvium, colluvium, valley fill alluvium), and in weathered and unweathered bedrock The most significant contamination is in surficial materials, but weathered bedrock is hydraulically connected to the surface materials and therefore part of the contaminated, unconfined flow system Unweathered bedrock is considered part of the confined system The discussion of ground-water quality addresses two groups of relatively closely-spaced IHSSs A western group includes IHSSs 102, 103, 105, 106, 107, 145, and 177 The eastern portion of the 881 Hillside includes IHSSs 119 1, 119 2 and 130

Eight monitor wells were completed in surficial materials downgradient of IHSSs 102, 103, 105, 106, 107, 145 and 177 (51-87, 52-87, 58-86, 69-86, 2-87, 53-87, 54-87 and 59-86R) Wells 1-87 and 68-86 were initially considered upgradient of these IHSSs, but water level and chemical data suggest that well 1-87 may be sidegradient Ground-water quality in both of these wells is occasionally above background and may be affected by Plant activities upgradient of the 881 Hillside Additional upgradient wells will be installed to investigate this possibility Well 58-86 was dry at all sampling attempts, and wells 51-87 and 54-87 were usually dry

Fourteen monitor wells were completed in the surficial materials downgradient of IHSSs 119 1, 119 2 and 130 (9-74, 10-74, 64-86, 4-87, 5-87, 6-87, 43-87, 47-87, 48-87, 63-86, 44-87, 49-87, 50-87, and 55-87) Several of these wells show significant contamination Ground-water levels in 63-86, 44-87, and 49-87 were always too low to yield samples Well 50-87 was usually dry, but one sample was collected in fourth quarter 1987

Three wells were completed in weathered sandstone (5-87, 62-86 and 59-86), and two were completed in unweathered sandstone (3-87 and 45-87) A third deep well (8-87) was completed in lignite (It is grouped with the unweathered sandstones in Appendix C)

All available data (fourth quarter 1986 through first quarter 1990) are considered in the following assessment which compares site data to the background ground-water quality tolerance intervals However, background ground-water data are available only for the second quarter of 1989, so the discussion compares site and background data from different seasons Section 2 3 1 includes a more complete description of the background study and emphasizes that conclusions regarding ground-water quality are necessarily preliminary Ground-water samples were analyzed for the parameters listed in Table 2-19, and all available data are presented in Appendix C

2 3 3 1 Volatile Organic Compounds

Unconfined Ground Water

Several wells had detectable volatile organic compounds in the surficial materials over the course of sampling from late 1986 to 1990 Maximum values are shown in Table 2-20 Concentrations plotted in Figures 2-11 and 2-12 illustrate the general distribution that characterizes the organic contamination, although these maps specifically show only PCE and TCE in the second quarter of 1989 Of the wells that are marked "dry" on Figures 2-11 and 2-12, only three wells were dry throughout all sampling (wells 63-86, 44-87, and 49-87)

At the westerly group of IHSSs, four volatile organic compounds occurred above detection limits in three wells At well 1-87 there was one occurrence of 1,1,1-TCA (130 $\mu g/\ell$), at well 54-87 there was one report each of chloroform ($CHCl_3$, 8 $\mu g/\ell$), PCE (4 $\mu g/\ell$), and 1,1,1-TCA (2J $\mu g/\ell$), and at well 2-87 there was 1,1-DCE (6 $\mu g/\ell$) and PCE (35J $\mu g/\ell$) At well 51-87, PCE and TCE were detected at 8 $\mu g/\ell$ and 3J $\mu g/\ell$, respectively The only other volatile organic compounds at the westerly IHSSs were methylene chloride (maximum - 35B $\mu g/\ell$ at well 2-87), and acetone (maximum - 280 $\mu g/\ell$ at well 1-87) Numerous other samples had methylene chloride and acetone concentrations estimated below detection limit and/or present in the blanks for wells that were otherwise free of organics These results may indicate laboratory rather than site contamination Isolated, low level reports of carbon disulfide, 2-butanone and total xylenes are shown in Table 2-20

TABLE 2-19

PHASE I AND PHASE II RI
GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

FIELD PARAMETERS

pH
Specific Conductance
Temperature
Dissolved Oxygen

INDICATORS

Total Dissolved Solids
Total Suspended Solids

METALS

Hazardous Substances List - Metals
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Tin
- Vanadium
- Zinc

Other Metals
- Chromium (hexavalent)
- Lithium
- Strontium

ANIONS

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate

ORGANICS

Oil and Grease
Hazardous Substances List - Volatiles
- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane

TABLE 2-19 (Continued)

PHASE I AND PHASE II RI
GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

ORGANICS

Hazardous Substances List - Volatiles ** (Continued)

trans-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon Tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
2-Chloroethyl Vinyl Ether
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

RADIONUCLIDES

Gross Alpha
Gross Beta
Uranium-233+234, -235, and -238
Americium-241
Plutonium-239+240
Strontium-90
Cesium-137
Tritium

* For surface water samples only
** Dissolved metals for ground-water samples, total and dissolved metals for surface water samples
*** Ground-water samples from the first quarter of 1987, and all surface water samples were analyzed for 9 of the HSL volatiles These volatiles are the chlorinated solvents historically detected in the ground water and are as follows PCE, TCE, 1,1-DCE, 1,2-DCA, t-1,2-DCE, 1,1,1-TCA, 1,1,2-TCA, CCl_4 and $CHCl_3$

TABLE 2-20

VOLATILE ORGANIC COMPOUNDS DETECTED IN UNCONFINED GROUND WATER (FOURTH QUARTER 1986 TO FIRST QUARTER 1990) (MAXIMA)

Material	Well	Chloroform (µg/l)	Carbon Tetrachloride (µg/l)	Tetrachloroethene (µg/l)	Trichloroethene (µg/l)	Methylene Chloride (µg/l)	1,1-Dichloroethene (µg/l)	1,1-Dichloroethane (µg/l)	1,2-Dichloroethane (µg/l)	1,1,1-Trichloroethane (µg/l)	1,1,2-Trichloroethane (µg/l)	1,1,2,2-Tetrachloroethane (µg/l)	Toluene (µg/l)	Ethyl benzene (µg/l)	Acetone µg/l
Rocky Flats Alluvium	01-87					3JB				130					3B
	51-87		1J	8	3J	3JB				3J			9		280
	52 87		3J	2J	5	21JB				5			1J		190
Colluvium	09-74	5	28000	13200	72000	1300B	48000	180J	16000	30250	14740		81J		9
	10-74	100J	8100	350	3600	580B	190		140	312			5J		120B
	63-86	dry													
	69-86					1JB									85
	02-87	5J		35J	2J	35B	6						5J		68B
	04-87	6	29	84	525	15B	8		32	20			2JB		56B
	06-87		1J		20	3JB									20B
	43-87		2995	8100	17000	1500B	32687	350EA	25	28000E	160J		270JB	6	180JB
	44-87	dry													
	47-87	1J	1J			8B									9
	48 87		3J			2JB									12
	49-87	dry													
	50-87			3J		2JB									4B
	53-87		6	3J	23	21	21			18			11		9B
	54-87	8		4J		11B			3J	2J			1J		13B

TABLE 2-20 (Continued)

VOLATILE ORGANIC COMPOUNDS DETECTED IN UNCONFINED GROUND WATER (FOURTH QUARTER 1986 TO FIRST QUARTER 1990) (MAXIMA)

Material	Well	Carbon disulfide µg/l	2-Butanone µg/l	Vinyl Acetate µg/l	Total 1,2, Dichloroethene µg/l	Total Xylenes µg/l	Benzene µg/l
Rocky Flats Alluvium	01-87						
	51-87		10			2J	
	52-87	5					
Colluvium	09-74		22				
	10-74			39J			
	63-86						
	69-86	1J					
	02 87						
	04-87						
	06-87						
	43-87				5070	2J	83J
	44-87						
	47-87						
	48-87	1J					
	49-87						
	50-87						
	53-87	1J					
	54-87	8					

TABLE 2-20 (Continued)

VOLATILE ORGANIC COMPOUNDS DETECTED IN UNCONFINED GROUND WATER (FOURTH QUARTER 1986 TO FIRST QUARTER 1990) (MAXIMA)

Material	Well	Chloro-form (µg/l)	Carbon Tetra-chloride (µg/l)	Tetra-chloro-ethene (µg/l)	Tri-chloro-ethene (µg/l)	Methy-lene Chloride (µg/l)	1,1-Di-Chloro-ethene (µg/l)	1,1-Di-Chloro-ethane (µg/l)	1,2-Di-Chloro-ethane (µg/l)	1,1,1-Tri-chloro ethane (µg/l)	1,1,2-Tri-chloro ethane (µg/l)	1,1,2,2-Tetra chloro ethane (µg/l)	Toluene (µg/l)	Ethyl benzene (µg/l)	Acetone (µg/l)
Colluvium (cont)	5 9 - 86R					3JB									150
Valley Fill	58-86														
Alluvium	64-86			8J		3J									2J
	68-86					24									7JB
	55-87					8									19
Weathered Sandstone	62-86		2J	29J		73B									2JB
	05-87	8	170		45	9JB			6						99
	59-86			6											2JB
Unweathered	0387			5J	6	6B							2J		3JB
Sandstone	4587	37B				23JB							0 7JB		210B
	0887	3J	130	20	35	4J	2J						1J		120

J - Estimated value below Contract Required Detection Limit (CRDL) High concentrations associated with a "J" indicate a dilution of the sample was necessary for analysis, which increased the CRDL

E - Estimated value beyond standard curve limits

B - Present in Blank

µg/l micrograms per liter

TABLE 2-20 (Continued)

VOLATILE ORGANIC COMPOUNDS DETECTED IN UNCONFINED GROUND WATER (FOURTH QUARTER 1986 TO FIRST QUARTER 1990) (MAXIMA)

Material (µg/ℓ)	Well (µg/ℓ)	Carbon disulfide (µg/ℓ)	2-Butanone (µg/ℓ)	Vinyl Acetate (µg/ℓ)	Total 1,2, Dichlorethene (µg/ℓ)	Total Xylenes (µg/ℓ)	Benzene (µg/l)
Rocky Flats Alluvium	59-86R	1J					
Valley Fill Alluvium	58-86						
	64-86		3JB				
	68-86						
	55-87	1J					
Weathered Sandstone	0387						
	4587	5					
	0887						

At the easterly group of IHSSs (119 1, 119 2, and 130), volatile organic contamination is more pronounced (Table 2-20) Wells 9-74, 10-74, and 43-87 show the most contamination, with PCE, TCE, 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA), 1,1,1-TCA, 1,1,2-trichloroethane (1,1,2-TCA), and carbon tetrachloride (CCl_4) reaching several thousand $\mu g/\ell$ in many samples Chloroform, toluene, 1,2-dichloroethene (1,2-DCA), and total 1,2-dichloroethene occurred at lower concentrations [estimated at less than detection limit or less than 100$\mu g/\ell$ with few exceptions (Table 2-20)] Levels of methylene chloride and acetone were typically low enough to be considered laboratory artifact according to CLP protocol (EPA, 1988a), although the high levels at wells 9-74, 10-74, and 43-87 suggest the actual presence of these compounds in the ground water at these locations Carbon disulfide, 2-butanone, vinyl acetate total xylene and benzene results in Table 2-20 show sporadic occurrences at low concentrations

The report of low level PCE for well 64-86 (8J $\mu g/\ell$) in the second quarter 1989 was not repeated in subsequent analyses Planned monitoring will help confirm the presence or absence of contamination in downgradient valley fill alluvium

In weathered sandstone, well 5-87 contained organics other than methylene chloride and acetone with PCE (170 $\mu g/\ell$), TCE (45 $\mu g/\ell$), $CHCl_3$ (8 $\mu g/\ell$), and 1,2-DCA (6 $\mu g/\ell$) The acetone was also quite high in that well (99 $\mu g/\ell$) Well 62-86 had 29J $\mu g/\ell$ of PCE and 2J $\mu g/\ell$ of CCl_4 Only 6 $\mu g/\ell$ of PCE was reported for well 59-86

Confined Ground Water

Volatile organics have been infrequently detected in samples of confined ground water of the unweathered sandstones (wells 3-87, 45-87, and 8-87) At least 11 quarters of data exist for these wells There were no greater than four occurrences of methylene chloride and acetone in samples from each well In almost every case, the concentrations were either estimated below detection limits and/or these analyses were present in the associated laboratory blank There are only two occurrences of 1,1-DCE (1J $\mu g/\ell$ and 2J $\mu g/\ell$), both in samples from well 8-87 Three samples from well 45-87 (fourth quarter 1987 and the first two quarters of 1988) contained chloroform (range 3J $\mu g/\ell$ to 37B $\mu g/\ell$) However, chloroform was not present in any sample from subsequent quarters Toluene was present in only one sample from each of the three wells Concentrations ranged from 0 7JB $\mu g/\ell$ to 2J $\mu g/\ell$ TCE was detected only once in samples from well 3-87 (6 $\mu g/\ell$) and only twice in samples from well 8-87 (2J $\mu g/\ell$ and 35 $\mu g/\ell$) TCE was not detected in well 45-87 PCE was only detected once in well 3-87 (5J $\mu g/\ell$) and twice in well 8-87 (2J $\mu g/\ell$ and 20 $\mu g/\ell$) PCE was not detected in well 45-87 CCl_4 was only detected once in well 8-87 (130 $\mu g/\ell$), and was not detected in wells 3-87 and 45-87 Carbon disulfide was detected once (5$\mu g/\ell$) in well 45-87 only It is concluded that the ground water in the unweathered sandstone at OU No 1 is not contaminated for the following reasons

- The common laboratory contaminants, acetone and methylene chloride, are not detectable in samples at least 60 percent of the time, and when detected, concentrations are low and/or the associated laboratory blank contained these contaminants

- All of the data, with the exception of the results for samples noted above, showed no volatile organic compounds These data include numerous sampling events, preceding and succeeding the infrequent detections

2 3.3 2 Inorganics

Major Ions in Unconfined Ground Water

All surficial materials wells (except dry wells 51-87, 53-87, and 58-86) in the vicinity of the western group of IHSSs contained some major anions above background The margin above background was small in many cases, and therefore presents only ambiguous evidence of contamination However the occurrences of nitrate significantly above estimated background [maxima of 7 7 milligrams per liter (mg/ℓ) in well 69-86, 55 mg/ℓ in well 68-86, 4 29 mg/ℓ in well 43-87], of chloride and/or sulfate above 100 mg/ℓ in wells 1-87, 52-87, 69-86, 43-87, and 53-87, and total dissolved solids (TDS) above 1000 mg/ℓ in wells 52-87, 43-87, and 69-86, do indicate that anions are significantly elevated in these wells Cyanide was analyzed for wells 52-87, 69-86, and 68-86, and occurred above background in one sample (0 106 mg/ℓ in well 69-86)

Major cations magnesium and sodium are significantly elevated at all of the wells in this group except at wells 68-86 and 54-87 Major cations calcium and potassium are also somewhat elevated at some of these wells

Several surficial wells in the vicinity of IHSSs 119 1, 119 2 and 130 also contained major anions above background (9-74, 10-74, 2-87, 4-87, 6-87, 43-87, 48-87 and 64-86) Wells 9-74 and 10-74 showed the highest concentrations of nitrate (91 2 and 55 mg/ℓ) and these wells had similar concentrations (several hundred mg/ℓ) of other major anions relative to the other wells TDS was typically approximately 2000 mg/ℓ Several of these wells were intermittently dry and therefore the available data cannot provide detailed trends However there is an association between IHSS 119 1 and the highest inorganic constituent results Isopleths of TDS and nitrate (Figures 2-13 and 2-14) for the second quarter of 1989 illustrate this, and are generally consistent with data for other sampling events Major cations calcium, magnesium and sodium were above background in almost all samples in this area

Both of the wells in weathered sandstone which were not persistently dry contained major ions above background TDS was typically just over 2000 mg/ℓ and chloride and sulfate were several hundred mg/ℓ as in the surficial wells, and nitrate was elevated up to ten times background Calcium, magnesium and sodium were slightly above background

Major Ions in Confined Ground Water

The ground water in the deeper wells, in contrast to the unconfined flow system, did not contain a large suite of elevated inorganics in the surficial ground-water system Only well 8-87 with a maximum TDS of 450 mg/ℓ and nitrate at 1 mg/ℓ had anions slightly above background Calcium and magnesium were the only elevated cations in that well

Metals in Unconfined Ground Water

All wells in surficial materials in the vicinity of the western group of IHSSs had some metals above background, but the suite of elevated metals was not consistent spatially or temporally Nickel, strontium, zinc, manganese, mercury and copper each exceeded background in three or more wells, and barium, beryllium, iron, antimony, chromium, lead, aluminum and cadmium occurred slightly above background in one or two wells Nickel, strontium, selenium, zinc and copper exceeded background in several samples from most wells near the eastern group of IHSSs, and several elements exceeded background once or infrequently (aluminum, antimony, barium, cadmium, chromium, cobalt, iron, lead, mercury, molybdenum and potassium)

The concentrations of selenium, strontium, nickel and zinc shown in Figures 2-15 through 2-18 are generally consistent with the patterns of high concentrations of inorganics around IHSS 119 1, although the dry wells and typically low concentrations hinder portrayal of possible patterns in the metals data The data sets for cesium, lithium, molybdenum, and tin are incomplete because the laboratory did not analyze for those elements in many samples Ground water in the weathered bedrock wells contained most of the metals that were elevated in surficial materials as well as lithium in well 5-87 up to 25 times background

Metals in Confined Ground Water

Of the deeper wells in unweathered units, only 8-87 contained metals that were elevated (nickel, strontium, manganese and iron exceeded estimates of background by more than a factor of four) The unweathered sandstone wells exhibited low concentrations for other elements (cadmium, chromium, barium, lithium, iron, mercury, and silver) which were either undetected or extremely low in background samples

Radionuclides in Unconfined Ground Water

Of the wells in surficial materials near the western group of IHSS's, five contained gross-alpha and beta, uranium and tritium above background (wells 1-87, 52-87, 69-86, and 59-86R) Within that group of wells, total uranium was typically less than 30 pCi/ℓ except at well 52-87 (maximum was 64 2 pCi/ℓ) Gross alpha and beta were highest at that well also (70 pCi/ℓ and 76 pCi/ℓ, respectively) The magnitude and frequency of those results suggest possible radionuclide contamination at this location Analytical results for strontium-89,90, cesium-137, and americium-241 were not reported by the laboratory for many samples Occurrences of tritium above background in wells 52-87 and 69-86, and americium and radium-226 in well 52-87 are isolated and just above background Therefore a determination of contamination based on those data is inconclusive

Well 4-87 of the eastern group of wells in surficial materials contained the highest concentrations of radionuclides Maximum gross alpha and beta results were approximately 300 pCi/ℓ, total uranium was approximately 50 pCi/ℓ, and tritium reached 777 pCi/ℓ Wells 9-74, 10-74, 6-87, and 43-87 contained these radionuclides above background, although the maximum levels were much lower than at 4-87 Strontium-89,90 also exceeded background at several of these wells (maximum was 5 6 pCi/ℓ at well 2-87), whereas cesium-137 and radium-226 were just above background in one or two samples Gross alpha and beta, uranium and tritium exceeded background in both weathered sandstone wells, whereas strontium-89,90 was elevated only in well 5-87 The concentrations are lower than in surficial materials with the exception of gross alpha and beta (99 and 91 pCi/ℓ in well 5-87)

Figure 2-19 portrays the distribution of total dissolved uranium in the unconfined ground-water flow system for the second quarter of 1989 The principal feature, elevated uranium concentrations in the vicinity of IHSS 119 1, is consistent with the data available from other sampling periods Because well 49-87 is persistently dry, the extent of contamination between wells 4-87 and 6-87 is unknown

__Radionuclides in Confined Ground Water__

Unweathered sandstone wells had either gross alpha or beta above background, one instance of uranium-235 above background in well 8-87, and one case of radium-226 just above background All other analytes were below background

2 3 3 3 Summary of Ground-Water Contamination

Organic, and possibly major ion, trace metal and uranium contamination exist in ground water within surficial materials and in some bedrock at the 881 Hillside Area Volatile organic contamination is most severe in the eastern portion of the site, and may be derived primarily from IHSS 119 1 The available data suggest that organic contamination is restricted to a small area around that apparent source The volatile organic compounds which were detected in previous investigations of soils and ground water at the 881 Hillside Area have not migrated to the proposed drain location However, toluene, which was not detected in soils during previous investigations, is present in soils along the proposed drain location The ground-water data for the western group of IHSS's show frequently unsaturated conditions that may have mitigated contaminant migration The presence of 1,1,1-TCA at well 1-87 may indicate contamination from an upgradient source or from a sidegradient portion of the 881 Hillside Area (IHSS 145) In either case, further characterization is required Uncertainties regarding the origin of methylene chloride and acetone in ground-water samples (site or laboratory contamination) do not alter the fundamental conclusions listed above and can be clarified with additional planned analyses

Conclusions regarding inorganic contamination are limited by the preliminary nature of background data The preceding sections listed all constituents above background as if each represents contamination On that basis the data indicate distinctly elevated major ions throughout most of the site, and apparent contamination emanating from both the western and eastern portions of the 881 Hillside The extent of such plumes of inorganics at the site has not been delineated by existing data The metals data exceed background more erratically than do the major ions, and offer more ambiguous evidence of contamination emanating from IHSS's It is not currently possible to determine whether this uncertainty is a function of incompletely defined background levels and/or the presence of contaminants from multiple sources The list of elevated constituents includes elements that could be attributed to natural sources in this sedimentary environment (e g selenium, zinc, strontium) as well as elements that may suggest human influence (nickel, beryllium) Radionuclide data are similarly ambiguous However, the uranium concentration in the vicinity of IHSS 119 1 is sufficient impetus for further investigation Interpretation of the extent of elevated uranium must be coordinated with better definition of background conditions Ongoing evaluation of background concentrations and additional data collection at the 881 Hillside will permit more definitive assessment of the influence of Plant operations on ground-water quality

Elevated constituents of all categories have migrated vertically from surficial materials to hydraulically connected upper bedrock units Possible impacts on the bedrock are most significant in the weathered zone

2 3 4 Surface Water

Surface water stations at the 881 Hillside Area are located along the South Interceptor Ditch, Woman Creek, and at various seeps and ponds Nine surface water stations in the vicinity of the 881 Hillside Area were sampled during field activities All available surface water data are compared to second quarter 1989 background data to preliminarily assess if inorganic or radionuclide contamination exist at these stations Section 2 3 1 explains the status of these background data Surface water locations are shown on Figure 2-20, and data are presented in Appendix D

2 3 4 1 South Interceptor Ditch

Surface water stations SW-45, SW-46, and SW-44 are just south of Building 881 SW-45 monitors the foundation drain discharge from Building 881 This water flows into a skimming pond Station SW-44 is the discharge from a pipe draining the skimming pond to the South Interceptor Ditch The foundation drain is a vitrified clay pipe which is buried 14 to 20 feet deep along the western and southern sides of the 881 Building The pipe drains water southward to a common pipe and then into the skimming pond SW-46 is located at a pond formed by ground-water seepage from the 881 Hillside SW-46 is west and hydraulically sidegradient of the skimming pond

Surface water runoff from the 881 Hillside Area flows into the South Interceptor Ditch and then into Pond C-2 Surface water in Woman Creek is routed around Pond C-2, however, water in Pond C-2 is discharged to Woman Creek in accordance with the plant NPDES permit SW-31 monitors water quality in the South Interceptor Ditch just downstream of SW-44 Surface water stations SW-66, SW-67, SW-68, SW-69 and SW-70 monitor the South Interceptor Ditch downgradient from the 881 Hillside

Volatile organics have been detected in samples from SW-45 (Building 881 foundation drain discharge), and at lower concentrations in SW-46 (pond formed by ground-water seepage at 881 Hillside), and SW-44 (discharge to the Interceptor Ditch) The concentration of PCE was 128 $\mu g/\ell$ at SW-45 in May 1987, but was near detection limits and then undetected in subsequent samplings until March 1990 PCE was 23 $\mu g/\ell$ in the last available sample There were isolated instances of toluene (12 $\mu g/\ell$) and CCl_4 (6 $\mu g/\ell$) in late 1987 at this station Samples from SW-46 in May and June 1989 indicate that PCE was present at estimated concentrations below detection limits (3J $\mu g/\ell$ and 2J $\mu g/\ell$, respectively) No other volatile organics were detected in samples from SW-46 SW-44 showed no detectable volatile organic compounds until fourth quarter 1989 (4J $\mu g/\ell$ of TCE), and first quarter 1990 (7 $\mu g/\ell$ of TCE) Methylene chloride and acetone concentrations were low enough to be considered inconclusive evidence of contamination by these organics at SW-44, SW-45, and SW-46

Volatile organics do not appear to be present at surface water stations SW-66, SW-67, SW-68, SW-69 and SW-70 (downgradient of South Interceptor Ditch) Methylene chloride, acetone, and 2-butanone were present between 2 and 38 $\mu g/\ell$ at all the stations, however, these compounds were also present in laboratory blanks Toluene was present in a sample from SW-69 only in August 1989 at a level of 4J $\mu g/\ell$ (also present below detection limits) No other volatile organics were detected in South Interceptor Ditch surface water stations downstream from the 881 Hillside Area

Results of inorganic analyses of surface water samples from these stations indicate that TDS, nitrate, and sulfate concentrations fluctuated above and below background Maximum concentrations were generally within a factor of two above background, however, there was one anomalous nitrate result at SW-44 (424 mg/ℓ) At all other stations maximum nitrate concentrations ranged between 4 and 10 mg/ℓ Dissolved magnesium exceeded background by approximately a factor of two at all the stations whereas dissolved calcium and potassium exceeded background by less than 5 mg/ℓ at stations SW 44, SW-45 and SW-46 Both calcium and magnesium consistently exceeded background when analyzed in unfiltered samples, but the margins above background varied Total potassium exceeded background at most of the stations by less than a factor of two

The following dissolved metals occurred intermittently above background aluminum, beryllium, cadmium, copper, mercury, lead, strontium, zinc, chromium, selenium, and vanadium The list of total metals which exceeded background is the same, except that barium and nickel are also included and copper is excluded Strontium and zinc were the only dissolved trace elements above background at nearly every station, however, total aluminum, barium, iron, strontium, and zinc exceeded the background for metals in suspension at most of the stations Total aluminum tended to exceed background by widely varying margins, reflecting the variable suspended clay content of surface water under different flow conditions Most of the trace metals exceeded background by less than a factor of two, but exceptions are notable For example, mercury was 0 46 mg/ℓ and 0 9 mg/ℓ at stations SW-44 and SW-45 in June 1988

Dissolved radionuclide results are only available for the South Interceptor Ditch stations for spring 1988 and spring 1989 sampling events Dissolved gross alpha, gross beta, uranium, and plutonium exceeded background at stations SW-31, SW-45, SW-66, SW-68, SW-69, and SW-70 during these sampling events Surface water at SW-46 and SW-67 also exceeded background for these constituents except that gross beta was not elevated Only gross alpha and uranium were elevated at SW-44 Gross beta and plutonium were elevated at SW-33 and SW-34, and only plutonium was elevated at SW-32

Total radionuclide results exhibit the same constituents above background, as well as strontium-89, 90, americium, cesium-137, and tritium Although the total radiochemistry results are typically higher than dissolved results as expected, the maximum dissolved plutonium did exceed total plutonium at stations SW-45, SW-66, SW-68, SW-69, and SW-70 Because samples for dissolved and total plutonium are separate grab samples, it is possible that the data reflect the variable colloidal content of different grab samples

2 3 4 2 Woman Creek

Surface water stations SW-32, SW-33, and SW-34 are located on Woman Creek directly south of the 881 Hillside and South Interceptor Ditch and upstream from the 903 Pad Area Volatile organics were not detected in Woman Creek surface water with exception of presumed laboratory contaminants methylene chloride, acetone, and one instance of toluene at SW-32 (12 µg/ℓ) Results of inorganics analyses from these surface water stations were all within tolerance interval values calculated from Round 1 background surface water sampling results Of the dissolved metals, only zinc at SW-32 to SW-34 (maximum 0 072 mg/ℓ), and strontium at SW-32 (0 496 mg/ℓ) were elevated above background Several major and minor elements exceeded background as at the other surface water stations Radiochemistry data for these stations are analogous to those from the South Interceptor Ditch, although total uranium values are typically lower in Woman Creek Plutonium and americium were both just detectable at several of these stations Radium-226 was not analyzed in the Woman Creek samples

2 3 5 Sediments

Bedload sediment samples were collected during 1989 site characterization from creeks and ditches that traverse the Rocky Flats Plant Sediment stations have been established along the Woman Creek drainage downgradient of the 881 Hillside Area All available data for eleven sampling stations are presented in Appendix E Stations SED-28, SED-29, SED-25 are located (in that order) within the South Interceptor Ditch in the Woman Creek drainage, 750 to 3000 feet downstream from surface water station SW-70 These stations are shown in Figure 2-21 SED-31 and SED-30 are seeps on the South Interceptor Ditch berm up- and downstream from station SED-29 SED-27 and SED-26 are along Woman Creek just upstream of Pond C-2 All of these stations are hydraulically downgradient of the 903 Pad Area and therefore may be influenced by that source Data for three, more distant stations are included in Appendix E SED-14 and SED-15 are upstream of the 881 Hillside Area (approximately 3300 and 10,000 feet upstream from SW-36), and SED-01 is downstream of the 881 Hillside and 903 Pad Areas (approximately 9000 feet downstream) The sediment station locations described above do not explicitly address sediments that are at the base of the hillside and upgradient of the 903 Pad Therefore the sediment chemistry results described below will be supplemented with data from new sampling stations in subsequent work to the extent possible (Section 5 0)

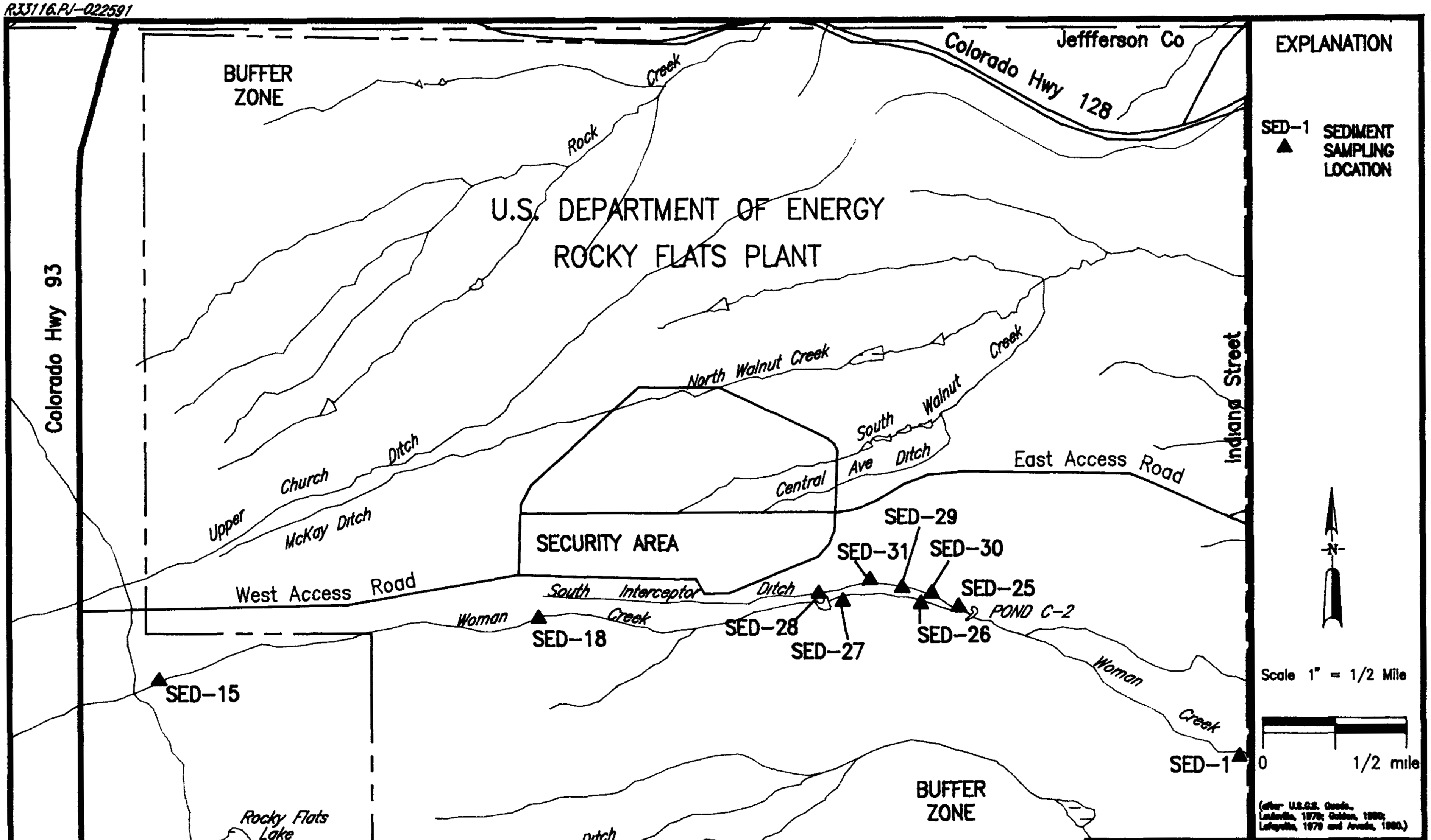
Volatile organic compounds were typically undetected or estimated below detection limits with the following exceptions SED-29 and SED-30 contained 60 μg/kg and 19J μg/kg of chloromethane, respectively SED-01, SED-14, SED-29 and SED-30 contained acetone in one sample at each station (85 μg/kg, 89 μg/kg, 18 μg/kg and 220 μg/kg, respectively) Acetone was present in the blank at the latter station, so the report of 220 μg/kg is of questionable significance Methylene chloride concentrations were 20 μg/kg and 22 μg/kg at SED-01 and SED-27, again associated with contaminated blanks Chloroform was detected at 18 μg/kg in the one sample from SED-31 and the TCE at the same station was 8 μg/kg

Low-level results, all estimated below detection limit, were reported for carbon disulfide at SED-30 (6J μg/kg), 2-butanone at SED-01 (1JB μg/kg), TCE at SED-25, SED-26 and SED30 (5J μg/kg, 3J μg/kg, and 7J μg/kg), toluene at SED-29 and SED-30 (2J μg/kg and 6J μg/kg), and methylene chloride and/or acetone at most stations The presence of acetone at upgradient SED-01, together with the low concentrations and contaminated blanks, demonstrate that the evidence of volatile organic compounds in these sediments is insufficient to prove contamination However, volatile organic contamination is still considered suspect and further investigation is necessary to clarify the ambiguity

Nitrate exceeded background at SED-01, SED-25, SED-26, SED-29, SED-30, and SED-31 The maximum concentration was 8 1 mg/kg at SED-30 Magnesium and potassium were the two major cations above background (5970 mg/kg and 67000 mg/kg, respectively)

Concentrations of beryllium, silver, and tin were the most elevated in the sediment of the South Interceptor Ditch Concentrations of silver were more than five times the upper limit of the background range at SED-25,

R33116.PJ-022591



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

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

SEDIMENT SAMPLING STATION LOCATIONS ASSOCIATED WITH 001

FIGURE 2-21

March, 1991

SED-29 and SED-30 (maximum was 49 1 mg/kg) Beryllium, undetected in background samples, and 2 5 mg/kg in upgradient station SED-15, ranged from 3 8 to 15 5 mg/kg in the South Interceptor Ditch sediments Tin was above background at stations SED-25, SED-26, SED-29 and SED-30, ranging from 364 to 1080 mg/kg

Several other metals exceeded background by smaller margins in one or two samples each from the downgradient stations SED-25 to SED-31, including aluminum, antimony, cadmium, chromium, copper, iron, lead, lithium, magnesium, manganese, mercury, selenium, strontium, thallium, vanadium, and zinc Woman Creek sediment samples, in contrast, contained only mercury and molybdenum above background (0 48 µg/kg of mercury at SED-14, and 40 mg/kg and 42 mg/kg at SED-14 and SED-15, respectively)

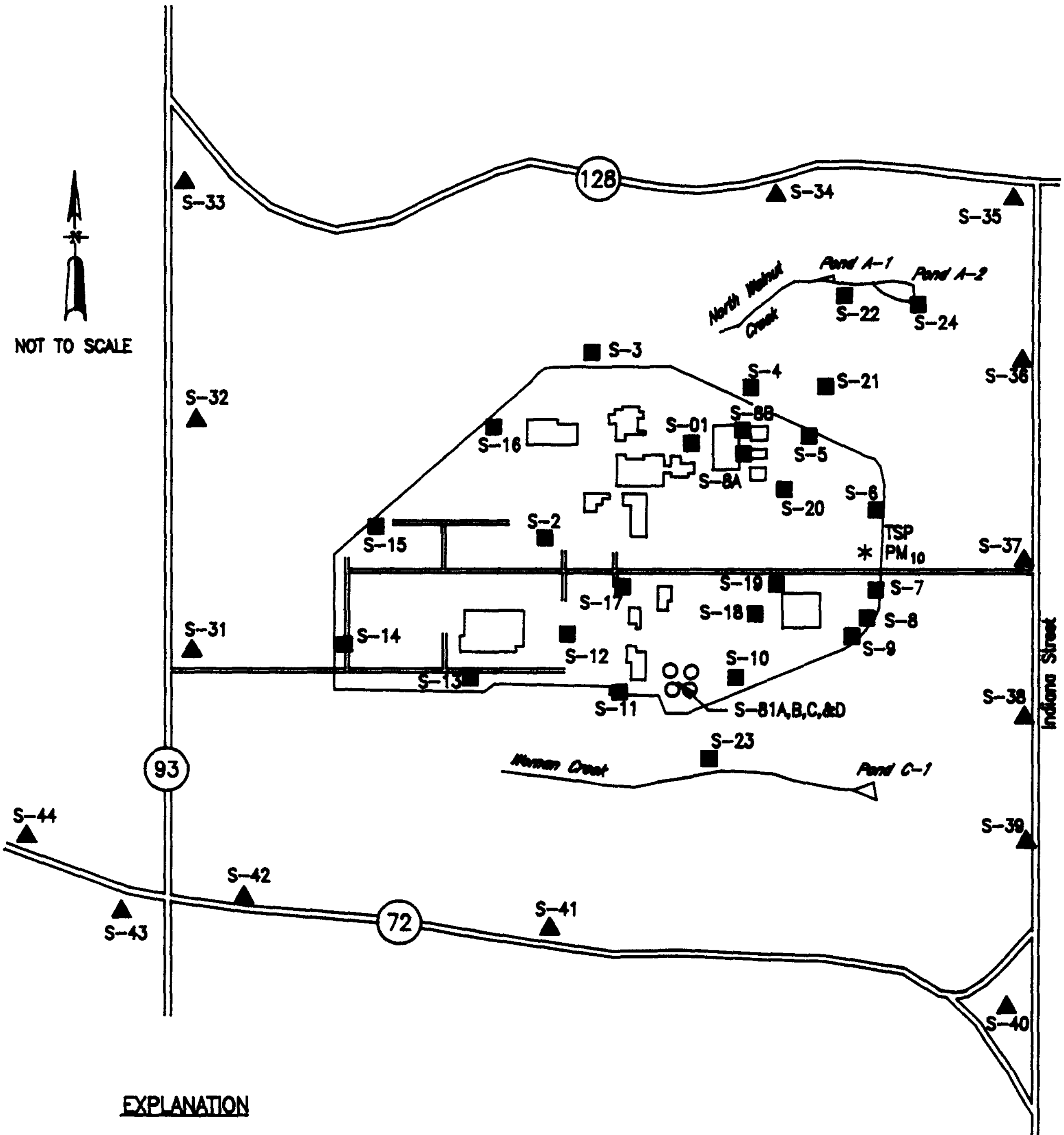
Plutonium was the principle radionuclide above background, occurring at concentrations ranging from 0 08 pCi/g to 3 3 pCi/g at stations SED-25, SED-26, SED-29, SED-30 and SED-31 The presence of plutonium in the sediments is consistent with the soil plutonium contamination found in the 881 Hillside and 903 Pad Areas Other exceedances of background (4 8 pCi/g of total uranium at SED-25, and 77 pCi/g of gross-alpha and 1 3 pCi/g of radium-226 at SED-30) occurred in single samples The Woman Creek sediment samples did not contain plutonium or other radionuclides above background

2 3 6 Air

Results of the continuous radionuclide monitoring program characterizing the air pathway at the Plant are reported in monthly reports and annually in the Annual Environmental Monitoring Reports (e g , Rockwell International, 1975 through 1985, 1986b, 1987b, and 1989c) In addition, the air pathway was further characterized in Rockwell International (1986f)

The Radioactive Ambient Air Monitoring Program (RAAMP) consists of 54 high-volume particulate air samplers which operate continuously (Figure 2-22) Twenty-six of the 54 samplers are within, or directly adjacent to, the Plant security area (on-site samplers), and 14 are located around the property boundary (perimeter samplers) An additional 14 samplers are located in neighboring communities (Figure 2-23)

The 903 Pad Area is recognized as one principal source of airborne plutonium contamination at the Plant (Rockwell International, 1975 through 1985, 1986b, and 1987b) Historically, the particulate samplers located immediately east, southeast, and northeast of the 903 Pad, Mound, and East Trenches Areas have shown the highest plutonium concentrations This finding is corroborated by the results of soil surveys which indicate elevated plutonium concentrations to the east, particularly the southeast of the area However, the RAAMP has found ambient air samples to be well within applicable DOE guidelines for the protection of human health and the environment for all plutonium (Rockwell International, 1987a)



EXPLANATION

- ○ TEMPORARY SAMPLERS
- ▲ PERIMETER SAMPLERS
- ■ ON-SITE SAMPLERS
- * TSP AND PM_{10} CRITERIA MONITORS (Suspended Particulates and Respirable Particulates)

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

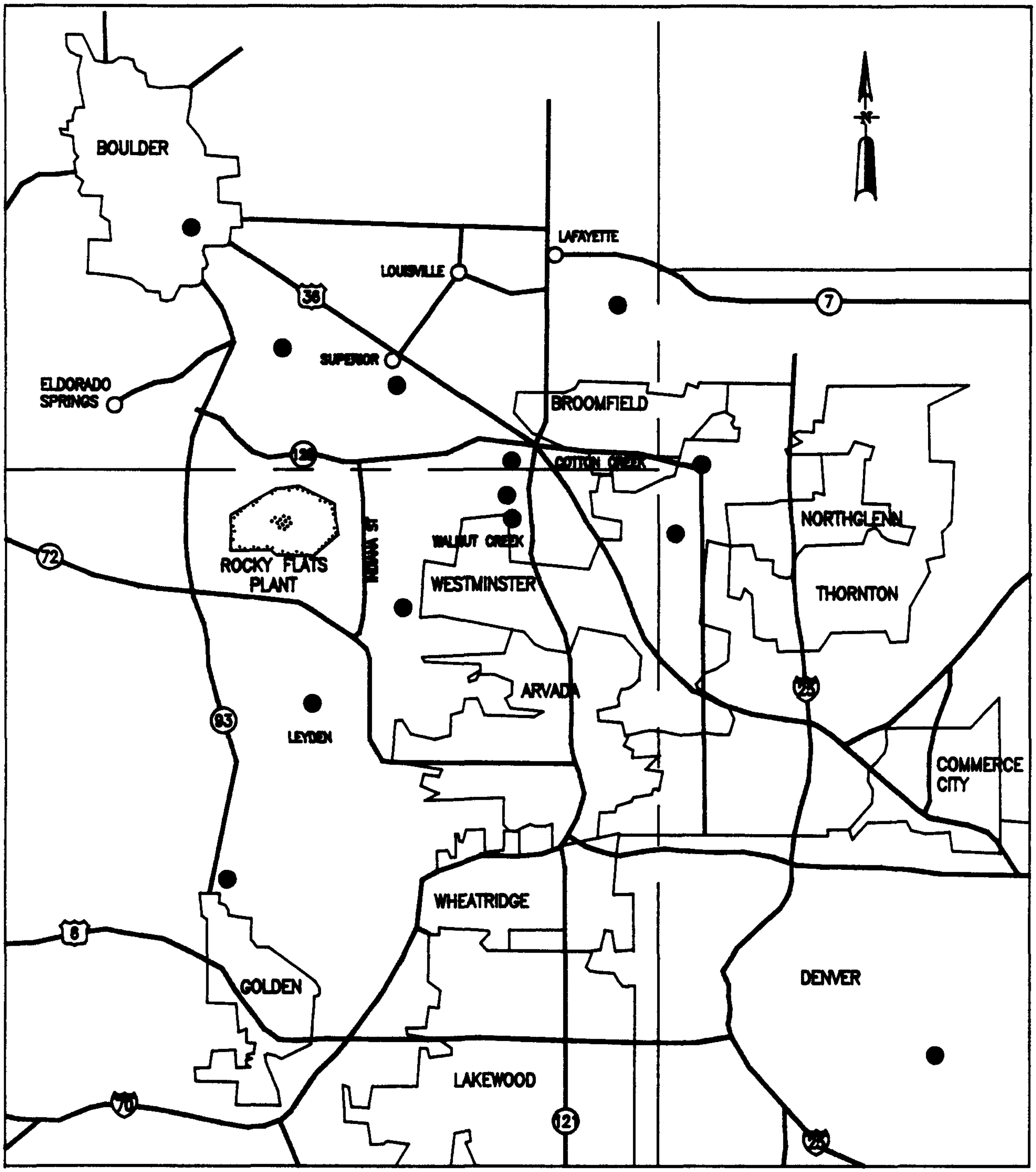
OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

LOCATION OF ON-SITE AND PLANT PERIMETER AMBIENT AIR SAMPLERS

FIGURE 2-22

March, 1991

r33120.pj-022591



NOT TO SCALE

EXPLANATION

● OFF-SITE COMMUNITY AMBIENT AIR SAMPLES (ANALYZED AS MONTHLY COMPOSITES FOR PLUTONIUM-239/240)

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

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

LOCATION OF OFF-SITE COMMUNITY AMBIENT AIR SAMPLERS

FIGURE 2-23

March, 1991

R33119.PJ-022591

During 881 Hillside IM/IRA activities conducted in 1990, four high-volume particulate air samplers were installed on the 881 Hillside for continuous monitoring These are indicated as S-81 A, B, C and D on Figure 2-22, and monitor radionuclide concentrations These stations will be operated until completion of the french drain construction and results are reported in monthly monitoring reports Additional air monitoring was conducted using field instrumentation of photoionization detectors (PID), flame ionization detectors (FID), and Minirams The PID and RID were used to detect volatile organic vapors at the borehole and in the breathing zone during drilling No above background volatile organic vapors were detected during drilling The Miniram is a miniature real-time ambient air monitor that was also used to monitor particulates during operations The Miniram was set up in close proximity to the boring to detect particulate concentrations over the range of 0 01 to 100 milligrams per cubic meter (mg/m^3)

2 3 7 Biota

The biota at the 881 Hillside Area have not specifically been previously studied, however studies on the biota at the 903 Pad, Mound and East Trenches Area have been conducted A survey was conducted for the Final Environmental Impact Statement, Rocky Flats Plant Site (U S DOE, 1980), and previous studies were summarized in the Radioecology and Airborne Pathway Data Summary Report (Rockwell International, 1986f) The Radioecology and Airborne Pathway Data Summary Report addresses the plutonium released from the 903 Drum Storage Site and its effects on the immediate environment Field studies were conducted over several years which compared various biological measurements and pathological data between ecologically similar study areas of widely varying plutonium levels Soil plutonium concentrations were measured along with biological measurements such as vegetation community structure and biomass, litter mass, arthropod community structure and biomass, small mammal species occurrence, population density, biomass, reproduction, and physical size of whole carcasses and organs In addition, pathological examination of small mammals, including x-ray for skeletal sarcomas, microscopy for lung tumors, and necropsy for general pathology and parasite occurrence were carried out Results of the studies showed no evidence of ecological impacts attributable to plutonium Although pathological conditions were found in some rodents, there were no significant pathological differences between control and plutonium contaminated areas Other minor differences in biological attributes for study are as at the Plant site could not be correlated to plutonium levels

Aquatic studies, conducted by Colorado State University, examined phytoplankton, some detritus and small zooplankton uptake of plutonium from the B-series holding ponds This study showed than an "increase in trophic-level concentration of plutonium did not occur apparently due to a selective mechanism that discriminated against plutonium at this level This would result in a decreased potential hazard when considering the transfer of plutonium through ingestion routes", (Paine, 1980)

Other aquatic studies revealed that 77 percent of the plutonium associated with crayfish is found in their exoskeleton Fish flesh and bone from the A and C-series ponds were never above the minimum detectable activity for plutonium

2 4 SITE CONCEPTUAL MODEL

A site conceptual model was developed based on site physical characteristics and the nature and extent of contamination discussed in Sections 2 1 through 2 3 This model is intended to summarize known and suspected sources of contamination, types of contamination, affected media, contaminant migration pathways, and environmental receptors It will be used to assist in identifying sampling needs and potential remedial alternatives The site conceptual model is depicted in Figure 2-24

2 4 1 Contamination Sources and Types

Sources of contamination at the 881 Hillside include radionuclide contaminated surface soils (originated from the 903 Pad Area), and subsurface contaminated soil and buried wastes Plutonium and americium are the principal contaminants of the surface soils Volatile organics, principally TCE, PCE, 1,1,1-TCA, and toluene are the most abundant contaminants of subsurface soils The TCE, PCE, and 1,1,1-TCA originated from historical waste spills and buried wastes The buried wastes also likely contain plutonium, americium, and depleted uranium, although the available data do not show clear evidence of migration of the constituents into surrounding subsurface soils The source of toluene in soils is hypothesized to be Coherex which was used as a dust suppressant/soil stabilizer at the 881 Hillside Area

The three principal volatile organic contaminants are all dense nonaqueous-phase liquids DNAPLs) and therefore have the potential to collect in pools or in fractures in the bedrock at the bottom of the upper hydro-stratigraphic unit If such pools of DNAPLs exist, there is a potential for them to remain as source areas even after the removal of other sources

2 4 2 Potential Release Mechanisms

Radionuclides in surface soils may be released via fugitive dust and wind erosion to the air (Figure 2-25) Once in the air, the contaminated dust will either settle on plants, soils, or water There is considerable evidence supporting this release mechanism as plutonium/americium contaminated soil exists at the 881 Hillside There is also potential for these contaminants to enter other media via surface runoff, infiltration/percolation, and biotic uptake

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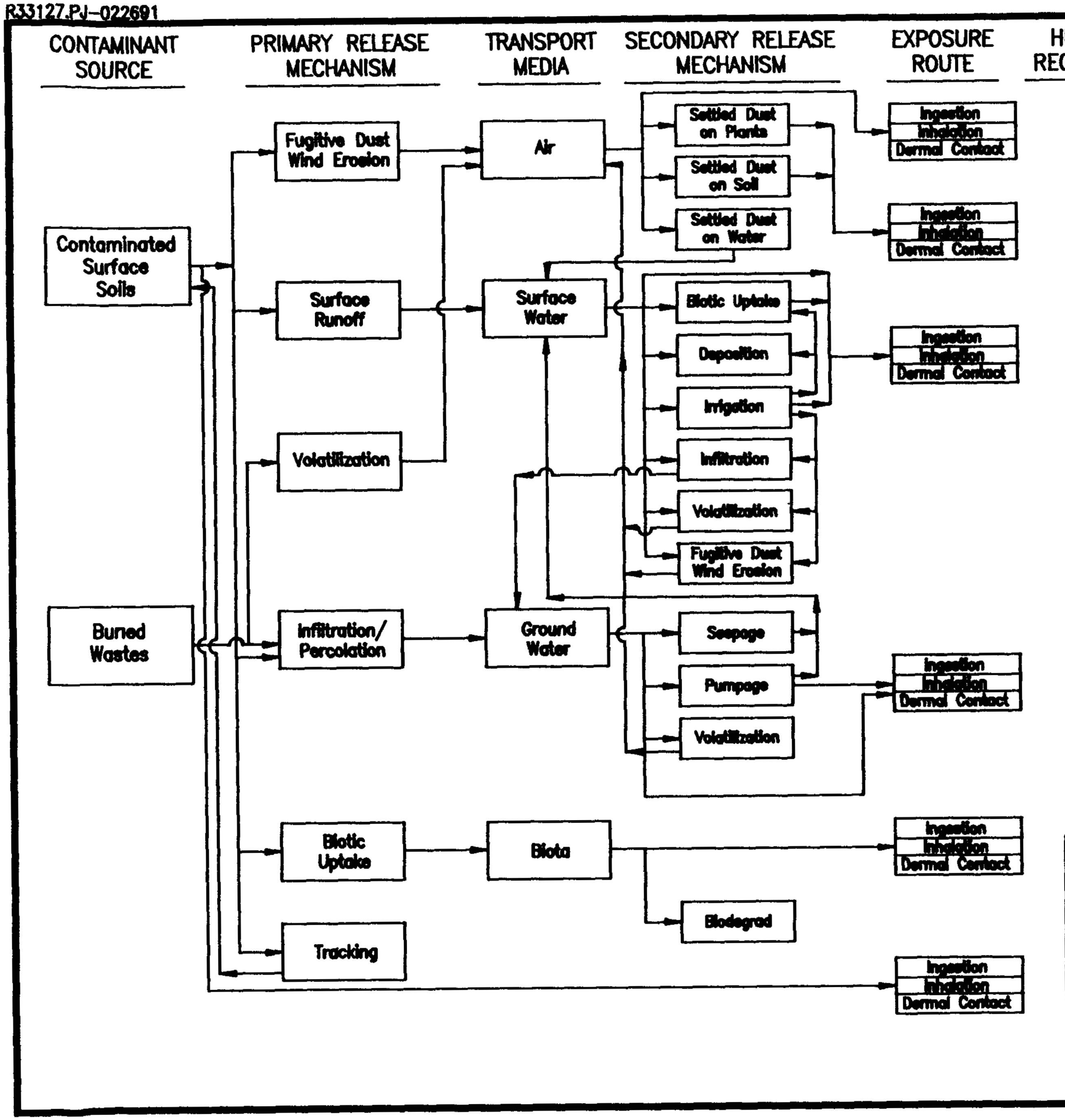

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OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

RISK ASSESSMENT
CONCEPTUAL MODEL

FIGURE 2-25

March, 1991

Contaminants in buried waste can directly enter either the air via volatilization, or the ground water via infiltration/percolation Ground-water quality data indicate contamination in the upper hydrostratigraphic unit including the alluvium, colluvium, siltstone, and weathered bedrock Contamination can also enter surface water through seepage

There is also potential for contaminants in the upper HSU to impact the lower HSU Contaminated alluvial ground water may potentially enter lower sandstones if they subcrop beneath the colluvium on the valley side slopes Another potential mechanism of release into the lower HSU is by leakage through the weathered and unweathered claystone bedrock downward to a lower sandstone layer This release mechanism is judged to have a low probability at this time as a result of the low hydraulic conductivity values reported for the unweathered claystone units However, there is a potential for DNAPLs to infiltrate down through fractures in the bedrock This would be most likely to occur in depressions or low areas in the bottom surface of the upper HSU Although well logs for most pre-1986 wells do not exist, ground-water chemical data and the depth of the wells suggest that these wells may be screened across more than one hydrostratigraphic unit, thus representing another potential mechanism for contaminant release into the lower HSU

2 4 3 Potential Exposure Pathways

Exposure to radionuclides in surface soils can occur through multiple pathways (Figure 2-25) This figure shows all potential pathways, however, the actual pathways of significance will be determined during the risk assessment Of primary importance is exposure through direct inhalation of contaminated dust or by ingestion of contaminated soils An important secondary exposure route is through ingestion of surface water contaminated via runoff

Exposure to contaminants in surface water can occur through direct ingestion or dermal contact, or by consumption of vegetation where biotic uptake has occurred

The primary potential pathways for migration of contaminants through ground-water flow to potential receptors would be either by seepage to the ground surface or by pumping from water supply wells that tap the affected ground water downgradient of the site It should be noted that there are currently no known water supply wells which tap affected ground water Other exposure pathways may include contamination of surface water by the interaction of surface water and ground water

2 4 4 Potential Receptors

Figure 2-25 summarizes the exposure routes and potential receptor populations via the potential exposure pathways described above For each pathway, there are three potential exposure routes ingestion, inhalation, and dermal contact Whether the human receptor is a resident or visitor will be determined during the risk assessment Biota may also be present at or downgradient of seep locations The potential for exposure and magnitude of risk (Figure 2-25) will be assessed during the risk assessment

2 4 5 Summary

The elements of the site conceptual model described above are shown in Figure 2-25 This figure depicts the potential sources of contamination, mechanisms of contaminant release, exposure pathways, and primary receptors The model as pictured is based on an initial evaluation of available data As additional information is obtained, the overall model and specific portions of the model (for example, the lower hydrostratigraphic ground-water flow regime) may be refined or expanded to address the issues of concern

2 5 SAMPLING AND ANALYSIS REQUIREMENTS FOR REMEDIAL ALTERNATIVES EVALUATION

The purpose of this section is to identify potential remedial technologies which are consistent with the available information regarding contamination at the 881 Hillside Area Based on the available site information, the contaminated media or areas for which remedial alternatives will be developed include wastes, soil/sediment, ground water, and surface water The following general remedial response actions were identified for further review and evaluation in the draft FS (Rockwell International, 1988b)

- Complete or partial removal of wastes and contaminated soils
- In-situ contaminated soils treatment
- Ground-water collection
- Infiltration and ground-water containment controls
- In-situ ground-water treatment/immobilization
- Ground-water/surface water treatment
- Treated ground water/surface water disposal

Combinations of these general response actions are appropriate and were evaluated during the draft FS Table 2-21 presents these general response actions along with applicable component technologies

At the time the draft FS was prepared, the extent and nature of contamination at the 881 Hillside Area was not well defined For example, organic contamination of soils may have been underestimated because maximum concentrations occurred in samples not necessarily collected from "hot spots", and the volatile organic data have since been rejected in the validation process The draft FS did not evaluate treatment and/or disposal

TABLE 2-21

RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

GENERAL RESPONSE ACTIONS	ASSOCIATED REMEDIAL TECHNOLOGIES
Complete or Partial Removal of Contaminated Soils	• Off-Site Landfill • On-Site Treatment*/Backfill
In-Situ Contaminated Soils Treatment	• Immobilization (cementation and vitrification) • Soil Flushing • Vapor Extraction • Bioreclamation
Ground-Water Collection	• Well Array • Subsurface Drains
Infiltration and Ground-Water Containment Controls	• Capping • Subsurface Barriers
In-Situ Ground-Water Treatment/ Immobilization	• Immobilization • Aeration • Bioreclamation
Ground-Water/Surface Water Treatment	• Bioreclamation Treatment • UV/Peroxide or UV/Ozone • Air Stripping • Carbon Adsorption • Ion Exchange • Electrodialysis • Reverse Osmosis • Coagulation/Precipitation/Filtration

* Thermal Treatment, Solvent Extraction, Immobilization (Cementation and Vitrification), Attrition Scrubbing for Radionuclide Decontamination

of organic contaminated soil, however, the Phase III RFI/RI may indicate such an evaluation is in order With respect to inorganic contaminants, the draft FS did not evaluate treatment technologies for their removal

Although this was performed for the 881 Hillside interim action (DOE, 1990a), the performance of the interim action treatment system will be important input in reevaluating these technologies for the draft final FS Lastly, inorganic contaminated ground water appears downstream of the interim action collection system designed on the basis of the extent of volatile organic compound contaminated ground water Remedial alternatives that address this issue will be evaluated in the revised FS As shown in Table 2-22, there are specific data requirements that are necessary to evaluate the technologies identified in Table 2-21 These data will provide for a thorough comparative evaluation of all appropriate technologies with respect to implementability, effectiveness, and cost, and allow for informed selection of preferred technologies The Field Sampling Plan (Section 5 0) reflects these information requirements

TABLE 2-22

REMEDIAL TECHNOLOGY DATA REQUIREMENTS

TECHNOLOGY	DATA PURPOSE	DATA NEEDED*
Off-Site Disposal	Evaluate whether material is acceptable for off-site disposal	- Determination of applicable RCRA waste codes (40 CFR Part 261) Determination of corresponding 40 CFR Part 268 requirements to establish necessary testing, if any - Full Suite of Radionuclide Analyses
	Cost Analysis	- Vertical and Horizontal Extent* of Contamination
On-Site Treatment/Backfill		
Thermal Treatment	Effectiveness	- Full Suite of Organic and Inorganic Analyses*
	Cost Effectiveness	- BTU Content - Ultimate Analysis**
Solvent Extraction	Effectiveness	- Soil Type (adsorption characteristics) - Soil Organic Matter Content (adsorption characteristics)
Non In Situ (soils) Immobilization/ Cementation	Determine Viscosity of Grout Material	- Soil Grain Size Distribution (sieve analysis)
Non In Situ (soils) Immobilization/ Vitrification	Effectiveness	- Depth of Contamination - Depth of Water Table - Soil Permeability - Metal Content
Attrition Scrubbing	Effectiveness	- Radionuclide Distribution vs. Soil Grain Size
In Situ Immobilization/Cementation (soils)	Determine Viscosity of Grout Material	- Soil Grain Size Distribution (sieve analysis)
In Situ Immobilization/Vitrification (soils)	Effectivness	- Depth of Contamination - Depth of Water Table - Soil Permeability - Metal Content
Soil Flushing/Bioreclamation	Effectiveness	- Soil Organic Matter Content - Soil Classification - Soil Permeability - BOD
Vapor Extraction	Effectiveness	- Subsurface Geological Characteristics - Depth to Ground Water - Soil Permeability
Well Array/Subsurface Drain	Hydraulic conductivity Storativity (transient flow)	- Aquifer tests - Hydrogeologic characteristics

TABLE 2-22 (Continued)

REMEDIAL TECHNOLOGY DATA REQUIREMENTS

TECHNOLOGY	DATA PURPOSE	DATA NEEDED*
Capping/Subsurface Barriers	Suitability of On-Site Soils for Use	- Gradation (Sieve Analysis) - Atterberg Limits (Plasticity Tests)
	Effectiveness	- Location of Subcropping Sandstones - Hydraulic Conductivity of Bedrock Materials
	Construction Feasibility	- Grade - Depth to Bedrock - % Moisture - Compaction (Proctor) - Permeability (Triaxial Permeability) - Strength (Triaxial or Direct Shear)
Immobilization (Ground Water Contaminants)	Determine Viscosity of Grout Material	- Soil Grain Size Distribution (sieve analysis)
In-Situ Aeration (Ground Water)	Effectiveness	- Subsurface Geological Characteristics - Depth to Ground Water - Soil Permeability
In-Situ Bioreclamation (Ground Water)	Effectiveness	- Soil Organic Matter Content - Soil Classification - Soil Permeability - BOD - Dissolved Oxygen - NO_3, PO_4^3, pH - Microbial Populations
Above Ground Biological Treatment	Effectiveness	- Soil Organic Matter Content - Soil Classification - Soil Permeability - BOD - Full Suite of Organic Analyses
UV Peroxide Oxidation	Process Control	- Iron and Manganese
Air Stripping	Process Control	- Hardness
	Effectiveness	

* The nature and extent of contamination determined through soils and water analyses for the parameters listed in Tables 2-5 and 2-9 is critical to determining the technical feasibility and cost effectiveness of the technologies listed here

** Ultimate analysis is the determination of percent carbon, hydrogen, sulfur, nitrogen, ash, and oxygen by difference
2 for a dried sample

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PHASE III RFI/RI WORK PLAN DATA QUALITY OBJECTIVES

The primary objective of a RI is to collect the data necessary to determine the nature, distribution, and migration pathways of contaminants The RI also supports the evaluation of remedial alternatives (EPA, 1987a) The five general goals of an RI are

1) Characterize site physical features
2) Define contaminant sources
3) Determine the nature and extent of contamination
4) Describe contaminant fate and transport
5) Provide a baseline risk assessment (EPA, 1988b)

Data quality objectives (DQOs) are qualitative and quantitative statements which specify the quality and quantity of data collection required by the RI (EPA, 1987a) Through application of the DQO process, site-specific RI/FS goals are established, and data needs are identified for achieving those goals This section of the RFI/RI Work Plan reviews conclusions from the Phase I and II RFI/RI as a basis for Phase III RFI/RI objectives and identifies data needs to meet the outlined objectives

3 1 SITE SPECIFIC RFI/RI DQO PROCESS

Through application of the DQOs process, site-specific RFI/RI DQOs are established, and data needs are identified for achieving identified goals DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI (EPA, 1987a) These determinations are facilitated through the development of DQOs

DQOs are developed using the following three-stage process

- STAGE 1 - Identify decision types
  - identify and involve data users
  - evaluate available data
  - develop conceptual model
  - specify objectives/decisions
- STAGE 2 - Identify data uses and needs
  - identify data uses
  - identify data types
  - identify data quality needs

- identify data quantity needs
- evaluate sampling/analysis options
- review Precision, Accuracy, Representatives, Comparability, and Completeness (PARCC) parameters

- STAGE 3 - Design data collection program
  - assemble data collection components
  - develop data collection documentation

The three stages are implemented for each phase of the RFI/RI The DQO stages are undertaken in an interactive and iterative manner whereby all the elements of the DQO process are continually being reviewed and applied during the execution of the data collection activities Throughout the RFI/RI, these stages occur in a natural progression and flow together without a formal stage delineation It may not be possible to identify all data needs during the RFI/RI activity Data needs will become more apparent as additional data are obtained and evaluated

3 2 PHASE I AND II RI CONCLUSIONS

Several investigations have been conducted in the vicinity of the 881 Hillside Area to date as discussed in Sections 1 0 and 2 0 General conclusions from these investigations are as follows

1) Surficial materials in the area consist of Rocky Flats Alluvium, colluvium, and valley fill alluvium

2) Bedrock beneath surficial materials consists of Arapahoe Formation claystones and sandstones dipping slightly to the east (less than two degrees) Bedrock materials are weathered below the base of surficial materials

3) Unconfined ground-water flow occurs in surficial materials, subcropping sandstones, and potentially in weathered subcropping claystones The flow system in surficial materials is not fully saturated year round Flow in weathered claystones has not been sufficiently documented, and flow directions in subcropping sandstones are incompletely defined due to the complex sandstone geometries

4) Confined ground-water flow occurs in deeper sandstones The flow system is incompletely defined at this time However, work pertaining to these units is part of an on-going geologic characterization

5) Ground-water recharge occurs as infiltration of incident precipitation and flow from ditches and surface water drainages Recharge to bedrock sandstones also occurs via leakage through overlying claystones

6) Discharge from the unconfined ground-water flow system occurs as evapotranspiration, seeps and springs at the edge of the Rocky Flats pediment, to surface water in Woman Creek and South Interceptor Ditch, and to bedrock sandstones and claystones

7) Wastes have been buried at IHSS 102 (Oil Sludge Pit Site) and IHSS 103 (Chemical Burial Site) In addition, wastes were potentially dumped or discharged at the Liquid Dumping Site (IHSS 104) and Outfall Site (IHSS 106) Organic contaminants have been released from the Hillside Oil Leak Site (IHSS 107), and the Multiple Solvent Spill Site (IHSSs 119 1 and 119 2) Soil contaminated with low levels of plutonium has been disposed of at IHSS 130, however, the Phase I and II RI did not detect radionuclide contamination Releases from IHSS 106 (Outfall Site) and IHSS 105 (Out-of-Service Fuel Oil Tanks) have not been determined based on the Phase I and II RI

8) Boreholes were drilled within and adjacent to IHSSs in the Phase I and II RIs, and soil samples were collected and analyzed for Hazardous Substance List (HSL) organics and metals, radionuclides, and inorganics Volatile chlorinated hydrocarbon contamination is apparently limited to soils in the vicinity of boreholes BH01-87, BH57-87, and BH58-87 However, available data were not validated, and further characterization of soils beneath IHSSs is needed

9) Surficial soils in the area are contaminated with plutonium and americium, possibly due to wind dispersal of these radionuclides from the 903 Pad Area Based on soil sampling results, these compounds appear to be limited to the surface, although further definition of source area(s) and extent of contamination is needed

10) Results of RI surface water and ground-water sampling at the 881 Hillside Area indicate that major ions, trace metals, and radionuclides are present above background Volatile organics are also present in ground water downgradient of the 881 Hillside Therefore, further characterization of contaminant sources and pathways is warranted

11) Ground water in surficial materials contains volatile organic compounds The principal volatile organics present are tetrachloroethene (PCE) and trichloroethene (TCE), but several other compounds are present as well The extent of these contaminants in alluvial ground water has not been fully determined

12) Trace metals including strontium, selenium, nickel, zinc, and others are elevated in the unconfined ground-water flow system Uranium is the principal elevated radionuclide in that system The source and extent of these contaminants has not been defined

13) Elevated uranium has been detected in the South Interceptor Ditch surface water The source of the uranium has not been determined

14) Although the remedial investigations have not provided biological data which specifically address conditions at the 881 Hillside Area, previous studies in that vicinity (903 Pad Area and Plant-wide), indicate non-detectable impacts to biota Considering the locally high concentrations of contaminants and proximity of the 881 Hillside to water and feed for wildlife, further characterization of OU No 1 is needed

3 3 SITE-SPECIFIC PHASE III RFI/RI OBJECTIVES AND ACTIVITIES

Based on the Phase I and II RI conclusions and the conceptual site model presented in Section 2 0, the site-specific Phase III RFI/RI objectives and associated data needs have been developed (Table 3-1) Specific plans for obtaining the needed data are presented in Section 5 0 (Field Sampling Plan)

TABLE 3-1

PHASE III RFI/RI OBJECTIVES AND ACTIVITIES

Objective	Activity
Characterize Site Physical Features	
1) Determine the extent of saturation and ground-water flow directions for the unconfined flow system both spatially and temporally	• Install additional monitoring wells and piezometers • Maintain and utilize the Rocky Flats Environmental Database System (RFEDS) for water level data from which potentiometric surface maps, saturated thickness maps, cross sections, and hydrographs can be prepared
2) Describe the interaction between the surface water and ground-water pathways	• Compare water levels and water quality data from surface water sampling locations and ground-water monitoring wells to evaluate the interconnection between these two media Data analysis will also rely on ground-water flow directions and seep locations
3) Quantify material properties	• Perform aquifer tests to develop hydraulic conductivity and storage coefficient values for surficial materials
4) Describe all soils and rock materials	• Implement field logging program utilizing EG&G's SOPs
5) Verify the hydrogeologic site conceptual model for OU No 2 presented in Section 2 4	• Integrate site-wide geologic and geophysical studies with hydrogeologic data from OU No 1
Characterize Contaminant Sources	
1) Characterize the nature and distribution of waste materials remaining on-site	• Collect samples from boreholes drilled directly through IHSSs where possible Collect waste samples as well as soil samples from beneath the wastes Analyze samples for TCL volatiles, semi-volatiles, and pesticides/PCBs, TAL metals, as well as radionuclides and inorganics
2) Characterize soils beneath wastes as well as soils at sites where wastes have been removed as potential contaminant sources	• Same as above
3) Identify which sites or subareas of sites are sources of contaminants in ground water	• Install alluvial ground-water monitoring wells directly beneath sites to assess ground-water levels and quality • Install alluvial ground-water monitoring wells directly up- and downgradient of each site to pinpoint the source of contaminants

TABLE 3-1 (Continued)

PHASE III RFI/RI OBJECTIVES AND ACTIVITIES

Objective	Activity
Characterize the Nature and Extent of Contamination	
1) Determine the horizontal and vertical extent of surficial radionuclide soil contamination due to wind dispersion	• Collect surficial soil scrapes in the study area following Colorado Department of Health sampling procedures and analyze for radionuclides • Sample vertical soil profiles and analyze for radionuclides
2) Determine the nature and extent of ground-water contamination in surficial materials	• Install alluvial ground-water monitoring wells in surficial materials located between areas of known ground-water contamination and areas with no ground-water contamination to delineate the extent Collect ground-water samples and analyze for TCL volatiles, semi-volatiles and pesticides/PCBs, Target Analyte List (TAL) metals, radionuclides, and inorganics
3) Determine the location and extent of weathered and unweathered sandstone units and associated contamination	• Install bedrock monitoring wells in new boreholes in which sandstones are encountered This will include boreholes which were initially planned for installing alluvial wells, as well as selected boreholes planned specifically to seek sandstone Produce east-west and north-south geologic and water-level cross-sections as data permit Collect ground water samples and analyze for TCL volatiles, semi-volatiles and pesticides/PCBs, TAL metals, radionuclides and inorganics
4) Characterize surface water quality	• Continue collection of surface water from existing monitoring stations on a quarterly basis Establish sediment stations directly associated with the 881 Hillside as sediment availability permits Analyze samples for TCL volatiles, TAL metals, radionuclides, and inorganics Analyze surface water samples for both dissolved and total metals and radionuclides to determine if constituents are suspended or dissolved Continue routine flow rate measurements at surface water stations

TABLE 3-1 (Continued)

PHASE III RFI/RI OBJECTIVES AND ACTIVITIES

5) Characterize radionuclides in Woman Creek sediments	• Continue collection of surface water from existing monitoring stations on a quarterly basis Establish sediment stations directly associated with the 881 Hillside as sediment availability permits Analyze samples for TCL volatiles, TAL metals, radionuclides, and inorganics Analyze surface water samples for both dissolved and total metals and radionuclides to determine if constituents are suspended or dissolved Continue routine flow rate measurements at surface water stations
6) Identify and implement data management procedures	• Maintain the RFEDS for all data collected during the Phase III RFI/RI Utilize this database system to evaluate resulting data
7) Collect data of sufficient quality to facilitate development of a site conceptual model and comparison to ARARs	• Adhere to the Rocky Flats Plant ER Program QAPjP, GRRASP, and the site specific QAA
Provide A Baseline Risk Assessment	
1) Describe contaminant fate and transport	• Use existing literature and field data to describe the physicochemical processes associated with site contaminants Incorporate Phase III results into risk analysis
2) Assess the threat to public health and the environment from the no action remedial alternative	• Prepare a baseline risk assessment as part of the RI data analysis based on Phase I, II, and III RI

High quality data will be collected by following the Rocky Flats Plant ER Program Standard Operating Procedures (SOPs) (EG&G, 1990g) and through adherence to the Rocky Flats Plant ER Program Quality Assurance Project Plan (QAPjP) (EG&G, 1990h), the General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1990i) and the site-specific Quality Assurance Addendum (QAA) Organic and metal analyses will be performed using CLP routine analytical services (RAS), and other analyses (radionuclides and inorganics) will be performed in accordance with the GRRASP-specified methods In addition, analytical methods with detection limits below or near chemical-specific ARARs are presented in Section 7 0 (Table 7-1) and will be used to facilitate comparison of resulting data to ARARs

4.1 REMEDIAL INVESTIGATION TASKS

4 1 1 Task 1 - Project Planning

The project planning task includes all efforts required to initiate this Phase III RFI/RI of OU No 1 Activities undertaken for this project have included detailed review of the Phase I and II RI results, responses to EPA comments on the FS and Phase II RI (Rockwell International, 1989a), responses to DOE comments on the FS, responses to EPA and CDH comments on the draft RI/FS work plan, historical aerial photography, preliminary results of the French Drain Geotechnical Investigation, and preliminary evaluation of ARARs Results of these activities are presented in Sections 1 0 (Introduction) and 2 0 (Site Evaluation)

Two project planning documents, including this Work Plan, have been prepared which pertain to this Phase III RFI/RI as required by the draft IAG between DOE, EPA, and CDH This Work Plan presents results of the project planning task in addition to plans for the Phase III RFI/RI A Field Sampling Plan (Section 5 0) presents the locations, media, and frequency of sampling efforts The second document required by the IAG is a Sampling and Analysis Plan (SAP) The IAG specifies that the SAP is to include a QAPjP and SOP for all field activities A draft QAPjP for site-wide RCRA and CERCLA activities (EG&G, 1990h) was submitted to the regulatory agencies in August 1990 A GRRASP (EG&G, 1990i) has also been prepared which is the scope of work for analytical services The current Rocky Flats Plant SOPs were submitted to EPA and CDH in August 1990 (EG&G, 1990g) The OU No 1 QAA is being submitted to the agencies with this RFI/RI Work Plan A Health and Safety Plan (HSP) defining the protocol for protection of field workers during Phase III operations will be submitted as well The HSP will be based on the Health and Safety Program Plan currently being finalized based on comments from EPA and CDH

4 1 2 Task 2 - Community Relations

In accordance with the draft IAG, the Rocky Flats Plant is developing a Community Relations Plan (CRP) to inform and actively involve the public in decision-making regarding environmental restoration activities The plan will address the needs and concerns of the surrounding communities as identified through approximately 80 interviews with state and local elected officials, business leaders, medical professionals, educational representatives, interest groups, media and residents adjacent to the Plant

The draft Community Relations Plan was submitted to EPA and CDH for review in November 1990 in accordance with the draft IAG schedules Accordingly, the site-specific CRP is not required for OU No 1

Following review by EPA and CDH, the proposed plan will be distributed for public review and comment in January 1991 The proposed CRP is scheduled for finalization in August 1991

During the February 1990 public hearing on the IAG, several commentors requested the development of an interim CRP for implementation until the final plan is available in August 1991 This draft Interim Community Relations Plan was prepared and was implemented in January 1991, pending finalization of the proposed plan

Current community relations activities concerning environmental restoration include participation by Plant representatives in informational workshops, meetings of the Rocky Flats Environmental Monitoring Council, briefings for citizens, businesses and surrounding communities on environmental restoration and monitoring activities, and public comment meetings on various ER Program plans and actions

In addition, a Speakers Bureau provides Plant speakers to civic groups and educational organizations, and a public tours program allows the public to visit the Rocky Flats Plant The Plant also produces fact sheets and updates on environmental restoration activities for public information and responds to numerous public inquiries concerning the Plant

4 1 3 Task 3 - Field Investigation

The Phase III RFI/RI field investigation is designed to meet the objectives outlined in Section 3 2 The following activities will be performed as part of the field investigation

- Drill and sample soils, bedrock materials, and wastes within IHSSs
- Sample surficial soils for radionuclides and subsurface soils for radionuclides, TCL volatiles, semi-volatiles, and pesticides/PCBs, TAL metals, and inorganics
- Install and sample ground-water monitoring wells
- Perform aquifer tests, tracer tests, and geotechnical tests
- Collect surface water and sediment samples
- Take water level measurements, stream flow measurements, and ground-water quality parameters

Sample locations, frequency, and analyses are presented in Section 5 0 All field activities will be performed in accordance with the Rocky Flats Plant ER Program SOP (EG&G, 1990g)

4 1 4 Task 4 - Sample Analysis and Data Validation

Analytical methods for chemical analyses are provided in the GRRASP (EG&G, 1990l) Also provided in this document are the analytical detection limits

Data will be reviewed and validated by the EG&G Environmental Monitoring and Assessment Division laboratory validation subcontractor Results of data review and validation activities will be documented in data validation reports and the RFI/RI report EPA data validation functional guidelines will be used for validating organic and inorganic (metals) data (EPA, 1988a) Validation methods for radiochemistry and major ions data have not been published by the EPA, however, data and documentation requirements have been developed by ER Department The functional guidelines which will be used to evaluate analytical data are presented in the QAPjP (EG&G, 1990h) and GRRASP (EG&G, 1990l)

4 1 5 Task 5 - Data Evaluation

Field and laboratory data collected during the Phase III RFI/RI will be incorporated into the Rocky Flats Environmental Database System (RFEDS) and used to better define site characteristics, source characteristics, the nature and extent of contamination, and contaminant migration rates The RFEDS is used to track, store, and retrieve project data Data will be input to the RFEDS via diskettes subsequent to data validation as outlined in the ER Program QAPjP (EG&G, 1990l) Hardcopy reports will then be generated from the system for data interpretation and evaluation

4 1 5 1 Site Characterization

Geologic and hydrologic data will be incorporated into existing site maps and cross sections Geologic data will be used to evaluate in detail the sedimentology and depositional framework of surficial materials and weathered bedrock Paleochannel trends and potential contamination pathways will be further delineated Hydrologic data will be used to evaluate seasonal variations in water levels, ground-water flow, and the extent of saturated surficial materials Also evaluated will be hydraulic conductivity, ground-water velocity, contaminant migration rates, and the interaction between ground water and surface water Site-wide geologic and geophysical study results will also be incorporated with available data for OU No 1 to develop a hydrogeologic site conceptual model

4 1 5 2 Source Characterization

Analytical data from source boreholes will be used to

- Verify IHSS locations

- Characterize the nature of source contaminants
- Characterize the lateral and vertical extent of source contaminants
- Determine the maximum on-site contaminant concentrations for input to the risk assessment
- Quantify the volume of source materials

4 1 5 3 Nature and Extent of Contamination

Analytical data from soil, sediment, ground-water, and surface water sampling efforts will be used to characterize the nature and extent of contamination The criteria for the identification of contamination will be analyte specific For organic compounds, any detectable concentrations in samples that are not attributable to laboratory contamination [defined according to CLP protocol (EPA, 1988a)] will be considered likely evidence of contamination Unvalidated or invalid data will be considered qualitative estimates of contamination only For inorganic compounds (including radionuclides) only those concentrations which exceed expected concentrations in background shall constitute evidence of contamination The statistical techniques which will be used to compare concentrations of inorganic compounds collected as part of the Phase III RFI/RI to background concentrations are documented in the Background Geochemical Characterization Report (Rockwell International, 1989d) Essential to the implementation of these statistical techniques for ground-water and borehole samples is the classification of each analytical datum by an appropriate geologic unit (such as Rocky Flats Alluvium or colluvium) This identification of the appropriate geologic unit will be based on geological data collected during the Phase III RFI/RI

The extent of contamination will be delineated through the use of contaminant isopleths maps and possibly cross sections The possibility of using kriging to contour the isopleths of the most widely distributed contaminants will be investigated with explicit attention to the assumptions required by kriging (Davis, 1986), and kriged contours will be generated only if appropriate Investigations to date indicate difficulty in identifying the source of contamination because of the close proximity of several possible sources The statistical technique of principal component analysis will be investigated as a method of identifying the releases from different sources The ability to estimate the individual effects of multiple sources at intermediate sampling sites will aid in the mapping of plumes and in the understanding of contaminant transport by the ground-water flow system

Comparisons of hydrogeologic and chemical data for ground water and surface water will be made to investigate the movement of contaminants from one pathway to another Temporal variations of contaminant concentrations in ground water and surface water will be evaluated both for seasonality and long-term trends to determine contaminant migration rates

Analytical data from surficial soil scrapes and vertical soil profiles will be evaluated in order to characterize the areal and vertical distribution of plutonium and americium contamination at the 881 Hillside Area

4 1 6 Task 6 - Baseline Risk Assessment

A baseline risk assessment will be prepared for the 881 Hillside Area as part of the Phase III RFI/RI to evaluate the potential threat to the public health and the environment in the absence of remedial action A risk assessment was previously prepared as part of the draft FS (Rockwell International, 1988b) The baseline risk assessment will evaluate data collected during Phase III and use information, as appropriate, developed in the original risk assessment The baseline risk assessment will provide the basis for determining whether or not remedial action is necessary in the area and serve as the justification for performing remedial action (EPA, 1988b) The risk assessment will assume no institutional controls

Several objectives will be accomplished under the risk assessment task including identification and characterization of the following (EPA, 1988b)

- Toxicity and levels of hazardous substances present in relevant media (e g , air, ground water, soil, surface water, sediment, and biota)
- Environmental fate and transport mechanisms within specific environmental media and cross-media fate and transport where appropriate
- Potential human and environmental receptors
- Potential exposure routes and extent of actual or expected exposure
- Extent of expected impact or threat, and the likelihood of such impact or threat occurring (i e , risk characterization)
- Level(s) of uncertainty associated with the above

The public health risk assessment and the environmental evaluation will be performed in accordance with EPA and other guidance documents listed in Table 4-1 The risk assessment will address the potential public health and environmental impacts associated with the site under the no-action alternative (no remedial action taken) This assessment will aid in the selection of site remedies based on the contaminants of concern and the environmental media associated with potential risks to public health and the environment

4 1 6 1 Public Health Evaluation

The risk assessment process is divided into four tasks (EPA, 1988b), including

- Contaminant identification

TABLE 4-1

EPA GUIDANCE DOCUMENTS WHICH WILL BE CONSULTED IN THE RISK ASSESSMENT TASK

- EPA's Integrated Risk Information System (IRIS) -- Office of Research and Development (continuously updated) Agency's primary source of chemical-specific toxicity and risk assessment information Includes narrative discussion of toxicity database quality and explains derivation of Reference Doses, cancer potency factors, other key dose response parameters IRIS presents information that updates data originally presented in Exhibits A-4 and A-6 of the SPHEM (see below) Further information IRIS Users Support, 513-569-7254 (EPA, continuously updated)

- Health Effects Assessment Summary Tables (HEAST) -- Office of Research and Development/Office of Emergency and Remedial Response (updated quarterly) Since the IRIS chemical universe (while growing), is currently incomplete, the HEAST has been produced to serve as a "pointer" system to identify current literature and toxicity information on important non-IRIS chemicals While HEAST data in some cases may be "Agency-verified", the information is considered valuable for Superfund risk assessment purposes Available from Superfund docket, 202-382-3046 (EPA, updated quarterly)

- Exposure Factors Handbook -- Office of Research and Development (March 1989), EPA/600/8-89/043 Provides statistical data on the various factors used in assessing exposure, recommends specific default values to be used when site-specific data are not available for certain exposure scenarios Further information Exposure Methods Branch, 202-382-5988 (EPA, 1989b)

- Superfund Public Health Evaluation Manual (SPHEM) -- Office of Emergency and Remedial Response The current program risk assessment guidance manual Explains how to conduct a baseline site risk assessment, set preliminary remediation goals, and evaluate risks of remedial alternatives

- Superfund Exposure Assessment Manual (SEAM) -- Office of Emergency and Remedial Response (April 1988), EPA/540/1-88/001 Provides a framework for the assessment of exposure to contaminants at or migrating from hazardous waste sites Discusses modeling and monitoring* (EPA, 1988c)

- Risk Assessment Guidance for Superfund -- Environmental Evaluation Manual, Interim Final (RAGS-EEM) -- Office of Emergency and Remedial Response (March 1989), EPA/540/1-89/001A Provides program guidance to help remedial project managers and on-scene coordinators manage ecological assessment at Superfund sites (EPA, 1989d)

- Superfund Risk Assessment Information Directory (RAID) -- Office of Emergency and Remedial Response (November 1986), EPA/540/1-86/061 Describes sources of information useful in conducting risk assessments Currently under revision *

- OSWER Directive on Soil Ingestion Rates -- Office of Solid Waste and Emergency Response (January 1989), OSWER Directive #9850 4 Recommends soil ingestion rates for use in risk assessment when site-specific information is not available Available from Darlene Williams, 202-475-9810 (EPA, 1989e)

- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Part A, Interim Final -- Office of Emergency and Remedial Response This volume provides updated risk assessment procedures and policies, specific equations and variable values for estimating exposure, and a hierarchy of toxicity data sources There is an expanded chapter on risk characterization to help summarize information for the decision makers and detailed descriptions of uncertainties in risk assessment (EPA, 1989a)

TABLE 4-1 (Continued)

EPA GUIDANCE DOCUMENTS WHICH WILL BE CONSULTED IN THE RISK ASSESSMENT TASK

- CERCLA Compliance With Other Laws Manual -- Office of Emergency and Remedial Response The guidance is intended to assist in the selection of on-site remedial actions that meet the ARARs of the RCRA, Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Clean Air Act (CAA) and other federal and state environmental laws as required by CERCLA, Section 121 (EPA, 1988d)

- Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA -- Office of Emergency and Remedial Response EAA/540/G-89/004 This guidance document is a revision of the U S EPA's 1985 guidance It describes general procedures for conducting an RI/FS (EPA, 1988b)

- Ecological Assessment of Hazardous Waste Sites, a Field and Laboratory Reference -- Office of Solid Waste and Emergency Response EPA 600-3/89/013 This report is a field and laboratory reference document that provides guidance on designing, implementing, and interpreting ecological assessments of hazardous waste sites It includes sections on ecological endpoints, field sampling design, quality assurance, aquatic and terrestrial toxicity and field survey methods, recommended biomarkers, and data analysis (EPA, 1989c)

* Available from Center for Environmental Research Information, 513-569-7562

- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty Analysis

The task objectives and description of work for each task are described below

Contaminant Identification

The objective of contaminant identification is to screen the information that is available on hazardous substances or wastes present at the site and to identify contaminants of concern to focus subsequent efforts in the risk assessment process Previous work characterizing the environment at the Rocky Flats Plant and the surrounding area has been done Additional sampling and analysis of various media will take place in order to support the human health risk assessment, the ecological assessment and to further characterize the site For this risk assessment, all chemicals detected above background concentrations in site-associated media at OU No 1 will be treated as site contaminants for the purpose of public health evaluation Determination that a chemical is above background is discussed in Section 2 3 1, however, it is noted that the latest Background Geochemical Characterization Report available when the Phase III RFI/RI Report is prepared will be used in this analysis The chemical contaminants will include

- Chemicals positively identified in one or more samples in a given medium
- Chemicals which have been tentatively identified and have historically been associated with the site or confirmed by special analysis

The potential transformation products of site-associated chemicals will be considered to the extent possible by the availability of chemical-specific transformation data and information regarding site specific environmental conditions (e g , potential for biodegradation)

All chemicals present below background will be eliminated from further consideration In addition, after the completion of the exposure assessment, any site contaminants which appear to have no potential for exposure will not be evaluated All chemicals that are deleted and the rationale for their deletion will be discussed

Exposure Assessment

The objectives of the exposure assessment are to identify actual or potential exposure pathways, to characterize potentially exposed populations, and to determine the extent of exposure A conceptual model for exposure assessment is shown in Figure 2-16 An exposure pathway is comprised of four elements

- A source and mechanism of chemical release to the environment
- An environmental transport medium or media (e g , air, ground water) for the released constituent.
- A point of potential contact of humans or biota with an affected medium (the exposure point)
- An exposure route (e g , inhalation of contaminated dust) at the exposure point

The exposure assessment process will include the following actions

- Analyze the probable fate and transport of compounds for both the present and the future uses
- Identify the human populations in the area, typical activities that would influence exposure, and sensitive population subgroups
- Identify potential exposure pathways under current and future land use conditions
- Develop exposure scenarios for each identified pathway and select those scenarios that are plausible
- Identify scenarios assuming both existing and potential future uses
- Identify the exposure parameters to be used in assessing the risk for all scenarios
- Develop an estimate of the expected exposure levels from the potential release of contaminants

Appropriate exposure scenarios will be identified for the site Scenarios which could potentially be considered include residential, commercial/industrial, and/or recreational Factors to be examined in the pathway and receptor identification process will include

- Location of contaminant source
- Local topography
- Meteorology
- Local geohydrology/surface water hydrology
- Surrounding land use
- Local water use
- Prediction of contaminant migration
- Persistence and mobility of migrating contaminants

For each migration pathway and for current and future conditions, receptors will be identified and characterized Potential receptors will be defined by the appropriate exposure scenarios

To assess the potential adverse health effects associated with access to the site, the potential level of human exposure to the selected chemicals must be determined Intakes of exposed populations will be calculated separately for all appropriate pathways of exposure to chemicals Then for each population-at-risk, the total chronic intake by each route of exposure will be calculated by adding the intakes from each pathway Total oral, inhalation, and dermal chronic exposures will be estimated separately Chronic daily intakes will be calculated based on the upper 95 percent confidence limit of the exposure data

In general, chemical intakes will be estimated using available region-specific exposure parameters developed by the EPA. Any deviation from these parameters will be documented and submitted to the regional EPA office for approval prior to preparation of the risk assessment

Toxicity Assessment

In accordance with EPA's risk assessment guidelines, the projected concentrations of all chemicals above background at exposure points will be compared with ARARs to judge the degree and extent of risk to public health and the environment (including plants, animals, and ecosystems) Because many ARARs do not exist for certain media (such as soils) nor are all ARARs necessarily health based, this comparison is not sufficient in itself to satisfy the requirements of the risk assessment process Moreover, receptors may be exposed to contaminants from more than one medium so that their total doses might exceed risk reference doses (RfDs) and/or might result in an excess cancer risk greater than an acceptable target risk as defined by EPA (i e , 10^{-6} to 10^{-4}) Nevertheless, the comparison with standards and criteria is useful in defining the exceedance of institutional requirements Aside from the ARARs discussed in Section 7 0, the following criteria will be examined

- Drinking water health advisories
- Ambient water quality criteria for protection of human health
- Center for Disease Control and Agency for Toxic Substances and Disease Registry soil advisories
- National Ambient Air Quality Standards

Critical toxicity values (e g , numerical values derived from dose-response information for individual compounds) will be used in conjunction with the intake determinations to characterize risk Toxicity reference values from EPA's IRIS will be used in preference to other EPA reference values

A summary of any toxicological studies performed will be provided for all chemicals above background in the baseline risk assessment The quality of these studies and their usefulness in estimating human health risks will be described A more detailed explanation of the toxic effects of target chemicals will be provided in the appendices to the human health risk assessment and the environmental evaluation Toxicity reference values will also be summarized For the human health risk assessment, this will include a brief description of the studies upon which selected reference values were based on analysis of the uncertainty factors used to calculate RfDs, and an analysis of the EPA weight-of-evidence classification for carcinogens For those chemicals without EPA toxicity reference values, a literature search, including computer data bases, will be conducted for selected chemicals A toxicity value will then if possible, be derived from this information EPA and CDH will be consulted regarding the appropriateness of the data and the methodologies to be used in deriving reference values Uncertainties regarding the toxicity assessment will be discussed

Two different types of critical toxicity values will be used

- RfDs for chronic exposure
- The slope factor (for carcinogenic chemicals only)

Risk Characterization

Risk characterization involves integrating exposure assumptions and toxicity information to quantitatively estimate the risk of adverse health effects Risk characterization will be performed in accordance with EPA guidance

Noncarcinogenic risk will be evaluated by comparison of contaminant intakes at exposure points to chronic reference doses for protection of human health Carcinogenic risk will be quantified using slope factors Risk will be qualitatively evaluated for those contaminants for which quantitative evaluation is not possible

The results of the baseline risk assessment will be used to define and evaluate the remedial alternatives during the FS

Uncertainty Analysis

An uncertainty analysis will be performed to identify and evaluate non-site and site specific factors that may produce uncertainty in the risk assessment, such as assumptions inherent in the development of toxicological endpoints (potency factors, reference doses), and assumptions considered in the exposure assessment model (input variability, population dynamics) First order or statistical sampling (Monte-Carlo) techniques may be employed The goal of this task will be to quantify, to the extent practicable, the magnitude and extent of uncertainty propagated through the risk assessment process The uncertainty analysis will present the spectrum of potential risks under specified scenarios so the risk management decision-maker can obtain an understanding of the level of confidence associated with all estimates of potential human health risk The uncertainty analysis will quantify, to the extent practicable, the impact of uncertainties in the risk assessment This may include application of uncertainty analysis techniques such as propagation of errors (i e , first order analysis) or numerical methods such as Monte Carlo Analysis Moreover, site-specific factors which may produce uncertainty will also be discussed

4 1 6 2 Environmental Evaluation

The principal objective of the environmental evaluation for OU No 1 is to assess impacts to the environment (biota), especially sensitive habitats and species protected under the Endangered Species Act and other applicable regulations, under the "no-action" remedial scenario The environmental evaluation will be conducted according to guidance in the "Risk Assessment for Superfund, Volume II, Environmental Evaluation Manual" (EPA, 1989d) and other pertinent guidance, as available Previous environmental studies, as well as soil, sediment, and surface water data collected during this RI will be used in the environmental evaluation Additional field and laboratory activities, including ecological field surveys and tissue analyses on selected species, will be conducted to assess the exposure of key food web receptors to site contaminants and to determine effects on ecological endpoints The environmental evaluation workplan and preliminary field sampling plan are presented in Section 6 0

4 1.7 Task 7 - Treatability Studies/Pilot Testing

A draft Treatability Studies Plan (TSP) (EG&G, 1990j) was prepared and submitted to the regulatory agencies in September 1990, in accordance with the draft IAG schedule This document provides comprehensive plans for treatability studies designed for remediation of waste sources, soils, and water at all operable units at Rocky Flats Plant The Treatability Studies Program that is addressed by the TSP will serve to determine the operability, reliability, cost-effectiveness, and overall implementability of technologies that are appropriate for the types of contaminants and contaminated media at the Plant but are not adequately proven

The Treatability Studies Program will address practical (e g , conventional) technologies and innovative/emerging technologies The TSP identifies both practical and innovative technologies that are applicable to the Rocky Flats Plant contamination, screens these technologies to determine candidates for treatability studies, and provides statements of work for each candidate treatability study Subsequently, work plans will be prepared for conduct of the treatability studies The treatability studies will then be performed, and a Treatability Studies Report (draft due in May 1993) will be prepared

The report timing may not permit full utilization of this information for the OU No 1 CMS/FS report (draft report due in March 1993) However, the IAG schedule for OU No 1 calls for scoping of treatability studies specific to OU No 1, beginning in February 1992, with studies completed by October 1992 During the scoping of treatability studies, the need to acquire additional data on the practical technologies, as well as the need to conduct treatability studies for innovative/emerging technologies applicable to OU No 1, will be determined Work plans will be subsequently prepared, as appropriate

The Treatability Studies Program and the OU No 1 treatability studies will be a coordinated effort with common project control The staff assigned for project control will also supervise site-specific treatability studies for other OUs as well as the Rocky Flats Plant contributions to the DOE Office of Technology Development (OTD), integrated demonstrations, and the EPA Superfund Innovative Technology Evaluation (SITE) program For example, the treatability studies project staff are participating in OTD's integrated demonstrations of plutonium in soils that is being conducted at the Nevada Test Site This participation in numerous treatability study programs will allow evaluation of all applicable innovative technologies, and will "streamline" each program to avoid duplication of effort

4 1 8 Task 8 - Remedial Investigation Report

A draft Phase III RFI/RI Report will be prepared to consolidate and summarize the data obtained during Phases I, II, and III RI field work This report will

- Describe in detail the field activities which serve as a basis for the RI report This will include any deviations from the work plan which occurred during implementation of the field investigation
- Thoroughly discuss site physical conditions This discussion will include surface features, meteorology, surface water hydrology, surficial and bedrock geology, ground-water hydrology, demography and land use, and ecology
- Present site characterization results discussing the nature and extent of contamination as well as contaminant migration rates The media to be addressed will include contaminant sources, soils, ground water, surface water, air, and biota All relevant quarterly ground-water and surface water sampling results will be used in this assessment
- Discuss contaminant fate and transport This discussion will include potential migration routes, contaminant persistence, and contaminant migration
- Present a baseline risk assessment The risk assessment will include human health and environmental evaluations
- Identify ARARs
- Identify remediation goals
- Present a summary and conclusions

4 2 FEASIBILITY STUDY TASKS

A CMS/FS is planned for the 881 Hillside Area to develop and evaluate remedial alternatives for clean up of contaminated soils, ground water, and surface water Results of the Phase III RFI/RI, including the ARARs analysis and baseline risk assessment, will allow development of remediation goals

As discussed in Section 2 5, the draft FS was incomplete in addressing the full extent and nature of contamination The organization of the draft report is also not consistent with more recent EPA guidance [Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988b)] This section describes the tasks to be performed that conform with the EPA guidance

The CMS/FS process occurs in two phases The first phase consists of developing and screening remedial alternatives, and the second phase includes a detailed analysis of alternatives (EPA, 1988b) Each of these two phases is discussed in the following sections

4 2 1 Task 9 - Remedial Alternatives Development and Screening

The goal of this task is to identify and screen remedial alternatives The work consists of five parts

- Developing media-specific preliminary remediation goals
- Identifying and screening remedial technology groups
- Identifying and screening remedial technology options within each technology group
- Developing remedial alternatives
- Screening remedial alternatives

4 2 1 1 Establish Preliminary Remediation Goals

Preliminary remediation goals will be established early in the FS to support the development and screening of remedial alternatives Preliminary remediation goals will be applied as performance objectives for evaluating those specific technology processes identified as candidate components of viable remedial action alternatives Within this context, preliminary remediation goals will be used to perform the following

1 Identify media, areas of the OU, and chemicals requiring remediation This will be accomplished by comparing, for each affected media, measured or estimated concentrations to preliminary remediation goals

2 Identify the degree of remedial action required for each media This will be accomplished by comparing, for each affected media, measured or estimated concentrations in areas indicating potential remediation with preliminary remediation goals

3 Combining 1 and 2 above provides the basis for estimating the volume of media potentially requiring remediation and for gauging the anticipated chemical or radionuclide concentration or activity gradient

Consistent with the NCP (FR 55, No 46) preliminary remediation goals for carcinogens will be established at a 1×10^{-6} excess cancer risk point of departure Preliminary remediation goals may be revised, as the FS evolves, to a different risk level based on the consideration of appropriate factors including, but not limited to exposure, uncertainty, and technical factors

4 2 1 2 Identify General Response Actions

General response actions that may prove appropriate at the site were identified in Section 2 5 These actions were identified in order to determine data gaps to be addressed in RI activities For each response action, potentially applicable remedial technologies were identified These are also presented in Section 2 5 As the Phase II RFI/RI progresses, additional potentially applicable technologies will likely be identified

4 2 1 3 Screening of Technology Types and Process Options

During screening, the broad expanse of potentially applicable technology types will be narrowed by eliminating those technologies that are not technically implementable Based on contaminant concentrations and other site-specific information contained in the Phase II RFI/RI, non-implementable technology types will be screened and eliminated from further consideration

Technology process options for each retained technology type will then be screened in order to select a representative process option for each technology type that is technically implementable Process options are compared and eliminated based on their effectiveness relative to other processes within the same technology type The screening is based on the volume of media to be treated, achievement of remediation goals, potential impacts on human health and the environment, and the proven performance and reliability of the option considering the contaminants and site characteristics In addition to effectiveness, the process options will also be evaluated based on administrative feasibility and relative cost Results of treatability studies and geotechnical analyses will also be used to evaluate effectiveness, as appropriate

4 2 1 4 Remedial Alternatives Development and Screening

To develop alternatives, response actions and the process options that are representative of the various technology types for each medium will be combined to form alternatives for the operable unit In general, more than one response action is applicable to each medium Response actions and process options will be assembled based primarily on medium-specific considerations and implementability Descriptions of each alternative will be developed for inclusion in the CMS/FS report

The response actions outlined in Table 2-21 must be applied to the potential exposure pathways that will be identified for OU No 1 The response actions can individually be capable of providing control over all or some of the potential pathways Partially effective response actions can be combined to form complementary sets of response actions that provide control over all pathways In general terms, potential human exposure may be avoided by prevention of contaminant release, transport, and/or contact Thus, application of the response actions may be considered at three different points in each potential exposure pathway (1) at the point where the contaminant could be released from the source, (2) in the transport medium, and (3) at the point where the contact with the released contaminant could be prevented

During alternative screening, the developed alternatives will be evaluated to ensure that they protect human health and welfare and the environment from each potential pathway of concern at the operable unit Treatment rates will be identified, and the size and configuration of on-site extraction and treatment systems or containment structures will be developed The time frame in which treatment, containment or removal can achieve remediation goals will be determined Lastly, spatial requirements for treatment units, containment structures, staging of construction materials, excavated wastes, etc will be determined If there are off-site actions such as surface water discharge, a regulatory review will be conducted to determine permit and compliance requirements Alternatives will then be evaluated in order to differentiate them with respect to effectiveness, implementability and cost

Effectiveness is an evaluation of the protectiveness of human health and the environment achieved by a remedial alternative action during construction and implementation, and after the response objectives have been met Evaluation of effectiveness in the short term is based on protection of the community and workers, impacts to the environment, and the time required to meet remedial response objectives Long-term evaluation of effectiveness addresses the risk remaining to human health and the environment and is based on the percentage of permanent destruction, decreased mobility, and/or reduction in volume of toxic compounds achieved after response objectives have been met

Implementability is a measure of both the technical and administrative feasibility of constructing, operating and maintaining a remedial action alternative It is used during screening to evaluate the combinations of process options with respect to the site-specific conditions Technical feasibility refers to the ability to construct, reliably operate and comply with action-specific (technology-specific) requirements in order to complete the remedial action Administrative feasibility refers to the ability to obtain required permits and approvals, to obtain the necessary services and capacity for treatment, storage and disposal of hazardous wastes, and to obtain essential equipment and technical expertise

Cost estimates for screening will be derived from cost curves, generic unit costs, vendor information, conventional cost estimating guides and prior estimates made for Rocky Flats and similar sites, with modifications made for Rocky Flats Plant conditions Absolute cost accuracy is not necessary The cost estimates for the alternatives, however, will have the same relative accuracy for comparison and screening The cost estimating procedures used during screening are similar to those that will be used during the later detailed alternatives analysis The later detailed analysis, however, will receive more in-depth and detailed cost estimates of the components of each alternative The screening cost estimates will include capital, operating, and maintenance costs The operating and maintenance costs will be calculated for the lifetime of the treatment unit operation at the site Present worth cost analysis will be used for alternatives in order to make the costs for the various alternatives comparable

Alternatives with the most favorable results from the composite evaluation will be retained for further scrutiny during the detailed analysis Not more than ten alternatives will be retained for detailed analysis (including containment and no action) At that time, it may be determined that additional site-specific information or technology-specific treatability studies are necessary for an objective detailed analysis Also, it will be necessary to identify and verify the action-specific ARARs that each respective alternative will be required to meet

4 2 2 Task 10 - Detailed Analysis of Remedial Alternatives

The detailed analysis is not a decision-making process, but it is the process of analyzing and comparing relevant information in order to select a remedial action Each alternative will be assessed against nine evaluation criteria, and the assessments will be compared to identify the key tradeoffs among the alternatives Assessment against the nine evaluation criteria is necessary for the CMS/FS and the subsequent Corrective Action Decision (CAD)/Record of Decision (ROD) to comply with the requirements of RCRA/CERCLA The nine evaluation criteria are described below

- Overall Protection of Human Health and the Environment

  The alternatives will be individually analyzed to determine if the alternative provides adequate protection of human health and the environment The protectiveness evaluation focuses on how the risks posed by each pathway are being eliminated, reduced or controlled by treatment, engineering or institutional measures

- Compliance with ARARs

  Each alternative will be analyzed to determine whether it will comply with all state and federal ARARs that have been identified The analysis will address compliance with chemical-specific, location-specific and action-specific ARARs in accordance with the NCP If an alternative will not comply with an ARAR, the CMS/FS report will propose a basis for justifying a waiver, if appropriate

- Long-Term Effectiveness and Permanence

  This criterion assesses the risks that are left at the site after the response objectives have been met The risks associated with any remaining untreated wastes or treatment residuals will be evaluated For each alternative, the magnitude of the residual risk, and the reliability and adequacy of the controls used to manage untreated wastes and treatment residuals will be addressed

- Reduction of Toxicity, Mobility or Volume Through Treatment

  This criterion evaluates the statutory preference of selecting remedial actions that permanently reduce toxicity, mobility or volume of the hazardous materials Factors evaluated for each alternative will include the proposed treatment process and the materials treated, the quantity of materials to be treated or destroyed, and how the primary hazardous threat will be addressed, the estimated degree of the reduction in toxicity, mobility or volume that will be achieved, the extent to which the treatment will be irreversible, the type and quantity of treatment residuals that will remain following treatment, and a determination if the alternative will comply with the statutory preference for treatment

- Short-Term Effectiveness

  Short-term effectiveness refers to the effects an alternative may have during the construction and implementation phases until the cleanup objectives have been achieved Alternatives will be evaluated to determine the effects on human health and the environment during implementation Each alternative will be assessed against the following factors protection of the community and workers during the remedial action, environmental impacts, and the time required to achieve the remedial action objectives

- Implementability

  This criterion assesses the technical and administrative feasibility of implementing an alternative, and the availability of the necessary services and materials The following factors will be analyzed during the implementability assessment the technical feasibility of construction and operation, the reliability of the technology; the practicability of employing additional remedial actions, the ability to monitor the effectiveness of the remedial action, administrative coordination with other offices and agencies, the availability of adequate off-site hazardous (or mixed) waste treatment, storage and disposal, and the availability of equipment, expertise and other services and materials

- Costs

  An in-depth cost estimate will be conducted, and if necessary, a cost sensitivity analysis will be prepared to evaluate costing assumptions Capital costs include direct construction costs, indirect non-construction costs, and overhead costs Operating and maintenance costs are incurred after construction in order to operate the remedial action on a continuous basis until the remedial action objectives have been achieved CMS/FS cost estimates are expected to be within an accuracy range of minus 30 percent to plus 50 percent If this accuracy cannot be achieved, it will be stated in the CMS/FS report

A cost sensitivity analysis may be conducted to determine the effect that specific cost assumptions have on the total estimated cost of an alternative The cost assumptions will be based on site-specific data, technological operating data, etc , although the assumptions will be subject to varying degrees of uncertainty depending on the accuracy of the data

- State Acceptance

  This criterion addresses the state's administrative and technical issues and concerns with each of the alternatives

- Community Acceptance

  Community acceptance addresses the public's concerns and issues with each of the alternatives

The CMS/FS report will contain a narrative discussion of each alternative's evaluation against the nine criteria The narrative will describe how each alternative addresses the technical treatability issues, long-term and short-term effectiveness, costs, protection of human health and the environment, compliance with ARARs, etc Once the alternatives have been described, a comparative analysis will be conducted to evaluate the relative performance of each alternative The relative advantages and disadvantages of each alternative with respect to the other alternatives will be determined in order to assess the key tradeoffs that must be made in selecting a remedial action A candidate alternative must generally attain the primary objectives of compliance with ARARs and overall protection of human health and the environment in order for it to be eligible for selection as the remedial action A narrative discussion of the alternatives comparison describing the tradeoffs, and the benefits and detriments of each alternative in comparison to the others will be included in the CMS/FS report

Following completion of the CMS/FS process, the results of the detailed alternatives comparison and risk management will be used as the rationale for selecting a preferred alternative and a remedial action Although the purpose of the CMS/FS report and process is not to select a remedial action, it will present and evaluate the alternatives in sufficient detail in order to objectively consider all significant issues and select a feasible, cost-effective and defensible remedial action

4 2 3 Task 11 - Feasibility Study Report

The CMS/FS Report will discuss and present the results of the feasibility study The results of the detailed alternatives comparison will be used as the rationale for selecting a preferred alternative and a remedial action Although the purpose of the FS report and process is not to select a remedial action, it will present and evaluate the alternatives in sufficient detail in order to objectively consider all significant issues and select a feasible, cost-effective, and defensible remedial action The report will include sections describing site background, nature and extent of problem, results of the RFI/RI, identification of ARARs, risk assessment and environmental evaluation, identification, screening and detailed evaluation of remedial alternatives, and the recommended remedial actions This task includes preparation of a Draft CMS/FS report, and preparation of a Final CMS/FS that incorporates EPA and CDH comments A preliminary outline of the CMS/FS report is shown in Table 4-2

TABLE 4-2

CMS/FS REPORT FORMAT

Executive Summary

1 Introduction

- 1 1 Purpose and Organization of Report
- 1 2 Background Information (summarized from RI Report)
  - 1 2 1 Site Description
  - 1 2 2 Site History
  - 1 2 3 Nature and Extent of Contamination
  - 1 2 4 Contaminant Fate and Transport
  - 1 2 5 Baseline Risk Assessment

2 Identification and Screening of Technologies

- 2 1 Introduction
- 2 2 Remedial Action Objectives

  Present the development of remedial action objectives for each medium of interest (i e , ground water, soil, surface water, air, etc)

  For each medium, the following should be discussed
  - Contaminants of interest
  - Allowable exposure based on risk assessment (including ARARs)
  - Development of remediation goals
- 2 3 General Response Actions

  For each medium of interest, describes the estimation of areas or volumes to which treatment, containment, or exposure technologies may be applied
- 2 4 Identification and Screening of Technology Types and Process Options - For each medium of interest, described
  - 2 4 1 Identification and Screening of Technologies
  - 2 4 2 Evaluation of Technologies and Selection of Representative Technologies

3 Development and Screening of Alternatives

- 3 1 Development of Alternatives

  Describes rationale for combination of technologies/media into alternatives Note This discussion may be by medium or for the site as a whole
- 3 2 Screening of Alternatives
  - 3 2 1 Introduction
  - 3 2 2 Alternative 1
    - 3 2 2 1 Description
    - 3 2 2 2 Evaluation
  - 3 2 3 Alternative 2
    - 3 2 3 1 Description
    - 3 2 3 2 Evaluation
  - 3 2 4 Alternative 3

4 Detailed Analysis of Alternatives

- 4 1 Introduction
- 4 2 Individual Analysis of Alternatives
  - 4 2 1 Alternative 1
    - 4 2 1 1 Description
    - 4 2 1 2 Assessment

4 2 2 Alternative 2
4 2 2 1 Description
4 2 2 2 Assessment
4 2 3 Alternative 3
4 3 Comparative Analysis

Bibliography

Appendices

The overall objectives of the Phase III RFI/RI is to characterize in detail the nature and extent of soil, ground-water and surface water contamination at OU No 1 The specific goals of the RFI/RI (EPA, 1988a) include the following

- Characterize site physical features
- Define contaminant sources
- Describe contaminant fate and transport
- Provide a baseline risk assessment
- Provide an adequate body of data for the Feasibility Study and the Record of Decision (ROD)

The purpose of Section 5 0 is to provide a detailed Field Sampling Plan (FSP) which will realize the goals and the data quality objectives described in Section 3 0

5 1 FIELD SAMPLING RATIONALE

A four step approach will be used for the FSP

Step One	Review of Existing Data
Step Two	Conduct Preliminary and Screening Study Activities
Step Three	Conduct Detailed Field Sampling Program
Step Four	Conduct Field and Analytical Laboratory Testing Programs

5 1 1 Step One - Review of Existing Data

This initial step consists of collecting, reviewing, and analyzing the Phase I and Phase II RI reports, previous drafts of the Phase III work plan, regulatory agency comments on the draft work plans, responses to these comments, and other relevant documents, e g , data, plans, and reports from adjacent or on-going operable unit investigations This has been performed in preparation of this work plan The current understanding of the nature and extent of contamination at OU No 1 is based on all available chemical data, however, only data collected through the summer of 1989 are presented More recent analytical data are not included in this work plan because they are still in the process of being validated and do not significantly alter the site conceptual model The existing data set also includes an electromagnetic geophysical survey of all the IHSSs [see Phase II RI Report (Rockwell International, 1988a)]

5 1 2 Step Two - Preliminary Field and Screening Study Activities

This second step involves preliminary field and screening study activities in advance of implementing the detailed FSP (Step 3) These include surveying of borehole and IHSS locations, FIDLER monitoring surveys, air monitoring, surface soil and environmental evaluation reconnaissance visits, mobilization for the drilling and sampling program, setting up temporary waste handling facilities, temporary sample storage facilities, and establishment of health and safety procedures SOPs have been prepared for these activities where appropriate

5 1 3 Step Three - Detailed Field Sampling Activities

The third step is to conduct detailed field studies that include

- Source characterization, borehole sampling and well installation/sampling
- Characterization of nature and extent of contamination, well installation/sampling and seep, surface water, sediment, and surficial soil sampling
- Environmental evaluation study

Sections 5 2 and 5 3 describe the details of the first two activities, respectively The environmental evaluation study is described in Section 6 0 The environmental evaluation will be conducted as an integrated study with the environmental evaluations for OU No 2, OU No 5, and OU No 6 The results relevant to OU No 1 of this integrated study will be incorporated into the OU No 1 Phase III RFI/RI Report

5 1 4 Step Four - Field and Analytical Tests

This last step includes all of the testing activities (also presented in Sections 5 2 and 5 3) such as field screening tests for volatile organics and radioactivity, hydraulic pumping and tracer tests, and chemical testing of soil and water samples All data obtained from these activities will be compiled in the EG&G Rocky Flats Environmental Data System (RFEDS)

5 2 SOURCE CHARACTERIZATION

Further source characterization is required for sites within OU No 1 Boreholes will be drilled into IHSSs to characterize any waste materials remaining in place and to assess the maximum contaminant concentrations in soils directly beneath the sites In addition, ground-water monitoring wells will be installed adjacent to some of the boreholes to characterize ground-water quality directly beneath the sites This section discusses those wells and boreholes which will be drilled for source characterization Wells to be drilled outside of IHSSs for characterizing the extent of contamination are discussed in Section 5 3 1 All proposed Phase III RFI/RI wells and boreholes are shown on Plate 1 Drilling, sampling, and well installation will follow the Rocky Flats Plant ER Program SOP (EG&G, 1990g)

Boreholes to be drilled into IHSSs will extend from the ground surface to the base of weathered bedrock Continuous samples will be collected for geologic descriptions for the entire borehole depth From this core, discrete samples will be submitted for laboratory chemical analyses every two feet from the ground surface to the water table In addition, a discrete sample will be submitted for laboratory chemical analysis if staining, discoloration, or odor is observed during drilling A discrete sample will also be collected for chemical analysis at the water table Core from saturated surficial materials will not be submitted to the laboratory, as the presence of water in this zone will affect interpretation of chemical results In order to prevent alluvial ground water from affecting weathered bedrock samples, surface casing will be grouted into the borehole through surficial materials Subsequent to grout hardening, the borehole will then be advanced through weathered bedrock with continuous sampling Discrete samples from the core will be submitted to the laboratory for chemical analysis from two feet immediately below the casing and every four feet thereafter to the base of weathering To further characterize weathered bedrock immediately beneath the sites, fracture patterns (both degree of fracturing and vertical extent) will be noted on the borehole logs and in situ packer tests will be performed in the bedrock where drilling conditions allow

Alluvial ground-water monitoring wells will be installed adjacent to some boreholes to characterize ground-water quality directly beneath IHSSs In addition, bedrock wells will be installed adjacent to boreholes where weathered sandstone is encountered to evaluate the potential downward migration of contaminants Wells will be drilled, sampled, and completed in accordance with the Rocky Flats Plant ER Program SOP (EG&G, 1990g) Source characterization borehole and monitor well locations are discussed in the following sections

5 2 1 Sample Locations

5 2 1 1 Oil Sludge Pit Site (IHSS Ref. No. 102)

The location of IHSS 102 has been revised from that shown in the Phase II RI report (Rockwell International, 1988a) based on further review of historical aerial photographs Specifically, the Oil Sludge Pit Site appears on a 1955 aerial photo Also evident on the 1955 photos is seepage from the pit as shown on Plate 1 The pit was covered after its use (Rockwell International, 1987c), and it is no longer visible on 1959 aerial photographs Additional soil and ground-water sampling are needed within, surrounding, and downgradient of IHSS 102 to document its location and to evaluate the nature and extent of potential contamination downgradient of the site

Two borings are proposed within this site to document its presence and location Boreholes BH01 and BH02 will be drilled and sampled within the revised site location to identify the nature and maximum concentration of any contaminants associated with IHSS 102 Colluvial monitor well MW01 will be completed adjacent to BH01 to monitor ground-water quality directly beneath the site

In order to assess the nature and extent of soil and ground-water contamination downgradient of the Oil Sludge Pit Site, five boreholes are proposed in the area of staining directly south of the site Boreholes BH03, BH04, and BH05 will all be drilled and sampled within the area of seepage from IHSS 102 identified on 1955 aerial photographs A colluvial monitor well (MW02) will also be installed adjacent to borehole BH04 to assess ground-water flow directions and quality in this area Boreholes BH06 and BH07 are proposed downgradient of the seepage area to assess the extent of soil contamination As the proposed french drain at the 881 Hillside is upgradient of the apparent seepage from IHSS 102, boreholes BH03, BH04, BH05, and BH06 will be drilled and sampled to evaluate potential soil contamination downgradient of its proposed alignment

Additional boreholes are proposed within and surrounding the former retention pond along Woman Creek to characterize soil and ground-water conditions in this area Two boreholes (BH08/MW36 and BH09) will be drilled within the former pond location, and two alluvial monitor wells (MW03 and MW33) are proposed south and southwest of the former pond These wells will serve to characterize the Woman Creek valley fill alluvial ground water downgradient of IHSS 102

5 2 1 2 Chemical Burial Site (IHSS Ref No 103)

No boreholes or monitor wells were installed directly within IHSS 103 during previous investigations Additional drilling and sampling are thus needed to characterize this site Three boreholes (BH10, BH11, and BH12) are proposed within the IHSS to identify the nature and maximum concentration of potential contaminants A colluvial monitor well (MW04) will be completed adjacent to BH10 to characterize ground water directly beneath the site, and colluvial monitor well MW05 will characterize ground-water quality immediately downgradient of the site The exact location of MW05 should be evaluated at the commencement of the drilling program to incorporate all available data on the potentiometric surface in that vicinity

5 2 1 3 Liquid Dumping Site (IHSS Ref No 104)

A site east of Building 881 was reportedly used for disposal of unknown liquids and empty drums prior to 1969 (DOE, 1986) The site was located as shown on Plate 1 by Rockwell International (1987c) based on 1965 aerial photographs, however, further review of these photographs indicates this site may be a shadow on the photo Based on their description, it is suspected that IHSSs 103 and 104 are actually the same site However, the Phase III RFI/RI will include sampling and analysis of soils at the originally reported Liquid Dumping Site location to document its presence or lack thereof Two boreholes will be drilled within this reported IHSS location (BH13 and BH14)

5 2 1 4 Out-of-Service Fuel Oil Tanks (IHSS Ref. Nos 105.1 and 105.2)

These two sites were effectively taken out of service in 1976 This is presumably when they were filled with asbestos containing materials and then with concrete As the materials inside the tanks are solidified, they do not pose an environmental hazard In addition, the tanks tested tight in 1973 when they were pressure tested However, in order to document the lack of soil contamination associated with these tanks, two adjacent boreholes (BH15 and BH16) and two downgradient boreholes (BH17 and BH18) are proposed

5 2.1 5 Outfall Site (IHSS Ref. No. 106)

The Outfall Site consists of a six inch diameter vitrified clay pipe which is an overflow line from the sanitary sewer sump in Building 887 Discharge from this pipe was observed in December 1977 (Rockwell International, 1987c), however, subsequent discharges have not been noted Phase III RFI/RI activities at this site will include verifying the connection between the outfall pipe and Building 887 (original reports of the discharge indicated this was a clean-up pipe for an overflow line from the Building 881 cooling tower) as well as soil and ground-water sampling downgradient of the outfall

In order to verify the source of IHSS 106, water will be introduced to the outfall pipe from the Building 887 sewer sump, and the outfall on the hillside will be observed for discharge If the water is observed at the outfall, then the Building 887 sewer sump is the source of IHSS 106, and measures will be taken to contain any future discharges If the Building 887 sewer sump is not the source of IHSS 106, further review of construction drawings for Buildings 881 and 887 and discussions with Plant personnel will be needed to identify the source of this outfall

Soil and ground-water contamination may exist downgradient of the Outfall Site due to previous releases from the site In order to characterize any contamination, two boreholes (BH19 and BH20) will be drilled and sampled immediately below the outfall A colluvial monitor well (MW06) will be installed adjacent to borehole BH19 to evaluate ground-water quality beneath the outfall

5 2 1 6 Hillside Oil Leak Site (IHSS Ref. No. 107)

The Hillside Oil Leak Site was originally designated as an IHSS because of an oil leak at this location in May, 1973 (Rockwell International, 1987c) It was later discovered that the oil had emerged through the Building 881 footing drain outfall, and a ditch and skimming pond were built to contain the oil (Owen and Steward, 1973) The skimming pond is still present, although, no oil has been observed in the outfall since 1973 (Rockwell International, 1987c) During the 881 Hillside Phase II RI, volatile organic compounds were detected in the outfall pipe discharge and in the skimming pond (Rockwell International, 1988a)

There are thus two issues associated with the Hillside Oil Leak Site

1) The nature and extent of soil and ground-water contamination potentially resulting from the original hillside oil leak

2) The source of volatile organic contaminants currently found in the Building 881 footing drain outfall

Two footing drains extend south from the Building 881 foundation (Figure 1-8) The western line joins the eastern line near the southeast corner of Building 885 This line then runs south where it daylights into the skimming pond The first step of this source investigation will consist of determining which of the two footing drains is the source of volatile organics at the footing drain outfall This will be accomplished by sampling the effluent in each footing drain line through a manhole located just south of their junction The line (or lines) responsible for contaminants at the outfall will then be sampled at clean-out points (if accessible) along its length to further isolate the contaminant source

Soil, ground-water, and surface water samples will be collected within IHSS 107 in order to characterize the nature and extent of contamination Soil samples will be collected from boreholes within the skimming pond Boreholes BH21 and BH22 are proposed and will be advanced to refusal using a hand auger MW17 will be installed to assess ground-water quality Routine surface water sampling will continue at stations SW-44 and SW-45

5 2 1 7 Multiple Solvent Spill Sites (IHSS Ref. Nos. 119 1 and 119 2)

IHSSs 119 1 and 119 2 were used from 1967 to 1972 for barrel storage Although the exact types and quantities of wastes stored at these sites are unknown, the barrels likely contained cutting oil wastes and solvents Spills and leaks from these drums likely occurred during the period of drum storage Barrel storage locations within the sites are shown on Figure 1-7

IHSS 119 1

A total of ten boreholes are proposed within the western barrel storage area to characterize the nature and extent of soil contamination associated with this site Boreholes BH23 through BH32 will be drilled and sampled within the drum storage areas as shown on Plate 1 In addition, colluvial monitor wells MW07, MW08, MW09, MW10, and MW11 will be installed to evaluate ground-water quality beneath the site and at the downgradient edge of the site Also, two piezometers will be installed on either side of the extraction well to help evaluate the effectiveness of the ground-water evacuation

IHSS 119 2

Seven boreholes (BH33 through BH39) are proposed within the barrel storage areas of IHSS 119 2 to evaluate the nature and extent of potential soil contamination Monitor wells MW12 and MW13 will serve to monitor ground-water quality at the site's east-southeast downgradient edge

5 2 1 8 Radioactive Site No. 1-800 Area (IHSS Ref No 130)

This site was used to dispose of soil contaminated with low levels of plutonium between 1969 and 1972 Radionuclides were not above background levels in soil samples collected from this site during the Phase I and Phase II RIs However, additional soil samples will be collected from eight boreholes during the Phase III RFI/RI to verify this finding Boreholes BH40 through BH47 will be drilled and sampled through the site to assess the nature and extent of soil contamination In addition, colluvial monitor wells MW14, MW15, and MW16 will be installed adjacent to boreholes BH45, BH46, and BH47, respectively, to monitor water quality at the downgradient edge of this site

5 2 1 9 Sanitary Waste Line Leak Site (IHSS Ref No 145)

IHSS 145 is an area at the southeast corner of Building 881 where the sanitary sewer leaked in January 1981 No hazardous or radioactive constituents were released to the environment by this leak and the leak was repaired (Rockwell International, 1987c), so contamination is not expected at this site However, two boreholes BH48 and BH49 are proposed to check that indications of possible contamination in the nearby well 1-87 are not from this IHSS MW18 will also be installed to monitor ground water downgradient of the site

5 2 1 10 Building 885 Drum Storage Site (IHSS Ref No 177)

Building 885 is currently used for satellite collection and 90-day accumulation of RCRA regulated wastes A plan for soil sampling at this site is provided in the RCRA Interim Status Closure Plan which is appended to the revised Post-Closure Care Permit Application for Hazardous and Radioactive Mixed Wastes at the Rocky Flats Plant (Rockwell International, 1988d) Since ground water must be addressed under the RFI/RI program, a borehole (BH50) will be drilled downgradient from IHSS 177, and monitor well MW19 will be installed adjacent to BH50

5 2 1 11 Toluene Contamination

Coherex sprayed on the ground surface at the 881 Hillside Area is hypothesized to be the source of toluene in borehole samples along the proposed french drain alignment Four additional boreholes (BH51, BH52, BH53, and BH54) will be drilled and sampled downgradient of the proposed french drain location to further define the extent of toluene in soils These boreholes are also located downslope of the gravel access road along Woman Creek, as this road is believed the southernmost location of Coherex application

5 2 2 Sample Analysis

5 2 2.1 Chemical Analysis of Soil Samples

Soil samples will be collected from boreholes within and adjacent to IHSSs to characterize sources All samples will be analyzed for the chemical parameters listed in Table 5-1 following CLP methods or the methods specified in the GRRASP These parameters are essentially the same as those analyzed in the Phase I RI except that oil and grease and RCRA characteristics are eliminated Oil and grease have not proven useful in determining extent of soil contamination, and RCRA hazardous waste characteristics have been within acceptable limits Total petroleum hydrocarbons were added to the analyte list for IHSSs 102 and 105 where fuel oil is a potential contaminant With a few exceptions, the TCL list for organics and the TAL list for inorganics are the same as the previously used HSL list for organics and inorganics The laboratory will be expected to analyze constituents to a detection limit at or below ARARs If that is not possible for some samples, the laboratory must provide a complete explanation for the reason(s)

5 2 2 2 Soil Blanks

Use of soil blanks is not necessarily standard protocol in the collection of soil samples for subsequent chemical analysis In the Phase I and II RIs, methylene chloride, acetone, and phthalates appear to be contaminants in samples that were introduced through sample handling or sample analysis Soil blanks were not used in the previous investigation but appear necessary to confirm these findings An investigation will be designed to determine the source of phthalate contamination in soil samples and the need for soil blanks If appropriate, an alternative to previous field methods sampling will be implemented to avoid phthalate

TABLE 5-1

PHASE III RFI/RI
SEDIMENT, BOREHOLES, SURFACE WATER AND GROUND-WATER
SAMPLING PARAMETERS

TOTAL METALS
- Target Analyte List - Sediment and Boreholes
  - Aluminum
  - Antimony
  - Arsenic
  - Barium
  - Beryllium
  - Cadmium
  - Calcium
  - Chromium
  - Cobalt
  - Copper
  - Iron
  - Lead
  - Magnesium
  - Manganese
  - Mercury
  - Nickel
  - Potassium
  - Selenium
  - Silver
  - Sodium
  - Thallium
  - Vanadium
  - Zinc

OTHER METALS
- Sediment and Boreholes
  - Molybdenum
  - Strontium
  - Cesium
  - Lithium
  - Tin

OTHER INORGANICS
- Sediment and Boreholes
  - pH
  - Sulfide
  - Nitrate-Nitrite (as N)
  - Percent Solids
  - Cyanide
  - Moisture Content
  - Orthophosphate
  - Bromide
  - Ammonium
  - Silica (as Si and SiO_2)

INDICATORS
- Sediment and Boreholes
  - Dissolved Organic Carbon
  - Total Organic Carbon

OTHER PARAMETERS
- Total Petroleum Hydrocarbons*

TOTAL METALS
- Target Analyte List - Ground Water (Dissolved Metals) and Surface Water (Total and Dissolved Metals)
  - Aluminum
  - Antimony
  - Arsenic
  - Barium
  - Beryllium
  - Cadmium
  - Calcium
  - Chromium
  - Cobalt
  - Copper
  - Iron
  - Lead
  - Magnesium
  - Manganese
  - Mercury
  - Nickel
  - Potassium
  - Selenium
  - Silver
  - Sodium
  - Thallium
  - Vanadium
  - Zinc

OTHER METALS
- Ground Water and Surface Water
  - Molybdenum
  - Strontium
  - Cesium
  - Lithium
  - Tin

FIELD PARAMETERS
- Ground Water and Surface Water
  - pH
  - Specific Conductance
  - Temperature
  - Dissolved Oxygen

INDICATORS
- Ground Water and Surface Water
  - Total Dissolved Solids
  - Total Organic Carbon
  - Dissolved Organic Carbon
  - pH

INDICATORS
- Surface Water
  - Total Suspended Solids

ANIONS
- Ground Water and Surface Water
  - Carbonate
  - Bicarbonate
  - Chloride
  - Sulfate
  - Nitrate as N
  - Cyanide
  - Fluoride
  - Bromide
  - Silica (as Si and SiO_2)
  - Ammonium
  - Orthophosphate

OTHER PARAMETERS
- Ground Water
  - Total Petroleum Hydrocarbons*

TABLE 5-1 (Continued)

PHASE III RFI/RI
SEDIMENT, BOREHOLES, SURFACE WATER AND GROUND-WATER
SAMPLING PARAMETERS

DISSOLVED RADIONUCLIDES
- Ground Water and Surface Water
  - Gross Alpha
  - Gross Beta
  - Uranium -233&234,235, and 238
  - Americium -241
  - Plutonium -239&240
  - Tritium
  - Strontium -89,90
  - Cesium 137
  - Radium 226,228**

TOTAL RADIONUCLIDES
- Sediment and Boreholes
  - Gross Alpha
  - Gross Beta
  - Uranium -233&234,235, and 238
  - Americium -241
  - Plutonium -239&240
  - Tritium
  - Strontium -89,90
  - Cesium -137
  - Radium -226, 288

TOTAL RADIONUCLIDES
- Surface Water
  - Uranium -233&234,235, and 238
  - Plutonium -239&240
  - Americium -241
  - Cesium -137
  - Strontium -89,90
  - Radium -226,228**

TOTAL RADIONUCLIDES
- Ground Water and Surface Water
  - Tritium

ORGANICS: VOLATILES
- Target Compound List - Sediment and Boreholes
  - Chloromethane
  - Bromomethane
  - Vinyl Chloride
  - Chloroethane
  - Methylene Chloride
  - Acetone
  - Carbon Disulfide
  - 1,1-Dichloroethene
  - 1,1-Dichloroethane
  - total 1,2-Dichloroethene
  - Chloroform
  - 1,2-Dichloroethane
  - 2-Butanone
  - 1,1,1-Trichloroethane
  - Carbon Tetrachloride
  - Vinyl Acetate
  - Bromodichloromethane
  - 1,1,2,2-Tetrachloroethane
  - 1,2-Dichloropropane
  - trans-1,3-Dichloropropene
  - Trichloroethene
  - Dibromochloromethane
  - 1,1,2-Trichloroethane
  - Benzene
  - cis-1,3-Dichloropropene
  - Bromoform
  - 2-Hexanone
  - 4-Methyl-2-pentanone
  - Tetrachloroethene
  - Toluene
  - Chlorobenzene
  - Ethyl Benzene
  - Styrene
  - Total Xylenes

ORGANICS: VOLATILES
- Target Compound List - Ground Water and Surface Water
  - Chloromethane
  - Bromomethane
  - Vinyl Chloride
  - Chloroethane
  - Methylene Chloride
  - Acetone
  - Carbon Disulfide
  - 1,1-Dichloroethene
  - 1,1-Dichloroethane
  - total 1,2-Dichloroethene
  - Chloroform
  - 1,2-Dichloroethane
  - 2-Butanone
  - 1,1,1-Trichloroethane
  - Carbon Tetrachloride
  - Vinyl Acetate
  - Bromodichloromethane
  - 1,1,2,2-Tetrachloroethane
  - 1,2-Dichloropropane
  - trans-1,3-Dichloropropene
  - Trichloroethene
  - Dibromochloromethane
  - 1,1,2-Trichloroethane
  - Benzene
  - cis-1,3-Dichloropropene
  - Bromoform
  - 2-Hexanone
  - 4-Methyl-2-pentanone
  - Tetrachloroethene
  - Toluene
  - Chlorobenzene
  - Ethyl Benzene
  - Styrene
  - Total Xylenes

TABLE 5-1 (Continued)

PHASE III RFI/RI
SEDIMENT, BOREHOLES, SURFACE WATER AND GROUND-WATER
SAMPLING PARAMETERS

ORGANICS: SEMI-VOLATILES
Target Compound List -
Sediment and Borehole

- Phenol
- bis(2-Chloroethyl)ether
- 2-Chlorophenol
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- Benzyl Alcohol
- 1,2-Dichlorobenzene
- 2-Methylphenol
- bis(2-Chloroisopropyl)ether
- 4-Methylphenol
- N-Nitroso-Dipropylamine
- Hexachloroethane
- Nitrobenzene
- Isophorone
- 2-Nitrophenol
- 2,4-Dimethylphenol
- Benzoic Acid
- bis(2-Chloroethoxy)methane
- 2,4-Dichlorophenol
- 1,2,4-Trichlorobenzene
- Naphthalene
- 4-Chloroaniline
- Hexachlorobutadiene
- 4-Chloro-3-methylphenol(para-chloro-meta-cresol)
- 2-Methylnaphthalene
- Hexachlorocyclopentadiene
- 2,4,6-Trichlorophenol
- 2,4,5-Trichlorophenol
- 2-Chloronaphthalene
- 2-Nitroaniline
- Dimethylphthalate
- Acenaphthylene
- 3-Nitroaniline
- Acenaphthene
- 2,4-Dinitrophenol
- 4-Nitrophenol
- Dibenzofuran
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- Diethylphthalate
- 4-Chlorophenyl Phenyl ether
- Fluorene
- 4-Nitroaniline
- 4,6-Dinitro-2-methylphenol
- N-nitrosodiphenylamine
- 4-Bromophenyl Phenyl ether
- Hexachlorobenzene
- Pentachlorophenol
- Phenanthrene
- Anthracene
- Di-n-butylphthalate
- Fluoranthene
- Pyrene
- Butyl Benzylphthalate
- 3,3'-Dichlorobenzidine
- Benzo(a)anthracene
- bis(2-ethylhexyl)phthalate
- Chrysene
- Di-n-octyl Phthalate
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenz(a,h)anthracene
- Benzo(g,h,i)perylene

ORGANICS: SEMI-VOLATILES
Target Compound List -
Ground Water

- Phenol
- bis(2-Chloroethyl)ether
- 2-Chlorophenol
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- Benzyl Alcohol
- 1,2-Dichlorobenzene
- 2-Methylphenol
- bis(2-Chloroisopropyl)ether
- 4-Methylphenol
- N-Nitroso-Dipropylamine
- Hexachloroethane
- Nitrobenzene
- Isophorone
- 2-Nitrophenol
- 2,4-Dimethylphenol
- Benzoic Acid
- bis(2-Chloroethoxy)methane
- 2,4-Dichlorophenol
- 1,2,4-Trichlorobenzene
- Naphthalene
- 4-Chloroaniline
- Hexachlorobutadiene
- 4-Chloro-3-methylphenol(para-chloro-meta-cresol)
- 2-Methylnaphthalene
- Hexachlorocyclopentadiene
- 2,4,6-Trichlorophenol
- 2,4,5-Trichlorophenol
- 2-Chloronaphthalene
- 2-Nitroaniline
- Dimethylphthalate
- Acenaphthylene
- 3-Nitroaniline
- Acenaphthene
- 2,4-Dinitrophenol
- 4-Nitrophenol
- Dibenzofuran
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- Diethylphthalate
- 4-Chlorophenyl Phenyl ether
- Fluorene
- 4-Nitroaniline
- 4,6-Dinitro-2-methylphenol
- N-nitrosodiphenylamine
- 4-Bromophenyl Phenyl ether
- Hexachlorobenzene
- Pentachlorophenol
- Phenanthrene
- Anthracene
- Di-n-butylphthalate
- Fluoranthene
- Pyrene
- Butyl Benzylphthalate
- 3,3'-Dichlorobenzidine
- Benzo(a)anthracene
- bis(2-ethylhexyl)phthalate
- Chrysene
- Di-n-octyl Phthalate
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenz(a,h)anthracene
- Benzo(g,h,i)perylene

TABLE 5-1 (Continued)

PHASE III RFI/RI
SEDIMENT, BOREHOLES, SURFACE WATER AND GROUND-WATER
SAMPLING PARAMETERS

ORGANICS: PESTICIDES/PCBs
Target Compound List -
Sediment and Boreholes

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

ORGANICS: PESTICIDES/PCBs
Target Compound List -
Ground Water

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

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* For samples collected from IHSSs 102 and 105 only (MW01/BH01, BH02, BH03, MW02/BH04, BH05, BH06, BH07, MW36/BH08, BH09, BH15, BH16, BH17, and BH18)

** Decision tree If Gross Alpha is ≥ 5 pCi/ℓ the sample will be analyzed for Radium-226,228 contamination from sample handling in the future The laboratory will be expected to avoid contamination of samples with volatile organics and phthalates using appropriate procedures

5 3 NATURE AND EXTENT OF CONTAMINATION

In addition to source characterization, the Phase III RFI/RI will focus on additional ground-water, surface water, and sediment sampling to further characterize the nature and extent of contamination in each of these media arising from the IHSSs These sampling programs are outlined in detail below

5 3 1 Ground Water

5 3 1 1 Monitor Well Locations

Based on data collected during the Phase I and II investigations, volatile organics are present in the unconfined ground-water flow system at the 881 Hillside Area The extent of contamination is not fully delineated, and additional monitor wells are needed to define the vertical and lateral extent of the organics Potential major ion, trace metal, and radionuclide impacts to ground water were not well characterized in the Phase II RI report due to the lack of appropriate background ground-water quality data Presented below are proposed monitor well locations and rationale to further characterize ground-water flow and quality in the unconfined flow system within OU No 1 Bedrock wells will be installed adjacent to alluvial wells at all locations where sandstone is encountered

Upgradient Wells

Four new alluvial monitoring wells are proposed upgradient of the 881 Hillside Area to characterize the quality of ground water entering the sites These wells (MW20, MW21, MW22, and MW23) will all be completed in Rocky Flats Alluvium MW20 and MW21 will be located east and north, respectively, of Building 881, and wells MW22 and MW23 will be located on the Rocky Flats Alluvium terrace north of IHSSs 119 1 and 119 2 (Plate 1)

IHSSs 119 1 and 130

Four alluvial and three bedrock wells will be installed downgradient of IHSS 119 1 to further characterize the extent of volatile organics detected in wells 48-87, 10-74, 9-74, and 4-87 Alluvial well MW24 will be located between 9-74 and 4-87 and will be completed in colluvial gravel Data from this well will serve to further characterize the transport of contaminants found in wells 9-74 and 43-87 to well 4-87 Alluvial wells MW25 and MW26 will further delineate the extent of colluvial saturation and water quality south of IHSSs 119 1 and 130

Further investigation of the bedrock sandstone at well 5-87 is also proposed for the Phase III RFI/RI, because TDS, strontium, and selenium were elevated during 1989 Three wells (MW27, MW28, and MW29) are proposed for completion in this sandstone (Plate 1) As the extent and orientation of the sandstone and the ground-water flow direction within the sandstone are uncertain, these wells will be located in presumably upgradient (west), sidegradient (south), and downgradient (east) directions Water level data from the wells will then be used to determine ground-water flow directions

South Interceptor Ditch

In addition to well MW02, three other colluvial monitor wells will be installed along the South Interceptor Ditch These wells (MW30, MW31, and MW32) will serve to monitor ground-water quality and levels adjacent to the ditch (Plate 1), and the resulting data will be used to evaluate the interaction between South Interceptor Ditch surface water and unconfined ground water

Woman Creek Valley Fill Alluvium

Further characterization of valley fill water quality and the surface water/ground-water interaction are also needed along Woman Creek downgradient of the 881 Hillside Area Wells MW33, MW34, MW35, and MW37 in addition to well MW03, will all be completed in Woman Creek valley fill alluvium (Plate 1)

5.3.1 2 Chemical Analysis of Ground-Water Samples

Ground-water samples will be collected on a quarterly basis from all new and existing monitoring wells at the 881 Hillside Area upon completion of well development Samples will be analyzed for the parameters listed in Table 5-1 during the first round of sampling after completion of new wells. This parameter list may be reduced in subsequent quarterly sampling events if certain parameter groups are not detected or are not significantly above background levels and if approved by EPA and CDH Ground-water samples will be analyzed in the field for pH, conductivity, and temperature Sample aliquots designated for metals, plutonium, americium and tritium analyses will be filtered in the field, and samples requiring preservation will be preserved in the field

5.3.1.3 Hydraulic Testing

In order to further characterize hydraulic conductivity values of geologic materials in the 881 Hillside Area, hydraulic tests will be performed in all newly installed monitor wells subsequent to well development These tests may be slug tests, bail down-recovery tests, or single hole pumping tests depending on the sustainable flow rate from a given well The testing program may be modified per conditions that are encountered in the field Hydraulic test data will be analyzed using a method appropriate to the field test method

- Slug Tests - Bouwer and Rice (1976)
- Bail-down/Recovery Tests - Theis (1935), Thiem (1906), or Cooper, et al (1967)
- Single Hole Pumping Tests - Theis (1935), Cooper and Jacob (1964)
- Multi-Well Pumping Tests - Theis (1935), Cooper and Jacob (1964)
- Tracer Injection Tests - Ogata (1970)

In addition, multi-well pumping and tracer tests will be performed along Woman Creek to further characterize the valley fill alluvium as discussed below Vertical hydraulic gradients will be determined from water level data

Pumping and Tracer Tests in Woman Creek Valley Alluvium

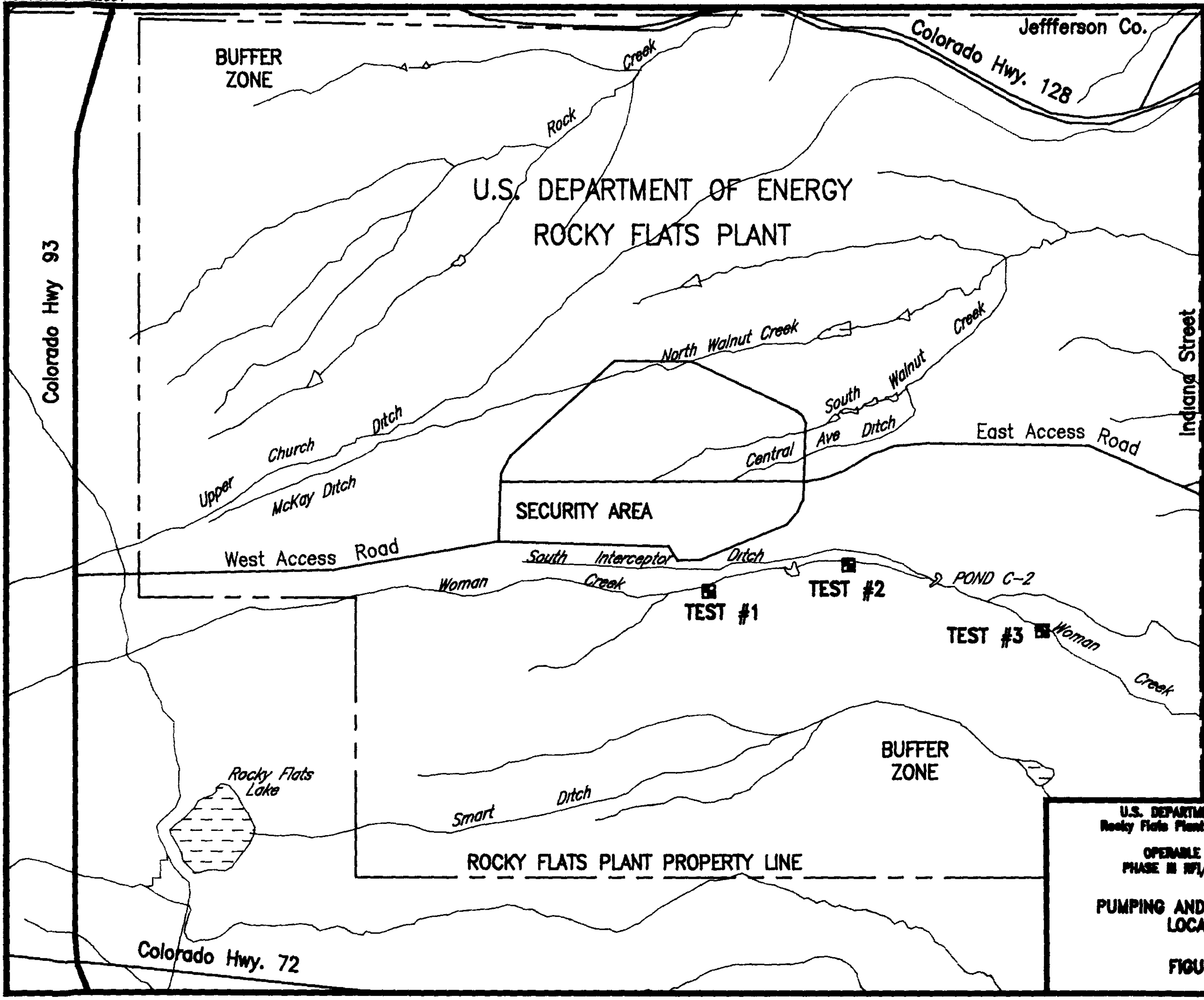
Pumping and tracer tests will be performed in the Woman Creek alluvium to develop better estimates of solute travel times Currently, the hydraulic conductivity and effective porosity are known to estimated accuracies of about a factor of three, the dispersivity is known to an estimated accuracy of about an order of magnitude In order to measure these parameters in the field (especially the effective porosity) and to account for spatial variability, three pumping and tracer tests will be performed in the Woman Creek alluvium between the 881 Hillside and Indiana Street Areas expected to have the greatest extent of saturated alluvium along Woman Creek were chosen as test locations (Figure 5-1) The testing program may be modified per conditions encountered in the field

Each test will be performed in an array of 15 wellpoints (Figure 5-2) The array has been designed to produce linear flow for the tracer test, however, the array is also suitable for the pumping test The wellpoints will consist of 1 5-inch diameter stainless steel wellpoints driven into the ground using a drill rig In order to minimize deviation from vertical while driving the wellpoints, a pilot boring will be made to approximately four feet below ground and the point driven through the hollow stem of the auger The screens will be five feet long so that the points are screened over the entire saturated thickness After completion of each test, the wellpoints will be pulled out of the ground and any remaining openings filled with neat cement grout with five percent bentonite The well points will be re-used in the next tests

Pumping Test

The pumping test will be performed by pumping Well A (Figure 5-2) at a constant rate for four hours In general, the Woman Creek alluvium varies in thickness from three to eight feet and the saturated thickness varies from about zero to four feet, although the alluvium can become fully saturated at times The alluvium

R33128.PJ-022691



EXPLANATION

TEST #1 LOCATIONS

N

Scale 1" = 1/2 Mile

0 1/2 mile

(after: U.S.G.S. Quads.: Louisville, 1979; Golden, 1980; Lafayette, 1979 and Arvada, 1980.)

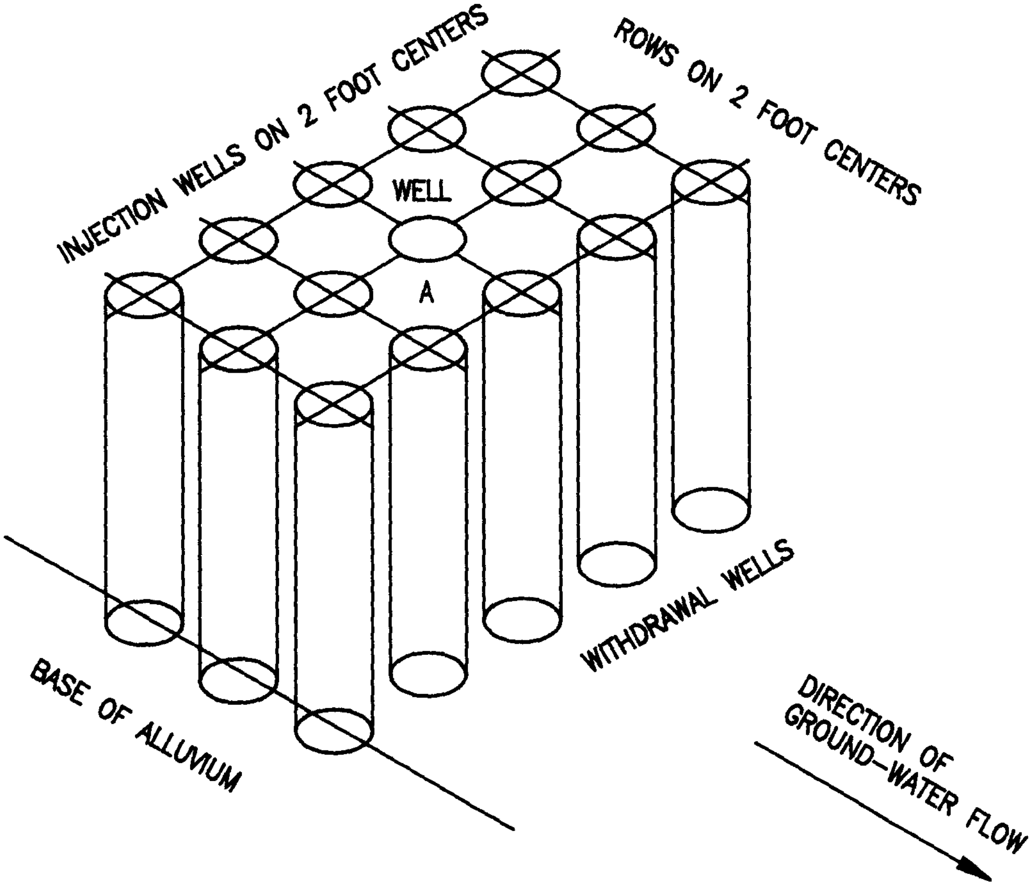
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

PUMPING AND TRACER TEST LOCATIONS

FIGURE 5-1

March, 1991



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

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

PUMPING AND TRACER TEST
WELL ARRAY

FIGURE 5-2

March, 1991

R33129.PJ-022891

is a minimum of seventy-five feet wide and the hydraulic conductivity is approximately 8 x 10^{-4} cm/s, based on baildown-recovery Preliminary calculations (assuming a saturated thickness of four feet, hydraulic conductivity of 8 x 10^{-4} cm/s, and a storage coefficient of 0 1) indicate that the Woman Creek alluvium can sustain a constant discharge of 0 14 gallons per minute (gpm) for the period of pumping with drawdowns ranging from two feet in a fully efficient pumping well to 0 19 feet at a distance of five feet

The well will be suction-pumped using an electrically operated peristaltic pump A peristaltic pump is expected to perform well in this application because the suction lift is small (estimated to be no more than ten feet) and because a peristaltic pump can be run at very small, constant flow rates All produced water will be drummed (41 gallons in four hours) and reinjected into the formation as part of the tracer test Time-drawdown data during both the pumping and recovery periods will be collected from all of the wells using either depth to water probes or pressure transducers

The pumping test will be analyzed as a constant rate withdrawal test in unconfined materials to yield hydraulic conductivity and storage coefficient Delayed yield will be considered, if appropriate In addition, the efficiency of the well (theoretical drawdown divided by observed drawdown, times 100 percent) will be evaluated for use in the tracer test calculations

Tracer Test

A linear flow system will be created by injecting water into the five upstream wells and withdrawing water from the five downstream wells Although two lines of three wells can produce linear flow between the middle wells, two lines of five wells will be used in order to provide greater assurance of linear flow between the middle wells Water will be supplied to the injection wells and withdrawn from the withdrawal wells (Figure 5-2) using peristaltic pumps controlled by electrical liquid level probes Water levels in both the injection and withdrawal wells will be allowed to fluctuate approximately 0 20 feet and will result in an average head differential of one foot (gradient of 0 25) The water levels will be maintained such that the upstream wells produce a one foot head increase and the downstream wells produce approximately an unchanged head condition Heads in the formation will be calculated assuming that the well efficiencies are as determined in the pumping test

Steady linear flow will be created by injecting the ground water withdrawn during the pumping test plus waters withdrawn from the withdrawal wells It is estimated that each well will require an average steady flow of approximately 0 03 gpm (calculated using the Darcy equation) and that steady linear flow will be achieved in approximately seven hours

The tracer test will be performed in two phases after linear flow has been achieved The first phase will inject a non-conductive fluid (distilled water) into the injection wells, the arrival of the injection fluid at the downstream withdrawal wells will be indicated by a reduction of the conductivity of the water The natural conductivity of the alluvial ground water is approximately 500 to 1,000 micromhos per centimeter and that of distilled water is near zero

Although there are many other tracers that could be used in this test, distilled water is felt to be the least environmentally damaging and was therefore selected Releases of adsorbed ions from the solid phase to the distilled water may occur during the course of the test, however, the magnitude of this effect is expected to be small because of the quartzitic and granitic mineralogy of the formation If adsorbed ions are released, the steady state conductivity at the downstream wells will be somewhat higher than zero, the actual value will be used as the 100 percent concentration for breakthrough and earlier values scaled accordingly The impact of using a lower concentration tracer will be tested by re-injecting the produced formation fluids (higher conductivity) as a second phase of the test All water withdrawn during the test will be drummed for this later use If the lower conductivity water cannot be detected in the withdrawal wells, an alternate test will be designed using Rhodamine WT dye with either a fluorimeter or a spectrofluorometer for quantitative detection

Time-conductivity data will be collected from all of the wells using dedicated conductivity probes Complete mixing of the water in the injection and withdrawal wells will be achieved with a recirculation system to avoid chemical stratification in the wellbore Conductivity will be measured in flow-through conductivity cells uphole Water will be added or withdrawn from the recirculation system on each well through solenoid valves controlled by the liquid level probes It is estimated that the 50 percent concentration will arrive at the withdrawal well approximately 400 minutes after injection begins (using an effective porosity of 0 1, hydraulic conductivity of 1×10^{-3} cm/s, gradient of 0 25 and a dispersivity of 0 1 feet) The test will continue until the conductivity in the middle withdrawal well stabilizes

During the second phase of the tracer test, the water collected during the first phase will be injected into the injection wells (approximately 150 gallons) without withdrawal from the withdrawal wells The intent of the second phase is to evaluate the impact of using a lower concentration tracer during the first phase The test will be performed as described above and the dispersivity recalculated for comparison with the original determination During this phase, linear flow will be maintained but gradients may vary somewhat during the test because downstream withdrawal will not occur, possibly resulting in unsteady flow Again, the water in the withdrawal wells will be mixed using the recirculation system to prevent stratification in the wellbore The test will continue until the conductivity of the water in the middle withdrawal well stabilizes

The time-conductivity data will be analyzed using the equation for dispersion in a semi-infinite medium in a unidirectional flow field (Ogata, 1970) The time at which the 50 percent concentration arrives at the downstream withdrawal well will be used to calculate the effective porosity (given that the gradient is known from the test conditions and the hydraulic conductivity is known from the pumping test) The dispersivity will be found by curve matching to the time-conductivity data

These calculations will yield a vertically averaged longitudinal dispersivity appropriate for use with a vertically averaged hydraulic conductivity The effects of hydraulic conductivity variations will be included in the calculated dispersivity It is recognized that spatial variation of both the hydraulic conductivity and the transport parameters is likely, therefore, three tests will be performed at different locations in the alluvium It is also recognized that dispersivity is a scale dependent parameter and that the dispersivity developed in these tests will only be appropriate for finely gridded analytical models (nodal spacings on the order of 4 to 40 feet) However, it is anticipated that the effective porosity values developed will be applicable for calculation of nondispersive ground-water flow velocities

A small test pattern was selected to cause measurable responses in a reasonable amount of time The 2-foot well spacing will permit measurable responses after four hours of pumping at 5 feet from the pumping well Each phase of the tracer test (establish linear flow, achieve 50 percent concentration, achieve 100 percent tracer concentration, repeat using natural salinity tracer to 50 percent concentration, achieve 100 percent natural salinity tracer concentration) is expected to require approximately seven hours Thus, the entire tracer test is expected to require approximately 35 hours for flow over only four feet of alluvium

Sediment stratification and artifacts of close well spacing and well development are potential sources of error for these aquifer tests The test designs described above address these issues as follows

- Sediment stratification may play an important role in the hydraulic behavior of the system during the pumping and tracer tests Calculations of system response in which thin, highly conductive layers are present will result in a slightly higher hydraulic conductivity and a considerably lower effective porosity However, these values will be appropriate for prediction of travel times in the layered system

- The ratio of the wellpoint spacing to the wellpoint diameter (2 feet divided by 1 5 inches, ratio of 16) is too great to achieve significant compaction between the wellpoints Department of the Navy (1983) predicts that an insignificant relative density can be achieved by driving piles at a spacing to diameter ratio of 16 This is consistent with field test reported by Basore and Boltano (1969) which resulted in no significant increased density for spacing to diameter ratios in excess of about 5

- Installation of wellpoints was selected as opposed to installation of monitor wells, to minimize disturbance of the alluvium for the purposes of these tests

- The degree of well development influences the response of the water level in the pumping well, but generally has little effect on the response of the observation wells The negligible impact of poor development on the response of observation wells results from the fact that head loss for flow through the well skin is proportional to the velocity squared Because very little water passes through the well skin (only that amount required to effect the water level change), the velocity is small and the head loss is even smaller Although significant removal of fines due to well development is not expected, the amount of development will be limited in order to minimize this effect The degree of development will be evaluated as well efficiency (the ratio of actual drawdown to the theoretical drawdown)

5.3 2 Surface Water and Sediments

5 3 2.1 Sample Locations

Ten surface water stations were established south of the 881 Hillside Area in the Woman Creek drainage during the 1986 and 1987 investigations Surface water sampling at these stations is currently conducted on a monthly basis and will continue through 1990 Concurrent flow measurements will be made Figure 2-20 presents surface water monitoring locations in the area, and Table 5-2 presents the surface water stations to be sampled during the Phase III RFI/RI Bedload sediment samples were taken in October 1989 at stations along Woman Creek and the South Interceptor Ditch (Figure 2-21) The resulting data should suffice as confirmatory information regarding the concentrations of volatile organics, metals, other inorganics, and radionuclides in the sediments However, sediment sampling is continuing at the Plant, and bedload sediment samples will be collected from the 881 Hillside Area For the Phase III RFI/RI, physical characteristics of the sediments (background and "downgradient") and the spatial distribution of the metal concentrations will be examined to assess the adequacy of the background sediment geochemical characterization and thus whether metals are contaminants in the sediments at the 881 Hillside Area Three new sediment stations will be established (SED-37, SED-38, and SED-39) near surface water sampling stations SW-35, SW-57, and SW-70, respectively These stations will presumably not be subject to influence by the 903 Pad Area as are the existing stations to the east

5 3 2.2 Chemical Analysis of Surface Water and Sediment Samples

Laboratory analyses of both surface water and sediment samples will consist of the parameters listed in Table 5-1 Surface water samples will be analyzed in the field for pH, conductivity, temperature, and dissolved oxygen All samples requiring filtration will be filtered in the field, and all samples will be preserved in the field Surface water sampling and stream flow measurements will follow the procedures described in the Rocky Flats ER Program SOP (EG&G, 1990g)

TABLE 5-2

SURFACE WATER SAMPLING STATIONS

Station	Seep	Stream	Pond	Ditch	Other	Area	Note
SW-31				X		SI Ditch	1,3
SW-35				X		SI Ditch	1,3
SW-44				X		SI Ditch	1,3
SW-45					X Pipe	881	1
SW-46			X			881	1
SW-56	X					PSZ	1
SW-67				X		SI Ditch	1,3
SW-68				X		SI Ditch	1,3
SW-69				X		SI Ditch	1,3
SW-70				X		SI Ditch	1,3
SW-20			X			Central	1,2
SW-32		X				Woman Cr	1,2
SW-33		X				Woman Cr	1,2
SW-34		X				Woman Cr	1,2
SW-66			X			SI Ditch	1,2
SW-71	X					881	1,2
SW-72	X					881	1,2

1 - Sample monthly as part of the Environmental Monitoring and Assessment Division (EMAD) site-wide program

2 - Stations not specifically associated with OU No 1, however, included in EMAD Listing

3 - Where the bottom of the ditch is below the ground-water table, it becomes a seep zone

5 3 3 Surficial Soils

Plutonium was elevated above background levels in Phase II RI boreholes from several sites in the 881 Hillside Area Plutonium contamination may be limited to the uppermost soil, for its suspected origin is windblown particulates from the 903 Pad Area In order to characterize the vertical and horizontal extent of surficial soil plutonium contamination, surficial soil scrapes and vertical soil profiles will be collected in remedial investigation areas, and in the Plant buffer zone south and east of these areas to Indiana Street during the 903 Pad, Mound, and East Trenches Areas (Operable Unit No 2) RI Surficial soil sampling planned for the Operable Unit No 2 Phase II RI also includes the 881 Hillside Area and is summarized below The surficial soil field sampling plan is presented in Attachment 1 0 of the Phase II RFI/RI Work Plan (Alluvial) OU No 2 (EG&G, 1991b)

The contamination of soils around Rocky Flats Plant by plutonium (Pu) oxides was mainly caused by leaking barrels of plutonium-contaminated oil in the area known as the 903 Pad (Krey and Hardy, 1970) Numerous studies (Krey and Hardy, 1970, Seed, et al , 1971, Poet and Martell, 1972, Johnson, et al , 1976, Little, 1980, Little, et al , 1980) concluded that surficial soils in the area east of the 903 Pad are contaminated with plutonium and americium (Am) due to wind dispersal of soil particles during cleanup operations More recently, the Phase I RI of the Operable Unit No 2 (Rockwell International, 1987d) found that the concentrations of plutonium and americium were elevated in composite soil samples adjacent to Trench T-2 (BH25-87, BH26-87, and BH27-87), the Reactive Metal Destruction Site (BH28-87), and T-1 (boreholes BH35-87 and BH36-87) In addition, the Phase I RI for OU No 2 found occasional elevated concentrations of plutonium (> 0 05 pCi/ℓ) in filtered surface water samples from seeps (SW-50, SW-53, and SW-54) and in stream sediments (> 0 9 pCi/g) along Woman Creek (SED-25, SED-26, SED-29, and SED-30) (Rockwell International, 1987d) It has been suggested that the source of the contaminated sediments is the surface soils from the 903 Pad Area which are transported by wind However, the elevated concentrations of plutonium in filtered and unfiltered seep waters above Woman Creek suggest that some of the plutonium may travel in surface and ground water Also, soil sampling results indicate that the actinides are enriched near the ground surface Further investigation is necessary to characterize the transport mechanisms that control the spatial and vertical distribution of these radionuclides

A detailed surficial soil sampling plan has been prepared to investigate actinide contamination at Rocky Flats The objectives of the proposed work plan for the surficial soils are to determine the spatial and vertical extent of plutonium and americium in soils of the remedial investigation areas and in the buffer zone, study the physicochemical association of plutonium and americium in surficial soils (static and mobile soil phases) above seeps SW-50, SW-53, and SW-54, study the movement of both water and radionuclides (colloidal and dissolved) down the soil column, and ascertain the hydrogeochemical relationships between the soil interstitial water and the seeps downslope The detailed sampling plan for surficial soils is provided in Attachment 1 0 of the Operable Unit No 2 Final Phase II RFI/RI Work Plan (Alluvial) (EG&G, 1991b)

5 3 3 1 **Spatial Distribution - Sample Locations**

In order to assess the spatial distribution of plutonium and americium in surficial soils within the Plant boundaries, pedologic soil samples will be collected across the area identified in Figure 5-3 consisting of approximately 800 acres Figure 5-3 was constructed based on review of previous investigation results, data analysis of unpublished material, and radiological surveys The geostatistical analysis of previous investigation results are presented in the surficial soil sampling plan [Attachment 1 0, Operable Unit No 2 Final Phase II RFI/RI Work Plan (Alluvial) (EG&G, 1991b)] The State of Colorado requires special techniques for construction on lands with plutonium concentrations greater than 0 9 pCi/g of dry soil To evaluate the soil-plutonium values relative to this guideline, the CDH sampling protocol will be used

The CDH sampling protocol requires 25 subsamples to be composited within a 10-acre area for plutonium and americium analysis Because of the large variations in soil-plutonium near the source area, a 2 5-acre grid will be sampled immediately east of the 903 Pad and around the East Trenches Area (Figure 5-3) This sampling design will serve two purposes (1) increase the confidence in soil-plutonium estimates around the 881 Hillside, 903 Pad and East Trenches Areas, and (2) expand the number of soil data for kriging estimates The soil sampling in the 2 5-acre areas will consist of 25 subsamples for plutonium, americium, and uranium determination The soil sampling in the 10-acre grid areas will also consist of 25 subsamples for plutonium and americium determination The northwest corner of each grid will be surveyed and identified with an appropriately marked steel post Grids will be oriented on the cardinal compass directions The 25 subsamples for each composite sample will be located with a hand held compass and tape measure using the northwest corner as the starting point

An in depth study has been proposed to investigate the vertical distribution of plutonium and americium in the buffer zone east and south of the 903 Pad Area and at the 881 Hillside Twenty-six locations have been identified as proposed soil pit locations (Figure 5-3) These pits will be excavated to expose the soil profiles which will then be described and sampled in order to assess the vertical distribution of plutonium-239, -240 and americium-241 in the surficial soils east of the Rocky Flats Plant In addition to investigating the spatial and vertical extent of plutonium and americium, the surficial soil sampling plan describes the program which has been designed to study the physiochemical association of those actinides in both the static and mobile soil phases The movement of both water and radionuclides (colloidal and dissolved) down the soil column will be studied as well as the hydrochemical relationships between the soil interstitial water and the seeps downslope

5.3 3 2 Chemical Analysis of Surficial Soils

Composite pedologic samples collected from the 40 2 5 acre grids (Figure 5-3) will be analyzed for plutonium-239, -240, americium-241, and uranium-232, -233, -235, and -238 Samples obtained from the 82 10-acre grids will be analyzed for plutonium and americium These analyses will be used to determine the spatial distribution of these actinides in the surficial soils at Rocky Flats Plant in the vicinity of the 881 Hillside and east of the 903 Pad

Pedologic samples from the 26 soil profiles will be analyzed for plutonium and americium to access their vertical distribution in the soils Soil organic carbon, soil pH, calcium carbonate content, and specific conductance determination will be also made on samples from each of the soil pits In addition, samples from pits X1 through X5 will also be subjected to sesquioxide extraction

In conjunction with the chemical analyses, geotechnical testing will also be conducted on samples from selected soil pits Specifically, particle size analysis and bulk density testing will be performed on a sample from one pit representative of each soil type (Table 2-7 and Figure 2-9)

6 1 INTRODUCTION

The objective of this Environmental Evaluation Plan is to provide a framework for addressing risks to the environment from potential exposure to contaminants resulting from the 881 Hillside Area This plan is prepared in conformance with the requirements of current applicable legislation, including CERCLA, as amended by SARA, and follows the guidance for such studies as provided in the NCP and EPA documents for the conduct of RCRA Facility Investigation activities Specifically, the EPA guidance provided in "Risk Assessment Guidance for Superfund, Vol II, Environmental Evaluation Manual" (EPA, 1989d) and Guidance of Data Useability in Risk Assessment (EPA, 1990) are followed All activities will be performed in accordance with the Rocky Flats Plant ER Program SOP (EG&G, 1990g)

The goal of the environmental evaluation is to determine the nature and extent of potential impacts of contamination from OU No 1 to plants and animals (biota) Determination of the effects on biota will be performed in conjunction with the human health risk assessment for the 881 Hillside Where appropriate, criteria necessary for performing the environmental evaluation will be developed in accordance with human health risk assessments and environmental evaluations for all Rocky Flats Plant operable units Information from the environmental evaluation will assist in determining the form, feasibility, and extent of remediation necessary for the 881 Hillside Area in accordance with CERCLA

6 1 1 Approach

This plan presents a three-stage, sequential approach for conducting the environmental evaluation at the 881 Hillside This phased and comprehensive approach is designed to ensure that all procedures to be performed are appropriate, necessary, and sufficient to adequately characterize the nature and extent of environmental effects to biota under the "no action" scenario As is recommended by EPA, this environmental evaluation is not intended to be or to develop into a research-oriented project The plan presented herein is designed to provide a focused investigation of potential contaminant effects on biota Each stage of the environmental evaluation activities will be coordinated with sitewide RFI/RI activities in order to avoid unnecessary duplication of effort and resources

Stage I of the environmental evaluation will focus on planning, review and integration of available data, and conduct an ecological field investigation Data quality objectives (DQOs) will be defined, and procedures for monitoring and controlling data quality will be specified Qualitative preliminary field surveys and an ecological inventory will be conducted to characterize the 881 Hillside study area biota and note the locations of obvious zones of chemical contamination and ecological effects Site history, chemical data, results from the RFI/RI fate and transport models, and existing ecological data will be reviewed and evaluated Qualitative field surveys will include a preliminary assessment of population-, community-, or ecosystem-level impacts (endpoints) to be measured Stage I activities will provide a preliminary determination of the contaminants of concern and their potential adverse effects to key receptor species at the 881 Hillside, and will allow a conceptual ecological model of the site to be prepared

Development of a conceptual pathways model will be based on the ecological field investigation and inventory This exposure-receptor pathways model will be used to evaluate the transport of contaminants from the 881 Hillside source to biological receptors The conceptual pathways model will provide an initial determination of the movement and distribution of contaminants, likely interactions among ecosystem components, and expected ecological effects

The primary endpoint for Quantitative field sampling is the detection of chemicals of concern in target species Tissues will be analyzed from selected species to document current levels of specific target analytes Selection of the target analytes, species, and tissues will be determined by which contaminants are likely to be present in sufficient concentrations, quantities, and locations as to be detected in biota The need for measuring additional endpoints through reproductive success, enzyme inhibition, or other toxicological-type studies will be evaluated based on results from quantitative sampling analyses as well as appropriate acceptance criteria

6 1 2 881 Hillside Contamination

Contamination of soil, ground water, surface water, and sediment occurs in the 881 Hillside Area, although the exact extent is difficult to assess, given uncertainties in much of the data Also, many possible contaminants have been found only infrequently and/or just above background levels, or may be associated with laboratory contamination From the data available, it appears that the major constituents (organics, metals, and radionuclides) present above background levels are the following

<u>Soil</u>

Organics PCE, TCE, 1,1,1-TCA, benzene, methylene chloride, toluene, acetone, 2-butanone, pyrenes, and phthalates,

Metals cadmium, arsenic, antimony, mercury, manganese and barium, and
Radionuclides plutonium, americium, uranium, cesium and tritium

Ground Water

Organics PCE, TCE, 1,1-DCE, 1,1-DCA, 1,1,1-TCA, 1,1,2-TCA, CCl_4, toluene, 1,2-DCA, $CHCl_3$, acetone, methylene chloride, ethyl benzene, carbon disulfide, 2-butanone, vinyl acetate, total 1,2-DCE, total xylenes, and benzene,

Inorganics nitrate, chloride, sulfate, TDS, magnesium, sodium, calcium, potassium, and cyanide,

Metals nickel, strontium, zinc, manganese, mercury, copper, selenium, lithium, barium, beryllium, iron, antimony, chromium, lead, aluminum, cadmium, cobalt and molybdenum, and

Radionuclides plutonium, uranium, tritium, strontium-89, -90, americium, radium-226 and cesium-137

Surface Water

Organics PCE, toluene, CCl_4, methylene chloride, acetone and 2-butanone,

Inorganics TDS, nitrate, sulfate, and potassium,

Metals strontium, zinc, aluminum, barium, iron, beryllium, cadmium, calcium, copper, magnesium, mercury, lead, chromium, selenium, vanadium and nickel, and

Radionuclides uranium, plutonium, strontium-89, -90, americium, cesium-137, tritium, radium-226

Sediments

Organics chloromethane, TCE, chloroform, acetone, methylene chloride, carbon disulfide, 2-butanone and toluene,

Inorganics nitrate, magnesium and potassium,

Metals beryllium, silver, tin, possibly aluminum, antimony, cadmium, chromium, copper, iron, lead, lithium, magnesium, manganese, mercury, selenium, strontium, thallium, vanadium, zinc and molybdenum, and

Radionuclides plutonium, uranium and radium-226

Many of the metal contaminants are likely to impact biota at OU No 1 if present at sufficient concentrations Several of the metal contaminants found in the 881 Hillside Area can be taken up by plants through their roots or deposited on plant leaves and stems In addition, they can be inhaled and ingested by animals These metals have various effects on biological organisms When ingested, antimony, arsenic, beryllium, cadmium, chromium, lead, mercury, selenium and tin can be toxic Arsenic, cadmium, lead and mercury function as cumulative poisons, while beryllium, chromium, nickel and arsenic are carcinogenic Cadmium and lead cause neurological disruption, and copper, mercury, tin, cobalt and nickel act as biocides to certain species at low concentrations Some trace metals such as arsenic are thought to be essential trace metals in mammalian species

Many of the metal contaminants biomagnify with increasing trophic levels In terrestrial habitats, this occurs from soil to plants for beryllium, cadmium, lead, mercury, nickel, selenium, tin and vanadium In herbivores, an increase occurs for antimony, arsenic, cadmium, chromium, copper, lead, mercury and selenium Only mercury and cadmium biomagnify in terrestrial carnivores In aquatic habitats, biomagnification has been found in algae for antimony, arsenic, cadmium, copper, chromium, cobalt, lead, mercury, nickel, selenium, tin and vanadium In aquatic herbivores, an increase occurs for antimony, arsenic, cadmium and mercury, in carnivores, an increase occurs for cadmium and mercury

Bioaccumulation occurs within an organism when the organism stores specific contaminants Arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, tin and vanadium are concentrated by a number of biological organisms potentially present in the 881 Hillside environment

Several of the volatile organic compounds found at 881 Hillside, such as PCE, are on the EPA Priority Toxic Pollutants List and are known to have acute and chronic toxic effects on aquatic life depending on their concentrations The elevated levels found in ground-water samples warrant evaluation for their potential exposure to receptor organisms

High nitrate levels were found in the ground water, surface water and sediments Nitrates are relatively nontoxic to organisms although they can cause eutrophication problems Under reduced oxygen conditions, nitrites and ammonia are especially toxic to aquatic organisms

According to the Radioecology and Airborne Pathway Summary Report (Rockwell International, 1986f), plutonium is not considered to pose an ecological hazard to biota unless extremely high levels [>1 milliCurie per square meter (mCi/m^2)] occur The reason for this is thought to be the extremely low biological mobility of the common forms of the element as demonstrated by a study that compared various biological measurements and pathological data between ecologically similar study areas at the Rocky Flats Plant of widely varying plutonium levels (Whicker, 1979) These findings and other studies on the ecological effects of radionuclides from both ingestion and inhalation will be reviewed for their applicability to the 881 Hillside environmental evaluation

6 1 3 Protected Wildlife, Vegetation and Habitats

6 1 3 1 Wildlife

The U S Fish & Wildlife Service has identified several listed endangered or threatened wildlife species which could possibly occur in the Rocky Flats Plant area However, none is expected to occur because of lack of habitat These species include the bald eagle (endangered), peregrine falcon (threatened), whooping crane (endangered) and black-footed ferret (endangered)

The bald eagle (Haliaeetus leucocephalus) is primarily a winter resident around rivers and lakes, and the closest known nesting pairs are found at Barr Lake, 25 miles to the east of Rocky Flats The whooping crane (Grus americana) passes through Colorado during its spring and fall migrations Whooping cranes, blown off their migration course, could use the Rocky Flats area as a night roost These birds prefer large marshes and wetlands in broad open river bottoms and prairies Such habitat is not present at Rocky Flats

Two subspecies of peregrine falcon (Falco peregrinus tundris and F p. anatum) may occasionally occur in the Rocky Flats area as they hunt for prey Nesting preferences are high cliff sides and river gorges, both of which are absent at Rocky Flats However, nesting sites have been recorded to the west about 4 to 5 miles from the site

The historical geographic range of the black-footed ferret (Mustela nigripes) coincides with that of the prairie dog, a principal prey species However, black-footed ferret populations are now extinct in the wild Large prairie dog towns (>80 acres for black-tailed prairie dogs) sufficient to support a black-footed ferret population are not expected to be present at Rocky Flats

6 1 3 2 Vegetation

Ten federally-listed or proposed plant species occur in Colorado, all of which are western slope species None of these is known or expected to occur on or near Rocky Flats A number of candidate species for federal listing are known to occur in Jefferson and Boulder Counties but have not been identified at Rocky Flats

6 1 3 3 Wetlands

Numerous regulations and acts have been promulgated to protect water-related resources, including wetlands Wetlands play an important role in ecosystem processing and in providing habitat to a variety of plant and animal species An assessment of Rocky Flats wetlands was completed in 1989 (EG&G, 1990k), these wetlands currently fall under the jurisdiction of the Corps of Engineers Wetlands occur along Woman Creek and Pond C-2, and DOE activities with a potential to impact wetlands must follow regulations designed for their protection

6 1 4 Scope of Work

In order to accomplish the plan objectives, a number of activities will be prepared and executed These are briefly described below

Stage I

- Project Preparation - This activity includes project planning, identification of DQOs, and final design of the ecological inventory field sampling plan Also included is the review and analysis of existing information, identification of data gaps, and a preliminary determination of the contaminants of concern and their documented ecological effects on key receptor species

- Ecological Field Investigation - This activity represents the field surveys, inventory and food habit studies necessary to characterize the biota and trophic relationships at the 881 Hillside Area Brief field surveys will be conducted in the winter, spring, summer and fall in the study area to obtain information on the occurrence, distribution, variability and general abundance of key plant and animal species A field inventory will be conducted in late spring to obtain quantitative data on community composition in terrestrial and aquatic habitats

- Samples collected as part of the activity will be saved wherever possible for use in the Stage III tissue analyses As part of these activities, all collected field data will be reduced, evaluated, compared with and integrated into the existing data bank model to update knowledge of site conditions

Stage II

- Contamination Assessment - This activity includes the toxicity assessment, exposure assessment, development of the site-specific food web pathways model and characterization of impacts to biota posed by exposures to 881 Hillside contaminants

Stage III

- Biological Contamination Studies - This activity includes field and laboratory analyses of contaminant levels in select plant and/or animal species This activity may include additional toxicological-type investigations such as reproductive success or enzyme inhibition studies

- Remediation Criteria - Statutes require the selection of remedial actions sufficient to protect the environment This activity entails consideration of federal and Colorado laws and regulations pertaining to preservation and protection of natural resources These laws and regulations are ARARs Available data on chemical exposures and toxicities will be evaluated and, to the extent practicable, criteria will be established that address biological resource protection

- Environmental Evaluation Report - This activity represents the preparation of the report which addresses the scope of the investigation, site environmental characteristics and contaminants, characterization of effects, remediation criteria, conclusions, uncertainty, and limitations of the assessment

6 2 PROJECT PREPARATION

An environmental evaluation of the 881 Hillside Area is necessary for Rocky Flats Plant to meet the requirements of Sections 121(b)(1) and (d) of CERCLA An environmental evaluation, in conjunction with the human health risk assessment, is required to ensure that remedial actions are protective of human health and the environment Guidelines for conducting this evaluation, which is also called an ecological assessment, are provided by EPA in Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (EPA, 1989d) Additional guidance is derived from EPA's Ecological Assessments of Hazardous Waste Sites A Reference Document (EPA, 1989c)

The environmental evaluation is both a qualitative and quantitative appraisal of the actual or potential injury to plants and animals (biota) other than humans and domesticated species due to contamination at the 881 Hillside The environmental evaluation is intended to reduce the inevitable uncertainty associated with understanding the environmental effects of contaminants present at the 881 Hillside and to give more definitive boundaries to that uncertainty during remediation

The plan for implementation of the 881 Hillside environmental evaluation provides a framework for the review of existing data, the conduct of subsequent field investigations, and the preparation of the contamination assessment The staged approach presented in this plan begins with the activities described in the following section preliminary planning, DQO development, support documentation, and review of existing information The field investigation and inventory is described in Section 6 3

6 2 1 Preliminary Planning

This task includes an initial determination of the scope of the environmental evaluation, identification of DQOs, and a plan for determining the types of information required for each stage of the environmental evaluation Types of information required in the evaluation include the following

- Species present at 881 Hillside, community structure and food webs

- Obvious signs of ecological impacts
- Contaminant inventory
- Contaminant sources and locations, chemical and radionuclide analyses of soil and water
- Sediment composition and quality, grain sizes and total organic carbon
- Toxicity data to provide a preliminary determination of potential effects of contaminated media on receptor species

As an integral part of the RFI/RI process, the qualitative field survey program of the environmental evaluation will focus on accumulating and analyzing pertinent information on three major areas

- Species, populations and foodweb interrelationships
- Presence, distribution and concentrations of contaminants in the environment (e g , surface soil, surface water, ground water and air)
- Potential exposure pathways and the effects of contaminants on various biological components in the affected ecosystems This is the conceptual pathways model

Data from past studies and preliminary data from current environmental studies will be used to better define the present distribution of contaminants in the abiotic environment Based on this information, a defined scope of work for Stage II and Stage III studies will be developed As part of this effort, a food web model will be developed to provide a preliminary identification of potential exposure pathways or combinations of pathways and receptor species at risk

Information that will be developed from the qualitative field survey of the environmental evaluation includes the following

- Criteria for selection of contaminants of concern, key receptor species and reference areas These criteria will be applicable to environmental evaluations at all operable units
- Species inventory - Plant and animal species known to occur within OU No 1 or to potentially contact contaminants at OU No 1
- Population characteristics - General information on the abundance of key species
- Food habit studies - Available information from literature sources to supplement field observations on key species
- Field surveys - Inventory of 881 Hillside biota and locations of obvious zones of chemical contamination and ecological effects

- Chemical inventory - Existing information including that obtained on chemical contaminants from other investigations at Rocky Flats and other DOE facilities will be used in the development of a preliminary list of contaminants of concern

This information will provide the basis for contamination assessment (Section 6 4) In the contamination assessment, comprehensive food webs and contaminant exposure pathways will be developed for 881 Hillside Information on these food webs will be related to quantitative data on contaminants in the abiotic environment These data will then be used to evaluate potential impacts to biota due to exposure from the contaminants

Field studies for contamination will be conducted for both aquatic and terrestrial systems Information from the field survey and the contamination assessment will determine the methods to be used Tissue analyses will be conducted on selected species from 881 Hillside and reference areas to document current levels of specific target analytes Selection of the target analytes, species and tissues will be determined by which contaminants are likely to be present in sufficient concentrations, quantities and locations at the 881 Hillside Area as to be detected in biota

The need for measuring additional endpoints through reproductive success or other identified endpoints will be evaluated based on pathway analysis Toxicity-based methods may involve the measurement of a biological effect associated with exposure to complex mixtures For this method, the selection of toxicological endpoints for indicator or target species will be based on a review of available scientific literature providing quantitative data for the species of concern Another approach involves the analysis of population, habitat or ecosystem changes (assessment endpoints) Analysis of population, habitat or ecosystem changes will be based on species or habitats that represent broad components of the ecosystem or are especially sensitive to the contaminants Selection of the methodology will be based on appropriate acceptance criteria, e g

- Measurement endpoint corresponds to or is predictive of the assessment endpoint
- Methodology is capable of demonstrating a measurable biological response distinguishable from other environmental factors such as weather or physical site disturbance
- Measurement is practical to perform and produces scientifically valid results
- Methodology and measurement endpoint are appropriate to the exposure pathway
- A standard acceptable protocol exists for the methodology

Determination of impacts will be based on establishment of a statistically significant difference in the biological response between samples from populations at 881 Hillside and at reference areas The determination as to what constitutes a statistically significant difference will be consistent with DQOs and quality assurance provisions of the QAPjP

6 2 2 Data Quality Objectives

The DQO development process will be initiated during the qualitative field survey preliminary planning Development of DQOs will follow the three steps recommended by EPA (EPA, 1990) Step I of the DQO process involves preparing definitions and concise DQOs Examples of Step I program DQOs for this environmental evaluation include the following

- Identify appropriate site-specific receptor species and contaminants of concern to determine if there is a potential for adverse impacts to occur as a result of potential contaminant release
- Evaluate the potential for impacts to occur to biological resources outside the boundaries of the 881 Hillside Area or Rocky Flats Plant
- Evaluate the need for remediation to protect the environment

Steps II and III of the DQO process include identification of data uses and needs and design of the data collection program Products of Step II include proposed statements of the type and quality of environmental data required to support the DQOs, along with other technical constraints on the data collection program The objective of Step III is to develop data collection plans that will meet the criteria and constraints established in Steps I and II Step III results in the specification of methods by which data of acceptable quality and quantity will be obtained The DQO development process will continue as scoping of the environmental evaluation becomes more refined Additional Step I decision-type DQOs may be needed or data collection-type DQOs may be modified based on results of the Stage I preliminary planning process and subsequent refinement of the field sampling plan

6 2 3 Support Documentation

In addition to the work plan, proper conduct of this environmental evaluation will be dependent upon development of a field sampling plan The purpose of the field sampling plan is to ensure that field data collection activities will be comparable to and compatible with previous data collection activities performed at the site while providing a mechanism for planning and approving new field activities The field sampling plan provides guidance for all fieldwork by defining in detail the sampling and data-gathering methods to be used on the project The preliminary field sampling plan for this environmental evaluation is presented in Section 6 8

Guidance for the selection and definition of field methods, sampling procedures and custody was acquired from the Compendium of Superfund Field Operations Methods, which is a compilation of demonstrated field techniques that have been used during remedial response activities at hazardous waste sites (EPA, 1987b, hereafter referred to as the Compendium) To the extent possible, procedures from the Compendium are incorporated by reference

6 2 4 Review of Existing Information

As an essential part of the environmental evaluation at the 881 Hillside Area, a review of documents, aerial photographs, and data relevant to the site will be completed This will allow compilation of a data base from which to determine data gaps and to provide evidence for a defensible field sampling program If available and applicable, historical data will be used

During preparation of this work plan, several documents were reviewed as part of an assessment of available information These included the Final EIS, Rocky Flats Plant (DOE, 1980), Wetlands Assessment (EG&G, 1990k), Draft RI Report for the High Priority Sites 881 Hillside Area (Rockwell International, 1987a and 1988a), Draft Final Remedial Investigation Report for the High Priority Site 881 Hillside (Rockwell International, 1988a), Final Proposed Interim Measures/Interim Remedial Action Plan and Decision Document, 881 Hillside (DOE, 1990a), Final Environmental Assessment for 881 Hillside (DOE, 1990c), among others Literature reviews will continue during the environmental evaluation Review of all available data formed the basis for the establishment of the initial sampling locations discussed in the Section 6 8

6 3 FIELD INVESTIGATION (STAGE I)

The following field investigation consists of three separate programs The air program will entail emissions estimation and modeling The soils and sediments, surface water and ground-water programs will be conducted as part of the Phase III RFI/RI activities The terrestrial and aquatic biota sampling program will be conducted as part of this environmental evaluation

6 3 1 Air Quality

It is necessary to model ambient air concentrations to estimate environmental risk which results from airborne transport of 881 Hillside contaminants to potential receptors Emission estimates will be calculated for surface wind erosion and for the diffusion of volatiles and semivolatiles existing below the surface through the top layer of soil Wind erosion emissions will be estimated for total particulates, metals and radionuclides while soil diffusion emissions will be estimated for volatiles and semivolatiles detected below the surface, as determined from ground-water, surface soil and soil boring sampling results Air quality dispersion modeling using a Chi/Q approach which assumes a unit emission rate, will be performed Compound-specific emission rates will then be multiplied by the modeled impacts to produce compound-specific ambient concentration estimates, since predicted concentrations are directly proportional to the emission rate

Based on the dispersion modeling results, 24-hour and annual compound-specific ambient concentrations will be estimated at a set of receptor points on and downwind of the actual 881 Hillside Area Pathways will then be defined using these receptors and risks calculated as necessary These estimates of ambient concentrations will then be used to perform a baseline risk assessment for each chemical of concern detected above background levels in the soil and ground water

6 3 2 Soils and Sediments

Site-specific soil and sediment chemistry data exist for the 881 Hillside Area These data were collected as part of Phases I and II of the RFI/RI for the 881 Hillside Drilling was conducted to identify and characterize past waste disposal sites Boreholes were drilled within and adjacent to the IHSSs, and soil samples were collected and analyzed for organics, inorganics, metals and radionuclides Sequences of Rocky Flats Alluvium, colluvium, recent valley fill and Arapahoe Formation were sampled and tested in the field and laboratory Geologic and hydrologic data from Phases I and II drilling programs provided the basic framework for defining a chemical/hydrologic/geologic model for the 881 Hillside Source contaminants and concentrations, as well as possible flow paths, rates and accumulations, were preliminarily assessed to characterize the dynamic system Sediment sampling was conducted in Woman Creek and the South Interceptor Ditch to characterize contaminants in sediment, and provide data to assess inter-media contaminant transfer to surface water

Volatile organics data for soils and sediments previously collected from the 881 Hillside Area were rejected during the data validation process and cannot be used in a quantitative sense Analytical results of the Phase III samples will be reviewed and interpreted for use in this environmental evaluation

The Phase III RFI/RI Work Plan proposes an additional soil and sediment sampling program at 881 Hillside to further characterize the extent of contamination, gain additional hydrologic data and resolve questions regarding the presence and concentration of volatile organics Under the program, boreholes will be drilled to provide continuous core of the Rocky Flats Alluvium, colluvium, recent valley fill and the Arapahoe Formation Soil samples will be analyzed for organics, inorganics, metals and radionuclides In addition to these analytes, sediments will be analyzed for grain size distribution and organic carbon, and characterized physically

As in prior programs, the soil sampling locations will be placed in areas to characterize specific sites Sample density as proposed in Section 5 0 is considered sufficient to provide a clear picture of soil characteristics and contaminant concentrations for all soil types found in the 881 Hillside Area The substances to be tested are also considered sufficient for the environmental evaluation

Soil analysis results are related to surface and ground-water regimens Fluids moving through the soils can act to leach contaminants, transport them through available flow paths and deposit them in downgradient environments Soil analyses may help define extent of contaminant sources as well as areas of accumulation

Near-surface soil scrapings (top 1 cm) will be of prime importance for determining source contaminants for biota This uppermost layer is a major source of nutrient and contaminant uptake for the vegetation under study and is a potential source of contaminant ingestion to wildlife Sampling and analysis programs under Phase III RFI/RI field investigations will be reviewed and modified when necessary to ensure that sampling intervals and methods are appropriate to collect surficial soil samples

6 3 3 Surface Water

Phase I and II surface water sampling and analytical results were evaluated with respect to this environmental evaluation plan Sampling locations presented in the work plan (Figure 2-20) are continuing to be sampled on a monthly basis through 1990 as part of the overall Plant sampling program All seeps and springs on the 881 Hillside will be sampled as part of this ongoing program Chemical results from the surface sampling locations will be reviewed and incorporated into the environmental evaluation

6 3 4 Ground Water

Results of the Phase I and II ground-water investigations along with planned Phase III activities for 881 Hillside were reviewed for incorporation in the preparation of this environmental evaluation Data from the Phase III program will aid in characterizing the nature and areal extent of ground-water contamination at the 881 Hillside The hydrogeologic information and laboratory analytical results from the planned Phase III boring and well installation program will likewise be used in the environmental evaluation The above information will be used to assess the nature and extent of contamination in ground water and help identify exposure pathways for the environmental assessment

6 3 5 Terrestrial and Aquatic Biota

Few site-specific biological data exist for the 881 Hillside Area Field surveys will be conducted to characterize biological site conditions in terms of species presence, habitat characteristics and/or community organization The emphasis will be to describe the structure of the biological communities at the 881 Hillside in order to identify potential pathways, biotic receptors and key species

6 3 5 1 Vegetation

The objectives of the vegetation sampling program are to provide data for (1) description of site vegetation characteristics, (2) identification of potential exposure pathways from contaminant releases to higher trophic-level receptors, (3) selection of key species for contaminant analysis to determine background conditions for the 881 Hillside, and (4) identification of any protected vegetation species or habitats There are currently no known protected species or habitats near the 881 Hillside Area Criteria for selecting key species are specified in Ecological Assessment of Hazardous Waste Sites (EPA, 1989c) and include

- Species of sufficient number to permit statistical significant comparisons within and outside the site
- Species of importance in the food web at the site
- Species which are susceptible to the contaminants of concern
- Species which can be compared to an unaffected reference area
- Species of economic value
- Species of social value (endangered, aesthetically valued, etc)
- Species of broad applicability to other studied sites

Terrestrial Vegetation

Vegetation is sparse and characteristic of disturbed areas except on the eastern edge of the 881 Hillside Grasses characteristic of the short grass plains are abundant Representative species include Junegrass (Koeleria cristata), Dropseed (Sporobolus spp), slender wheatgrass (Agropyron trachycaulum) and green needlegrass (Stipa viridula), which are interspersed with other grasses, shrubs, and a variety of annual flowering plants Transects will be established on 881 Hillside and along the Woman Creek drainage to collect phytosociological data on density, cover, frequency, biomass and species presence

Wetland Vegetation

Wetlands have been identified along Woman Creek (EG&G, 1990k) These occur as linear wetlands which support hydrophytic vegetation species including sandbar willow (Salix exigua), american watercress (Barbarea orthoceras), and plains cottonwood (Populus sargentii) Other species associated with these wetlands include broad-leaf cattail (Typha latifolia), baltic rush (Juncus articus), cordgrass (Spartina pectinata), silver sedge (Carex praegracilis) and various bulrushes (Scirpus spp)

Periphyton

The periphyton community is a closely-adhering group of organisms that form mat-like communities on rocks and other solid objects on the stream bottom The community composed of algae, bacteria, fungi, detritus and other macroscopic heterotrophic organisms Because of the large surface-to-volume ratio of its constituents, periphyton have been found to be an excellent indicator community for accumulation of contaminants Periphyton samples will be collected at designated locations on Woman Creek and Pond C-2

Periphyton communities provide a sensitive mechanism to detect changes in aquatic environments that result from the introduction of contaminants Taxonomic composition and relative abundance of periphyton can be measured on natural substrates as well as standardized artificial substrates On hard artificial substrates, data on algal abundance, biomass and species composition will be obtained by removing the substrate and by scraping or brushing the flora from a measured area into a container

6 3 5 2 Wildlife

A field survey will be conducted to gather data on animal communities at the 881 Hillside The objective of the animal life survey is to (1) describe the existing animal community, (2) identify potential contaminant pathways through trophic levels, (3) develop food web models including contribution from vegetation, (4) identify key species for potential collection and tissue analysis, and (5) identify any protected species

Terrestrial Species

Songbirds, larger mammals, reptiles and raptors may use the area daily, seasonally or sporadically, or wander through as vagrants The field survey will document the presence of terrestrial species and allow for a general description of the community

Aquatic Species

Benthic macroinvertebrates probably exist as both hard and soft bottom communities in Woman Creek and soft bottom communities in Pond C-2 The soft-bottom benthos is defined as those macroscopic invertebrates inhabiting mud or silt substrates Because these communities are essentially stationary, they are good integrators of past and present habitat contamination Hard bottom species in riffle habitats are subject to stream drift and are thus somewhat less stationary The feeding methods for both soft and hard substrate benthic species (filtering microscopic organisms and fine materials and grazing periphyton), suggest that they are incorporating other organisms that are potentially concentrating contaminants Designated locations in Woman Creek and Pond C-2 will be sampled for benthic organisms

6 3 6 Reference Areas

Reference areas will be selected where current and historical data are not available to assess impacts from 881 Hillside contaminants One or more reference areas will be selected based upon their similarity to the 881 Hillside Area and their lack of exposure to contamination from Rocky Flats or other sources Data collected at the reference area will be compared where possible to values reported in the scientific literature to demonstrate that the data represent a normal range of conditions Methods used to collect data at the reference area will be comparable to those used at the 881 Hillside Area

Reference areas will be identified for terrestrial, wetland and aquatic species to the west or north of the Plant away from potential effects associated with releases from either Rocky Flats Plant or the 881 Hillside Sampling rationale, methodologies and procedures for both terrestrial and aquatic sampling are presented in Section 6 8, the Field Sampling Plan

The selection of reference areas will meet Step I DQOs and the selected assessment and measurement endpoints Criteria for the selection of reference areas will be developed during the qualitative field survey and preliminary planning

Two basic criteria will be employed in the selection and establishment of reference areas

1. The reference areas will be similar to the 881 Hillside Area in terms of soil series, topography, aspect, vegetation and habitat types and plant and animal assemblages

2. The reference areas, including vegetation and wildlife, have not been impacted by releases from the 881 Hillside Area or other Rocky Flats Plant operable units

6 4 CONTAMINATION ASSESSMENT

The two major objectives of the contamination assessment are to

- Obtain quantitative information on the types, concentrations, and distribution of contaminants in selected species
- Evaluate the effects of contamination in the abiotic environment on ecological systems

Conducting a contamination assessment requires an evaluation of chemical and radiological exposures and the subsequent toxicological effects on key species Of specific importance in the contamination assessment are the identification of exposure points, the measurement of contaminant concentrations at those points and the determination of potential impacts or injury Impacts may result from movement of contaminants through ecological systems or from direct exposure (inhalation, ingestion, deposition)

Contamination Assessment for 881 Hillside will be based on existing environmental criteria, published toxicological literature and existing, site-specific environmental evaluations The program design will be integrated with other ongoing RFI/RI studies so that concentrations of contaminants in abiotic media can be related to contaminant levels and effects in biota

The contamination assessment process is divided into the following five tasks

- Site characterization
- Contaminant identification
- Toxicity assessment
- Exposure assessment
- Impact evaluation

The objectives and description of work for each of these tasks is described below

6 4 1 Site Characterization

Environmental resources at the site will be characterized based on data reviews from existing literature and reports, including results from the Phase III RFI/RI investigation and the environmental evaluation field studies The description of the site will be presented in terms of the following distinct resource areas

- Meteorology/Air Quality
- Soils and Geology

- Surface and Ground Water Hydrology
- Terrestrial Ecology
- Aquatic Ecology
- Protected/Important Species and Habitats

The purpose of the site characterization is to describe resource conditions as they exist without remediation The narrative with supporting data will include descriptions of each resource, with attendant tables and figures, as appropriate, to depict, in a concise and clear fashion, site conditions, particularly as they influence contaminant fate and transport

6 4 2 Contaminant Identification

Because there is a variety of individual contaminants associated with the 881 Hillside Area, it is critical to narrow the list of chemicals to a manageable number Chemical and species-specific criteria will be used for selecting those contaminants which are of particular concern from an ecological perspective at the 881 Hillside Although the selection process will parallel that for the human health risk assessment, the lists will differ somewhat based on contaminant fate and transport characteristics and species-specific toxicities Selection of the contaminants of concern will be evaluated in accordance with EPA guidance

6 4 3 Exposure Assessment

This task will identify the exposure or migration pathways of the contaminants, taking into account environmental fate and transport through both physical and biological means Each pathway will be described in terms of the chemical(s) and media involved and the potential ecological receptors The exposure assessment process will include the following four subtasks

- Identify exposure pathways
- Identify key receptor species
- Determine exposure points and concentrations
- Estimate chemical intake for receptors

Each of these subtasks is described below

6 4 3 1 Exposure Pathways

The purpose of this subtask is to qualitatively identify the actual or potential pathways by which various biological receptors at or near the 881 Hillside might be exposed to site-related chemicals or radionuclides The exposure pathway analysis will address the following four elements

- A chemical/radionuclide source and mechanism of release to the environment
- An environmental transport medium (soil, water, air) for the released chemical/radionuclide
- A point of potential biological contact with the contaminated medium
- A biological uptake mechanism at the point of exposure

All four elements must be present for an exposure pathway to be complete and for exposure to occur

Through contamination assessment, exposure pathways will be evaluated and modeled Toxicity tests may eventually be conducted based on model results or the need to conduct a direct effects-related investigation

6 4 3 2 Identification of Key Receptor Species

Key receptor species are those species which are or may be sensitive to the particular contaminants of concern Species that need to be considered in the contamination assessment include threatened and protected species, game species and species at higher trophic levels in food webs where contaminants are expected to bioaccumulate

Criteria for the selection of key receptor species will be based on a preliminary analysis of exposure routes and food web relationships as well as the known toxicological effects of the contaminants of concern This analysis will include an evaluation of the species in relation to potential contaminant exposure through both direct contaminant accumulation from the abiotic environment and bioaccumulation through the food chain

Key receptor species may include game species such as mule deer (Odocoileus hemionus) which is mobile and has a large home range, or an organism which is sedentary or has a more restricted movement such as plants, some invertebrates, and some small vertebrates For contaminants that bioaccumulate, the effects are usually most severe for organisms at the top of the food chain (e g , top predators) Examination of contaminant effects on these more mobile species may necessitate the integration of data from different operable units

6 4 3 3 Determination of Exposure Points and Concentrations

The identified exposure points are those locations where key ecological receptor species may contact the contaminants of concern Determination of exposure points entails an analysis of key receptor species, locations and food habits in relation to potential contaminant exposure through both direct contaminant accumulation or deposition from the abiotic environment and through indirect bioaccumulation

A discussion of the nature and extent of contamination in the abiotic media (air, soils, surface water, and ground water) is presented in Section 2 0 of this Phase III RFI/RI Work Plan Phase III data will be summarized and used to characterize source areas and release characteristics at the site The exact exposure points can be expected to vary depending on both the contaminant and the key receptor species under consideration

Concentrations of chemicals that are likely to have the greatest impact (based on concentration in the environment, toxicity values, and biological uptake) will be determined by environmental fate and transport modeling or actual environmental media sampling for each exposure point Fate, transport and endpoint contamination levels will be modeled using environmental multi-media risk assessment models Such models can provide the potential maximum concentrations of chemicals at the exposure points by which to evaluate the "worst-case" scenario

6 4 3 4 Estimation of Chemical Intake by Key Receptor Species

This step includes an evaluation of key receptor species' contaminant uptake by direct routes (inhalation, ingestion, dermal contact) and indirect routes (bioaccumulation) The amounts of chemical and radiological uptake will be estimated during the contamination assessment using appropriate conservative assumptions, site-specific analytical data, and guidance from EPA's Wildlife Exposure Factors Handbook (to be published in 1991) Direct measurement of contaminant uptake through tissue analyses will be conducted

6 4 4 Toxicity Assessment

This assessment will include a summary of the types of adverse effects on biota associated with exposure to site-related chemicals, relationships between magnitude of exposures and adverse effects, and related uncertainties for contaminant toxicity, particularly with respect to wildlife Ecological receptor health effects will be characterized using EPA-derived critical toxicity values when available in addition to selected literature pertaining to site- and receptor-specific parameters

Tissue contaminant analyses will be performed on samples of key species These measurement endpoints will be chosen based on the predicted concentrations and the known toxicological effects of single contaminants on receptor species The species, contaminants and tissues to be sampled will be evaluated during Stage I preliminary planning

Toxicity tests may be performed to address the biological effects associated with exposure to complex mixtures The need for toxicity testing will be evaluated during the qualitative field survey program of the environmental evaluation

6 4 5 Impact Evaluation

Impact evaluation entails the integration of exposure concentrations and reasonable worst-case assumptions with the information developed during the exposure and toxicity assessments to characterize the current and potential impacts to the environment posed by contamination of the 881 Hillside Area The potential impacts from all exposure routes (inhalation, ingestion and dermal contact) and all media (air, soil, ground water and surface water/sediment) will be included in the impact evaluation as appropriate

Characterization of ecological impacts on receptor species is generally more qualitative in nature than characterizing human risks This is because the toxicological effects of most chemicals have not been well documented for most species Where specific information is available in the published literature, a more quantitative evaluation of effects will be made This approach is in agreement with EPA guidance documents (EPA, 1989d)

6 4 5 1 Ecological Effects Criteria

Criteria that are usable and applicable for the evaluation of ecological effects are generally limited EPA AWQC and Maximum Allowable Tissue Concentrations (MATC) are the most readily available criteria Criteria found in federal and Colorado state laws and regulations pertaining to the preservation and protection of natural resources can also be used Criteria may also be derived from information developed for use under other environmental statutes, such as the Toxic Substances Control Act or the Federal Insecticide, Fungicide and Rodenticide Act

General information on the toxicity and environmental behavior of chemical contaminants in relation to biological resources will be compiled The selection of ecological effects criteria will be based on available data which document the adverse effects of each potential contaminant of concern Selection of these criteria will be coordinated with other RFI/RI studies and environmental evaluations

6 4 5 2 Uncertainty Analysis

The process of assessing ecological effects is one of estimation under conditions of uncertainty To address these uncertainties, the environmental evaluation for the 881 Hillside Area will present each conclusion, along with the issues that support and fail to support the conclusion, and the uncertainty accompanying the conclusion Factors that limit or prevent development of definitive conclusions will also be discussed In summarizing the assessment data, the following sources of uncertainty and limitations will be specified

- Variance estimates for all statistics
- Assumptions and the range of conditions underlying use of statistics and models
- Narrative explanations of other sources of potential error

6 5 CONTAMINATION STUDIES

Contamination studies will include the tissue analysis studies and any additional toxicity studies used to determine impacts from the contaminants of concern on receptor species Contaminants of concern and key receptor species will be selected during the qualitative field sampling program Species to be sampled for tissue analyses will be designated to the extent possible prior to implementation of the field inventory in order to avoid a duplication of sampling effort

In order to demonstrate an impact, the biological response under consideration and the proposed methodology should satisfy program DQOs as well as the following more specific criteria

- The biological response is a well-defined, easily identifiable and a documented response to the contaminant
- Exposure to the contaminant is known to cause the biological response in laboratory experiments or experiments with free-ranging organisms
- The biological response can be measured using a published standardized laboratory or field testing methodology
- The biological response measurement is practical to perform and produces scientifically valid results
- The determination of impact will be based on the establishment of a statistically significant difference in the biological response between samples from populations in the reference areas and the 881 Hillside Area

6 5 1 Tissue Analysis

Tissue analyses will be conducted to measure the total concentration of specific chemical compounds in key receptor species Because individuals and species accumulate contaminants differentially in their tissues, environmental concentrations and general uptake rates will not necessarily predict biotic concentrations or adverse effects Analysis of tissue contaminant concentrations will provide data to evaluate the predicted relationship, if any, between environmental concentrations and the amount of contaminants accumulated in receptor species Selection of the species and specific tissues for analysis will be based on a preliminary evaluation of site-specific food webs and potential contaminant transport pathways

To the extent possible, tissue samples will be collected simultaneously with environmental media samples This will allow for a determination of site-specific bioconcentration factors (BCFs) These BCFs will be incorporated into the final exposure assessment and pathways analysis model Where BCFs cannot be determined, published or predicted BCF values will be used in the pathways model to assess potential impacts

Prior to conducting the tissue analysis studies, the field sampling plan will be refined and more specific DQOs will be formulated The field sampling plan will address the following

- The number and types of analyses to be run
- The species, locations, and tissues to be sampled
- The number of samples to be taken
- The detection limits for contaminants
- The acceptable margin of error in analyzing results

6 5 2 Toxicity Tests

Toxicity tests may include either in-situ (in-field) or laboratory toxicity tests In-situ methods usually involve exposing laboratory animals to field (aquatic or soil) conditions Laboratory toxicity tests can be used to evaluate the lethal or sublethal effects of chemicals as they occur in environmental media Both approaches can be used to test for toxicity of mixtures as they actually occur in the environment Selection of a particular methodology will be based on the capability of the method to demonstrate a measurable biological response to the selected contaminant(s) of concern

6 6 REMEDIATION CRITERIA

Remediation criteria protective of site-specific plants and animals for the contaminants of concern can be developed based on detailed food web analyses using the pathways model These ecological effects criteria are determined by tracing the biomagnification of contaminant residues from organisms at the top of the food web back through intermediate trophic levels to the abiotic environment The "no effects" criteria levels for abiotic media are then derived from contaminant concentrations known to produce effects in the highest trophic level organisms

The acceptable (no effects) criteria levels will be used in conjunction with ARARs to evaluate potential adverse effects on biota as is appropriate for the environmental evaluation portion of the Phase III RFI/RI This approach will be integrated with the human health risk assessment process and will assist in the development of potential remediation criteria

6 7 ENVIRONMENTAL EVALUATION REPORT

An Environmental Evaluation Report will be prepared in a clear and concise manner to present study results and interpretation All relevant data from the environmental evaluation, in addition to relevant Phase III RFI/RI data, will be integrated and evaluated in the characterization of potential environmental impacts The following topics will be covered in the report

- Objectives
- Scope of Investigation
- Site Description
- Contaminants of Concern and Key Receptor Species
- Contaminant Sources and Releases
- Exposure Characterization
- Impact Characterization
- Remediation Criteria
- Conclusions and Limitations

A proposed, detailed outline of the report is shown in Table 6-1

TABLE 6-1

DRAFT ENVIRONMENTAL EVALUATION REPORT OUTLINE
881 HILLSIDE AREA, OPERABLE UNIT NO 1

EXECUTIVE SUMMARY

1 0 INTRODUCTION

- 1 1 OBJECTIVES
- 1 2 SITE HISTORY
- 1 3 SCOPE OF EVALUATION

2 0 SITE DESCRIPTION

- 2 1 PHYSICAL ENVIRONMENT
  - 2 1 1 Air Quality/Meteorology
  - 2 1 2 Soils
  - 2 1 3 Surface Water
  - 2 1 4 Ground Water
- 2 2 BIOTIC COMMUNITY
  - 2 2 1 Freshwater Community
  - 2 2 2 Terrestrial Community
  - 2 2 3 Protected/Important Species and Habitats

3 0 CONTAMINANT SOURCES AND RELEASES

- 3 1 SOURCES
- 3 2 RELEASES

4 0 CONTAMINANTS OF CONCERN

- 4 1 CRITERIA DEVELOPMENT FOR SELECTION OF CONTAMINANTS OF CONCERN
- 4 2 DEFINITION OF CONTAMINANTS

5 0 TOXICITY ASSESSMENT

- 5 1 TOXICITY ASSESSMENTS OF CONTAMINANTS OF CONCERN
- 5 2 CONTAMINANT EFFECTS
  - 5 2 1 Terrestrial Ecosystems
  - 5 2 2 Aquatic Ecosystems

6 0 EXPOSURE ASSESSMENT

- 6 1 CONTAMINANT PATHWAYS AND ACCEPTABLE CRITERIA DEVELOPMENT
  - 6 1 1 General Methodology for Pathway Analysis
  - 6 1 2 Selection of Key Receptor Species

TABLE 6-1 (Continued)

DRAFT ENVIRONMENTAL EVALUATION REPORT OUTLINE
881 HILLSIDE AREA, OPERABLE UNIT NO 1

6 2 EXPOSURE POINT IDENTIFICATION

6 2 1 Air
6 2 2 Soil and Sediment
6 2 3 Water
6 2 4 Vegetation

6 3 CHEMICAL FATE AND TRANSPORT

6 4 EXPOSURE POINT CONCENTRATIONS

6 4 1 Air Concentrations
6 4 2 Soil and Sediment Concentrations
6 4 3 Surface Water Concentrations
6 4 3 1 Surface Water
6 4 3 2 Ground Water
6 4 4 Vegetation Concentrations

6 5 EXPOSURE PATHWAYS

6 5 1 Terrestrial Ecosystem
6 5 2 Freshwater Ecosystem

7 0 IMPACT CHARACTERIZATION

7 1 DEVELOPMENT OF ECOLOGICAL EFFECTS CRITERIA

7 1 1 Air Criteria
7 1 2 Soil and Sediment Criteria
7 1 3 Freshwater Criteria
7 1 4 Vegetation Criteria

7 2 EFFECTS CHARACTERIZATION

7 2 1 Terrestrial Pathway

7 2 1 1 Air
7 2 1 2 Soil
7 2 1 3 Vegetation

7 2 2 Freshwater Pathway

7 2 2 1 Air
7 2 2 2 Surface Runoff
7 2 2 3 Seeps and Springs
7 2 2 4 Woman Creek

8 0 ASSUMPTIONS AND UNCERTAINTIES

TABLE 6-1 (Continued)

DRAFT ENVIRONMENTAL EVALUATION REPORT OUTLINE
881 HILLSIDE AREA, OPERABLE UNIT NO 1

9 0 RECOMMENDATIONS AND CONCLUSIONS

10 0 REFERENCES

6 8 PRELIMINARY FIELD SAMPLING PLAN

6 8 1 Introduction

This FSP for the EE of the OU No 1 describes a program designed to assess the source-receptor pathways and measure the ecological effects from the release of contaminants The EE FSP will follow the QAPjP, and the DQOs developed for the RFI/RI program The FSP will conform to field sampling procedures identified in the ER Program SOPs (EG&G, 1990g and 1991c), health and safety regulations, and sample and waste management protocols (EG&G, 1990g and EPA 1987b) The EE FSP will coordinate efforts with the RFI/RI field sampling program and the EMAD which identify contaminant concentrations in environmental media (water, soils, sediments, and air), describe source and plume characteristics, and determine the extent of contaminant migration

The EE FSP will coordinate ecological field sampling activities with collection of other environmental media as recommended in the EPA Environmental Evaluation Manual (EPA, 1989d) Ecological sampling of periphyton and macroinvertebrates will be collected in conjunction with surface water and sediment sampling efforts, vegetation, root, and microbe sampling will coincide with soil sampling efforts

Ecological field sampling procedures will follow the Ecology SOPs (EG&G, 1991c) to produce compatible data with the adjacent 903 Pad, Mound, and East Trenches Areas, OU No 2 Furthermore, the EE FSP for OU No 1 is integrated with the EE FSP for OU No 2 and OU No 5 with respect to biological field sampling for aquatic ecosystems (periphyton, benthic macroinvertebrates, and fish) in reference and common test areas to allow comparative ecological assessments wherever possible The three OU (OU No 1, OU No 2 and OU No 3) field programs will run simultaneous to facilitate this integration

The EE FSP divides field procedures into qualitative survey efforts and quantitative sampling efforts with emphasis on health and safety, QA/QC, statistical analysis, and equipment calibrations A qualitative reconnaissance ecological field survey will be conducted in the spring of 1991, followed by two quantitative sampling efforts in late spring-early summer and late summer-early fall of the same year Quantitative sampling data will supplement the existing database from the RFI/RI on contaminant concentrations in environmental media in order to identify the relationship between the release of contaminants and the ecological consequences

6 8 2 Sampling Objectives

Contaminant concentrations at exposure points will be compared to ARARs and toxicological literature to determine if contaminants are at concentrations potentially toxic to the species present at OU No 1 Tissue sample analysis from terrestrial and aquatic species will provide information necessary to develop a quantitative dose-response assessment of contaminant concentrations, comparing actual intake rates with acceptable intake rates

The qualitative ecological field survey objectives are to provide the necessary data to characterize the aquatic and terrestrial ecosystems and supplement the RFI/RI database to provide adequate information for an ecological impact assessment of OU No 1 The field surveys will be conducted to obtain information on the occurrence, distribution, and general abundance of biota Qualitative field survey objectives are as follows

- Review existing data to identify gaps

- Conduct brief field surveys and an ecological inventory to describe the existing ecological setting in terms of habitats, vegetation, wildlife, and aquatic species Observations for obvious signs or zones of contamination or impacts to biota and their habitats will be made The inventory will be accomplished through the use of established ecological field methodologies

- Select reference and test areas for quantitative aquatic and terrestrial field sampling

- Identify the presence or absence of protected or other important species and habitats

- From the above data, identify key plant and animal species which represent the major flow of energy through the food web and thus the major pathways for contaminant transfer from physical environmental media to higher trophic-level ecological receptors

- Provide site-specific information for determining objectives, measurement endpoints, and methodologies for quantitative field sampling

The quantitative ecological field sampling objectives are to provide the necessary data to compare aquatic and terrestrial communities from impacted and unimpacted reference areas by measuring levels of contaminants in biota The quantitative field sampling objectives are as follows

- Fill data gaps identified during literature review and qualitative field surveys
- Collect data on species distribution and habitat
- Measure terrestrial vegetation for composition, productivity, and biomass
- Collect tissue samples to analyze for intake rates, exposure times, and food chain relationships
- Measure ecological endpoints of toxicity to assess the differences in populations and communities between impacted and unimpacted reference areas

6 8 3 Qualitative Field Surveys

The qualitative reconnaissance field surveys will be designed to identify species and habitats present, thereby describing and recording aquatic and terrestrial ecosystems Site features such as topography, drainages, and soil types will also be recorded Reference areas will be selected for comparative ecological studies, sampling locations, frequencies, and protocol will be confirmed Key contaminant-receptor species will be identified, and representative samples of vegetation, macroinvertebrates, and fish will be collected Aquatic and terrestrial habitats will be checked with field instruments for the presence of contaminants (e g , the presence of volatile organics in soil or seep areas, specific conductivity, and pH changes in aquatic habitats) Observations will be recorded in field notebooks, field instruments will be calibrated daily, as outlined in Ecology SOP (EG&G, 1991c)

The qualitative field survey will note the presence or absence of terrestrial/wetland species and their food habits The survey procedure will include a systematic walk-through of the 881 Hillside Area, South Interceptor Ditch and Woman Creek to record ecological features Data from the qualitative field surveys and inventory will be summarized, tabulated, and accompanied with a narrative description of the following data types

- Species present
- Habitat descriptions
- Critical/protected habitats
- Protected species
- Terrestrial and aquatic foodwebs
- Potential exposure pathways
- Abundance of key species
- Vegetation biomass
- Vegetation cover
- Vegetation frequency and density (shrubs/trees)
- Vegetation importance (community dominance) values
- Characteristics of impacted sampling locations and reference locations
- Description of obvious areas of contaminant impact

Species presence will be determined by

- Visual observation
- Vocalizations heard
- Burrows/dens observed

- Nests observed
- Droppings/scat observed and characterized

6 8 3 1 Aquatic Ecosystems

The qualitative reconnaissance survey of aquatic habitats will be along the SID and Woman Creek south and east of OU No 1 The northern buffer zone of Rock Creek will also be included in this survey to identify potential reference areas for comparative quantitative sampling efforts Survey efforts will also confirm the spatial relationship of contaminant source areas to water springs and seeps, wetlands, ponds, and streams The survey results will include descriptions of recommended sampling stations and reference areas

Physical descriptions of stream sections and ponds will include parameters such as stream width and depth, pool/riffle ratios, water velocity, substrate, bank vegetation, proportion of undercut banks, and channel morphology Temperature, specific conductivity, pH, and dissolved oxygen will be measured at all springs, seeps, and points of discharge (e g , the Building 881 footing drain), as well as at various reaches along the ditch and creeks, particularly at points where the flow or vegetation characteristics change

Biological characteristics of stream sections, ponds, and seeps will be described as follows

- Observations of filamentous algae, slimes, aquatic macrophytes, vertebrate, and invertebrate species
- Sampling of fish with seines and dip nets
- Sampling benthic macroinvertebrates utilizing the Rapid Bioassessment Protocols (RBP I) developed by EPA (1989d)

Fish collected will be identified by species, measured (total length in mm), checked for abnormalities (fin rot, lesions, and parasites) and released alive

Quantitative sampling stations will be assessed using the RBP I technique supplemented by further investigation of periphyton, macrophytes, fish, and slimes The RBP I technique will assess the relative abundance of benthic macroinvertebrate orders and help determine impacted from unimpacted reference areas Standardized field data forms will be formatted to include the following information

- Relative abundance of macroinvertebrate orders (families for Megaloptera and Diptera)
- Occurrence of periphyton, algae, and aquatic macrophytes
- Abundance of fish species
- Water quality measurements (pH, temperature, dissolved oxygen, and specific conductivity)

Selection of sampling sites will be based on water quality measurements and biological indicator criteria such as changes in species diversity, absence of pollution-sensitive taxa or dominance of pollution-tolerant taxa, abundance of filamentous algae, and obvious differences between the contaminated site and reference areas Results from the qualitative survey will be summarized in a technical memorandum that will also address any revisions necessary for the quantitative field sampling program

6 8 3 2 Terrestrial Ecosystems

Qualitative reconnaissance field surveys for terrestrial ecosystems will include identification and recording of terrestrial species, delineating habitats and vegetation community types, soil types, and the general physical condition of OU No 1 Specimens will be collected, identified, and marked for future reference Wetlands, springs, and seeps will be identified to assist in locating sampling stations close to source areas Survey efforts will include observations of small and large mammals, predators, birds, reptiles, animal tracks, vegetation types, and community structure Data collections will also include observations of disturbance due to animal excavations, burrowing, or other activity Observations and specimen identification numbers will be recorded in field notebooks

Key contaminant-receptor species will be identified for quantitative sampling Wetlands, springs, and seeps will be examined for signs of contamination Root depths and densities will be determined from shallow hand-dug trenches Systematize qualitative surveys of mammals, birds, and reptiles will be conducted at dawn and dusk Standardized data forms will include information on species, abundance, health, habitat, and activities

Medium and larger sized mammals will be counted by relative abundance surveys ("time-area" counts) Reptiles will be counted in conjunction with the large mammal surveys and the habitat searches Opportunistic sightings will be recorded as well Species and activity encountered will be recorded as specified in the Ecology SOPs (EG&G, 1991c) Pellet counts will be conducted as an adjunct to small mammal, songbird, or vegetation surveys

The results from the qualitative terrestrial surveys will be summarized to include site specific information on habitats and how they relate to exposure pathways Pathological conditions related to contamination include necrosis, chlorosis, and stunting of growth in vegetation Revisions in the quantitative field sampling stations may be a result based on the conclusions of the qualitative terrestrial field survey

6 8 3 3 Reference Areas

Tissue analysis studies will require the sampling of contaminated and control areas in order to establish a relationship between contaminated conditions and background conditions in areas not exposed to Rocky Flats

Plant contamination Selection of reference areas will be based on criteria developed in the qualitative field survey and preliminary planning process Potential selection criteria include the presence of species to be sampled, and similarities to OU No 1 and OU No 2 in terms of topography, aspect, soils, vegetation, range type and land use history Reference areas will be upwind relative to prevailing air flow patterns and upstream of all known areas of plant activity

The aquatic species reference areas ideally should be located in Rock Creek A site visit will be made to the proposed aquatic sampling locations (existing surface water sampling points SW-31, SW-32, SW-46, SW-70, Pond C-2) at the 881 Hillside Area (Figure 2-20) Habitat characteristics will be noted if not previously recorded in on-going Plant studies (depth, flow, substrate type, pool/riffle, aquatic/ streamside vegetation, etc) This process will be repeated at all potential reference sites

6 8 4 Quantitative Field Surveys

Quantitative field sampling will be used to assess exposure pathways of contamination and determine the actual or potential ecological consequences and the overall nature of risk The quantitative sampling program of aquatic and terrestrial communities will include species identification at sample stations, tissue sampling for bioaccumulation analysis at potentially impacted sites and unimpacted reference areas, and measurement of toxicity levels in surface water

Quantitative field procedures will conform to SOP 5 1, Ecology 5 0 (EG&G, 1991c), and will be integrated with the NPDES program which assesses water quality discharges Sampling will be coordinated with the RFI/RI sampling of other environmental media, and sampling efforts conducted by EMAD Sampling procedures will be integrated with a similar assessment program for OU No 2, and will also be integrated and conform to sample and waste management protocols and the QA/QC requirements for the ER program

6 8 4 1 Aquatic Ecosystems

6 8 4 1 1 Periphyton

Periphyton samples will be collected at locations along the South Interceptor Ditch, Woman Creek, and Pond C-2 Periphton samplers will be set for two full-colonization periods coinciding with high and base flow conditions

Location/Frequency

Periphyton samples will be collected at the following surface water sampling locations SW-31, SW-32, SW-46, SW-70, and Pond C-2 (Figure 2-20) If visual observation reveals an absence of periphyton on hard substrates at a particular location, or preliminary collection of soft sediments and observation with field microscopes reveals an unexpected absence of periphyton on soft substrates at a particular location, the nearest location adjacent or downstream which supports periphyton will be sampled and located on a map

Field Methods

Periphyton will be sampled using floating samples as outlined in the Ecology SOP 5 1 (EG&G, 1991c) The methodology will include

- Surface-floating samplers constructed of styrofoam and a submerged rack containing six plexiglass slides will be used to collect periphyton The upper end of the vertically-suspended slides will be placed about 30 cm below the surface of the water During low-flow periods, the samplers will be suspended at 45° instead of vertically To anchor the sampler in place, sufficient weight will be attached at the end of a cord from the bottom of the sampler (cord length varied depending upon the depth at the sampling site) The exposure period in the field will be 14 days minimum If surface-floating samplers cannot be placed, periphyton will be scraped from substrate (natural)

- Physical and biological characteristics of the sampling station will be recorded when the sampler is set and picked up Water quality parameters such as temperature, pH, conductivity and dissolved oxygen will be measured at the beginning and end of the exposure period, and whenever aquatic organisms are collected Water samples will also be collected When aquatic organisms are collected

Sample Preparation/Analysis

Samples will be prepared for analysis following guidelines in the Ecology SOP 5 1 (EG&G, 1991c) The methodology will include

- For direct cell counts (identification and enumeration), algal growth will be scraped from both sides of the slide and rinsed with distilled water After the sample is diluted (as necessary) and preservative added, a subsample will be taken and allowed to settle for approximately 12 hours in a sedimentation cylinder The dilution volume usually 200 ml to 1000 ml and the volume of the subsample (1 ml to 5 ml) are dependent upon the amount of growth on the slide Organisms will be identified to genus and enumerated with a microscope at about 320X

- Biomass determinations will be made by scraping the growth from both sides of the slide into a pre-weighed crucible The residue is to be dried at 105°C for 12 hours (or until a constant weight is obtained), weighed, and then ashed in a muffle furnace at 600°C for 1 hour and weighed again The difference between the two weights is the ash-free dry weight or organic weight of the sample

- To determine the concentrations of chlorophyll-a and phaeophytin-a, both sides of the slides will be scraped and rinsed with a 90 percent acetone solution, resulting in extract volumes of 20 ml to 50 ml After the extract is homogenized and steeped for a minimum of 12 hours, it will be clarified by centrifuge tube The absorbance (optical density) of the extract is to be read at 750 nanometers (nm) and 630 nm in a spectrophotometer If dilution is necessary, 2 ml of the extract will be added to 10 ml of 90 percent acetone solution The amount of phaeophytin-a, a natural degradation product of chlorophyll-a, will be determined by examining the optical density at 633 nm before and after acidification

- All analyses will be completed within five days of the collection of the slides from the field (EPA, 1987b)

Ecological Endpoints

Periphyton samples will be analyzed for cell counts, genera, species, biomass to estimate colonization rate, and chlorophyll-a and phaeophytin-a to estimate productivity Ratios of pollutant-sensitive and pollutant-tolerant genera will also be recorded

Equipment

- Field data sheets for recording site descriptions, water quality data, flow conditions, chain of custody forms and labels
- Mesh net sampler
- Dredge or grab sampler
- Artificial substrate rack with glass slides
- Styrofoam floats

- No 35 mesh brass screen
- No 60 mesh brass screen
- Forceps and glass vials
- 10% formalin
- Dry ice and sample coolers
- Permanent markers
- One gallon zip-loc plastic bags
- Sample containers, labels
- Water quality field instruments
- Decontamination equipment
- Instrument calibration standards
- Spare slide racks with extra slides
- Distilled water
- Containers for water and sediment samples

6 8 4 1 2 Benthic Macroinvertebrates

Benthic macroinvertebrates are the most common fauna used in ecological assessments of contaminant releases and are defined as the invertebrates retained by screens of mesh size greater than 0 2 millimeters (mm) Two types of sample collectors will be used to obtain macrobenthos samples an invertebrate sampler such as a Surber or Hess sampler with a mesh net, and a grab sampler such as an Ekman Specific requirements are outlined in the Ecology SOP 5 2 (EG&G, 1991c)

Location/Frequency

Benthic organisms and fish will be collected at SW-31, SW-32, SW-46, SW-70 and Pond C-2 If no aquatic habitat is present at these designated locations, the nearest downstream location with suitable habitat will be sampled Benthic macroinvertebrate sampling stations will be at locations that also are sampled for sediment and surface water Sampling stations will run along a 50-meter segment of creek, and a 50-meter section of pond shoreline

Field Methods

At those stations where shallow flowing waters dominate, a sampler (0 09 m^2 or 1 square-foot) with a No 30 mesh net will be used Samples will be placed in small plastic jars and preserved in a solution as outlined in the Ecology SOP 5 2 (10% formalin) (EG&G, 1991c) Supplemental data on the time the samples are collected, weather conditions, water temperature, depth and general nature of the substrate for each sample, and width of the creek at the transect will also be recorded Triplicate samples will be taken within the 50-meter creek segment and transferred directly into plastic sample containers with 10% formalin

At creek locations where the water is deeper and the bottom is soft mud or silt with little current, a pole-mounted dredge or Ekman grab sampler will be used The Ekman may also be used with a remote messenger to trigger the sampler At Pond C-2, triplicate samples will be taken with an Ekman grab sampler, transferred to a wash bucket with No 30 sieve mesh, washed, and transferred to a sample container with 10% formalin

At stations with significant debris, samples will be collected and labeled Benthic organisms will be selected out of the debris and categorized into Functional Feeder Groups (EPA, 1989d) in order to assess the proportion of scrapers, filterers, and shredders

Benthic macroinvertebrates will be collected for tissue samples to determine presence of inorganic or radionuclide contaminants Samples will be collected with nets or samplers Samples will be field washed, placed on ice, and shipped to the laboratory within 48 hours

Other physical and biological conditions will also be measured at the sampling stations including water quality data, and the occurrence of other aquatic species Water quality and sediment samples will also be collected All samples will be numbered and recorded in the field notebook

Sample Preparation/Analysis

Once the sample is obtained, the entire contents will be placed in a large plastic bag and returned to the field laboratory where the contents will be sieved through a No 35 mesh (500 μm) sieve and placed in a large white tray Organisms will be separated from the debris with forceps under a table-mounted magnifier Specimens will be preserved in vials of 10 percent formalin solution Samples will be identified to genus except for chironomids Identification and enumerations, generally to genus, will be made using dissecting microscopes

Ecological Endpoints

Benthic macroinvertebrate samples will be analyzed for genera, species, biomass, total number of organisms by taxa, and ratio of pollutant-tolerant or pollution-sensitive taxa

Equipment

- Field data sheets, chain-of-custody forms and labels
- Field logbook

- Surber sampler with 352 micron (μ) mesh net
- Ekman sampler
- Benthic wash buckets with No 30 sieve (or smaller)
- Dip nets
- Boots and waders
- Sample containers, labels, and preservatives
- Boat and oars, anchor, and life preservers
- Water quality field instruments
- Cooler and ice
- Decontamination equipment
- Instrument calibration standards
- Tape Measure
- Brush with soft plastic bristles
- Forceps
- Squirt bottle
- Plastic tub (50 cm square or larger to use with Surber or Core Samplers
- Rinse bucket for use with Ekman dredge
- Distilled water

6 8 4 1 3 Fish

Location/Frequency

Fish will be collected at SW-31, SW-32, SW-46, SW-70 and Pond C-2 If no aquatic habitat is present at these designated locations, the nearest downstream location with suitable habitat will be sampled The intent is to sample fish at locations that also are sampled for sediment and surface water

Field Methods

Fish will be collected from 50 meter stream segments A standard sampling time of 20 to 30 minutes will be used at all sampling stations The section will be fished using a Smith-Root backpack shocker The anode on the shocker will be fitted with a nonconducting collection net, and the operator will be assisted by one person equipped with a fine-mesh, long-handled dip net for fish capture A standard effort of approximately 900 shocking-seconds will be used to collect the fish An alternative method consists of seining the blocked-off creek sections, one person on each side of the seine The seine is moved along one end to the other with poles on the bottom At the end of a given length of collection area, the seine is lifted from the creek and fish are collected

Block nets will be set across the creek at the upstream and downstream end of the section prior to sampling, and one or two electroshocking or seine passes will be made through the area

Captured fish will be held in a floating pen until processed Fish will be identified to species, counted, and measured for length (mm) Most fish will be set free unless retained for tissue analysis Weights will be determined by water displacement or by spring balance Data will be recorded on standardized field sheets shown in the Ecology SOP 5 4 (EG&G, 1991c) Samples will be taken for laboratory identification/confirmation

The physical characteristics of each sampling station will be recorded, water quality measurements will be taken

Sample Preparation/Analysis

Fish retained for sample analysis (minnows and/or sunfish) will be transferred to plastic bags, kept on ice and processed within 24 hours after initial capture Larger fish such as bullheads and catfish may be kept if needed for additional biomass analysis Larger fish will be filleted with each fillet being wrapped separately, labeled and frozen Fillets may be used as duplicates for laboratory analysis of inorganics and radionuclides Smaller fish will be cleaned and frozen whole

Analyses will consist of compiling and summarizing the number, size, and weight of each species of fish captured at each sampling site Graphic presentations may include fish length-frequency histograms and plots of catch per effort for each sampling area

Ecological Endpoints

Fish will be identified by species, counted, and measured Data will be analyzed for relative abundance of herbivores, carnivorous, and omnivorous, catch-per-unit-effort statistics, and length-frequency histograms

Equipment

- Field data sheets, chain-of-custody forms and labels
- Field logbook
- Backpack electroshocker
- Measuring board and scales
- Boots and waders
- Sample containers, labels, and preservatives
- Boat and oars, anchor and life preserver

- Water quality field instruments
- Cooler and ice
- Decontamination equipment
- Instrument calibration standards
- Fish identification keys and hand lens
- Seines (beac seine, kick seine)
- Reinforced dip-nets
- Small dip-nets
- Rubber gloves
- 5-gallon bucket or equivalent to be used as live well
- Aluminum foil

6 8 4 2 Terrestrial Ecosystems

Quantitative field sampling efforts for terrestrial ecosystems will be directed at wetlands, vegetation communities, small mammals, invertebrates, roots, and microbes Reference areas for quantitative sampling will be selected based on similar physical and biological characteristics

6 8 4 2 1 Vegetation

Vegetation inventory and sampling for phytosociological data will be performed at OU No 1, along the South Interceptor Ditch and Woman Creek south and east of the 881 Hillside Area A systematic walk-through of these areas will be conducted during the field surveys and spring field inventory

Location/Frequency

Vegetation sample plots will be located near soil sampling sites whenever possible The exact location of the study plots will be selected by a double randomization procedure The first procedure is selection of the soil sample locations as described in Section 5 0 of this RFI/RI Work Plan From each soil sampling point, the centerpoint of a vegetation plot will be selected based on a random distance (to 10 m) and random direction, using random numbers tables Plot locations will be selected until an adequate number has been selected for each major vegetation type Locations will be discarded under several conditions where the selected location is in a vegetation type for which an adequate number of plots has already been selected, where the vegetation of the plot is not homogeneous (located in more than one type, or across an ecotone), and where the plot would be located in buildings or paved areas A similar process will be used for transects along Woman Creek and the SID, where the sample locations will be in the general area of the surface water/sediment sampling points Since vegetation types associated with these features tend to be linear, the randomization process may require limits on direction In addition, multiple plots will be located near (within 50 m) of each surface water sampling point to provide an adequate sample size

The second procedure involves stratified randomization to identify sampling locations for the quantitative vegetative description portion of the field inventory The basis for selecting a random procedure of vegetation transect/plot location is to obtain as unbiased an estimator as possible of true population parameters for cover, density and frequency Stratification is required because several distinct vegetation types appear to be present in the study area, including prairie grassland, marsh, streambank vegetation, well-vegetated disturbed areas, and sparsely vegetated disturbed areas

Field Methods

The basis for stratification will be a vegetation type map, to be prepared based on the 1975 University of Colorado vegetation map of Rocky Flats, updated by visual observations during the field surveys This map will cover the 881 Hillside Area and the nearby areas along Woman Creek and the SID

The following quantitative procedures will be used in the Stage I field inventory to collect structural and compositional data

- At each plot selected by the process described in Section 6 8 2 1, a transect will be laid out in the randomly-selected direction The transect will be in accordance with either the point intercept, belt transect, or production plot survey methods, as detailed in the Ecology SOP 5 10 (EG&G, 1991c)

- All shrubs will be enumerated which are rooted within 1 m of the transect centerline Shrubs are defined as woody vegetation if over 0 5 m in height, and with a stem diameter of less than 2 5 cm at 1 4 m aboveground, smaller woody plants will be counted within the herbaceous stratum, and larger ones as trees For each shrub rooted within the belt transect, the following data will be recorded species, height, and two cover diameters at right angles (to calculate areal average)

- Herbaceous cover will be visually estimated by species to the nearest percent within a 1 m^2 plot, as discussed in the production plot section of the Ecology SOP 5 10 (EG&G, 1991c)

- Trunk diameter, height, canopy diameter, and species of each tree within 5 m of the transect centerline will be recorded

Sample Preparation/Analysis

- Field data will be processed to yield mean cover, density (shrubs and trees), diameter (trees), biomass, and frequency by species and/or life form Each plot/transect will be considered as an observation in calculating the mean and variance Sample adequacy will be determined for total herbaceous cover using Cochran's formula (1977)

$$N = \frac{(t^2)(s^2)}{[(x)(d)]^2}$$

where	N	=	the minimum number of samples needed
	t	=	t distribution value for a given level of confidence
	s^2	=	the variance estimate
	x	=	the mean of the sample
	d	=	the level of accuracy desired

Ecological Endpoints

Quantitative vegetation sampling will determine composition, cover, and productivity Tissue sample analysis will determine effects from bioaccummulation of contaminants

Equipment

- 30 m and 100 m flexible tape
- Brunton compass
- 1 m rule
- 1 m^2 quadrat frames
- 1/4 m^2 quadrat frames
- Survey stakes or rebar for transect locations
- Small sledge hammer
- Field forms and clipboards, labels, chain-of-custody forms
- Plant press
- Triple beam balance
- Dissecting scope
- Paper collection bags

- Drying oven
- Stainless steel shears for tissue clipping
- Small spade for root collection
- Knife
- One gallon plastic zip-loc bags
- Glass sample containers
- Permanent markers
- Dry ice
- Coolers
- Freezer
- Field identification guide
- Decontamination equipment

6.8 4.2 2 Small Mammals

A terrestrial wildlife inventory will be conducted within the 881 Hillside Area, the South Interceptor Ditch and along Woman Creek south and east of 881 Hillside Small mammal sampling will be conducted as outlined in the Ecology SOP 5 6 (EG&G, 1991c) Searches for reptiles will be conducted in the appropriate habitats in addition to small mammal trap grids

Location/Frequency

Live trapping of small mammals will take place both on the 881 Hillside and along the South Interceptor Ditch and Woman Creek Trapping will occur in mid-June to determine early densities, and in late-August to determine reproduction rates and densities

Field Methods

Live traps will be laid out in five-rows of five-traps each at five-meter intervals for a total of 50 traps or 25 traps per grid Traps will be baited with rolled oats, cornmeal or peanut butter The traps will be run for four consecutive nights and checked at four-hour intervals using recommended procedures in the Ecology SOP 5 6 (EG&G, 1991c) Data recorded from the trappings will include species, weight, sex, breeding condition, presence of tumors and ectoparasites Mammals will be marked with food coloring in order to determine success rate of trapping Some species will be collected for tissue analysis, asphyxiated by nonchemical manual suffocation, placed in plastic bags, and stored on dry ice in preparation for shipment to laboratory for analysis

Sample Preparation/Analysis

Mammals will be prepared for analysis according to the criteria specified by the laboratory depending on what analysis will be performed

Ecological Endpoints

Parameters analyzed for mammals will be species diversity, density, and reproductive success

Equipment

- Field data sheets for recording sampling information, labels, chain-of-custody forms
- Sherman or equivalent live traps
- Plastic bags
- Field scales in grams to the nearest gram
- Cooler and dry ice
- Bait (rolled oats, cornmeal or peanut butter)
- Stiff brush and squirt bottle
- 25-meter or 50-meter fiberglass tape measure
- Food coloring (three colors)
- Glass sample jars
- Field identification guide
- Field notebook
- Metafane

6 8 4 2 3 Roots and Microbes

One-hundred grams of roots will be collected in late summer, excavated from the sides of trenches Roots will be collected from incremental depths of 10 cm to the bottom of the trench Samples will be placed in plastic bags and stored on ice until transported to the laboratory for analysis Tissues will be analyzed to determine amount of transport of contaminants by root uptake Microbial biomass will be sampled with a chloroform fumigation and extraction method

6 8 4 2 4 Invertebrates

Sampling of terrestrial anthropods will conform to the Ecology SOP 5 9 (EG&G, 1991c) Ground arthropods encountered will be identified to order in the field, if possible If not, they will be placed in killing jars, returned to the laboratory, processed, and identified to order Preservation of species will be used as appropriate following guidelines in the SOP

Data to be recorded will include

- Species
- Host plant
- Habitat type
- Phenology (stage of development)

6 8 4 2 5 Wetlands

Wetlands will be sampled because of the importance of this sensitive habitat Wetlands will be characterized for location, size, and physical condition Samples will be collected for the dominant species in late summer for analysis of bioaccumulation of contaminants from springs and seeps Field sampling procedures will conform to the Ecology SOP 5 10 (EG&G, 1991c)

6 8 5 Quality Assurance/Quality Control

6 8 5 1 Sample Handling and Analytical Protocols

The methodologies selected for tissue analysis studies will depend on the contaminants of concern and their anticipated effects on the selected key contaminant receptor species Contaminants of concern and key receptor species will be determined as early as possible in the qualitative surveys and planning process Standardized site protocol for preserving samples for tissue analyses will be followed in those instances where it is anticipated that tissue analyses will be conducted

Analyses for metals and radionuclides in biota may call for a greater biomass of tissue than is available through standard collection methods At least 80 grams of material (wet weight) is needed per sample for metals analysis, and 100 grams of material is needed for radionuclides Obtaining this amount of sample may be impractical for some species of vegetation, periphyton, benthos, and macrobenthos It is not the intent of the sampling program to cause unnecessary disturbance or damage to the biota communities in order to collect sufficient samples Any decrease in sample size, however, could make data interpretation more difficult Sampling design should be adequate to ensure statistically valid results DQOs for the tissue sampling program will be evaluated with respect to this determination prior to the Stage I field inventory and during design of the Stage III field sampling plan

It is anticipated that tissue samples collected for contaminant analysis will be sent to a laboratory for the following metals and radionuclide analyses

- Metals determined by Inductively Coupled Argon Plasma Emission Spectroscopy (ICP) (barium, hexavalent chromium, copper and iron)
- Metals determined by Graphite Furnace Atomic Absorption Spectroscopy (GFAA) (arsenic, cadmium, lithium, lead, selenium, strontium and zinc)
- Mercury
- Uranium-233, -234, -235, -238
- Americium-241
- Plutonium-239, -240

Holding times, preservation methods, sample containers, and field and laboratory quality control sample numbers are contained in the QAPjP and shown in Table 6-2

6 8 5 2 Statistical Analysis and Procedures

Appropriate statistical tests will be used to analyze the data so that precision and accuracy of the results can be presented at a stated level of confidence Depending on the data types being analyzed, within-and-between station differences, within-and-between season differences, and within-and-between species differences will be presented Means, variances, standard errors, analyses of variance, regression, and correlation coefficients will be computed as appropriate Non-parametric methods will be employed where variances are heteroscedastic and population distribution is non-normal Where sample sizes are insufficient to detect differences, only descriptive statistics will be prepared

TABLE 6-2

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

	Maximum Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size*
SAMPLES FOR METALS ANALYSES				
TERRESTRIAL VEGETATION				
- Metals Determined by ICP**	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Metals Determined by GFAA+	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	5 g
Periphyton and Benthic Macroinvertebrates				
- Metals Determined by ICP	6 mos.	Freeze & ship w/dry ice	Plastic	25 g
- Metals Determined by GFAA	6 mos	Freeze & ship w/dry ice	Plastic	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/dry ice	Plastic	25 g
- Mercury	28 days	Freeze & ship w/dry ice	Plastic	5 g
SAMPLES FOR RADIONUCLIDE ANALYSES				
Terrestrial Vegetation				
- Uranium-233, -234,- 235, -238 Americium-241 Plutonium-239, -240	6 mos	Freeze & ship w/dry ice	Paper bag inserted into plastic bag and sealed	100 g

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TABLE 6-2 (Continued)

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

	Maximum Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size*
SAMPLES FOR RADIONUCLIDE ANALYSES (continued)				
<u>Periphyton and Benthic Macroinvertebrates</u>				
- Uranium-233, -234, -235, -238 Americium-241 Plutonium-239, -240	6 mos	Freeze & ship w/dry ice	Plastic	100 g

* Sample size may vary with specific laboratory requirements

**ICP = Inductively Coupled Argon Plasma Emission Spectroscopy. Metals to be determined include Ba, Cr, Cu, and Fe

+GFAA = Graphite Furnace Atomic Absorption Spectroscopy Metals to be determined include As, Cd, Li, Pg, Se, and Sr

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a preliminary identification of chemical-specific ARARs for ground water and soils at OU No 1 so that appropriate analytical detection limits are used during the RFI/RI Use of appropriate detection limits is necessary to allow evaluation of compliance with ARARs in the CMS/FS report As described in Section 7 2, evaluation and establishment of location-specific ARARs are a part of the RI process and will be addressed in the RFI/RI Report Final chemical-specific ARAR determinations will also be addressed in the RFI/RI Report Identification of action-specific ARARs and remediation goals is a part of the feasibility study process and will be addressed in the CMS/FS Report

7 1 THE ARAR BASIS

The basis for ARARs is cited in Section 121(d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), which requires that Fund-financed, enforcement, and federal facility remedial actions comply with all applicable or relevant and appropriate federal environmental or promulgated state environmental or facility siting laws For the purposes of identification and notification of promulgated state standards, the term "promulgated" means that the standards are of general applicability and are legally enforceable [National Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300 400(g)(4)]

Health-based, chemical-specific ARARs pertinent to ground water and soils (environmental media addressed by this work plan) have been identified for the EPA CLP, TCL organic, and TAL inorganic compounds, as well as radionuclides and conventional pollutants, that were detected above background The chemical-specific ARARs are derived primarily from federal and state health and environmental statutes and regulations As discussed below, in some instances these standards are classified as items "to be considered" (TBC) A summary of chemical-specific ARARs for the contaminants found at the 881 Hillside Area in ground water is presented in Table 7-1 Maximum contaminant concentrations identified in ground water at OU No 1 are shown in the table for comparison to the ARAR or TBC

One medium for which chemical-specific ARARs do not currently exist is soils As the remedial investigation proceeds, information will become available from the baseline risk assessment which will allow a determination of acceptable contaminant concentrations in soils to ensure environmental "protectiveness " This is discussed further in Section 7 5

ARARs addressing contaminants in air will be included in the CMS/FS Report In general, federal and state standards for air exist only as source- or activity-specific requirements and, accordingly, will be addressed in detail in the FS process

For the purpose of identifying ARARs, the seeps at OU No 1 are treated as points at which to evaluate ground water quality, much the same as monitoring wells Accordingly, no discussion of ARARs relative to surface water is presented in the section Ground-water seeps, their relationship to surface water in OU No 5, and surface water ARARs are subjects of the OU No 5 Work Plan

7 2 THE ARAR PROCESS

7 2 1 ARARs

"Applicable requirements," as defined in 40 CFR 300 5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be "applicable" "Relevant and appropriate requirements," also defined in 40 CFR 300 5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate" The most stringent promulgated standards are applied as ARAR (Preamble to NCP, 55 FR 8741)

7 2 2 TBCs

In addition to applicable or relevant and appropriate requirements, advisories, criteria, or guidance may be identified TBC for a particular release As defined in 40 CFR 300 400(g)(3), the TBC category consists of advisories, criteria, or guidance developed by EPA, other federal agencies, or states that may be useful in developing remedies Use of TBCs is discretionary rather than mandatory, as opposed to the use of ARARs, which is mandatory

7 2 3 ARAR Categories

In general, there are three categories of ARARs These categories are

1 Ambient or chemical-specific requirements

2 Location-specific requirements

3 Performance, design, or other action-specific requirements

ARARs are generally considered to be dynamic in nature in that they evolve from general to very specific in the CERCLA site cleanup process Initially, during the RI work plan stage, probable chemical-specific ARARs may be identified, usually based on a limited amount of data Chemical-specific ARARs at this point have meaning only in that they may be used to establish appropriate detection limits, so that data collected in the RI will be amenable for comparison to ARAR standards These proposed chemical-specific ARARs are not necessarily representative of the final ARARs which will ultimately control selected remedial actions It is also appropriate to identify location-specific ARARs early in the RI process so that information may be gathered to determine if restrictions have been placed on the concentration of hazardous substances or on the conduct of an activity solely because it occurs in a special location

7 2 4 Feasibility Study ARAR Requirements

Development of a preliminary list of potential chemical-specific ARARs in the RI process also allows the establishment of a list of preliminary remediation goals in the early FS process, which is essentially a tentative listing of contaminants together with initially anticipated cleanup concentrations or risk levels for each medium Preliminary remediation goals serve to focus the development of alternatives on remedial technologies that can achieve the remediation goals, thereby limiting the number of alternatives to be considered in the detailed remedial alternative analysis, conducted later in the FS process As more information becomes available during the RI stage, chemical-specific ARARs may become more refined as constituents are added or deleted Once data collection is complete, revised chemical-specific ARARs may be proposed

When the data collection is complete, it is also appropriate to refine location-specific ARARs which may affect the development of remedial alternatives In addition, during development of remedial action alternatives at the beginning of the FS process, a preliminary consideration of action-specific ARARs will be conducted As remedial alternatives are screened during the FS, action-specific ARARs will be identified When a detailed analysis of the remedial alternatives is conducted, all action-specific ARARs are refined and finalized with respect to each alternative before a comparison of alternatives begins At this point, a discussion is provided in the FS report for each remedial alternative regarding the rationale for all ARAR determinations

7 3 REMEDIAL ACTION AND REMEDIATION GOALS

CERCLA §121 specifically requires attainment of all ARARs Moreover, as explained in the preamble to the NCP (55 FR 8741), in order to attain all ARARs, a remedial action must comply with the most stringent requirement, which then ensures attainment of all other ARARs Furthermore, CERCLA requires that the remedies selected must attain ARARs and be protective of human health and the environment Consequently, preliminary remediation goals based on ARARs will require modification as new information and data are collected in the RI, including the baseline risk assessment (to be conducted), when ARARs are not available or are determined to be inadequate for protection of human health and the environment

Development of remediation goals is actually a portion of the overall development of remedial action objectives, which ultimately will define the required endpoint of the selected remedial action As stated in the preamble to the NCP (55 FR 8713), "remedial action objectives are the more general description of what the remedial action will accomplish Remediation goals are a subset of remedial action objectives and consist of medium-specific or operable unit-specific chemical concentrations that are protective of human health and the environment and serve as goals for the remedial action The remedial action objectives " should specify (1) the contaminants of concern, (2) exposure routes and receptors, and (3) an acceptable contaminant level or range of levels for each exposure medium (i e , a preliminary remediation goals)" According to 40 CFR 300 430 (e)(2)(i), "Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment and shall be developed by considering the following"

(A) ARARs (chemical-specific) and

   (1) Acceptable exposure levels for systemic toxicants,
   (2) Acceptable exposure levels for known or suspected carcinogens,
   (3) Technical limitations (e g , detection limits),
   (4) Uncertainty factors, and
   (5) Other pertinent information

(B) Maximum Contaminant Level Goals (MCLGs) [or Maximum Contaminant Levels (MCLs) where MCLGs are zero or where MCLGs are not relevant and appropriate], where relevant and appropriate

(C) Acceptable exposure levels where multiple contaminants or multiple exposure pathways will cause exposure at ARAR levels resulting in cumulative risk in excess of 10^{-4}

(D) CWA and Ambient Water Quality Criteria (AWQC), where relevant and appropriate

(E) A CERCLA Alternative Concentration Limit (ACL) established pursuant to CERCLA § 121(d)(2)(B)(ii)

(F) Environmental evaluations, performed to assess specific threats to the environment

Once a preferred remedial action alternative is formally selected, all chemical-, location-, and action-specific ARARs have also been defined in final form If it is found that the most suitable remedial alternative does not meet an ARAR, the NCP at 40 CFR 300 430 (f)(1)(ii)(C) provides for waivers of ARARs under certain circumstances, such as technical impracticability, risk, or inconsistent application of state requirements From this point, the alternative will become the final remedy as it is incorporated into the ROD Once the final ROD has been signed, requirements may be modified only when they are determined to be applicable or relevant and appropriate and necessary to ensure that the remedy is protective of human health and the environment (40 CFR 300 430(f)(1)(ii))

7 4 OPERABLE UNIT NO 1 GROUND-WATER ARARs

The ARARs for alluvial ground water listed in Table 7-1 were developed using the ARARs rationale described above and were identified by examining the following promulgated standards

- SDWA MCLs
- RCRA 40 CFR Part 264 Subpart F concentration limits

7.4 1 Safe Drinking Water Act MCLs

SDWA MCLs represent the maximum permissible level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system (40 CFR 141 2(c)) Furthermore, the NCP [40 CFR 300 430 (e)] requires that, in development of alternatives for final remediation, the following be considered for current or potential sources of drinking water attainment of MCLGs or MCLs, if MCLGs are zero, and attainment of CWA AWQC, where relevant and appropriate Because ground water at OU No 1 is a potential source of drinking water, the MCLGs (or MCLs) are relevant and appropriate and should be attained (note the MCLGs are currently zero or equal to the MCLs) It should be noted that on January 30, 1991 (56FR3526), EPA published new MCLs and MCLGs in final form for a number of the constituents identified in Table 7-1 These standards are effective July 30, 1992 and will be regarded as relevant and appropriate at that time For the purposes of this work plan, the new MCLs (new MCLGs are zero or equal to the MCLs) have been determined to be proposed TBC and are identified as such in Table 7-1 The AWQC are not ARAR and are not considered with respect to ground water, since they are intended for the protection of surface water relative to fish ingestion and drinking water or only fish ingestion Therefore, it is inappropriate to apply such CWA criteria to ground water

7 4 2 RCRA 40 CFR Part 264 Subpart F Concentration Limits

Owners or operators of facilities that treat, store, or dispose of hazardous waste must ensure that hazardous constituents listed in 6 Colorado Code of Regulations (CCR), 1007-3 and 40 CFR 261 Appendix VIII entering the ground water from a regulated unit do not exceed concentration limits (6 CCR 1007-3 and 40 CFR 264 94) at the point of compliance in the uppermost aquifer The concentration limits include standards for 14 compounds (these standards are equivalent to and a subset of SDWA MCLs and are identified at 40 CFR 264 94, Table 1), with background or ACLs used as the standards for the other RCRA 40 CFR Part 261

TABLE 7-1
PROPOSED CHEMICAL SPECIFIC ARARS
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water* (µg/ℓ)	Well Designation # & Sample Date	Detection Limit (µg/ℓ)	Proposed ARAR (µg/ℓ)	Proposed TBC (µg/ℓ)	Reference	Comment
Organic Compounds							
Acetone	280	5187 (08/14/89)	10		10U	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC	
Methylene Chloride	1500B	4387 (08/18/89)	5		5U	Parameter is RCRA (40 CFR Part 261) Appendix VIII constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC	
Tetrachloroethene	13200	0974 (05/21/87)	5		5	SDWA MCL [40CFR141.61(a)] is TBC*	
Toluene	270JB	4387 (08/18/89)	5		1000	SDWA MCL [40CFR141 61(a)] is TBC*	Maximum detected concentration is below proposed TBC standard.
Trichloroethene	72000	0974 (05/21/87)	5	5		SDWA MCL [40 CFR 141 61 (a)]	
Carbon Disulfide	8	5487 (07/26/89)	5		5U	Parameter is RCRA (40 CFR Part 261) Appendix VIII constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC	Maximum detected concentration is below proposed TBC standard
Chloroform	100J	1074 (06/09/89)	5	100		SDWA MCL (40 CFR 141.12)	Standard is for total trihalomethanes
Carbon Tetrachloride	28000	0974 (05/21/87)	5	5		SDWA MCL [40 CFR 141 61 (a)]	

TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water* (µg/ℓ)	Well Designation # & Sample Date	Detection Limit (µg/ℓ)	Proposed ARAR (µg/ℓ)	Proposed TBC (µg/ℓ)	Reference	Comment
Organic Compounds (cont)							
1,1-Dichloroethane	350EA	4387 (10/17/88)	5		5U	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC	
1,2-Dichloroethane	16000	0974 (05/21/87)	5	5		SDWA MCL [40 CFR 141 61(a)]	
1,1-Dichloroethene	48000	0974 (05/21/87)	5	7		SDWA MCL [40 CFR 141 61 (a)]	
Vinyl Acetate	39J	1074 (08/23/89)	10		10U	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC	
1,1,1-Trichloroethane	30250	0974 (10/20/87)	5	200		SDWA MCL [40 CFR 141 61(a)]	
1,1,2-Trichloroethane	14740	0974 (04/14/88)	5		28	WQCC Ground Water Standard, Interim Organic Pollutant Standard is TBC	
2-Butanone	22	0974 (08/29/86)	10		10U	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC	
1,2-Dichloroethene (total)	5070	4387 (12/18/87)	5		5U (70)	Parameter is RCRA (40 CFR Part 261) Appendix VIII constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC SDWA MCL, in parentheses, [40CFR141 61(a)] is TBC*	

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TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water* (µg/ℓ)	Well Designation # & Sample Date	Detection Limit (µg/ℓ)	Proposed ARAR (µg/ℓ)	Proposed TBC (µg/ℓ)	Reference	Comment
<u>Organic Compounds (cont)</u>							
Xylene (total)	2J	5187 (06/12/89) 4387 (07/26/89)	5		5U (100)	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC SDWA MCL, in parentheses, [40 CFR 141 61(a)] is TBC*	
Ethyl Benzene	6	4387 (07/26/89)	5		680 (10000)	WQCC Ground Water Standard, Interim Organic Pollutant Standard is TBC SDWA MCL, in parentheses, [40 CFR 141 61(a)] is TBC*	
Benzene	83J	4387 (10/17/88)	5	5		SDWA MCL [40 CFR 141 61(a)]	

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TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water* (mg/ℓ)	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Dissolved Metals							
Aluminum	4 75	6286 (10/16/86)	0 20		5 0	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	Maximum detected concentration is below proposed TBC standard
Antimony	0 208	6986 (10/08/86)	0 06		0 06U	Parameter is RCRA (40 CFR Part 261) Appendix VIII constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC	
Arsenic	0 0182	0587BR (06/12/89)	0 01	0 05		SDWA MCL [40 CFR 141 11 (b)]	Maximum detected concentration is below proposed ARAR standard
Barium	0 926	5986 (04/09/87)	0 20	1 0		SDWA MCL [40 CFR 141 11(b)]	Maximum detected concentration is below proposed ARAR standard
Beryllium	0 029	5986 (10/08/86)	0 005		0 1	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	Maximum detected concentration is below proposed TBC standard.
Cadmium	0 0138	0887BR (06/12/89)	0 005	0 01	0 005	SDWA MCL [40 CFR 141 11(b)] SDWA MCL [40 CFR 141 62(b)]	
Calcium	355 9960	0487 (07/09/87)	5	NS		No Standard	
Chromium	0 0782	0487 (10/14/87)	0 01	0 05	0 1	SDWA MCL [40 CFR 141 11(b)] SDWA MCL [40 CFR 141 62(b)] is TBC*	Analytical results are for total chromium
Copper	3 13	5487 (06/08/89)	0 025		0 2	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	

TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water* (mg/ℓ)	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Dissolved Metals (cont)							
Iron	25 3	0887BR (01/23/89)	0 1		0.3	WQCC Ground Water Standard, Table 2, Secondary Drinking Water Standard is TBC	Analytical results are for soluble iron
Lead	0 037	6986 (10/08/86)	0 005	0 05		SDWA MCL [40 CFR 141 11(b)]	Maximum detected concentration is below proposed ARAR standard.
Lithium	0 7	0974 (11/17/87)	0 1		2 5	WQCC Ground Water Standard, Table 2, Secondary Drinking Water Standard is TBC	Maximum detected concentration is below proposed TBC standard
Magnesium	105	4887 (06/09/89)	5	NS		No Standard	
Manganese	3 33	0187 (06/06/89)	0 015		0.05	WQCC Ground Water Standard, Table 2, Secondary Drinking Water Standard is TBC	Analytical results are for soluble manganese
Mercury	0 006	6486 (07/16/87)	0 0002	0 002		SDWA MCL [40 CFR 141 11(b)]	
Molybdenum	0 185	4887 (06/09/89)	0 008	NS		No Standard	
Nickel	11 70	5487 (06/08/89)	0 04		0 2	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	
Potassium	54 8	6986 (10/08/86)	5	NS		No Standard	
Selenium	3 2	1074 (10/25/88)	0 005	0 01	0 05	SDWA MCL [40 CFR 141 11(b)] SDWA MCL [40 CFR 141 62(b)] is TBC*	

TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water[a] (mg/ℓ)	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
<u>Dissolved Metals (cont)</u>							
Silver	0 031	0974 (08/29/86)	0 01	0 05		SDWA MCL [40 CFR 1411 (b)]	Maximum detected concentration is below proposed ARAR standard
Sodium	341 75	0487 (07/09/87)	5	NS		No Standard	
Strontium	3 832	0587BR (10/20/88)	0 2	NS		No Standard	
Thallium	0 016	6986 (10/08/86)	0 01		0 01U	Parameter is RCRA (40 CFR Part 261) Appendix VIII constituent RCRA 40 CFR Part 264 Subpart F (background) is TBC	
Vanadium	0 0368*	6486 (07/16/87)	0 05		0 1	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	Maximum detected concentration is below proposed TBC standard
Zinc	2 4559	4887 (02/15/88)	0 02		2 0	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	

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TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water[a] (mg/ℓ)	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
<u>Non-Metallic Inorganics</u>							
pH (min)	7 0	0187 (08/17/89)	0.1		6 5	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	Minimum pH value is within proposed standard
pH (max)	9 9	6286 (10/19/89)	0 1		8 5	WQCC Ground Water Standard, Table 3, Agricultural Standard is TBC	
Nitrite	91 2	0974 (08/29/86)	1 0		1 0	WQCC Ground Water Standard, Table 1, Human Health Standard is TBC 1 0 mg/ℓ is also SDWA MCL [40 CFR 141 62(b)]*	Analytical results are total nitrite plus nitrate as nitrogen Reanalysis is required to determine if proposed nitrite standard is exceeded.
Nitrate	91 2	0974 (08/29/86)	5	10 0		SDWA MCL [40 CFR 141 11 (b)]	Analytical results are total nitrite plus nitrate as nitrogen
Chloride	838	4887 (02/15/88)	5		250	WQCC Ground Water Standard, Table 2, Secondary Drinking Water Standard is TBC	
Sulfate	1110	6286 (07/19/89)	5		250	WQCC Ground Water Standard, Table 2, Secondary Drinking Water Standard is TBC	
Bicarbonate	640	0187 (06/06/89) 0587BR (02/14/90)	10	NS		No Standard	

TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water[a] (mg/ℓ)	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Non-Metallic Inorganics (con't)							
TDS	2374	0487 (07/09/87)	5		1643	WQCC Ground Water Standard, Table 4, Standard is TBC	Proposed standard is calculated from the upper tolerance interval in background wells. Value includes 95% of the population at 95% confidence multiplied by 1 25
Cyanide	10 2	0974 (10/26/89)	0 01		0 2	WQCC Ground Water Standard, Table 1 Standard is TBC	

TABLE 7-1 (Continued)
PROPOSED CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED IN
GROUND WATER AT THE 881 HILLSIDE AREA

Chemical	Maximum Concentrations 881 Hillside Area Ground Water* (pCi/ℓ)	Well Designation # & Sample Date	Detection Limit (pCi/ℓ)	Proposed ARAR (pCi/ℓ)	Proposed TBC (pCi/ℓ)	Reference	Comment
Radionuclides							
Gross Alpha	319 ±241	0487 (07/09/87)	2	15		SDWA MCL [40 CFR 141.15 (b)]	
Gross Beta	286 ±83	0487 (07/09/87)	4	4 (mrem/yr)		SDWA MCL [40 CFR 141 16 (a)]	
$Pu^{239\ 240}$	0 6 ±1 4	0587BR (07/06/87)	0 01		15	WQCC Ground Water Standard, State-wide Radionuclide Standard is TBC	Maximum detected concentration is below proposed TBC standard
H^3	777 ±333	0487 (07/09/87)	400	20000		SDWA MCL [40 CFR 141 16 (b)]	Maximum detected concentration is below proposed ARAR standard
$Sr^{89\ 90}$	5 6	0287 (07/09/87)	1	8		SDWA MCL [40 CFR 141 16 (b)]	Maximum detected concentration is below proposed ARAR standard
U^{total}	64 2 ±2 3	5287 (06/12/89)	1 8		5	WQCC Surface Water Standard is TBC	

*	-	Maximum compound concentrations determined from data collected through the first quarter of 1990
B	-	Compound also present in blank
J	-	Estimated below detection limit
U	-	Detection limit
A	-	Accepted with qualifications
NS	-	No ARAR Standard
mrem/yr	-	Millirem per year
E	-	Estimated value
*	-	Constituent reported below contract required detection limit
**	-	MCL was published January 30, 1991 (56 FR 3526) with an effective data of July 30, 1992 Because these new standards will become ARAR on the effective date, these MCLs have been identified whenever they will cause a change in the ARAR

Appendix VIII constituents or 40 CFR Part 264 Appendix IX constituents These concentration limits apply to RCRA "regulated units" subject to permitting (defined at 40 CFR 264 90 to include landfills, surface impoundments, waste piles, and land treatment units) that received RCRA hazardous waste after July 26, 1982 Although OU No 1 does not contain RCRA-regulated hazardous waste management units, it does contain IHSSs As a result, these RCRA 40 CFR Part 264 Subpart F regulations are considered relevant and appropriate for ground water

As discussed above, an ACL may be established for a hazardous constituent if it is determined that attainment of a Subpart F Table 1 constituent standard or background standard is not necessary to ensure adequate protection of human health and the environment Furthermore, EPA has stated that for potential drinking water sources, the Agency's preference is to set remediation levels that are the equivalent of exposure- or health-based ACLs under RCRA (EPA, 1988d) Therefore, it is inappropriate to establish background as an ARAR unless it may be determined through risk assessment that attainment of background is necessary for adequate protection of human health and the environment. Accordingly, 40 CFR Part 264 Subpart F Table 1 standards and hazardous constituent background values will be applied as TBC until such time as risk assessment information indicates some other alternative standard is necessary to ensure "protectiveness" TBC background ground water values for Subpart F are applied using maximum concentrations from background ground water in both the alluvial and bedrock lithologies at Rocky Flats Plant

7.4.3 Ground-Water TBCs

The Colorado Water Quality Control Commission (WQCC) state-wide ground-water standards have been applied as TBC since they are not yet enforceable Similarly, since ground water at Rocky Flats Plant has not been classified, the use-specific standards in Tables 1 through 4 of the WQCC Basic Standards for Ground Water at 3 11 0 (5 CCR 1002-8) have also been applied as TBC where ARARs are not available In this application, the most stringent of the standards in Tables 1 through 4 has been identified as TBC

7 5 OPERABLE UNIT NO. 1 SOIL ARARs

As discussed in Section 7 1, one medium for which chemical-specific ARARs do not currently exist are soils, however, a risk assessment will be performed to determine acceptable contaminant concentrations in soils to ensure environmental "protectiveness" At this time, with respect to establishing analytical detection limits for soils, use of the method detection limits provided in the GRRASP (EG&G, 1990i), which are CLP contract required quantitation limits, should enable meaningful interpretation of soil sample results

7 6 OPERABLE UNIT NO. 1 ARARs SUMMARY

Table 7-1 shows that certain volatile organics, metals, and major ions that were analyzed have exceeded proposed chemical-specific ARARs at some locations within OU No 1 This does not indicate releases of these constituents are occurring, since the concentrations of some substances may be due to past releases or to natural geochemical processes The listing of Table 7-1 has been presented to identify parameters for which analysis should be conducted in the Phase II RFI/RI, and to identify the minimum acceptable detection limits for analytes found in OU No 1 ground water The FS will evaluate technologies that address these constituents

Of the elements/compounds detected in ground water at OU No 1, there are no ARARs or TBCs for calcium, magnesium, molybdenum, potassium, sodium, strontium, or bicarbonate However, the TDS TBC provided by the WQCC Ground Water Standards establishes the acceptable aggregate concentration for the major metal ions (excludes strontium and molybdenum)

For any contaminants detected in ground water for which no ARARs or TBCs were found, analytical detection limits will be based on the method detection limits provided in the GRRASP (EG&G, 1990i), which are CLP contract required quantitation limits and should enable meaningful interpretation of sample results Risk-based concentrations based on the baseline well risk assessment, establish the remediation goals for these trace metals and organics, thus ensuring environmental "protectiveness "

SCHEDULE

The schedule for conducting the Phase III RFI/RIFS is summarized in Figure 8-1 The schedule includes both the RFI/RI and the CMS/FS activities The schedule is in accordance with the signed January 22, 1991 IAG

As discussed in Section 5 0 (FSP), monitoring wells will be installed for plume characterization, and borings and monitoring wells will be drilled for source characterization Borehole, ground-water, sediment, and surficial soil samples will be collected for chemical analysis The data will be validated and evaluated for incorporation into the draft and final RFI/RI reports

During RFI/RI report preparation, on-going treatability studies will be in progress and the CMS/FS will start The CMS/FS will include remedial alternatives development and screening, and detailed analysis of alternatives According to this schedule, nearly three years will elapse from the time this work plan is finalized until the final CMS/FS report is prepared

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LIST OF ACRONYMS

AEC	U S Atomic Energy Commission
ARARs	Applicable or Relevant and Appropriate Requirements
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
Ci	Curies
CLP	Contract Laboratory Program
cm	centimeter
CMS/FS	Corrective Measure Study/Feasibility Study
CWA	Clean Water Act
1,2-DCA	1,2-Dichloroethane
DOE	U S Department of Energy
EE	Environmental Evaluation
EPA	U S Environmental Protection Agency
ERHSPP	Environmental Restoration Health and Safety Project Plan
FS	Feasibility Study
g/ℓ	grams per liter
GC	Gas Chromatograph
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HASL	Health and Safety Laboratory
IAG	Inter-Agency Agreement
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IRIS	Integrated Risk Information System
LDRs	Land Disposal Restrictions
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
mCi/km^2	milliCuries per square kilometer
mg/kg	Milligrams per Kilogram
mg/ℓ	Milligrams per Liter
MSDS	Material Safety Data Sheet
OU	Operable Unit
PCE	Tetrachloroethene
pCi/g	picoCuries per gram
pCi/ℓ	picoCuries per liter
PPCD	Prevention of Contaminant Dispersion

LIST OF ACRONYMS (Continued)

PQLs	Practical Quantitation Limits
QAA	Quality Assurance Addendum
QA/QC	Quality Assurance/Quality Control
QAPjP	Quality Assurance Project Plan
RAAMP	Radioactive Ambient Air Monitoring Program
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act of 1976
RfDs	Risk Reference Doses
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SAS	Special Analytical Services
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SSHSP	Site-Specific Health and Safety Plan
SWMU	Solid Waste Management Unit
TBC	To be Considered
TCE	Trichloroethene
TDS	Total Dissolved Solids
TSP	Total Suspended Particulate
$\mu Ci/\ell$	microCuries per liter
$\mu Ci/m^2$	microCuries per square meter
$\mu g/kg$	micrograms per kilogram
$\mu g/\ell$	micrograms per liter
VOC	Volatile Organic Compound
WQCC	Water Quality Control Commission

1 1 INTRODUCTION

This document presents responses to U S Environmental Protection Agency (EPA) and Colorado Department of Health (CDH) comments on the Final Phase III RFI/RI Work Plan for the 881 Hillside Area [Operable Unit No 1 (OU No 1)] at the Rocky Flats Plant The Final Work Plan was submitted to EPA and CDH in October 1990, and written comments were received from EPA and CDH in December 1990 This response to comments is a companion document to the revised Phase III RFI/RI Work Plan that has been prepared pursuant to these regulatory agency comments The Phase III Work Plan has been revised to better assure that the RFI/RI and CMS/FS are conducted in accordance with a plan to which all parties are in agreement It is noted that the Phase III Work Plan has also been modified for consistency with the revised Final Phase II RFI/RI Work Plan (alluvial) for Operable Unit No 2 (to be submitted under separate cover) This consistency in planning is necessary in that comments received on the Operable Unit No 2, Phase II Work Plan are often relevant to the OU No 1 Phase III RFI/RI Work Plan The substantative changes to the plan that are not pursuant to a specific Phase III Work Plan comment are noted in these responses to comments

1 2 RESPONSE TO EPA COMMENTS

GENERAL COMMENTS

EPA submitted comments in October 1990 on the Site-Wide Quality Assurance Project Plan (QAPjP) and the Standard Operating Procedures (SOPs) which together make the Sampling and Analysis Plan (SAP) The SAP comments should have been taken into account in generating the OU 1 Quality Assurance Addendum (QAA) document A major concern is that the SAP did not adequately address the major QA procedures that will be employed at all the individual hazardous substance sites (IHSS) Much of the basic concepts were deferred to the site-specific QAA and the OU 1 QAA defers to the SAP The QAA is designed to and must supplement the QAPjP where site-specific information is needed The QAA provides site-specific information and should have been referenced in the Field Sampling Plan of the work plan The QAA should state the accessibility of the SAP for worker instruction These issues must be resolved to EPA satisfaction prior to EPA's final approval of this workplan

While the nature and extent of contamination section in Chapter 2 does provide summaries of contaminants in the different media, the section should have presented sufficient graphic representation of data in the form of tables, cross sections and plume maps Even where insufficient data prevents detailed analysis (i e , plume maps), chemical data could have been plotted along with hydrogeologic data to identify trends, correlations, and data gaps Trend analyses are lacking The data that have been collected for over three years at the site could have been used for trend analyses in characterizing the nature and extent of contamination The information generated through implementation of this work plan must be presented to address this comment in the Phase III RFI/RI Report

The approach in the revised work plan of evaluating the groundwater conditions by hydrologic unit rather than by SWMU is appropriate as contamination from the SWMUs is likely commingled However, it is still necessary to define the type of contamination at each source for determining appropriate cleanup methods It should be noted that the unconfined aquifer can be locally interconnected with the underlying sandstones Thus, contaminated groundwater from the surficial deposits can be transmitted to the underlying claystones and sandstones

It is apparent that the Phase I and Phase II site evaluation investigations did not adequately characterize the site in terms of the soil, surface water and groundwater systems The Phase III RFI/RI investigation must result in an accurate conceptual model of the hydrogeologic system in the vicinity of OU 1 The conceptual model should be developed for an area somewhat larger than OU 1 to account for the fact that physical earth systems are not limited by artificial boundaries

A site conceptual model is lacking for development of the baseline risk assessment The text describes a site conceptual model only in terms of geology and hydrology In the context of the risk assessment, the model should include all media and be based on an analysis of potentially complete exposure pathways In the RI work plan, the site conceptual model should have been evaluated for likely exposure points These exposure points should have been considered when sampling and analysis plans were written For several environmental contaminants, particle size may be important in determining exposure concentrations Failure to examine appropriate particle sizes may result in under estimation of exposure concentrations Sampling for extent of contamination over large areas provides little data for estimation of specific exposure point concentrations If sampling is not extensive enough to detect a "hot spot," it may not be sufficient for estimation of exposure point concentrations in a residential setting where such a "hot spot" might impact 4 to 8 or more homes/living units This comment needs to be addressed in order to develop an accurate assessment of risk for presentation within the Phase III RFI/RI Report

A key element is missing from the description of activities for the baseline risk assessment Before identifying chemicals of concern, a data evaluation step is critical This step ensures that the risk assessment uses appropriate and reliable data, noting any data gaps or other data problems that contribute significantly to uncertainty Of particular concern are quantification limits, uses and limitations of qualified data, evaluation of tentatively-identified compounds (if any), statistical analysis of background and increases over background, and representativeness of data The data evaluation develops a subset of all the RI data which is to be used in the risk assessment This data will then define the chemicals of concern and, if necessary, provide numerical criteria for reducing the number of chemicals of concern This evaluation can also identify data necessary to support the risk assessment This comment needs to be addressed in order to ensure that the work plan will provide the necessary data to support an accurate risk assessment

The RFI/RI work plan should have addressed the possibility of archeological and historic sites on the plant site and OU 1 (Indian artifacts were found outside of the buffer zone along Rock Creek during Fall 1990) Since the presence of archaeological and historic sites may trigger additional ARARs, this issue must be addressed in the Phase III RFI/RI Report

The work plan should have included an investigation of the retention pond located approximately 790 feet southeast of Bldg 881 as shown in the October 1964 air photos It appears that the pond collected drainage from SWMUs 107 and 103 This issue must be resolved prior to submittal of the Phase III RFI/RI Report

The response to comments (pages 1-1 and 3-1) indicates that supporting documents requested by EPA and CDH will be submitted under separate cover These documents should have been submitted concurrently with the work plan

At some point in the RI/FS process, remediation goals (i e , cleanup levels) need to be established With the exception of the "no action alternative," the alternatives scrutinized in the FS should be tailored to obtain those goals The remediation goals should be based on both ARARs and on the baseline risk assessment That is, the contaminants should be remediated such that their concentrations do not exceed any ARARs and do not pose a threat to human health or the environment Since it is most appropriate for the remediation goals to be established at the conclusion of the RI phase (at the conclusion of the baseline risk assessment) or early in the FS phase, the RI/FS work plan should have *defined a process which would be used to determine the process for identifying those remediation goals*

The document should have set forth the process whereby location specific ARARs would be identified Potential location specific ARARs must be identified during the RI phase (see 40 CFR 300 430(d)(3)) Action-specific ARARs need to be identified during the FS phase, as appropriate for a given remedial alternative

There are still many uncertainties regarding appropriate background values for metal, radionuclides and major inorganic cations and anions for groundwater, surface water and soil (Natural background concentrations of major ions may range over two orders of magnitude Natural background concentrations of metals and radionuclides are a function of the mineralogy of the sediments which comprise the unconsolidated deposits and bedrock which underlie the site) Comparison of concentrations of metals, radionuclides and major ions to the estimated background levels should be done with caution and this comparison should not be the only factor used to decide if contamination has occurred In light of the uncertainties, conservative assumptions must be used in the use of any background level unless the existence and genesis of the background level(s) can be substantiated

RESPONSE

Because these general comments are a summary of the specific comments, the responses provided herein address these general concerns

EXECUTIVE SUMMARY

Figure 1-6

Preliminary results of the IM/IRA indicate the presence of toluene along the proposed french drain alignment Follow-up testing has not been completed to verify the presence of toluene The RFI/RI work plan fails to mention the possibility of toluene contamination The work plan should have included information from the IM/IRA, and should have proposed investigations to determine nature and extent of toluene contamination The Phase III RFI/RI Report must resolve this issue

Indiana Street and Highway 128 should have been shown on the map as these are major roads which bound the buffer zone As a general practice, scales should be included on all maps submitted to EPA

RESPONSE

At the time the Final Phase III RFI/RI Work Plan was prepared, the occurrence of toluene in the French Drain Investigation soil samples was under review and evaluation Providing those data in the RFI/RI work plan along with plans to characterize the extent of the contamination was premature, and in many ways, "putting the cart before the horse" (the French Drain Investigation Report had not yet been submitted) If the toluene was determined to be a site contaminant, an addendum to the RFI/RI Work Plan would have been prepared Because the Final Phase III RFI/RI Work Plan is being revised, the available data have now been included (Appendix B) and discussed (Section 2 3 2), and specific plans have been developed that address the occurrence of toluene in soils at the 881 Hillside Area (Section 5 0)

The map scales and boundary highways are shown on Figure 1-1 in Revision 1 of the Final Phase III RFI/RI Work Plan

Section 1 3 2.2 - Surface Water Hydrology

The section should have been updated to reflect the past and present discharge practices in the Walnut and Woman Creek drainages

RESPONSE

This section of Revision 1 of the Phase III RFI/RI Work Plan now discusses the diversion ditch from Pond C-2 to the Broomfield Division Canal

Figure 1-2

The figure should have been updated to show the diversion structures in Woman and Walnut Creeks

RESPONSE

Figure 1-2 of Revision 1 of the Phase III RFI/RI Work Plan includes these diversion structures

Section 1 3 2 3 - Regional and Local Hydrology

The term descending can be misleading without qualification The language should have been changed to "Geologic units at the Rocky Flats Plant, in order of descending age, are the "

RESPONSE

Section 1 3 2 3 has been revised and no longer refers to descending units

Section 1 3.2 3 - Rocky Flats Alluvium

The extent of the Rocky Flats Alluvium should have been shown (refer to figure 2-2) A cross section should have been added that illustrates eastward thinning of the Rocky Flats Alluvium

RESPONSE

Figure 1-3 in Revision 1 of the Final Phase III RFI/RI Work Plan, presents a simplified east-west cross section of the "surficial alluvial deposits" and illustrates the limited extent of the Rocky Flats Alluvium Figure 2-3 presents the extent of the Rocky Flats Alluvium in the vicinity of the 881 Hillside

Section 1 3 2 3 - Arapahoe Formation

A cross section should have been presented to illustrate the geologic relationships between the units

RESPONSE

A generalized east-west cross section of the regional geology has been included in Revision 1 of the Final Phase III RFI/RI Work Plan (Figure 1-4)

Section 1.3 2 3 - Laramie Formation and Fox Hills Sandstone

The thickness of the upper claystone should have been provided Structural controls can allow for penetration of contaminants to deeper units The work plan should have accounted for this possibility, and the remedial investigation must include an assessment

RESPONSE

The Final Phase III RFI/RI Work Plan states, "The upper Laramie Formation is greater than 700 feet thick and is of very low hydraulic conductivity" This statement was retained in the revised final work plan No extensive faulting has been documented within the Rocky Flats Plant and for several miles downgradient of the Plant boundary (Hurr, 1976, Spencer, 1961)

Section 1 3 2 4 - Meteorology

The section should have been updated to reflect the current TRAC model studies A conceptual model within the work plan should have included a detailed description of the air pathway so that likely exposure points could be identified and monitored The specific air flow patterns at OU 1 must be addressed in the Phase III RFI/RI Report, as there are variations due to changing topography

RESPONSE

The TRAC model studies specific air flow patterns at OU No 1 These will be addressed in the Phase III RFI/RI Report The revised work plan presents a site conceptual model that includes a discussion of the air pathway (Section 2 4)

Section 1 3 2 6 - Ecology

This section appeared incomplete A description of the studies that were completed to reach the conclusions provided in this document should have been provided The description should have included a list of the plant and animal life found in the area The Environmental Evaluation Plan should have been referenced to show that further work will be undertaken All conclusions reached and assumptions made in the Phase III RFI/RI Report must be substantiated either within the report or by reference

RESPONSE

This section of the Work Plan now references Section 6 0, the Environmental Evaluation Plan, where future studies are described As discussed in Section 6 0, the first phase of the environmental evaluation will be an in-depth review of previous work in order to lay the foundation for the Phase III environmental studies The Phase III RFI/RI Report will adequately document and substantiate all findings and conclusions

Section 1.4.6 - Hillside Oil Leak Site (IHSS Ref. No 107)

The work plan should have included all information regarding any sampling of the oil spill prior to removal to the present landfill This information must be presented in the Phase III RFI/RI Report

RESPONSE

All available information pertaining to IHSS 107 was presented in the Final Phase III RFI/RI Work Plan If more information becomes available, it will be presented in the Phase III RFI/RI Report

Section 1 4 9 - Page 1-23

There are no provisions within the Phase III RFI/RI work plan to confirm the presumption that the 4-inch sewer line, an outfall pipe from Building 881, was indeed replaced It seems prudent to perform a dye or smoke test to verify replacement The Phase III RFI/RI Report must present information to resolve this issue

RESPONSE

The presumption that the sewer line was replaced is based on review of current construction drawings It is unclear how a dye or smoke test will assist in evaluating replacement of the sewer line pipe Review of Plant construction records seems a more plausible method of verifying the sewer line replacement, and such a review will be performed

Section 1 4 10 - Building 885 Drum Storage Site (IHSS No 177)

The section should have referenced OU 10 which contains IHSS 177

RESPONSE

Section 1 4 10 of Revision 1 of the Final Phase III RFI/RI Work Plan references OU No 10

Section 2 1 - Page 2-1, Paragraph 1

This section states that four bedrock wells were installed during Phase I and Phase II activities In contrast, Figure 2-1, which shows Phase I and II monitoring well locations, indicates seven bedrock monitoring wells were installed This discrepancy should have been corrected in this work plan and must be resolved in the Phase III RFI/RI Report

RESPONSE

Figure 2-1 is correct Seven bedrock monitoring wells were installed The text of Revision 1 of the Final Phase III RFI/RI Work Plan has been corrected and modified to include a discussion of all field activities in the area of the 881 Hillside conducted since 1986

Section 2 2 1.1 - Surficial Geology

The text should have described the surficial deposits in greater detail (see CDH comments, p 3-1)

The interpretation of the geometry of the gravel layers in the alluvium must be verified during the Phase III work The data from Phase I and Phase II do not allow this interpretation to be made with certainty It is very important that the existence of these gravel layers and the interpreted geometry be verified during the remedial investigation as the gravels may be preferred paths of contaminant transport

The work plan should have discussed the origin of the north-south trending "swales" that "drain" Hillside 881, and/or should propose investigation of these swales if this is important to the conceptual model of the Hillside The importance, impact and characterization of the swales, if appropriate, must be provided in the Phase III RFI/RI Report

RESPONSE

Detailed descriptions of the surficial geology based on existing and new data will be provided in the Phase III RFI/RI Report

The gravel layers in the alluvium and colluvium will be defined by borehole sampling and preparation of stratigraphic cross sections as proposed in Revision 1 of the Phase III RFI/RI Work plan and will be included in the Phase III RFI/RI Report

The swales occur by downward erosion of the hillside caused by surface water runoff from the Rocky Flats Alluvium terrace toward the Woman Creek drainage The resultant erosional pattern is reflected in the swales and ridges observed

Figure 2-2

The map should have presented the location of all of the disturbed ground in SWMU 119 2

RESPONSE

All of IHSS 119 2 has been shown as disturbed ground in Figure 2-3 (formerly Figure 2-2) in Revision 1 of the Final Phase III RFI/RI Work Plan

Section 2 2 1.2 - Bedrock Geology

The terminology "mild fracturing" should have been defined (see CDH comments, pg 3-2)

RESPONSE

Weathered claystones may typically exhibit a fracture density of three to seven iron oxide-filled, healed fractures per foot, unweathered claystones may typically exhibit a fracture density of zero to three iron oxide filled to manganese oxide filled, healed fractures per foot This fracture density information was obtained from borehole logs of the French Drain Geotechnical Investigation (EG&G, 1991a) and will be provided in the Phase III RFI/RI Report

Section 2 2 1 2 - Claystones

The lithologic unit(s) in which the packer tests for well 5-87 were completed should have been stated Information pertaining to the nature of the claystone and the depths of testing are necessary Packer test information and results should have been provided for each well and must be provided in the Phase III RFI/RI Report

What is the orientation of the 45 degree fracture identified in weathered claystone in well 8-87? The Phase III investigation must include looking for any fault traces or fractures in the surface and subsurface

RESPONSE

Tables 2-3 through 2-6 have been added to Section 2 2 2 1, Groundwater Flow Rates, in the revised Phase III RFI/RI Work Plan These tables include all available hydraulic conductivity data for the 881 Hillside Area

The orientation of the 45 degree fracture identified in well 8-87 cannot be determined because coring operations were not conducted to retrieve the core in its in-situ orientation Fracture orientation is not considered necessary for contaminant characterization of the bedrock, and oriented core drilling is not practical for the planned extensive drilling program

Section 2 2 1 2 - Sandstones

Preliminary cross sections (north-south and west-east) should have been provided illustrating the relationships of the geologic units (surficial and bedrock), wells, boreholes and water levels described in the document The specific data that allowed calculation of the mean hydraulic conductivity should have been provided in the work plan and must be presented in the Phase III RFI/RI Report The work and anticipated schedule pertaining to OU 1 in the high resolution seismic reflection program and plant-wide geologic characterization study should have been provided These important studies must be incorporated while developing the Phase III RFI/RI Report

The Phase I and II data indicate that the mean hydraulic conductivity of weathered claystone (7×10^{7} cm/s) and weathered sandstone ($3 9 \times 10^{7}$ cm/s) are about the same The work plan should have explained this The Phase III investigation must include more aquifer testing of the weathered claystone and weathered sandstone so that the Phase III RFI/RI Report can present this information

RESPONSE

Preliminary north-south cross sections were provided in the Phase II RI (Plates 5-2, 5-3, and 5-4), and east-west cross sections of the bedrock are presented in the French Drain Geotechnical Investigation Report (EG&G, 1991a-Plate 1) This information, updated with data collected during the Phase III RFI/RI, will be provided in the Phase III RFI/RI Report

The data used to calculate the mean hydraulic conductivity have been provided in the revised Final Phase III RFI/RI Work Plan

A high resolution seismic reflection program is not scheduled for OU No 1

During the French Drain Geotechnical Investigation, numerous packer tests were performed in the weathered claystone directly below the bedrock contact Tables of the results are provided in the revised Final Phase III RFI/RI Work Plan (Tables 2-4 and 2-5) It seems unnecessary to perform more hydraulic tests in the bedrock claystone based on these results However, with respect to weathered sandstone, Section 5 2 1 3 of the Final Phase III RFI/RI Work Plan notes that hydraulic tests will be performed in all newly installed monitor wells subsequent to development

Section 2 2 2 1 - Unconfined Flow System

The text should have indicated that subcropping claystone is saturated locally References should have included the page numbers The data used to determine the vertical gradients should have been provided within the work plan and must be presented within the Phase III RFI/RI Report

In Section 2 2 2 1 it states that there is a strong downward gradient between groundwater in surficial materials and bedrock The specific bedrock unit should have been stated

RESPONSE

Subcropping claystone that locally exhibits a saturated condition has been added to the listed surficial and bedrock geologic units that are mediums for the unconfined ground-water flow system

The vertical gradient data are presented in Section 2 2 2 1 of the revised Phase III RFI/RI Work Plan

The bedrock unit referenced is sandstone except at 8-87BR, which is completed in lignite and unweathered claystone This has been included in the revised Final Phase III RFI/RI Work Plan

Section 2 2.2 1 - Groundwater Flow Directions

Well 47-87 is north of the Interceptor Ditch Cross section 2-3 does not extend far enough south to include the south interceptor ditch This does not support conclusions stated in the text Additionally, the response to CDH comments (pg 3-2) indicates that the groundwater flows under the interceptor ditch This inconsistency should have been corrected in the work plan and must be resolved prior to drafting the Phase III RFI/RI Report

RESPONSE

The cross section shown in Figure 2-3 in the Phase III RFI/RI Work Plan does include the South Interceptor Ditch, located south of well 47-87 The subsurface geology south of well 47-87 is interpolated based on the next well along the line A-A', 55-87, which is completed in gravelly sand of the terrace alluvium The exact location of the transition from colluvium to terrace alluvium is not precisely known The available water level data for well 47-87 indicate that ground water is below the base of the South Interceptor Ditch This is inferred from extrapolation of the ground-water gradient Under these conditions, ground water would flow beneath the base of the South Interceptor Ditch However, during periods of maximum colluvium saturation, it is possible for discharge to occur into the ditch The proposed french drain will intercept the ground water before it reaches the South Interceptor Ditch, which eliminates the possibility of potential flow into or beneath the ditch

Figures 2-4, 2-5, 2-6 and 2-7

The water-level data show that well 55-87 is dry, yet the 5850 contour interval is illustrated downgradient of the well The water-level data show that well 47-87 is dry for all four quarters yet *groundwater levels are plotted downgradient of the well The figures in the work plan should have been corrected to illustrate the actual conditions Well depth information should have been provided An explanation for the 5950 contour interval loop around well 51-87 should have been provided These inconsistencies must be resolved in the Phase III RFI/RI Report*

RESPONSE

The 5850 contour interval has been relocated in the vicinity of well 55-87 on Figures 2-4, 2-5, 2-6, and 2-7 of the revised Final Phase III RFI/RI Work Plan

The elevation of the bottom of monitoring well 47-87 is 5875 22, which will be the basis for the 5875 contour interval This contour interval has been relocated on Figures 2-6 and 2-7 of the revised Final Phase III RFI/RI Work Plan

A table listing well depth and elevation at bottom depth has been presented as Table 2-1 for all listed wells in Figure 2-4, 2-5, 2-6, and 2-7 in the revised Final Phase III RFI/RI Work Plan

Well 51-87 is located adjacent to the Building 881 footing drain (Figure 1-7) Water levels are higher to the north and south of this well suggesting that the footing drain is effectively lowering the water table in this area The effect is represented by the 5950 contour interval loop around well 51-87

Section 2 2 2 1 - Groundwater Flow Rates

The information from packer testing along the proposed french drain alignment designed for the IM/IRA should have been included in this work plan and must be included in the Phase III RFI/RI Report Data collection was completed several months prior to submittal of this Phase III RFI/RI work plan

RESPONSE

Tables 2-4, 2-5, and 2-6 have been included in Section 2 2 2 of the revised Final Phase III Work Plan which detail all packer test information and results The data were not provided in the Final Phase III Work Plan because the French Drain Geotechnical Investigation Report had not yet been released, and the data were still being evaluated

Page 2-16

It is stated here that well 47-87 was normally dry but some samples were obtained from this well An explanation for this should have been presented Were these samples collected after precipitation events? This question must be answered and presented within the Phase III RFI/RI Report

RESPONSE

Well 47-87 is completed in colluvium on the 881 Hillside The saturated thickness of the colluvium fluctuates with the seasonal precipitation The dry summer and fall months and the middle of the winter months correlate with dry well conditions In the spring months, during snowmelt and increased precipitation, the colluvium becomes saturated resulting in measurable water levels in this and other wells The quarterly measurements, climatic conditions, and sampling procedures for this and all wells will be included in the Phase III RFI/RI Report

Page 2-17

With respect to the Woman Creek Alluvium, a hydraulic conductivity value of 1 5 x 10^{3} cm/s is equal to 1552 ft/yr not 1035 ft/yr

RESPONSE

The correction has been made in the revised Final Phase III RFI/RI Work Plan

Page 2-18

All of the mean hydraulic conductivity values for the various geologic units should have been included in a table for easy reference

RESPONSE

Tables 2-3 through 2-6 are presented in Section 2 2 2 of the revised Final Phase III RFI/RI Work Plan These tables present the mean hydraulic conductivity values for all the various geologic units in which drawdown recovery tests, slug tests, or packer tests were conducted

Section 2 2 2 2, Page 2-18, Paragraph 2

Hydraulic conductivities should have been provided for the Arapahoe Formation claystone This information will be valuable in estimating the capability for water transport through claystone to the underlying sandstone and must be presented in the Phase III RFI/RI Report

RESPONSE

Hydraulic conductivities for the Arapahoe Formation claystone have been provided in the revised Final Phase III RFI/RI Work Plan Tables 2-3 through 2-6 in Section 2 2 2 present the hydraulic conductivity values for all geologic units Hydraulic conductivities for claystone were derived from packer test results There are no wells completed in the claystone at the 881 Hillside, therefore, no slug tests or drawdown-recovery tests have been conducted in the claystone

Section 2 2 3 - Surface Water Hydrology

The section should have been updated to reflect the recent changes due to diversion of the drainages Dates for the surface water measurements were not presented in this section nor referenced (see response to CDH comments pg 3-5)

RESPONSE

The sections on surface water hydrology of Woman Creek (Sections 1 3 2 2 and 2 2 3 1) have been changed to include the Pond C-2 Diversion and the Broomfield Diversion Canal in the revised Final Phase III RFI/RI Work Plan Dates for the surface water measurements are provided in Section 2 2 3 in the revised Final Phase III RFI/RI Work Plan

Section 2.3 1 - Background Characterization

Can temporal variations in water chemistry be determined prior to two years if more samples are taken? The text states that volatile organic compounds were not analyzed for background samples because the sample locations are potentially outside of contaminated areas The response to CDH comments (pg 3-5) states that background samples will be collected and analyzed for VOCs The RFI/RI work plan should have mentioned this in this section Table 2-2 provides information regarding the background surface water tolerance interval upper limits or maximum detection values The data is for Round 1, 7 samples In the previous RI, the data was for Round 1, 9 samples and Round 2, 7 samples The difference should have been explained in the work plan and must be resolved in the Phase III RFI/RI Report

RESPONSE

Temporal variations in water chemistry will be presented in the Phase III RFI/RI Report Seasonal variability would not be better characterized if more samples were taken over a shorter time frame As of first quarter 1990, ground-water and surface water samples are being collected in background areas for volatile organic compound (VOC) analysis The text has been changed to reflect this addition in the revised Final Phase III RFI/RI Work Plan The surface water tolerance intervals are for Round 1, 7 samples

Table 2-3, Page 2-24

There are discrepancies between the units assigned to background data in the Draft Background Characterization Report (DBGCR) and the RFI/RI work plan First, inorganic concentrations are given in milligrams per kilogram (mg/kg) in the DBGCR for soils, while the same are given in milligrams per liter (mg/ℓ) in the RIF/RI In addition, radionuclide concentrations are presented in picocuries per gram (pCi/g) in the DBGCR and picocuries per liter (pCi/L) in the RFI/RI This should have been corrected in the RFI/RI work plan showing inorganic data as mg/kg and radionuclide data as pCi/g and must be corrected in the Phase III RFI/RI Report

RESPONSE

The units on both the tables and text have been corrected to mg/kg for inorganic soil data and pCi/g for radionuclide soil data in the revised Final Phase III RFI/RI Work Plan

Page 2-26

The units on several tables (e g , Table 2-4) seem to be in error Either the water concentrations are extraordinary (e g , 25 g/L of aluminum in Table 2-4) or the denominator (L) is incorrect for the medium (soil)

RESPONSE

The units for sediment samples have been corrected to mg/kg for sediment and mg/ℓ for water in the revised Final Phase III RFI/RI Work Plan

Section 2 3 2 - Soils

The data should have been presented even though unvalidated The validation of OU 1 sample results should be a priority as the work plan will need to be amended if unexpected results are present Table 2-5 does not include cesium and molybdenum as sampling parameters These parameters should have been added to the list

RESPONSE

The rejected volatile organic data are summarized and discussed in Section 2 3 2 1 of the work plan The data have been presented in previous RI reports and their presentation in the work plan does not provide any additional basis for the Phase III soil sampling plan Phase III sampling and analysis/validation will provide quantitative information on the nature and extent of contamination in soils at OU No 1 Table 2-13 (formerly Table 2-5) of the Revised Final Phase III RFI/RI Work Plan is the list of parameters for which Phase I and II RI soil samples were analyzed Cesium and molybdenum are included in the Phase III RFI/RI Work Plan parameter list (Table 5-1)

Section 2 3 2 1 - Volatile Organic Compounds

The occurrences of toluene in the borehole samples collected along the proposed drain alignment needs to be addressed The last sentence on page 2-28 continued on page 2-37 is incomplete and should have been corrected Table 2-6 should have included the contaminant encountered for the direct hit samples The description in the text should have mentioned the direct hit at borehole 63-87 These issues must be addressed in the Phase III RFI/RI Report

RESPONSE

The toluene data collected during the French Drain Geotechnical Investigation are discussed in the Revised Final Phase III RFI/RI Work Plan The incomplete sentence has also been corrected The volatile organic compounds detected in soils during the French Drain Geotechnical Investigation are presented in Appendix B

Section 2 3 2, Page 2-28

A discussion of semivolatile organic compound (SVOC) soil contamination should have been provided in this section which addresses analytical results from Phase I and II investigations These contaminants will be important to the calculation of risk at OU 1

RESPONSE

A discussion of semivolatile organic compound results for soils has been added to Section 2 3 2 of the revised work plan

Section 2 3.2.3 - Radionuclides

Table 2-7 should have specified the sample depth intervals The ratios of U233 + U234 to U238 and of U235 to U238 should have been presented in Table 2-8 (see PRC comments, pg 2-3) Is it possible to conclude preliminarily that the uranium ratios for samples 1-15 are greater than one when dilution *from compositing over several feet is possible? Cross sections DO NOT always need to show trends but should display the data It is extremely helpful to display the data graphically for evaluation purposes This information must be presented within the Phase III RFI/RI Report*

RESPONSE

Table 2-17 (formerly Table 2-7) is a summary of Phase I and Phase II RI soil sampling results The surface soil tabulation is based on the uppermost soil sample results from each borehole, and the subsurface soil tabulation is based on soil sampling results from the remainder of all boreholes Sample depths for all boreholes are provided in Table 2-13

The information provided in the work plan is sufficient to establish that radionuclide contamination is largely confined to the surface soils This will be confirmed in the Phase III RFI/RI where an exhaustive battery of tests are proposed to ascertain the extent of radionuclide contamination and the mobility of plutonium in soils Detailed data evaluation, including cross sections as appropriate, will be provided in the Phase III RFI/RI Report With respect to Table 2-18 (formerly Table 2-8), these samples are not composites but are discrete surface samples

Section 2 3 2.3, Page 2-38

No data should be discarded from further consideration if, by adding the tolerance level (since it is a plus as well as a minus tolerance), the concentration is pushed above applicable or relevant and appropriate requirements (ARARs), maximum contaminant levels (MCLs), or both As discussed earlier, such concentrations may exceed cleanup levels even though they meet ARARs

RESPONSE

The text in Section 2 3 2 3, first paragraph (formerly page 2-38) does not call for discarding any data nor does it make reference to ARARs It is simply stated that a site datum where the error term is larger than the value is below the MDA and cannot be considered statistically different from background, or as suggested, ARARs The MDAs established for the Phase III RFI/RI will provide measurements that allow for meaningful interpretation of the site data relative to background or ARARs

Section 2 3 3 - Groundwater

Well 1-87 water and contaminant data may also indicate another source of contamination and may not indicate that the well is sidegradient This must be verified through development of the Phase III RFI/RI Report Of the three wells listed as being dry during all sampling attempts, two of the wells, 51-87 and 54-87 are shown to have sample results (see figure 2-10) Of the 14 wells listed as being downgradient from the "eastern" SWMUs, well 55-87 is shown to have sample results (see Figure 2-10) The figure should have been consistent with the text and Appendix B

On page 2-42 it is stated that unweathered bedrock is considered part of the confined flow system A discussion should have been presented to clarify why if the bedrock is unweathered that groundwater is contained under confined conditions Storage coefficient values obtained from aquifer tests in unweathered bedrock should be used to verify confined conditions A discussion of SVOC groundwater contamination is not, and should have been, presented in this section which addresses analytical results from Phase I and II investigations This information must be presented in the Phase III RFI/RI Report

RESPONSE

The Final Phase III RFI/RI Work Plan states, "Wells 1-87 and 68-86 were initially considered upgradient of these IHSSs, but water level and chemical data suggest that well 1-87 may be sidegradient Ground-water quality in both of these wells is occasionally above background and may be affected by Plant activities upgradient of the 881 Hillside Additional upgradient wells will be installed to investigate that possibility " These statements were retained in the revised final work plan

Wells 51-87 and 54-87 were usually dry but enough water was available for sample collection during second quarter 1989 This has been noted in the text of the revised Final Phase III RFI/RI Work Plan

The text concerning the 14 wells downgradient from the "eastern" IHSSs is now consistent with Figure 2-10 and Appendix C

The statement that the ground water within the unweathered sandstone is confined is based on the water level in the well being above the top of the screened interval, and the top of the screen being at the top of the water bearing strata

Ground-water samples were not analyzed for semivolatile organic compounds in the Phase I and II sampling events, but the Phase III field effort will include these analytes Results of the semivolatile analyses will be presented in the Phase III RFI/RI Report

Page 2-43

Why were monitoring wells 51-87, 54-87, 58-86, 63-86, 44-87, 49-87, 50-87 and 55-87 always dry? This should have been explained at least preliminarily, and may be important to the conceptual model Was the entire thickness of colluvium dry or were the well screens improperly located?

RESPONSE

Well 51-87 is located adjacent to the Building 881 footing drain (Figure 1-7) and based on the water level data from 51-87, it appears the footing drain is effectively lowering the water table in the area south of Building 881 With respect to the other wells, the entire thickness of the colluvium is dry The wells are screened over the entire thickness of the surficial materials Many areas of the colluvium and surficial materials are observed to be unsaturated based both on the water level data in these wells and the drilling for the French Drain Geotechnical Investigation (EG&G, 1991a)

Section 2 3 1 1 - Volatile Organic Compounds

Unconfined Groundwater The text should have described the TCE and PCE contamination at well 51-87 as shown on Figure 2-9 The toluene occurrences are not minor as the text implies Table 2-10 shows toluene present at 270 $\mu g/\ell$ for well 43-87 and 81 $\mu g/\ell$ for well 9-74

RESPONSE

The text in Section 2 3 3 3 of the revised Final Phase III RFI/RI Work Plan discusses the occurrence of TCE and PCE in well 51-87 The text does not imply the toluene occurrences are minor It states, "Chloroform, toluene, and 1,2-dichloroethene (1,2-DCA) occurred at lower concentrations (estimated) at less than detection limit or less than 100 $\mu g/\ell$ " The toluene in well 43-87 was estimated below the detection limit and also present in the laboratory blank, and the toluene in well 9-74 was also estimated below the detection limit

Table 2-10, Page 2-47

Units should have been presented for organic data on the second page in Table 2-10, which lists VOCs detected in unconfined groundwater These data should have been represented in micrograms per liter (μg/ℓ)

This data and data from borehole samples from the OU 1 IM/IRA indicate toluene contamination The remedial investigation needs to address this Acetone and methylene chloride occur in a significant number of wells in concentrations one to three orders of magnitude greater than in blanks Acetone, methylene chloride and other possible lab contaminants should presently be considered as potential contaminants The remedial investigation must resolve this issue

The concentration plots for TCE and PCE are useful in evaluating the nature and extent of contamination Plots of the other contaminants present should have also been presented in the work plan and must be present in the Phase III RFI/RI Report

It is not clear what high matrix noise is (see response to EPA comments, pg 1-7) and the affect this will have on obtaining quality data from which characterization of contamination can be accomplished Detection limits should not be set so high that low levels of contamination are masked The response should clearly present what is well above low-level contract-required detection limits and/or well above CLP-accepted levels for common laboratory contaminants

Confined Groundwater Data should be graphically displayed and in tabular form for the unconfined groundwater conditions The data indicate that a potential for contamination is present in the sandstones TCE was detected at concentrations exceeding the Colorado Department of Health Basic Standards for Ground Water (CDH, September 30, 1989) in wells 3-87 (6 μg/ℓ) and 8-87 (35 μg/ℓ) Also, carbon tetrachloride greatly exceeded the CDH standard in well 8-87 (130 μg/ℓ) on one occasion The conclusion reached in the RFI/RI work plan stating that groundwater in the unweathered sandstone is not contaminated is premature as the extent of contamination is not yet adequately characterized This question must be answered through implementation of the remedial investigation

RESPONSE

The micrograms per liter units are shown on all pages of Table 2-20 (formerly Table 2-10) in the revised Final Phase III RFI/RI Work Plan

The occurrence of toluene in soils based on the French Drain Geotechnical Investigation is discussed in detail in the revised Final Phase III RFI/RI Work Plan

The work plan states, "Levels of methylene chloride and acetone were typically low enough to be considered laboratory artifact according to CLP protocol (EPA 1988a), although the high levels at wells 9-74 and 10-74 suggest the actual presence of these compounds in the ground water at these locations" Implementation of the Final Phase III RFI/RI Work Plan will resolve this important issue

TCE and PCE occur in the highest concentrations in ground water and are also the most ubiquitous of all the contaminants at OU No 1 Therefore, TCE and PCE were used to illustrate the estimated extent of organic contamination Plots of the other contaminants will be presented in the Phase III RFI/RI Report

Results of data validation and evaluation for Phase I and Phase II RI data, as well as ongoing quarterly ground-water sampling data will be presented in the Phase III RFI/RI Report Detection limits and analytical methods for the Phase III RFI/RI field work are presented in the QAPjP (EG&G, 1990h) and GRRASP (EG&G, 1990i) These detection limits will allow for evaluation of site data with respect to ARARs

The Phase III RFI/RI Report will establish the presence of volatile organic contamination in the confined ground-water system based on existing and Phase III data All data will be displayed in tabular form and graphically, as appropriate The work plan simply provides a preliminary interpretation of the existing data

Page 2-53

Time versus concentration graphs should have been prepared for all or a select set of wells from all geologic units Parameters to be graphed should have included representative analytes from each of the major groups of analytes - i e , metals, radionuclides, organics and major ions Temporal trends must be presented and explained in the Phase III RFI/RI Report

RESPONSE

Time versus concentration graphs will be presented and explained in the Phase III RFI/RI Report

Page 2-53

The conclusion that the groundwater in the unweathered sandstone is not contaminated cannot be stated with certainty in light of the analytical results from well 8-87 The Phase III investigation should look more closely at well 8-87 This question must be answered through implementation of the remedial investigation

Trilinear diagrams or stiff diagrams should have been plotted up for groundwater in each of the geologic units Background data could be used for this Construction of the diagrams would allow comparison of groundwater in various geologic units Such a comparison is important in the development and presentation of a conceptual model and must be performed during the remedial investigation

RESPONSE

Additional data are necessary to determine whether the confined ground-water system is contaminated More quarterly ground-water samples are being collected from all bedrock wells to further evaluate bedrock contamination in that vicinity Trilinear or Stiff diagrams are useful tools in characterizing ground-water quality These have been presented in previous responses to EPA and CDH comments and will be presented in the Phase III RFI/RI Report

Section 2 3 3.2 - Major Ions in Unconfined Groundwater

The text describes the maximum concentrations for major ions but these values are not graphically displayed in figures 2-11 and 2-12 The figures present second quarter 1989 data for comparative purposes with sample data from the background investigation This indicates the need to perform trend analyses The figures, as they are presented, are misleading The elevated TDS concentrations at well 43-87 are not specifically described in the text (see response to PRC comments, pg 2-5)

RESPONSE

The maximum concentrations of major ions are not necessarily of greatest utility for presenting the extent of contamination The second quarter 1989 data are typical of results from previous quarters and were therefore used for graphical presentation Trend analysis would be useful and will be performed for the Phase III RFI/RI Report The elevated TDS concentrations observed in well 43-87 are discussed in the revised Final Phase III RFI/RI Work Plan

Section 2.3.3.3 - Summary of Extent of Contamination

The conjecture that organic contamination is restricted to a small area around Individual Hazardous Substance Site (IHSS) 119 1, one of the multiple solvent spill sites, is not supported To the contrary, VOC contamination has been detected in wells 0687 and 6486 at 20 parts per billion (ppb) trichloroethene (TCE) and 8J ppb tetrachloroethene (PCE), respectively Wells 06887 and 6486 are approximately 150 feet and 700 feet downgradient of IHSS, respectively In addition, many of the wells downgradient of IHSS 119 1 have been dry during previous sampling events Although dry conditions inhibit contaminant migration, the lack of groundwater data from these wells provides little indication of the extent of contaminant transport in the alluvium downgradient of IHSS 119 1 No conclusions regarding the extent of contamination from IHSS 119 1 can be made based on the data provided in the RFI/RI work plan Slugs of contamination could have been released periodically and their detection could be missed due to sampling frequency or well location The number of bedrock wells is insufficient to determine the vertical extent of contamination The work plan should have been designed to verify these presently unsupportable conclusions and the Phase III RFI/RI Report must resolve these issues

RESPONSE

PCE has been detected only once in well 64-86 (8J $\mu g/\ell$) It was present below the detection limit and therefore is an unreliable indicator of contamination The TCE concentration of 20 $\mu g/\ell$ in well 0687 is considered part of the localized volatile organic plume downgradient of IHSS 119 1 The additional alluvial and bedrock wells proposed in the revised Final Phase III RFI/RI Work Plan will help define the extent of saturation in surficial and weathered bedrock materials and the nature and extent of the ground-water contamination in these materials

Section 2 3 4 - Surface Water

The Phase III RFI/RI Report must reflect the recent diversion structures from pond C-2 Background values and the surface water results should have been presented in a table for evaluation and must be presented in the Phase III RFI/RI Report

RESPONSE

The Revised Final Phase III RFI/RI Work Plan will include these diversion structures in the figure and discussion on surface water

Section 2 3 4 1 - South Interceptor Ditch

The contaminants found in surface water should have been compared to those found in the groundwater, sediments and soils The Phase III RFI/RI Report must do this It is important to correlate the sample results, if possible, in determining contaminant sources and means of migration Results of the borehole samples collected under the IM/IRA should have been presented or referenced and must be presented in the Phase III RFI/RI Report Toluene was detected potentially in the IM/IRA borehole samples and may be related to that found in the sample from SW-69 It should have been noted at which sample locations dissolved gross alpha and beta, uranium and plutonium exceeded background This information must be presented in the Phase III RFI/RI Report

RESPONSE

It is obvious without doing a direct comparison that many of the contaminants occurring in surface water are those found in the ground water or soils at OU No 1 This strongly suggests that ground-water recharge or surface water runoff are contaminant transport pathways to surface water Nevertheless, the Phase III RFI/RI Report will provide a detailed comparison of the contaminants found in the surface water to those found in the other media The results of the borehole samples from the French Drain Geotechnical Investigation (EG&G, 1991a) are presented in the revised Final Phase III RFI/RI Work Plan The sample locations where the radionuclides exceeded background are also presented in the revised work plan

Section 2.3 5 - Sediments

The sample locations should have been shown on a map Figure 2-17 does not show the sediment sampling locations (see also response to EPA and CDH comments) The sampling locations must be presented in the Phase III RFI/RI Report Results of sediment sampling should have been compared with surface water, groundwater and soil sampling results This must be done in the Phase III RFI/RI Report The question arises once again about whether the low levels of certain volatile organic compounds in the samples represent contamination especially if present in blanks Until it can be demonstrated that the presence of these contaminants is due to lab contamination, they should be considered present Additionally, not all the volatiles sampled for were in low concentrations

Background values and sediment results should have been presented in a table This must be done in the Phase III RFI/RI Report

RESPONSE

The surface water and sediment sampling locations are presented on Figures 2-20 and 2-21, respectively, in the revised Phase III RFI/RI Work Plan The results of sediment sampling will be compared with other media in the Phase III RFI/RI Report Chloromethane, acetone, chloroform, and TCE will be considered as possible contaminants, and further investigation is needed to determine if these constituents are site contaminants or laboratory artifacts Section 2 3 3 3 states that for the purposes of defining the field sampling plan all constituents above background are considered representative of contamination

Background values of sediment are presented in Table 2-10 and sediment results are given in Appendix E of the revised Final Phase III RFI/RI Work Plan

Section 2 3 6

The air monitors in the IM/IRA construction site should have been added to this section of the work plan and included in the location map   A map showing the location of the air monitors is necessary and must be presented in the Phase III RFI/RI Report

RESPONSE

The revised Final Phase III RFI/RI Work Plan has been modified to include a discussion of the ambient air monitoring conducted during the 1990 IM/IRA field activities   Figure 2-22 shows the locations of on-site ambient air monitor stations, and Figure 2-23 presents the locations of off-site community ambient air samplers in the revised Final Phase III RFI/RI Work Plan

Section 2 4 - Applicable or Relevant and Appropriate Requirements

The units for VOCs in Table 2-11 should have been μg/ℓ and not mg/ℓ   Detection limits for Cs and Li were 1 and 0 1 mg/ℓ and not changed to 1 and 01 mg/ℓ (see EPA comments)   There is a discrepancy between the lab data and the detection limits (the recorded concentration is less than the detection limit and not noted as such)   GC is not applicable to metals and inorganics   These corrections must be made in the Phase III RFI/RI Report

Organic concentrations should be represented in μg/ℓ

RESPONSE

These comments refer to typographical errors all of which have been corrected in the revised Final Phase III RFI/RI Work Plan   It is noted that the ARARs section has been revised significantly and is included in the revised work plan as Section 7 0   The ARARs discussion is consistent with that in the Phase II Work Plan for Operable Unit No 2   Of note, for ground water, the Water Quality Control Commission (WQCC) Ground Water Standards are no longer considered ARAR because of their unenforceable status at this time   Also WQCC Surface Water Standards are not considered ARAR for ground water   Both of these state standards are considered TBC

Page 2-72

This section does not contain a discussion of location-specific or action-specific ARARs   In addition, chemical-specific ARARs for soil, sediment, and air media are not given   At a minimum, the RFI/RI work plan should have stated these additional ARARs will be identified and reference the submittal (for example, the Feasibility Study Report) that will contain the discussion   These issues must be resolved in the Phase III RFI/RI Report

The discussion of "RCRA Subpart F concentration limits" as ARARs is unclear   The intention apparently was to identify the maximum groundwater concentrations specified in 40 CFR 264 94 as relevant and appropriate requirements   These are not "RCRA Subpart F regulations"   RCRA Subpart F is an inappropriate citation and should not have been used to reference the Code of Federal Regulations   This must be corrected in the Phase III RFI/RI Report

RESPONSE

As discussed in Section 7 0, evaluation and establishment of location- and action-specific ARARs are part of the RI and FS processes, respectively They will be addressed in the RFI/RI and CMS/FS reports Chemical-specific ARARs for soils/sediments are also addressed in Section 7 0 Investigation of the air medium is not within the scope of the Phase III RFI/RI Work Plan, thus, a discussion of chemical-specific ARARs for air is not included in the work plan It is recognized that there are several federal and state statutes that regulate air emissions which will be evaluated during the FS as action-specific ARARs

The RCRA Subpart F terminology has been modified as suggested

Page 2-74

The ARAR reference should have included citations Greater discussion of LDR ARARs was needed In addition, DOE should have presented in table format all potential ARARs associated with a contaminant (Note Unlike the OU 2 IM/IRA Decision Document, the concept of "potential ARARs" is appropriate here since we are only in the RFI/RI work plan stage It is the RI which transforms potential ARARs into actual ARARs for use in identifying and assessing remedial alternatives) These corrections must be made in the Phase III RFI/RI Report

The table cites RCRA Subpart F as the ARAR reference for 1,1-dichloroethane, methylene chloride, and carbon disulfide These constituents are not specifically cited in 40 CFR 264 94 The RFI/RI work plan should have clarified this reference In addition, land disposal restrictions (LDRs) are cited as the ARAR reference for acetone A discussion should have been provided regarding LDRs and whether they are applicable or relevant and appropriate to the site These comments must be addressed in the Phase III RFI/RI Report

RESPONSE

ARAR references have been revised to include citations where appropriate LDRs are action-specific ARARs relating to land disposal or "placement" and will be addressed with other action-specific ARARs in the CMS/FS Report "Potential" ARARs including the 40 CFR Part 264 Subpart F requirements as they apply to the above noted compounds and others are explained in detail in Section 7 0

Page 2-80

Since the RCRA Groundwater Protection Standards should be either applicable or relevant and appropriate, it is erroneous to classify background concentrations for cesium and strontium as "TBC" The appropriate RCRA Groundwater Protection Standard ARAR is either ACL or background However, the cleanup requirements established during the RI/FS process is analogous to the RCRA process to determine ACLs and obviates the need to consider background concentrations as the cleanup standards Therefore, the sentence classifying background concentration as a "TBC" should have been deleted and the following inserted "The cleanup levels for these contaminants, as with all other contaminants, will be established upon the conclusion of the Baseline Risk Assessment described in Section 4 6 1" This comment must be addressed in the Phase III RFI/RI Report

RESPONSE

Cesium and strontium are not hazardous constituents under RCRA, and therefore, RCRA is not applicable or relevant and appropriate However, background concentrations for these constituents should not be considered TBC, because they are not health-based With respect to the hazardous constituents for which RCRA is ARAR, background concentrations are identified as TBC as a benchmark for evaluating site data, recognizing that the ACL variance provision will be realized through the conduct of the baseline risk assessment

<u>*Section 2 5 - Sampling and Analysis Requirements for Remedial Alternatives Evaluation*</u>

> *Table 2-13 should have included coagulation and precipitation technologies for groundwater and surface water treatment (see PRC comments, pg 2-8) The Phase III RFI/RI Report must address these technologies*

RESPONSE

Coagulation and precipitation are listed in Table 2-21 (formerly Table 2-12) They were not identified in Table 2-22 (formerly Table 2-13), because there are no special data requirements that need be considered in the collection of RFI/RI field investigation data to permit an adequate evaluation of these technologies These technologies will be addressed in the Phase III CMS/FS Report

<u>*Section 3 1 - Phase I and II RI Conclusions*</u>

> *There is indication that soil contamination is present at 14-87, 61-87 and 63-87 in addition to 1-87, 57-87 and 58-87 This should have been presented and discussed and this issue must be resolved in the Phase III RFI/RI Report*

RESPONSE

The most notable organic contamination occurs at boreholes BH01-87, BH57-87 and BH58-87 Much lower concentrations (below or near detection limit) were reported for boreholes BH14-87, BH12-87, and BH61-87 as discussed in the revised Final Phase III RFI/RI Work Plan The Phase III RFI/RI Report will present a thorough analysis of all available soil sampling results

<u>*Page 3-2, Section 3 1, Item 5*</u>

> *Ground-water recharge also occurs via movement of water from one aquifer or hydrogeologic unit to another aquifer or hydrogeologic unit The impact of such recharge must be assessed during the remedial investigation*

RESPONSE

Recharge to bedrock sandstones via leakage through overlying claystones is acknowledged in Section 3 2 (formerly Section 3 1), Item 5, and will be assessed during the RFI/RI

<u>*Section 3.2 - Site-Specific Phase III RFI/RI Objectives and Activities*</u>

> *The site-specific QAA should have been mentioned in this section*

RESPONSE

The site-specific QAA is now referenced in Section 3 3 (formerly Section 3 2)

Section 3 2, Table 3-1

The site-wide geologic and geophysics study activities should be tied into the Characterize Site Physical Features Objective and must be acknowledged in the Phase III RFI/RI Report Use of the Rocky Flats Environmental Database System (RFEDS) for data evaluation should have been included into the objective of Characterizing the Nature and Extent of Contamination A QA/QC objective should have been included Three additional objectives, identifying IM/IRAs for OU 1, identifying and implementing data management procedures, and identifying upgrades to the air monitoring system should have been included in this section and Section 4 1 3 (see CDH comments, pg 3-10)

RESPONSE

The objectives mentioned have been added to Table 3-1 as described with the exception of identifying IM/IRAs for OU No 1 and upgrading the air monitoring system No additional IM/IRAs are planned for OU No 1, and additional monitoring stations are not considered necessary for OU No 1

Page 3-4, Table 3-1

Phase III RFI/RI objectives should have included the development of a conceptual hydrogeologic model for the area around Hillside 881 (not a numerical model) This should have included a subsurface geologic model and a hydrologic model These objectives must be achieved and presented in the Phase III RFI/RI Report

RESPONSE

Verification of the hydrogeologic site conceptual model for OU No 1 presented in Section 2 4 is now included as an objective of the Phase III RFI/RI (Table 3-1) Results of this effort will be included in the Phase III RFI/RI Report

Page 3-5

Preliminary plume maps for contaminants of concern should have been prepared in the vicinity of all IHSSs Consideration should have been given to fate and transport modeling Verified plume maps must be presented in the Phase III RFI/RI Report

RESPONSE

Preliminary plume maps for OU No 1 are presented in Section 2 0 of the revised Final Phase III RFI/RI Work Plan Verified plume maps will be presented in the Phase III RFI/RI Report

Section 4 1 1 - Task 1 Project Planning

The site-specific QAA should have been referenced The site-specific Health and Safety Plan and the Standard Operating Procedure Amendments should have been submitted as appropriate The QAPjP and the SOPs (which together are the Sampling and Analysis Plan or SAP) submitted by DOE were reviewed by the regulatory agencies Those comments should have been reviewed in conjunction with activities for the OU 1 RFI/RI A major concern is that the SAP deferred the details to the site-specific plans and the GRRASP and the site-specific plans and the GRRASP have not been submitted The GRRASP is referenced in this document as are the site-wide SOPs for defining the analytical scope of work The GRRASP should have been submitted for review or the QAPjP should have been revised to include the pertinent information of the GRRASP This issue must be resolved prior to approval of this work plan

RESPONSE

Section 4 1 1 now references the QAA The GRRASP has now been submitted to the regulatory agencies

Section 4 1 2 - Task 2 Community Relations

Site-specific community relations plans are not required for submittal The interim community relations plan is supposed to cover community relation activities until the final Community Relations Plan is completed The Interim Plan was not implemented in November 1990

RESPONSE

A draft Community Relations Plan was submitted to EPA and CDH in November 1990 and is scheduled for finalization in August 1991 The draft Interim Community Relations Plan was implemented in January 1991 Section 4 1 2 has been updated to reflect the new schedule for community relations plans

Section 4 1 5 - Task 5 Data Evaluation

The RFEDS database should have been specifically referenced and the methods of evaluation should have been explained This information must be provided within the Phase III RFI/RI Report

RESPONSE

The RFEDS is now referenced in Section 4 1 5 Data evaluation methods will be provided in the Phase III RFI/RI Report

Section 4 1 5 1 - Site Characterization

The site-wide geology and geophysics studies should have been referenced and must be utilized in developing the Phase III RFI/RI Report

RESPONSE

Site-wide geologic and geophysical study results will be used in developing the Phase III RFI/RI Report Section 4 1 5 1 has been modified accordingly

Section 4 1 5 2 - Source Characterization

The analytical data from the source boreholes must also be used to determine risk information important to development of the Phase III RFI/RI Report

RESPONSE

Section 4 1 5 2 now notes that on-site contaminant concentrations will be used as input to the risk assessment

Section 4 1 5.3 - Nature and Extent of Contamination

The extent of contamination should also have been depicted in cross sections This must be presented in the Phase III RFI/RI Report The technique of principal component analysis for identifying the releases from different sources should have been explained, and must be explained in the Phase III RFI/RI Report Hydrogeologic information data along with the chemical data should have been used to investigate the movement of contaminants from one pathway to another This must be evaluated in the Phase III RFI/RI Report Nature and extent of contamination via the air pathway should have also been addressed and must also be evaluated in the Phase III RFI/RI Report

RESPONSE

The extent of contaminants in subsurface soils will be presented in cross section in the Phase III RFI/RI Report The technique of principle component analysis will be explained in the Phase III RFI/RI report if the technique is used in data evaluation during the RFI/RI Hydrogeologic and chemical data for ground water and surface water will be used to evaluate movement from one pathway to another The nature and extent of contamination via the air pathway will be addressed by the Phase III RFI/RI Report

Page 4-5

Using kriging to contour isopleths generally does not produce accurate plume maps Be aware of the many limitations of kriging

RESPONSE

The limitations of kriging are understood and acknowledged in Revision 1 of the Final Phase III RFI/RI Work Plan

Section 4 1 6 - Task 6 Baseline Risk Assessment, Page 4-7

The Endangerment Assessment Handbook has been superseded and should no longer be used

RESPONSE

The Endangerment Assessment Handbook has been superseded by the Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A (EPA, 1989a) and the Risk Assessment Guidance for Superfund-Environmental Evaluation Manual (EPA, 1989d) Section 4 1 6 has been revised to reflect this change

Section 4 1 6 1 Contaminant Identification

The text states all chemicals detected above background concentrations will be treated as site contaminants for the public health evaluation The method for determining "above background" should have been discussed and must be discussed in the context of the Phase III RFI/RI Report

RESPONSE

Determination that a chemical is above background is discussed in Section 2 3 1 This section is now referenced in Section 4 1 6 1 It is further noted in the text that this "identification of contaminants" will be based on the latest Background Geochemical Characterization Report available when the Phase III RFI/RI Report is being prepared

Public Health Evaluation Contaminant Identification

As stated in EPA's previous comments (see pg 1-12), chemicals must not be eliminated from further consideration until the exposure assessment phase of the baseline risk assessment is completed Comparison of site contaminants to ARARs and toxicological summaries is very important (see response to CDH comments, pg 3-12) It is also necessary to attempt to evaluate the data in terms of synergistic effects and evaluate the data in terms of additive effects Therefore, prior to dropping a chemical from further consideration, the toxological, synergistic and additive effects must be investigated This investigation and the results thereof must be presented in the Phase III RFI/RI Report

RESPONSE

In the response to previous comments (pg 1-12), it was agreed to not eliminate a chemical from further consideration until the exposure assessment is completed It is not practical to consider additive or synergistic effects of chemicals that are determined to not be site contaminants or for which there is no potential for exposure On the contrary, additive and synergistic effects will be qualitatively discussed in the baseline risk assessment for all contaminants retained after screening

Exposure Assessment

Exposure pathways presented in the work plan should have included evaluation of transfer of contaminants from one medium to another Onsite workers are receptors who should be considered These factors must be evaluated in the context of the Phase III RFI/RI Report

RESPONSE

Cross transfer of contaminants from one medium to another is considered in the site conceptual model presented in Section 2 4 of the revised Final Phase III RFI/RI Work Plan On-site workers will be considered potential receptors

Toxicity Assessment Page 4-11

The term "cancer potency factor" has been replaced by the term "slope factor" in all superfund guidance

RESPONSE

The terminology has been changed in the revised Final Phase III RFI/RI Work Plan

Section 4 1 6 2 - Environmental Evaluation

The Guidance for Data Useability in Risk Assessment (EPA/540/G-90/008) should have been used for guidance in planning the environmental evaluation The discussion of the biological field surveys is not consistent with the program described in Section 6 This discussion should have reflected the actual information to be obtained from that program The upper reaches of Woman Creek that will be used as a reference area for comparison with site results should have been defined This area must be upgradient from all known sites of contamination and must not be affected by wind-blown contaminants The text repeats a paragraph on pages 4-13 and 4-14 These issues must be addressed in order to develop the Phrase III RFI/RI Report

RESPONSE

The above cited reference was used in the planning of the environmental evaluation although not explicitly stated The document is now referenced in Section 6 0 of the revised Final Phase III RFI/RI Work Plan The text in Section 4 1 6 2 has also been revised so that the discussion is general and therefore consistent with Section 6 0 Section 6 0 discusses the use of Rock Creek as a reference area because of its upwind location relative to the prevailing air patterns The reference to Woman Creek has been deleted from Section 4 1 6 2 The "repeated" paragraph has been deleted in the revised text

Section 4 1 7 - Task 7 Treatability Studies/Pilot Testing

EPA comments, which will be submitted December 20, 1990, regarding the Treatability Study Plan (TSP) should be considered The TSP submitted did not provide comprehensive plans for treatability studies and did not provide information regarding innovative technologies The treatability activities related to OU 1 need not be delayed to await the results of the site-wide treatability studies Table 4-2 should have identified technologies for groundwater and surface water remedial evaluation

RESPONSE

Section 4 1 7 has been revised to address the following planning and implementation of treatability studies specific to OU No 1, review of treatability studies performed for other operable units and/or interim remedial actions, Rocky Flats Plant involvement with the DOE integrated demonstration studies, and Rocky Flats Plant involvement with the Superfund Innovative Technology Evaluation (SITE) Program Table 4-2 has been deleted in that specific plans will be prepared for treatability studies which will be submitted to the regulatory agencies for review

Section 4 1 8 - Task 8 Remedial Investigation Report

The Phase III RFI/RI Report must contain graphical representations of data (i e , cross sections) Trend analyses must also be provided

RESPONSE

The Phase III RFI/RI Report will contain graphical data representations and the results of trend analyses

Page 4-16

The Phase III RFI/RI Report must also include the following

- *Identification of ARARs (chemical-specific and action-specific)*
- *Identification of remediation goals (i e , the goal is not to meet only the ARARs, but also the risk assessment levels)*

A discussion of these activities should have been included in the work plan

The Phase III RFI/RI Report must contain a thorough discussion of the bedrock geology and an evaluation of contamination within the bedrock

RESPONSE

The Phase III RFI/RI Report will include an identification of chemical- and location-specific ARARs as well as a detailed hydrogeological and chemical characterization of bedrock geology The Phase III CMS/FS report will include an identification of remediation goals and action-specific ARARs Section 4 1 8 and other appropriate sections have been modified in the revised Final Phase III RFI/RI Work Plan to reflect this comment

Section 4 2 1 - Task 9 Remedial Alternatives Development and Screening

Land ban requirements must also be met during the cleanup process

RESPONSE

Land ban is an action-specific ARAR that will be addressed in the Phase III CMS/FS report for all remedial alternatives involving disposal or placement

Section 4 2 3, Page 4-24

The Feasibility Study must 1) summarize ARARs identified in the RI, 2) discuss the remediation goals, and 3) identify action- and location-specific ARARs that bear on the alternatives analyzed in the FS

RESPONSE

Table 4-2 (formerly Table 4-3) has been modified accordingly in the revised Final Phase III RFI/RI Work Plan

<u>*Section 5 - Phase III RFI/RI Field Sampling Plan*</u>

The field operations are presented in the Site-Wide Sampling and Analysis Plan which includes the QAPjP and the SOPs The SAP refers to site-specific quality assurance plans and SOPs which should have been presented here and not referred to the 1989 Operational Safety Analysis document This paragraph states that precautions may include the containerization of drill cuttings and/or groundwater removed during RFI/RI field activities Containerization of collected groundwater and drill cuttings is not optional, but must follow the approved SOPs

RESPONSE

The site-specific QAA is provided with the revised Final Phase III RFI/RI Work Plan Containerization of collected ground water and drill cuttings will follow approved SOPs

<u>*Section 5 1 - Source Characterization*</u>

The SOP (1990) deferred site-specific information to the work plans The individual OU 1 work plan is referencing the SOP The site-specific information should have been added if it differs from the SOPs In new boreholes and wells where contamination is found, additional drilling will be necessary to determine the vertical extent of the contamination For example, if contamination is found in the surficial deposits, additional characterization will be necessary to determine if the contamination has progressed farther down Bedrock wells must be installed where borehole sampling indicates bedrock is contaminated (see EPA comments, pg 1-14) These issues must be resolved to develop an acceptable Phase III RFI/RI Report

RESPONSE

Drilling and sampling procedures which deviate from the SOPs are presented in the revised Final Phase III RFI/RI Work Plan Bedrock wells will be installed where subcropping sandstones are encountered

<u>*Section 5 1 1 3 - Liquid Dumping Site (SWMU Ref No 104)*</u>

A monitoring well will need to be installed if samples from the boreholes indicate contamination If contamination is found, the remedial investigation will need to fully characterize it

RESPONSE

The proposed boreholes are designed to fully characterize IHSS 104

Section 5.1.1 4 - Out-of-Service Fuel Oil Tanks (IHSS Nos 105.1 and 105 2)

This should have been clarified Remedial alternatives regarding the underground storage tank removal should be addressed in the FS

RESPONSE

Remedial alternatives to be considered for IHSSs 105 1 and 105 2 during the FS will include tank removal and remediation of soils and ground water as appropriate

Section 5 1 1 6 - Hillside Oil Leak Site (IHSS Ref No. 107)

Monitoring well MW17 may need to be moved slightly southward to detect groundwater flowing from under the skimming pond Groundwater level data will need to be evaluated more precisely to determine the best location for MW17

RESPONSE

In the revised Final Phase III RFI/RI Work Plan, the proposed location of MW17 has been moved slightly to the south as suggested (see Plate 1, Proposed Borehole and Monitor Well Locations)

Section 5 1 1 7 - Multiple Solvent Spill Sites (IHSS Ref Nos 119 1 and 119 2)

Proposed well MW23 is not located downgradient of IHSS 119 2 as stated in the response to CDH comments (pg 3-14) Well MW29 will monitor groundwater flowing under IHSS 119 1 and not 119 2 as stated in the response to CDH comments (pg 3-14) The potentiometric surface data should be used to locate well MW25 so that it is downgradient from well 43-87 as contaminants were detected in this well Soil contamination is indicated at BH15-87 and possibly BH61-87 which require follow-up investigation of soil and groundwater These issues must be addressed in order to present an acceptable Phase III RFI/RI Report

RESPONSE

The response to comments was in error The three monitoring wells downgradient of IHSS 119 2 are MW12, MW13, and MW32

In the revised Final Phase III RFI/RI Work Plan, the proposed location of MW24 has been moved slightly west to a location more directly south of existing well 43-87

No volatile or semi-volatile compounds have been detected in concentrations above the established detection limits for borehole BH61-87 samples The low concentrations of compounds that were detected do not provide conclusive evidence that this area is contaminated The existing and proposed boreholes and monitor wells within and downgradient of IHSS 119 2 should provide adequate data for characterizing that source area Samples from borehole BH15-87 are similar except for one volatile (acetone) and three semi-volatile compounds (phenanthrene, fluoranthene, bis(2-ethylhexyl)phthalate) that were detected in concentrations above the established detection limits There are potential problems associated with acetone and phthalate analyses (discussed in Section 2 3 2 1 of the work plan) that indicate these results may be artifacts of sampling or analytical procedures The phenanthrene and fluoranthene concentrations are very close to the established detection limits Because BH15-87 (and BH61-87) are not within defined IHSS boundaries, it is unlikely the soils in these areas are contaminated If results from the proposed Phase III boreholes indicate contamination with these compounds, it will be conservatively assumed that this contamination extends to these boreholes

Section 5.1.1 8 - Radioactive Site No. 1-800 Area (IHSS Ref No. 130)

The work plan should have stated the need for careful sampling at this IHSS (see EPA comments, pg 1-15)

RESPONSE

Careful sampling will be performed at all sites during the RFI/RI as defined in the QAPjP, QAA, and the SOPs

Section 5 1 2 1 - Chemical Analysis of Soil Samples

Procedures should have been identified and not referred to the GRRASP as the GRRASP was not provided for review with the Sampling and Analysis Plan Therefore, it is not certain what the procedures are The procedures should be those defined in the Sampling and Analysis Plan and the site-specific plan EPA comments on the SAP apply to this document as well This issue must be resolved prior to approval of this work plan

RESPONSE

The GRRASP has now been provided to the regulatory agencies for review

Section 5 1.2 2 - Soil Blanks

The investigation of sample contamination should be ongoing in order to get quality data for evaluation This issue could precipitate conservative decisions later on in the decision-making process for OU 1 In order to prevent this, DOE must address this issue and resolve it during the Phase III RFI/RI

RESPONSE

DOE fully intends to address sample contamination in order to provide the highest quality data, and to avoid unnecessary conservative assumptions regarding contamination

Section 5 2 1 1 - Monitor Well Locations

The location of well MW29 is not downgradient of the majority of SWMU 130 (see response to EPA comments, pg 1-1) An additional well, located between MW34 and MW35 and near well 55-87, in the Woman Creek Valley Fill is necessary for the characterization described in the section This location is downgradient from IHSSs 130 and 119 1 (see potentiometric surface map) The seismic study should have been referenced in this section as stated in response to CDH comments (pg 3-15)

RESPONSE

MW 26 is proposed downgradient of SWMU 130 Well MW37 has been added in Woman Creek Valley fill alluvium as suggested At the time the draft Phase III RFI/RI work plan was prepared, conduct of a seismic reflection study at OU No 1 was under discussion, and the work plan was to indicate reference to the study for locating bedrock wells However, it has been determined that a seismic reflection study will not be conducted at OU No 1 Nevertheless, the shallow bedrock characterization plan is comprehensive in that bedrock wells will be installed adjacent to alluvial wells <u>at all locations</u> where sandstone is encountered, as stated in the work plan

<u>*Section 5 2 1 2 - Chemical Analysis of Ground-Water Samples*</u>

The sample and analyses procedures used must be those described in the approved site-wide SOPs If additions or changes to the SOPs are necessary for this work plan, then these items should have been addressed specifically The SOPs should have been referenced here (with page numbers) It is not necessary to describe the SOP procedures in this section

RESPONSE

Ground-water sampling will follow approved site-wide SOPs

<u>*Section 5.2 1.3 - Hydraulic Testing*</u>

An explanation of how the pumping tests in Woman Creek Alluvium will provide the necessary information to determine hydraulic conductivity for all the geologic materials in the 881 Hillside area should have been presented within the work plan (see CDH comments, pg 3-15) The work plan should have explained the selection of locations for the three pumping wells located in Figure 5-2 This discussion is necessary within the text of the Phase III RFI/RI Report

RESPONSE

Pumping tests in Woman Creek Alluvium will only characterize valley fill alluvium along Woman Creek Because of the limited saturated thicknesses or low hydraulic conductivity of other materials at the 881 Hillside, pumping tests are not feasible Drawdown-recovery or slug tests will be used to evaluate the hydraulic conductivity of other geologic materials at the 881 Hillside Area Areas expected to have the greatest extent of saturated alluvium along Woman Creek were chosen as test locations This note has been added to the revised Final Phase III RFI/RI Work Plan

<u>*Page 5-22*</u>

It is stated here that the hydraulic conductivity and effective porosity of the Woman Creek Alluvium are known to estimated accuracies of a factor of three and that dispersivity is known to an estimated accuracy of an order of magnitude This should have been explained within the work plan, including an explanation of how these accuracies were determined This information must be substantiated and presented in the Phase III RFI/RI Report The hydraulic conductivity value derived from Phase I and II for Woman Creek (1×10^{-3} cm/s) seems low based on the lithologic description of the Alluvium

RESPONSE

Current estimates of hydraulic conductivity, effective porosity, and dispersivity for the Woman Creek alluvium will be presented in the Phase III RFI/RI Report

Page 5-25

An explanation of why multiple well aquifer tests are planned only for the Woman Creek Alluvium should have been provided EPA recommends multiple well aquifer tests for the colluvium, the Rocky Flats alluvium and the Arapahoe Formation

RESPONSE

Because of the limited saturated thickness or low hydraulic conductivity of other materials at the 881 Hillside, pumping tests are not feasible Drawdown-recovery or slug tests will be used to evaluate the hydraulic conductivity of other units

Section 5 2 2 1 - Surface Water and Sediments - Sample Locations

The sediment sample locations should have been shown in Figure 2-17 (see response to EPA comment, pg 1-17)

RESPONSE

Sediment sampling locations are presented in Figure 2-21 of the revised Final Phase III RFI/RI Work Plan

Section 5 2 3 - Surficial Soils

Approved procedures in the Plan for the Prevention of Contaminant Dispersion must be employed during the surface and subsurface sampling Surface scrape locations 1, 2, 3, 6, 10, 11, 12, 13, 16, 17, 18 and 19 (Table 2-8) all indicate elevated uranium and plutonium This signifies the need to collect samples on a denser grid, and in, and adjacent to IHSSs, more than proposed in the work plan The lack of this information may force DOE to make conservative judgments regarding contamination which may overestimate the actual risk

RESPONSE

Additional plans for surficial soil sampling for radionuclides are presented in Section 5 2 3 of the revised Final Phase III RFI/RI Work Plan

Section 5 3 - Evaluation of the Proposed Interim Remedial Action

Hydrogeologic information was obtained through packer testing The locations of the six boreholes not along the 100-foot centers should have been identified in the work plan and must be presented in the Phase III RFI/RI Report Piezometers should also be located west of the recovery well location

The method of sampling along the influent/effluent pipeline alignment for the IM/IRA results in compositing over 5-foot intervals This will cause significant dilution of potential contaminants and potentially non-representative samples The criteria for choosing the discrete VOC soil sample should have been provided with the work plan The methods described do not indicate that they are adequate to determine the appropriate health and safety protocol This information must be presented in the Phase III RFI/RI Report

Results of the packer tests and sample analyses should have been provided and summarized within the work plan and must be presented within the Phase III RFI/RI Report

RESPONSE

The locations of the six boreholes that are off-set to the french drain alignment boreholes are identified and referenced in the revised Final Phase III RFI/RI Work Plan (B303790-B304290) These six boreholes are also included in Figure 2-2 of the revised Final Phase III RFI/RI Work Plan

One piezometer will be installed east and one west of well 9-74 This is included in the revised Final Phase III RFI/RI Work Plan, and the location is presented on Plate 1

A Moss sampler retrieved soils in two-foot intervals at 0-2 foot and 2-4 foot depths Because gravels drastically reduced the volume and quantity of a retrieved sample, an additional sample at 4-6 foot would be retrieved if gravels were encountered in the 2-4 foot interval A discrete soil sample for VOC analysis from the 2-4 foot or 4-6 foot interval was obtained using a 2-1/2 inch stainless steel sleeve inserted and secured directly at the tip of the Moss sampler The sample was submitted for VOCs, the remaining material was composited with the 0-2 foot or 2-4 foot material and submitted for the other analytes

The analytical results of the soil samples will be used to determine the appropriate health and safety protocol for pipeline construction and the soil characterization for proper disposal of excavated soils

The results of the packer tests are provided as Tables 2-3 through 2-6 in Section 2 2 2 of the revised Final Phase III RFI/RI Work Plan

Section 6 1 - Introduction

There is no reason to exclude contaminants because of lack of specific data on ecological impacts At worst, structure activity relationships, known toxicity in non-target species and/or basic physical/chemical properties provide a basis for qualitative discussion of potential ecologic impact Further, although the RFI/RI should not be a basic research project in itself, DOE efforts as a whole need to be cognizant of information gaps so that research funds can be allocated appropriately Thus, identification of potential, but poorly studied, contaminants could be significant outside of the Region VIII Superfund process

RESPONSE

The sentence that states "determination of ecological impacts will be limited to contaminants whose effects on biota are adequately documented in the scientific literature" has been deleted in the revised Final Phase III RFI/RI Work Plan The statement is inconsistent with the environmental evaluation as proposed

Section 6 1 2 - 881 Hillside Contamination

Toluene also seems to be a contaminant present in soil as indicated by sample results from the IM/IRA french drain alignment activities Other possible contaminants in soil are 2-butanone, pyrenes and benzenes The ecological hazard to biota caused by inhalation of plutonium should be reviewed in addition to the hazard caused by ingestion (see pg 6-5) The text states plutonium is not considered an ecological hazard to biota "unless extremely high levels [> 1 microcurie per square meter (Ci/M^2)] occur" It is not clear whether microcurie (μCi) or millicurie (mCi) are meant The report that this statement was taken from is identified, but the basis for the statement is not The assessment of impacts in the RFI/RI work plan should have discussed the rationale behind the determination of little effect related to a possible constituent of Rocky Flats soils responsible for a great deal of public concern This position must be justified within the context of the Phase III RFI/RI Report

RESPONSE

Toluene, 2-butanone, pyrenes and benzenes have been added to the list of possible contaminants Statements in the text and previous studies that were performed do not rule out inhalation of plutonium as an exposure pathway "Micro" has been changed to "milli" as noted The text in this section now states that the conclusions drawn regarding the ecological effects of plutonium are based on biological measurements and pathological data for Rocky Flats Plant sites and ecologically similar "control" areas

Section 6 1 3 - Protected Wildlife, Vegetation and Habitats

Vegetation The ten federally-listed or proposed plant species should have been listed in the evaluation within the work plan and must be considered during the Phase III RFI/RI

RESPONSE

The ten federally-listed or proposed plant species were not listed because, as mentioned in the text, they are not known or expected to occur at the site If they do not occur at the site, they will not be considered in the Phase III RFI/RI Report

Section 6 1 4 - Scope of Work

The natural resources are not ARARs ARARs are used along with risk levels to determine levels of cleanup to meet protectiveness standards

RESPONSE

Natural resources are not ARARs The sentence was poorly worded and has been modified to identify the federal and Colorado laws as ARARs, as originally intended

Section 6 2 1 - Preliminary Planning

The plans should have taken into account the schedules for OU 1 activities (RFI/RI and IM/IRA) as presented in the IAG to meet the needs of the investigations The determination as to what constitutes a statistically significant difference in the biological response between tissue samples is not identified *in the QAPjP The environmental evaluation section is missing in the QAPjP This issue must be rectified prior to approval of this work plan*

RESPONSE

The plans were written in full recognition of the schedules for the OU No 1 activities The QAPjP will be modified to include an environmental evaluation section that, among other details, will address determination of statistically significant differences in biological responses between tissue samples

Section 6.2 3. - Support Documentation

The field sampling plan must be consistent with that provided for the Site-Wide SAP If specific conditions exist for OU No 1, then these should have been identified Procedures that will be used generally should be presented in the SAP This problem must be resolved prior to approval of this work plan

RESPONSE

The Site-Wide SAP has been updated to include Standard Operating Procedures (SOPs) for conduct of the environmental evaluation

Section 6 2 4 - Review of Existing Information

Any information generated from the RFI/RI and IM/IRA studies should have been reviewed

RESPONSE

All relevant information pertinent to OU No 1 was reviewed The two previous RI reports and the IM/IRA plan have been listed in Section 6 2 4 of the revised Final Phase III RFI/RI Work Plan

Section 6 3 - Field Investigation

Sediment information must be collected per requirements listed on page 6-9 The SOPs related to the particular field activity should have been identified

RESPONSE

Section 6 3 2 has been modified to include a discussion of past and proposed sediment sampling The proposed sediment sampling includes analysis for grain size distribution and organic carbon, and physical characterization Reference to the SOPs is made in the opening paragraph of Section 6 1 in the revised work plan

Section 6.3 2 - Soils

The chemical/hydrologic/geologic model for the 881 Hillside is not well defined at this time The Phase III investigation must provide the additional information necessary to develop an overall conceptual model

RESPONSE

A draft site conceptual model for OU No 1 has been prepared and is presented in Section 2 4 of the revised Final Phase III RFI/RI Work Plan A major focus for the Phase III RFI/RI is better characterization of the site contaminant distribution and migration pathways

Section 6 3.4 - Groundwater

The hydrogeologic information and laboratory analytical results from the Phase III investigation program are an integral part of the environmental assessment and must be included The remedial investigation must evaluate the effects of contaminated ground-water regardless of the depth

RESPONSE

The comment seems to refer to the term "shallow ground water" used in the text "Shallow" has been deleted from the text, but it must be recognized that the focus of the ground-water investigation is characterization of the upper hydrostratigraphic unit (includes weathered bedrock) Existing wells in the lower hydrostratigraphic unit (unweathered sandstone) will continue to be monitored on a quarterly basis to provide a definitive basis for concluding that this "deep" ground water is not contaminated

Section 6 3 5 1 - Vegetation

The work plan states that the criteria will be determined for the selection of key species The criteria should have been identified in the work plan At the very least, the method for determining the criteria should have been mentioned The work plan should have identified any protected species This issue must be addressed and justification presented within the Phase III RFI/RI Work Plan

RESPONSE

There are currently no known protected species or habitats near the 88 Hillside Area Criteria for selecting key species are specified in Ecological Assessment of Hazardous Waste Sites (EPA, 1989) and include

- Species of sufficient number to permit statistically significant comparisons within and outside the site
- Species of importance in the food web at the site
- Species which are susceptible to the contaminants of concern
- Species which can be compared to an unaffected reference area
- Species of economic value

- Species of social value (endangered, aesthetically valued, etc)
- Species of broad applicability to other studied sites

Section 6 3.5 2 - Wildlife

The text identifies benthic macroinvertebrates as probably existing as soft bottom communities in Woman Creek and Pond C-2 The reason for the apparent elimination of harder-bottom communities in Woman Creek is unclear, especially because the later inclusion of Surber sampling methods indicates finding something other than soft bottom habitats (riffle habitats discussed page 6-40) The discussion should have been written to concur with the rest of the section, or the rest of the section qualified for the unlikelihood of finding aquatic habitat other than those related to soft bottoms It should be noted that if the stream bottom is in fact made up only of soft sediments, the plan to walk through it while electroshocking will probably make the water too turbid to see any stunned fish If this is the case, an alternative method should have been proposed This issue must be resolved prior to conducting the environmental evaluation field work so as to prevent a problem within the Phase III RFI/RI Report

RESPONSE

The text of Section 6 3 5 2 has been modified to address both soft and hard bottom benthic macroinvertebrates as both types of benthic organisms will be present in the Woman Creek sediments depending on the reach investigated Section 6 8 4 4, as pointed out by the commenter, presents methods for collection of hard and soft bottom benthic organisms A SOP will be prepared for each method In areas characterized by soft bottoms, the stream width is such that electroshocking can be performed by standing adjacent to the stream to avoid stirring up the sediment

Section 6 4.2 - Contaminant Identification

The chemical list used in the evaluation must be comprehensive

RESPONSE

The development of a list of contaminants of concern using EPA methodology will not compromise the quality of the environmental evaluation The chemical list will be comprehensive

Section 6 5 2 - Toxicity Tests

The text states in-situ methods of toxicity testing involve the exposure of "animals in the field to existing aquatic or soil conditions" It is not clear whether laboratory animals will be exposed to these conditions or whether animals that already live in the ecosystem will be exposed to existing conditions The discussion should have been clarified and more detail provided The resolution to this issue must be justified and presented within the Phase III RFI/RI Report

The table identifies exposure points as air, soil, water, and vegetation, but identifies exposure point concentration related to soil and sediment, surface water, groundwater, and vegetation Exposure pathways are identified as terrestrial and freshwater On page 6-29, terrestrial and aquatic ecosystems are identified As an outline for the environmental evaluation, the same terms and topics should have *been used for discussions which are related to each other to reduce the possibility of future confusion This must be resolved and clearly presented within the Phase III RFI/RI Report*

RESPONSE

The statement regarding in-situ methods was confusing The statement now reads that the methods will "involve exposing laboratory animals to field (aquatic or soil) conditions" The terminology in Table 6-1 has been changed so that it is consistent throughout the outline

Section 6 7 - Environmental Evaluation Report

Section 7 in the draft environmental report outline must include Woman Creek in the freshwater pathway analysis The Stage 1 field sampling plan may be modified with EPA approval

RESPONSE

Woman Creek has been added to the freshwater pathway effects characterization in Table 6-1

Section 6.8 2 2 - Locations for Periphyton Sampling

The text states the absence of periphyton at any location will result in sampling of periphyton at the nearest downstream location The method for determining the presence or absence of periphyton is not identified and must be clear before conducting the field work It is unlikely that a visual review of site conditions will adequately identify the absence of periphyton in any situation other than the absence of water The procedure to be used should have been identified and must be before entering the field If that procedure is expected to be visual, the text should have stated this This problem must be addressed, resolved and presented within the text of the Phase III RFI/RI Report

RESPONSE

Presence or absence of periphyton on hard substrates can be determined visually without difficulty Rocks, gravel and other hard surfaces will simply be examined for the presence of algae and other flora Observing and collecting algae from soft sediments is more difficult Vacuum suction devices will be used to remove the soft organic surficial sediment layer Material collected will be screened in the field with the assistance of field microscopes. In this manner relative algal concentrations can be quickly estimated, and the appropriateness of the site for detailed analysis can be quickly determined It is expected that the soft substrate of Pond C-2 will support adequate growth of periphyton to allow accurate species quantitation Section 6 8 2 2 of the October 1990 Final Phase III RFI/RI Work Plan is Section 6 8 4 1 1 in the revised work plan

Section 6 8 4.4 - Macrobenthos

The text states that samples will be placed in plastic jars and reference specimens preserved "in a 70 percent isopropanol solution" It was not clear whether the samples themselves will be preserved It is unlikely that use of an alcohol solution that starts at 70 percent will be adequate to preserve macroinvertebrate samples The final solution should be 70 percent for preservation It should also be noted that the list of equipment on page 6-45 includes 70 percent ethanol rather than isopropanol

The methods and text should have been revised and this issue must be resolved prior to conducting the field work

RESPONSE

Only those samples where it is necessary to preserve specimens for future reference will be preserved in alcohol Either ethanol or isopropanol can be used as a preservative, and a 70% solution is of adequate strength for this purpose For consistency, reference is only made to ethanol in the revised text Section 6 8 4 4 of the October 1990 Final Phase III RFI/RI Work Plan is Section 6 8 4 1 2 in the revised work plan

Section 6.8 4 5 - Fish

Established criteria to determine the number of passes that define "multiple" should have been presented The text should have discussed the specific number of passes expected for each location This must be justified and presented within the Phase III RFI/RI Report

RESPONSE

The revised text (now Section 6 8 4 1 3) is more specific, stating that one or two passes will be made through the area

Section 6 8 5 - Stage III

The text should have stated the expectation for the sampling program to provide the necessary amounts of biomass

RESPONSE

The text is explicit in defining the sample mass requirements There is no control over the quantity of available biomass for sampling Section 6 8 5 of the October 1990 Final Phase III RFI/RI Work Plan is Section 6 8 4 in the revised work plan

Appendix B

Data from several 1989 and early 1990 sampling events have not been received by DOE An explanation of why data is not available for these samples should have been provided This data must be utilized to develop the Phase III RFI/RI Report

Soil concentrations in parts per billion reported for BH13-87 indicate methylene chloride concentrations of 27B and acetone concentrations of 15(JB) On a later page for the same surficial unit, the concentrations are 27 9 methylene chloride and 22 acetone There appears to be a discrepancy in the data which should have been explained Detection limits appear to be high and possibly are masking low levels of contaminants

The cover sheet for Appendix B groundwater wells refers to OU 2 instead of OU 1

RESPONSE

The referenced samples had not been received by DOE because of protracted turnaround times from the laboratories due to the abundance of samples received The data will be utilized in preparation of the Phase III RFI/RI report

There is no discrepancy in the data The data cited in this comment are from different intervals of the borehole As noted, detection limits were high for historical analyses and this problem will be corrected in the future by adherence to the GRRASP

The cover sheet for Appendix B (now Appendix C) has been corrected as noted

QUALITY ASSURANCE ADDENDUM COMMENTS

Section 3 1 - Data Quality Objectives

> *Table 1 - Characterize the nature and extent of contamination, item 1, should have addressed the extent of surficial radionuclide soil contamination due to release from the IHSS not just from wind dispersion This table should have been merged with Table 3-1, in the work plan It is not clear why this information is repeated in the QAA. The text states that only precision and accuracy can be expressed in purely quantitative terms of the five data quality parameters Completeness is also a quantitative evaluation and should have been added to the statement*

RESPONSE

Table 1 was reproduced from the work plan (Table 3-1), which is where the site-specific objectives and associated data needs should, and are, developed Therefore, any comments that address site-specific RFI/RI objectives should be included in the work plan review In response to the second part of this comment, Table 1 will be deleted and substituted with reference to the work plan (Table 3-1) for Phase III field investigation objectives Information presented in the work plans and the site-wide SAP (the QAPjP and SOPs) does not need to be reproduced in the QAA The collection of surficial soil scrapes and analysis for radionuclides will determine the extent of radionuclide contamination from wind dispersion and any released from the IHSS

Completeness is a quantitative measure of data quality and will be expressed as such in the QAA. The equation for determining completeness is included in Appendix A of the QAPjP A goal of 100% completeness is established in the QAPjP, however, this is now a requirement Completeness of 90% is required Incomplete data packages will be reviewed to determine the need for corrective action

Precision and Accuracy

> *Any non CLP protocols used must be approved by EPA prior to implementation Table 2 should have given the analytical procedure for all types of analyses*

RESPONSE

Table 2 has been removed from the QAA The QAA now references Appendix B of the QAPjP which lists analytical methods, detection limits and DQOs (precision and accuracy objectives) for parameters that will be analyzed Table 1 of the QAA lists the analytical methods, detection limits, and precision and accuracy objectives for parameters that are not listed in Appendix B Specific analytical methods are listed where non-CLP protocols are used

<u>*Section 3 2 - Sampling Locations*</u>

The entire discussion of the environmental evaluation does not agree with that presented in Section 6 of the Phase II RFI/RI work plan The inconsistencies include discussions of timeframes, sample locations, and discussions of procedures This document and the work plan should have been reviewed side by side, and revised for concurrence As they currently exist, they do not seem to discuss the same program Information on sample locations should have been included in the field sampling plan within the work plan This issue must be resolved to EPA's satisfaction prior to approval of this work plan

RESPONSE

Section 3 2 of the QAA presents a summary of the types of samples and sampling locations that are presented in the work plan The methods of field surveys and sample collection presented in the QAA are also summaries of the methods described in the work plan There are no discrepancies between the QAA and the revised work plan

<u>*Section 3 7 - Quality Control Checks*</u>

Lab contamination has been cited as a likely reason for elevated concentrations of acetone, methylene chloride, phthalate, toluene and other chemicals in the environmental samples Verification of this is necessary The outcome of this analysis could impact the risk assessment Phase III RFI/RI Report and ultimately the cleanup decision The means of verifying and preventing any future contamination should have been fully described The reference used to determine the 30 percent and 40 percent relative percent difference for field duplicate samples should have been given The percentages may vary with the analytical method Field matrix spikes and matrix spike duplicates are necessary and the numbers of each should have been identified The compounds and the concentrations used to prepare the spikes should have been identified Table 4 lists the QC sample collection frequency but also should have listed the number of samples to be taken based on the work plan

RESPONSE

The GRRASP, which is the analytical services protocol for the RFP ER Program that all laboratory contractors must follow, requires development of internal laboratory SOPs that are consistent with EPA-CLP QC procedures These procedures require the use of laboratory QC checks including the use of laboratory spikes and blanks, that are used by laboratories to detect for possible contamination The data validation guidelines cited in the QAPjP describe assessment procedures that are adhered to by EMAD and laboratory subcontractors to determine if laboratory contamination may be occurring A paragraph has been added to the QAA regarding laboratory QC

The difference between field duplicates is a difference between the sample and a duplicate of that sample and is not an analytical quality check A difference of greater than the acceptable difference review specified in the QAPjP to determine if field procedures are being followed

Data Validation

The QAA lists a number of guidance documents that will be used for data validation A specific set of steps should have been listed for the data validation process The process for data verification should have been added to the QAA if different from those in the QAPjP This issue must be addressed prior to conducting field work

RESPONSE

The documents listed are now included in the QAPjP and are the guidance documents that are used by EG&G Rocky Flats and their subcontractors to validate laboratory data The laboratory validation process is illustrated graphically in Figure 3-1 of the QAPjP In addition to the steps shown in Figure 3-1, the entire sample collection, chain-of-custody, analysis and data validation and verification process for the ER Program has been added to the QAPjP and is illustrated in Figure 8-1 This process shall be adhered to for OU No 1 data Figure 3-1 has been referenced for the validation process in the QAA

Section 3 9 - Data Reduction, Validation, and Reporting

The necessary information concerning field data validation is referenced among several documents but not detailed in any document This section states "field data validation shall be performed as specified in Section 3 3 3 2 of the QA Project Plan " The cited section of the site-wide QA Project Plan (found on page 23 of the QA Project Plan) notes that field data will be validated on two different levels The first level of validation involves periodic surveillance during the sample collection activity as specified "by following Rocky Flats Plant standard operating procedures (SOPs) for data validation " (The second validation level involves only a review of the data to ensure correct codes and units were used) The coordination of the work plan with the site-wide QAPjP and SOP is necessary prior to EPA approval of this work plan

The following example illustrates the continuing circular nature of the references involving field data validation A common criterion used in the validation of field data is whether an adequate number of quality assurance/quality control (QA/QC) samples were taken in the field QA/QC samples include field duplicates, equipment rinsates, trip blanks, field blanks, and matrix spike/matrix spike duplicates The appropriate SOP for this activity is SOP 1 13 "Containerizing, preserving, handling, and shipping of soil and water samples " Section 7 0 of SOP 1 13 (Quality Assurance/Quality Control Samples, page 18) includes descriptions of the types of QA/QC samples discussed above However, the frequency for collection of these samples is "specified in the project specific field sampling plan (FSP) " The FSP (Section 5 0 of the Phase III work plan for OU No 1) does not, however, contain any information regarding the frequency of collection of field QA/QC samples Although criteria for validation of field data are referenced in this QAA, the site-wide QA Project Plan, the sample storage SOP, and the FSP, the necessary QA/QC sample frequency information is missing

Other items that should have been considered (in the site-wide QA Project Plan, in the QAA, or in the FSP) include collection of sufficient sample volume, adherence to proper preservation techniques, and adherence to chain-of-custody procedures Information regarding the frequency of collection of QA/QC samples should be appropriately placed in the QA Other items related to validation of field data would be most useful as part of the site-wide QA Project Plan or the SOP

RESPONSE

Field validation (i e , validation of sampling techniques) is described in Section 3 3 4 2 of the QAPjP and includes the performance methods referenced by the comments The QC procedures that will be followed to validate the field samples are described and referenced (each field sampling SOP lists and describes the process for the QC checks that are applicable to that particular type of sampling) in Section 3 3 5 1 of the

QAPjP Section 3 7 describes the QC checks for field samples (also described in the QAPjP) that are applicable to OU No 1 Table 3 of the QAA lists the "Field QC Sample Collection Frequency" for OU No 1 The SOPs should reference to the work plan QAA for the frequencies of QA/QC samples, as does Table 3-2 of the QAPjP

With regard to "other items that should have been considered," Table 8-1 has been added to the QAPjP, which lists sample volumes, appropriate containers, preservation requirements, and holding times Additional discussion of sample identification and chain-of-custody has been added to Section 8 3 The entire sampling, sample tracking, validation and analysis process is illustrated in Figure 8-1 of the QAPjP

Section 5 0 - Instructions, Procedures and Drawings

New procedures will need approval by EPA

RESPONSE

All SOPs and SOP addenda that are used to conduct and/or control ER Program activities will be submitted to EPA and CDH for review and approval

Section 6.0 - Document Control

Documents relating to the OU 1 IM/IRA should have been added

RESPONSE

These documents have been added to the revised QAA

Section 11 0

This discussion of test control requirements did not include specific information on the QAA but references the Site-Wide QAPjP The Site-Wide QAPjP references the QAA and the work plan/FSP, and the work plan/FSP does not contain the cited information test control requirements This must be rectified to EPA satisfaction before approval will be granted for this work plan

RESPONSE

Testing is limited to pump and tracer tests The QAA now references the appropriate section of the work plan and SOPs for these test specifications

1.3 RESPONSE TO CDH COMMENTS

COMMENT

Executive Summary

The recurring problem of laboratory contamination of soil samples with methylene chloride, acetone and phthalates needs to be solved If a different laboratory procedure will correct the problem, submit an addendum to the SOP Are all of the samples in an identical test run contaminated with acetone, methylene chloride and phtalates, or just one and a blank?

RESPONSE

Methylene chloride and acetone are common laboratory solvents pervasive in the laboratory atmosphere However, laboratory contamination of samples with these constituents can be controlled, eg, segregating solvent extraction activities from GC/MS analysis All attempts will be made to prevent samples from being contaminated in the laboratory so that the quality of the data is not compromised Soil blanks will also be used to ascertain sampling and/or laboratory contamination with these solvents as well as with phthalates (see Section 5 1 2 2) Previously collected samples were analyzed using an inappropriately small sample size that compounded the laboratory contamination problem These problems have now been corrected

Section 2 1 - 881 Hillside Area Previous Investigations

Where are the results of the geophysical surveys using electromagnetometry, resistivity, magnetometry and metal detection?

RESPONSE

The results of the geophysical surveys mentioned is given in Appendix B, Volume V of the Phase II Draft Final Remedial Investigation Report (Rockwell International 1988a)

Section 2 2 1 1 - Surficial Geology

Does the term "artificial fill" refer to fill brought into the plant from an off-site area or is it anthrogenic, manmade material?

RESPONSE

The artificial fill is both natural fill generated from the excavation of Building 881 and fill that was placed in IHSS 130 from both manmade and natural sources (see Section 1 4 8 Radioactive Site - 800 Area #1) (IHSS Ref No 130) The distinction will be made in the revised Final Phase III RFI/RI Work Plan

Section 2 2 2 1 - Unconfined Flow System (Ground-water Flow Rates) pg. 2-16

The ground-water velocity measured using actual contaminant movement is 11-13 ft/yr and the calculated ground-water velocity based on geometric mean hydraulic conductivity and assumed effective porosity is between 1035-3100 ft/yr What does this large difference in ground-water velocity *suggest about both techniques used to measure ground-water velocity? What ground-water velocity should be used for design and placement of collection systems?*

RESPONSE

The Final RFI/RI Work Plan states the rate of organic contaminant movement is less than 11-13 feet/yr in colluvium on the 881 Hillside in the vicinity of IHSS 119 1 This rate is based on organic contaminants in ground-water moving less than 200 feet in 15 to 20 years This represents an estimate of organic contaminant migration rate, not ground-water flow velocity The solvent contaminants at the 881 Hillside will not travel at the ground-water velocity rate because of volatilization and adsorption The velocity quoted by the commenter represents the hydraulic conductivity of the Woman Creek Valley fill alluvium which is not equal to the ground-water velocity Ground-water velocity or average linear velocity is a function of the hydraulic conductivity, volumetric porosity, and hydraulic gradient The ground-water flow velocity for the Woman Creek valley fill ranges from 167 to 652 ft/yr

Section 2 3 3 2 - Inorganics (pg 2-62)

Typographical error in "occurrence of tritium above background in wells 52-87 and 69-87" Well 69-87 should be 69-86

RESPONSE

This has been corrected in the revised Final Phase III RFI/RI Work Plan

Section 2 3 5 - Sediments (pg 2-69)

A sediment sample map should be provided to aid review of the laboratory sediment findings

RESPONSE

This map has been provided in the revised Final Phase III RFI/RI Work Plan (Figure 2-21)

Table 2-13 - Remedial Technology Data Requirements (pg 2-83)

At the recent conference of "Remediation of Radioactive/Mixed Waste Sites" in Scottsdale, AZ, Dr Gloria Patton, and Dr James Epler with the USDOE Office of Technology Development, Office of Environmental Restoration and Waste Management presented several innovative technologies dealing with radioactive/mixed waste which are under study for use at various DOE facilities One of the technologies, which has been studied at Rocky Flats by Jack Blakslee, involves ferrate ions (Fe^{+6}) to complex radionuclides The trade name of this process is TRU-CLEAR All of the innovative technologies dealing with radioactive/mixed waste currently under review by DOE should be included in the remedial technology assessment

RESPONSE

The ferrate process was evaluated for the 881 Hillside FS, and will be reevaluated for the OU 1 CMS/FS The Rocky Flats Plant will participate in the DOE Office of Technology Development Integrated demonstrations and the EPA Superfund Innovative Technology Evaluation program

Table 3-1 - Phase III RFI/RI Objectives and Activities (pg 3-4)

Identification of the source of the plutonium in sediment and surface water in Woman Creek should be included on this table of objectives, under "Characterize the Nature and Extent of Contamination "

RESPONSE

This point has been included as objective 5 in Table 3-1 under "Characterize the Nature and Extent of Contamination" in the revised Final Phase III RFI/RI Work Plan

Section 4 1 3 - Task 3 Field Investigation (pg 4-3)

Section 1 4 3 IHSS Ref No 104 states that there were "empty drums" disposed of in IHSS 104 A survey to verify the location and presence or absence of the drums should be included in the list of Field Investigational Activities

RESPONSE

Appendix B, Volume V of the Phase II RI Report presents the results of several geophysical surveys performed on the 881 Hillside in 1987 (Rockwell International, 1988a) Figure 2 of the report shows no magnetic anomalies in the vicinity of IHSS 104 Therefore, it is concluded that the empty drums no longer exist in the vicinity of IHSS 104 and no further geophysical surveys are deemed necessary

Section 4 1 6 - Task 6 Baseline Risk Assessment (pg 4-5)

A complete literature search including DOE studies of the effects of individual and combinations of contaminants of concern should be done prior to entering the field to collect specimens Have similar risk assessments been performed at the Oak Ridge and Hanford DOE facilities?

RESPONSE

It is assumed that the commenter is referring to the environmental evaluation as this activity will involve field sampling and collection of specimens As described in Section 6 0, the first phase of the environmental evaluation is to conduct a thorough literature search that includes review of documents pertaining to the Rocky Flats Plant as well as documents relating to other DOE facilities that are germane to this investigation

RESPONSE

Table 4-2 has been deleted in the revised Final Phase III RFI/RI Work Plan because it is not necessary, at this time, to define (and possibly limit) the scope of treatability studies for Operable Unit No 1 Specific plans will be prepared for treatability studies specific to OU No 1

__Section 5 3.1 - Borehole Locations (pg 5-37)__

On two different occasions during 881 inspections of the borehole drilling, "Division" personnel were informed by Greg Litus that there had been several toluene hits of unknown origin What are the results of the lab tests and DOE's conclusions about the source and extent of the toluene? We were also informed that some of the boreholes were redrilled because the first boreholes caved in during the 881 construction shutdown while air monitors were installed

RESPONSE

It has been hypothesized that Coherex is the source of the toluene observed during the French Drain Geotechnical Investigation Coherex has been used as a dust suppressant/soil stabilizer both before and during the Phase II RI field activities of 1986 and 1987 The Material Safety Data Sheet (MSDS) for Coherex does not discuss toluene as a component but mentions petroleum distillates as a major constituent, so toluene may be a product of degradation Toluene may also have been used as a thinning agent to reduce the viscosity of the Coherex before application Several proposed tests to confirm Coherex as the toluene source are being discussed In addition, four boreholes will be drilled and sampled to evaluate the extent of the toluene contamination downgradient of the 881 Hillside as discussed in Section 5 0 of the revised Final Phase III RFI/RI Work Plan

__Section 6 1.2 - 881 Hillside Contamination (pg 6-3)__

The radionuclides listing under Groundwater should include plutonium

RESPONSE

Plutonium has been added to the list of contaminants

__Section 6 1 2 - (pg 6-5)__

Copper, mercury, tin, cobalt and nickel act as biocides to "certain species" at low concentrations Are any of the "certain species" present at Rocky Flats? If so, please identify them

Before actual field sampling is done, it would be worthwhile to identify four parameters for each species to be sampled

1) Identify the contaminant to be studied

2) Identify an appropriate group of receptors which suffer some documented quantifiable detrimental effects from exposure to the contaminant chosen

3) Pick a specific species from the list of receptors which is __known__ to exist at Rocky Flats

4) *Have an experimental laboratory procedure in place ready to receive specimens and measure the deleterious effects of the identified contaminant*

If no receptor which exists at Rocky Flats Plant can be identified and exhibits documented quantifiable detrimental effects from exposure to the contaminants in question, then risk assessments will have to be made from the best available data found from extensive well-documented literature search It is unacceptable to conduct experimental research for a risk assessment without the above parameters

RESPONSE

Section 6 1 2 discusses the potential impact of metals on biota when present in sufficient concentrations The study will show if any species affected by low concentrations of these metals are present on-site The approach described by the commenter is not different than that proposed in Section 6 0 All potential receptors will be identified, and testing will be performed to determine any detrimental effects due to exposure to site contaminants If detrimental effects are not found, it will not be necessary to perform a literature search to complete the risk assessment In fact, the literature search is the first phase of the environmental evaluation that focuses subsequent sampling and testing efforts

Section 6 3 5 1 - Vegetation

Are any of the species of grasses or wetlands vegetation listed in this section known to be sensitive to or suffer measurable detrimental effects on exposure to the contaminants present at Rocky Flats?

RESPONSE

This will be determined during the environmental evaluation None are known at this point Section 6 3 5 1 of the October 1990 Final Phase III RFI/RI Work Plan is Section 6 8 4 2 1 in the revised work plan

Section 6.8.4.5 - Fish

Does any historical data exist on the fish populations in Woman Creek? What is to be gained by doing population studies on the fish presently in Woman Creek if there is no background or historical data to compare it to? How many of the fish are likely to be killed? The procedure makes no mention of whether or not the fish will be returned to the waters of Woman Creek We do not recommend that fish studies or any other ecological studies on plants and animals be conducted without a well designed experimental and laboratory procedure in place before any sampling is done

RESPONSE

Previous studies have been performed on fish, and are identified in the Radioecology and Airborne Pathway Summary Report Regardless of previous studies, the proposed environmental evaluation calls for use of reference areas for comparative analysis It is difficult to predict at this time how many fish will be killed If the commenter believes the proposed ecological study plan is not well designed, it will be necessary to receive more specific comments in order to further discuss any perceived shortcomings Section 6 8 4 5 of the October 1990 Final Phase III RFI/RI Work Plan is Section 6 8 4 1 3 in the revised work plan

QUALITY ASSURANCE ADDENDUM COMMENTS

General

There are major portions of the QA plan missing entirely and many others which are indeterminate. The final version of the Quality Assurance Project Plan for the Interim Remedial Action Operable Unit 1, Phase I-A, did an adequate job for the construction, drilling and air monitoring activities which Phase I-A covered All of the appropriate parts of the Final Version Quality Assurance Project Plan Phase I-A for drilling and air monitoring activities should be lifted in its entirety with appropriate revisions and included in the Phase III RI/RFI Quality Assurance, since additional drilling activities, boreholes and soil sampling, and air monitoring are continued activities in Phase III

Section 1 2 Objectives lists nine activities to be performed as part of the field investigation Five of the nine activities do not have any project plans, one or two pages of incoherent fragmented material does not constitute a project plan for performance of aquatic and terrestrial field surveys for example

Each of the nine activities should have a QA Project Plan associated with it

1) *Drill and sample soils and wastes within IHSSs*
   Major portions of the QA Phase I-A IM/IRA project plan for drilling can be adopted with appropriate revisions, and deletions for example, references to the french drain line

2) *Install and sample ground-water monitoring wells.*
   Again the format for drilling boreholes can be adjusted for installation of ground-water monitoring wells

3) *Determine sediment composition and quality, grain sizes and total organic carbon.*
   The sole reference to sediment sampling consists of two whole lines on page 28, and a list of three sediment stations to be sampled Where is the project plan for determination of sediment composition, quality, grain size and total organic carbon?

4) *Perform aquifer tests and geotechnical tests*
   We were unable to locate a single reference to these activities in the QA. What aquifer and geotechnical tests are to be performed at 881? What sites are the aquifer and geotechnical tests to be performed on? What pieces of information are expected to be gained from the aquifer and geotechnical tests? A project plan for aquifer and geotechnical tests must be included in the QA Phase III RI/RFI

5) *Assess air quality*
   The project plan for assessment of air quality can be taken with few modifications from the Final Version Phase I-A IM/IRA

6) *Perform aquatic and terrestrial field surveys.*
   This is the most incoherent ill designed project plan in the QA. What species are being sampled? How are they being sampled? What are they being sampled for? Is there a laboratory protocol in place to receive the samples? Tissue samples cannot be treated in the same manner as soil and rock samples The project plan for aquatic and terrestrial field survey must be rewritten

7) *Collect surface water and sediment samples*
   An eight line reference to surface water sampling locations does not constitute a project plan for surface water sampling The project plan for collection of sediment samples could be included in the third activity project plan The absence of a surface water project plan needs to be addressed

8) *Collect and analyze terrestrial and aquatic vegetation and animals*
One project plan could conceivably cover activities six, eight and nine If scientific substantiated documented literature searches cannot identify a plant or animal species living at Rocky Flats with a quantifiable biomarker, or other measurable indicator of contaminant effects, then a baseline risk assessment should be performed using environmental evidence gathered from other studies of both real life data and experimental studies of contaminants done in academic settings

9) *Perform toxicity tests to measure the effects of contaminated environmental media on representative species*
We are unable to find a single reference to any toxicity test in the QA The project plan for toxicity tests should include species, test, and laboratory procedures

The SOP reference chart sandwiched in the middle of the environmental evaluation does not have any key associated with it What do the black dots indicate?

RESPONSE

The quality assurance program for Rocky Flats Plant consists of a site-wide Sampling and Analysis Plan (SAP), which is comprised of the site-wide QAPjP and Standard Operating Procedures (SOPs), and supplemental OU-specific Quality Assurance Addenda (QAA), and where necessary, SOP Addenda These Addenda provide the additional QA/QC and procedural detail specific to a particular OU that was unable to be addressed in the site-wide SAP The Addenda also provide documentation for any differences between the site-wide QA Program and the OU-specific QA/QC requirements

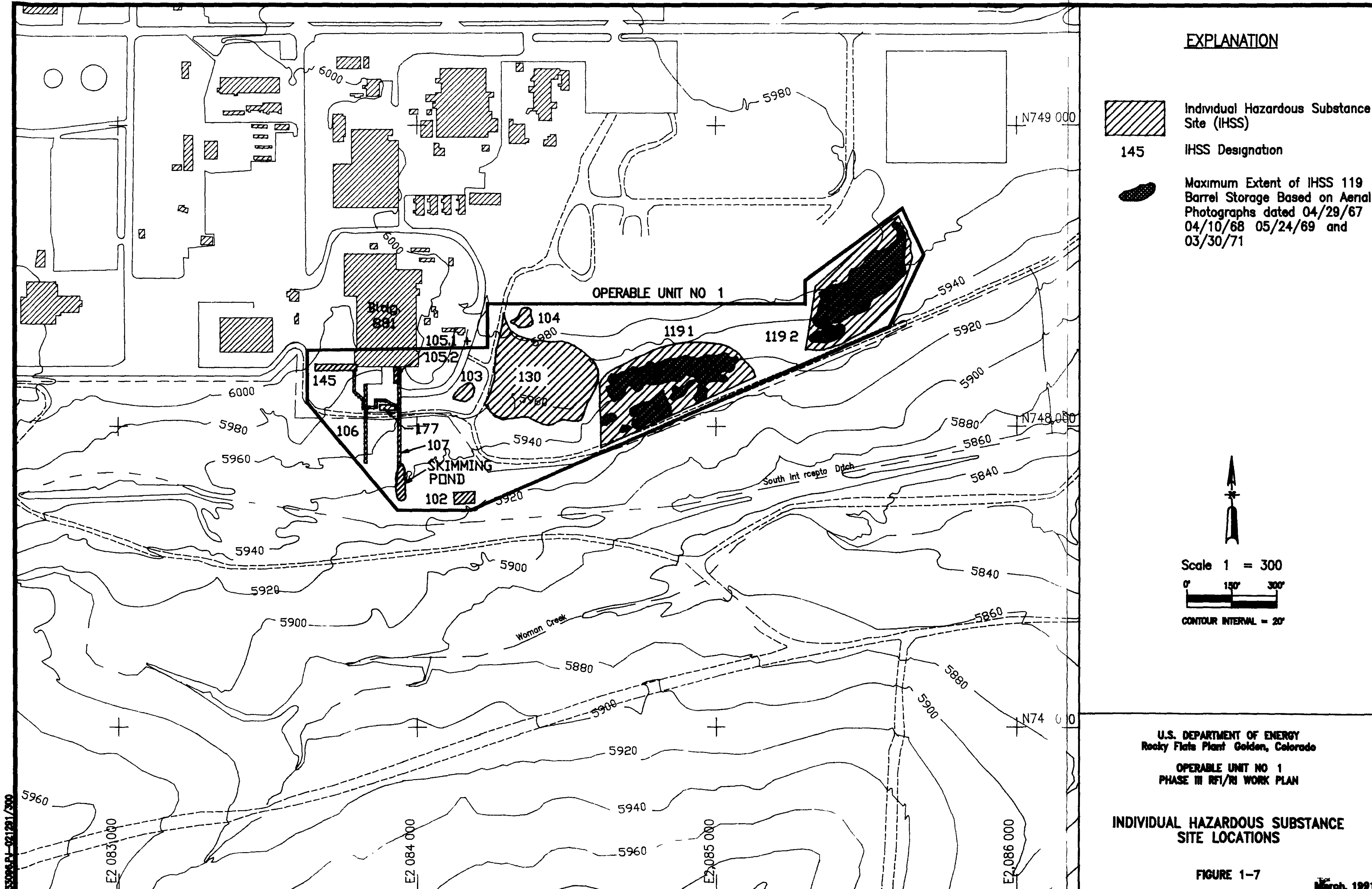
The first draft of the site-wide QAPjP, for which the OU No 1 QAA supplements, was submitted to the EPA and CDH for review and comment That draft QAPjP has since been revised based on the comments received from EPA and CDH The revised draft of the site-wide QAPjP now contains additional information regarding analytical methods and respective DQOs, sample identification and tracking, data verification and validation, and field sampling and laboratory QA/QC

As a result of the revisions to the site-wide QAPjP, some of the information contained in the subject QAA and future QAAs will be deleted and substituted with references to the QAPjP The revisions made to the QAPjP address several of the subject QAA review comments, particularly those dealing with coordination between SAP, work plans, and OU QAAs

The QAPjP for interim remedial actions at OU No 1 was developed because the site-wide QAPjP had not yet been developed for the ER Program That QAPjP was specific to interim remedial actions at OU No 1 only The QA Project Plan development suggested by the reviewer is contrary to previous discussions EG&G Rocky Flats has had with EPA and CDH regarding this issue The FSP/WPs and field activity SOPs provide instructions and controls for the various RI/FS field activities The SOPs address each of the nine activities listed The SOPs address the various field activities and the GRRASP establishes the analytical protocol for the ER Program

The SOP Table addresses "Field Activities and Applicable SOPs" Since not all SOPs are applicable to each field activity, the black dots infer applicability

The work plan states that the EE will be a three-phased program Phase I will involve a site visit and planning which will result in a detailed field sampling strategy which will be approved by EG&G prior to sampling as specified in the QAPjP



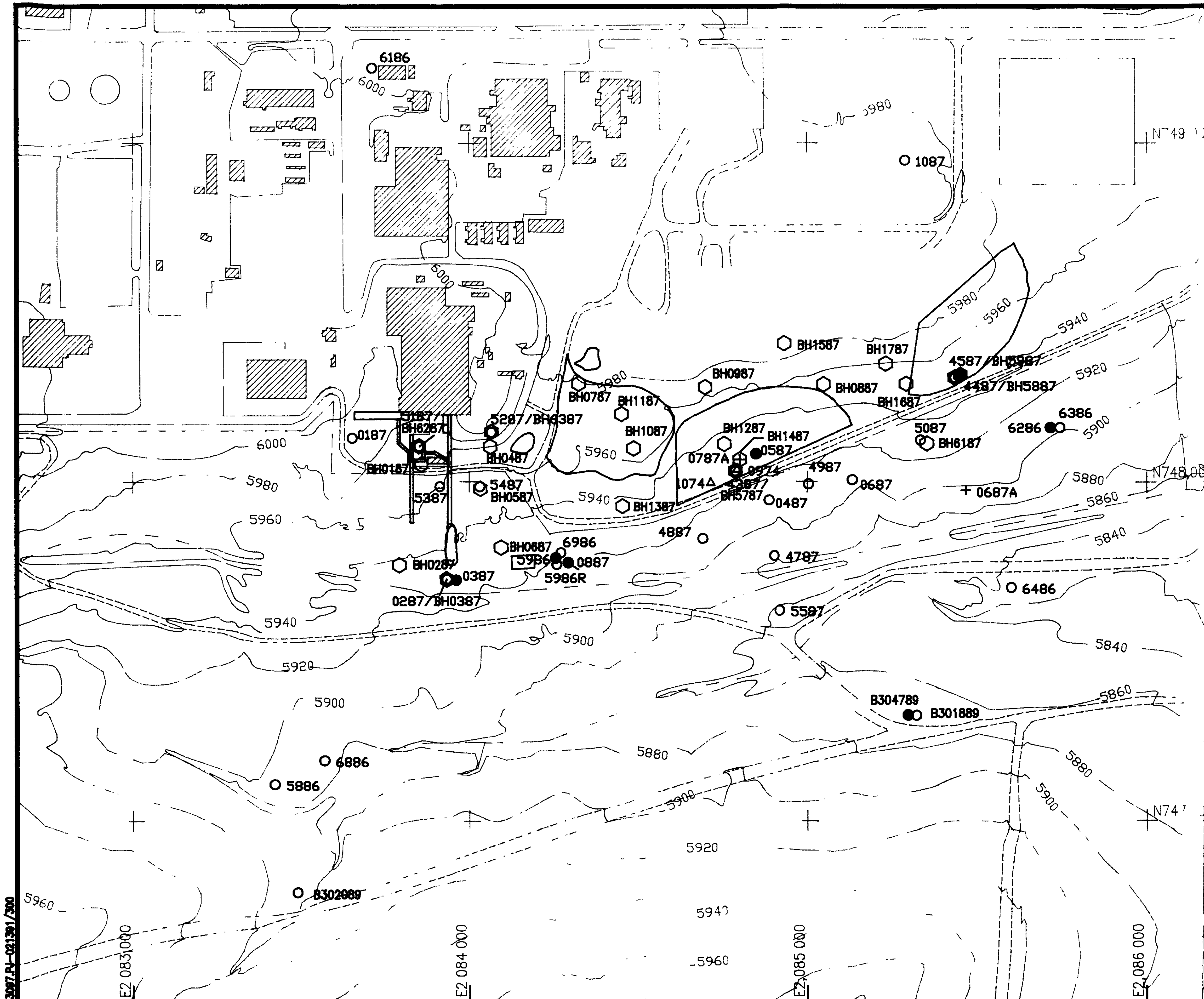
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATIONS

FIGURE 1-7

March, 1991



EXPLANATION

▭	Individual Hazardous Substance Site (IHSS)
B301889 ○	Alluvial Monitoring Well
B304789 ●	Bedrock Monitoring Well
0271 △	Pre-1986 Well
1187A +	Abandoned Hole
BH0987 ⬡	Borehole

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

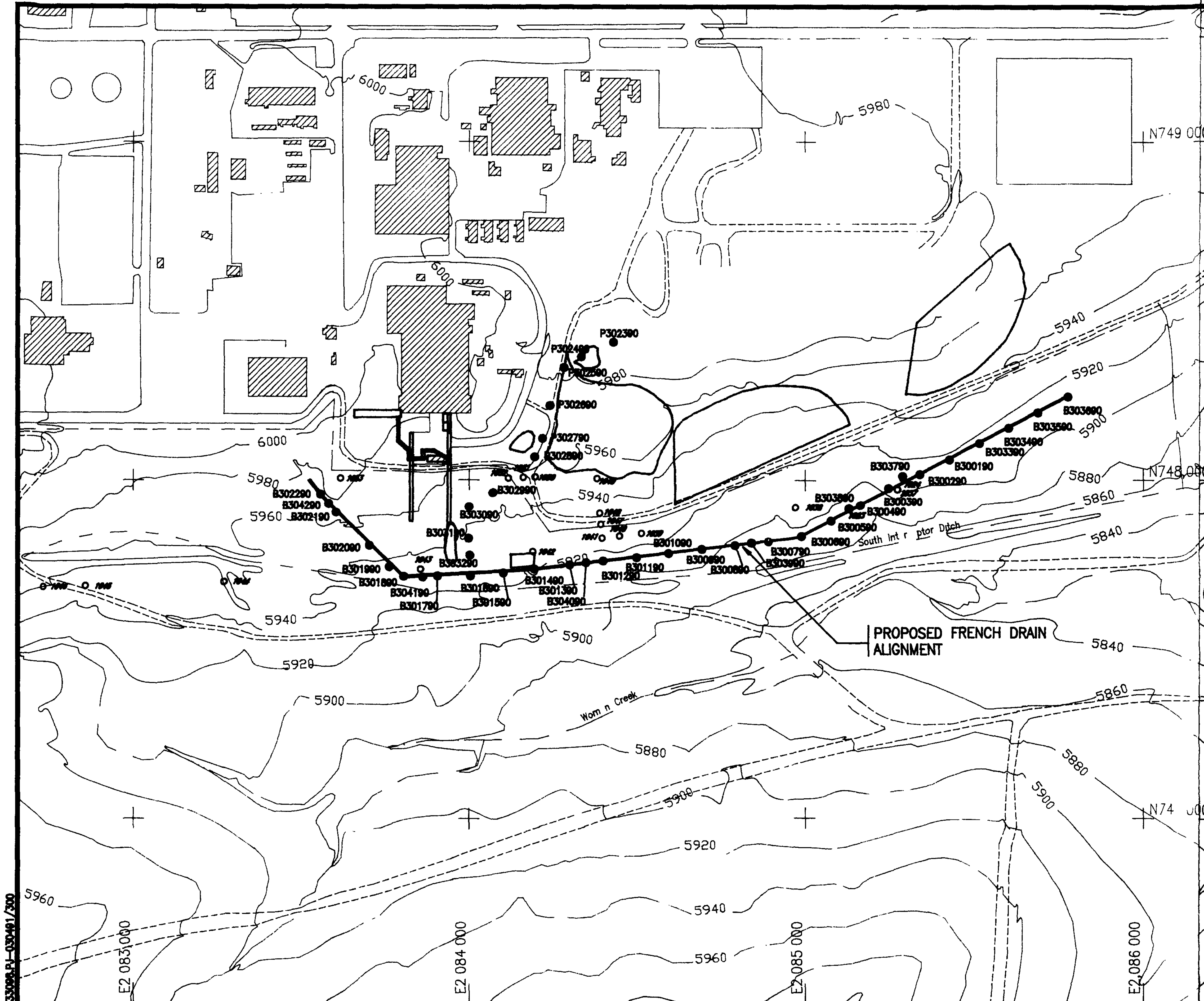
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

PHASE I AND PHASE II RI BOREHOLE AND MONITOR WELL LOCATIONS

FIGURE 2-1

March, 1991



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B303690 Boring Location and Number French Drain Alignment

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

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

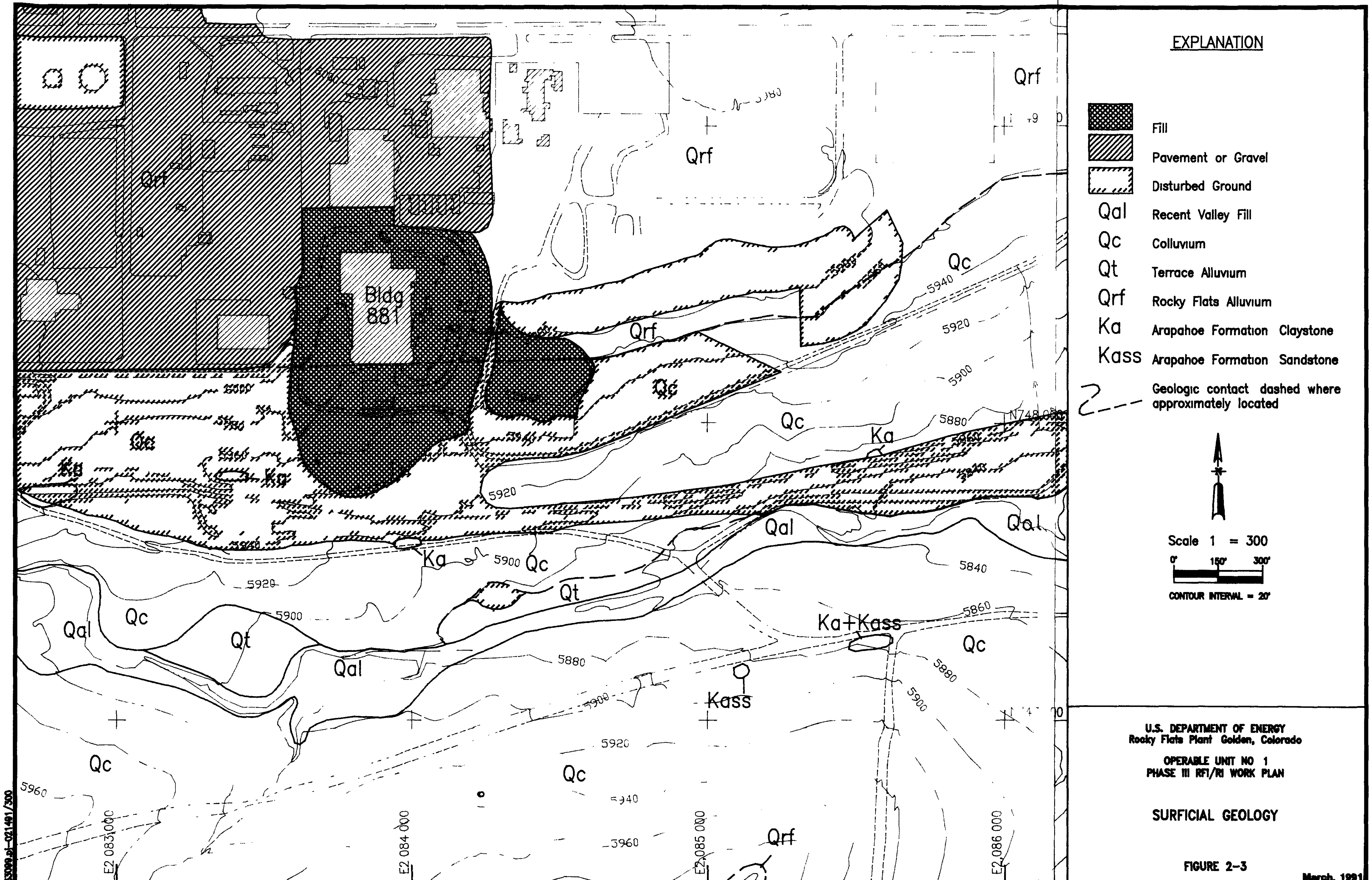
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

FRENCH DRAIN GEOTECHNICAL INVESTIGATION BOREHOLE LOCATIONS

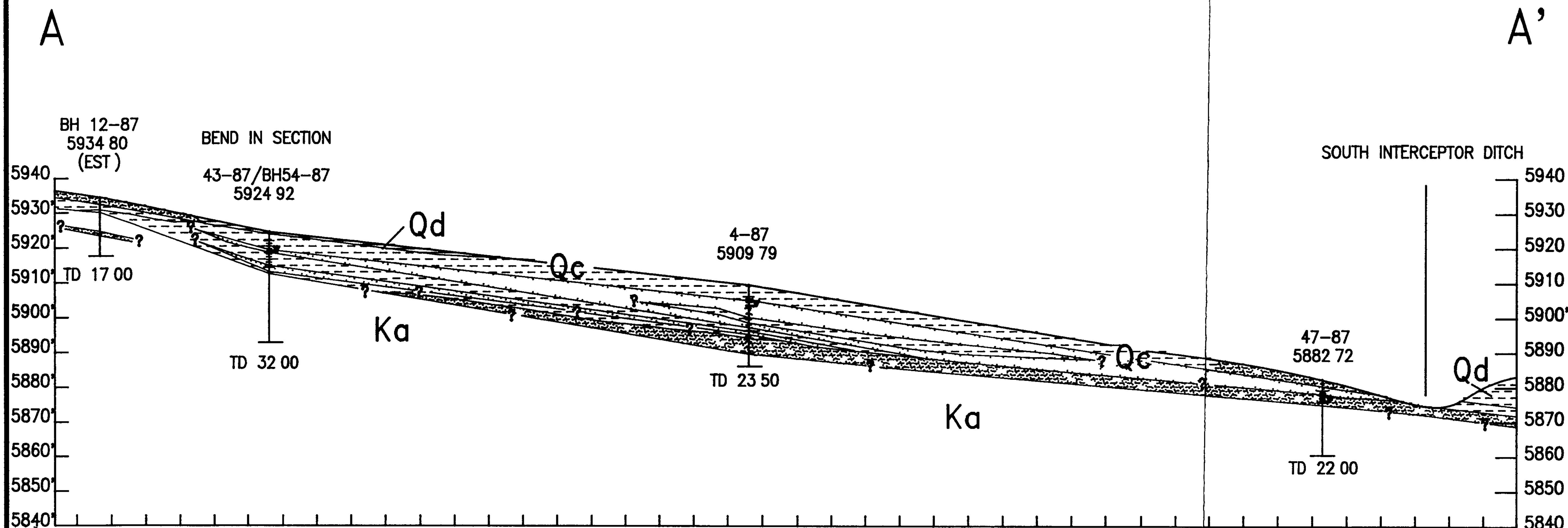
FIGURE 2-2

March, 1991

R33098.PJ-030491/300



Qrf
Qc
Ka
Kass
Qal
Qt
Ka+Kass
Bldg 881
5940
5920
5900
5880
5860
5840
5960
N748,000
E2 083,000
E2 084,000
E2 085,000
E2 086,000
EXPLANATION
Fill
Pavement or Gravel
Disturbed Ground
Qal Recent Valley Fill
Qc Colluvium
Qt Terrace Alluvium
Qrf Rocky Flats Alluvium
Ka Arapahoe Formation Claystone
Kass Arapahoe Formation Sandstone
Geologic contact dashed where approximately located
Scale 1 = 300
0' 150' 300'
CONTOUR INTERVAL = 20'
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN
SURFICIAL GEOLOGY
FIGURE 2-3
March, 1991



EXPLANATION

30
0 30'
Scale 1 =30

43-87/BH54-87
5924 92 — Well/Borehole Identification; Ground Surface Elevation (Surveyed)

Water Level (Measured 2/4/88)

Geologic Contact (Queried where inferred Dashed where approximately located)

Screened Interval

TD 32 00 — Total Depth Drilled

NOTE. Geology inferred between data points

QUATERNARY

- Qt — Terrace
- Qd — Disturbed Ground
- Qc — Colluvium
- Qrf — Rocky Flats Alluvium
- Qal — Alluvium

CRETACEOUS

- Ka — Arapahoe Formation (Claystone)
- Kass — Arapahoe Formation (Sandstone)

- Clay
- Clayey Sand or Sandy Clay
- Cobbles and/or Gravel
- Silt or Siltstone

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

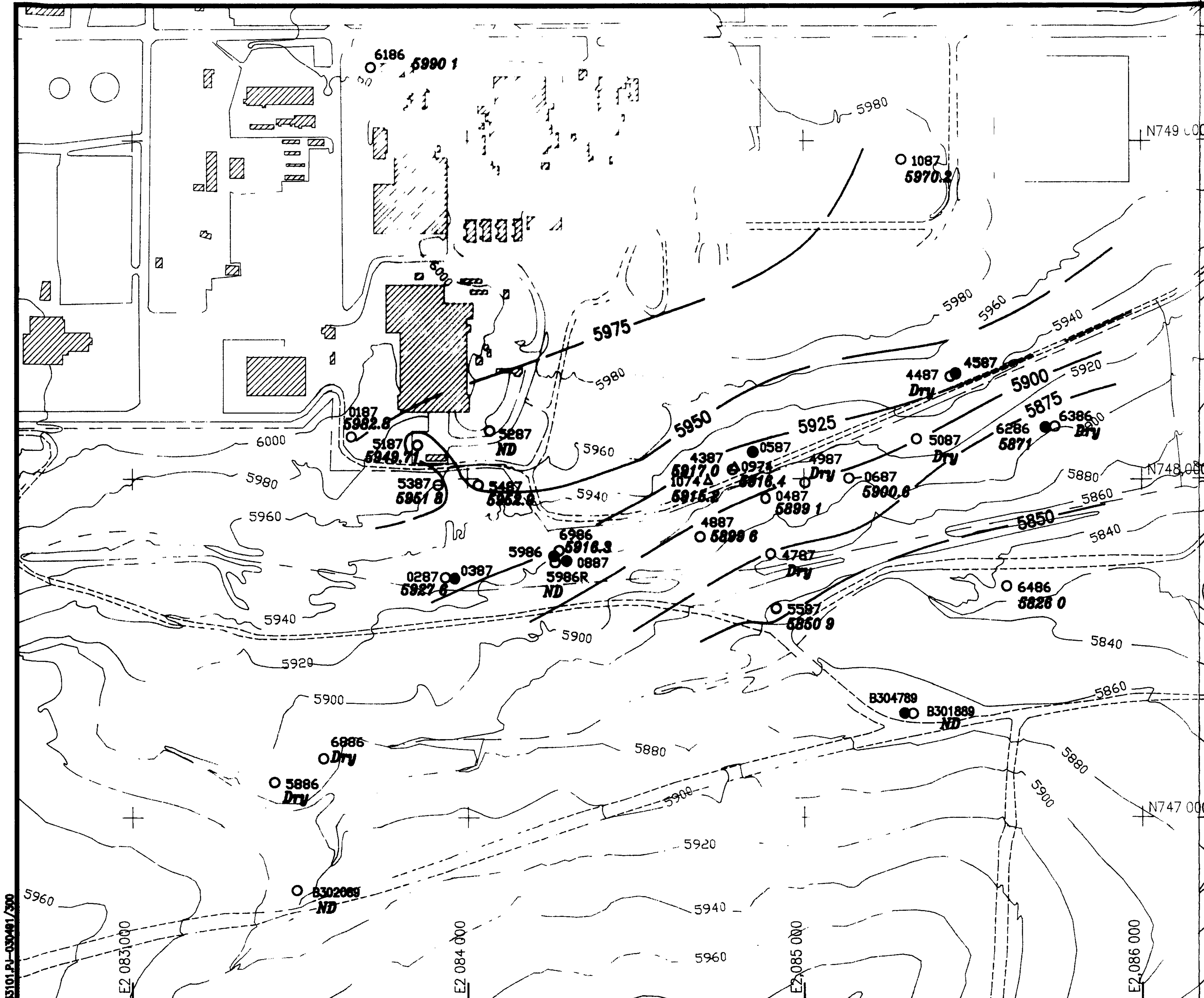
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

CROSS SECTION A – A

FIGURE 2-4

March, 1991

R33100.PJ-021591/1=1



EXPLANATION

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

5851 Water Table Elevation (feet above mean sea level)

5920 Line of Equal Water Table Elevation (feet above sea level – dashed where approximately located)

ND No Data

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

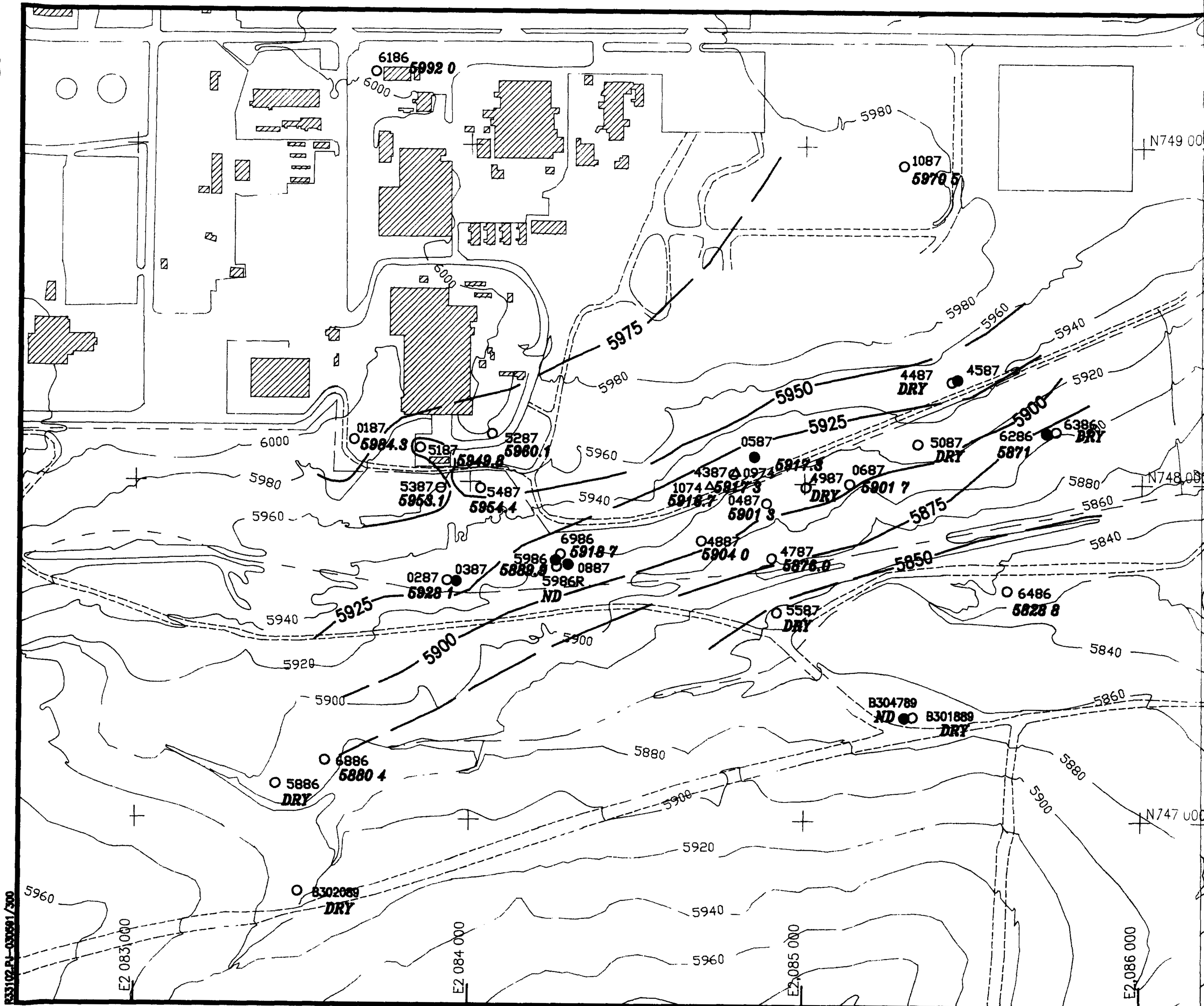
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

ELEVATION OF WATER TABLE
January 1989

FIGURE 2-5

March, 1991



EXPLANATION

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

5851 Water Table Elevation (feet above mean sea level)

5920 — Line of Equal Water Table Elevation (feet above sea level – dashed where approximately located)

ND No Data

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

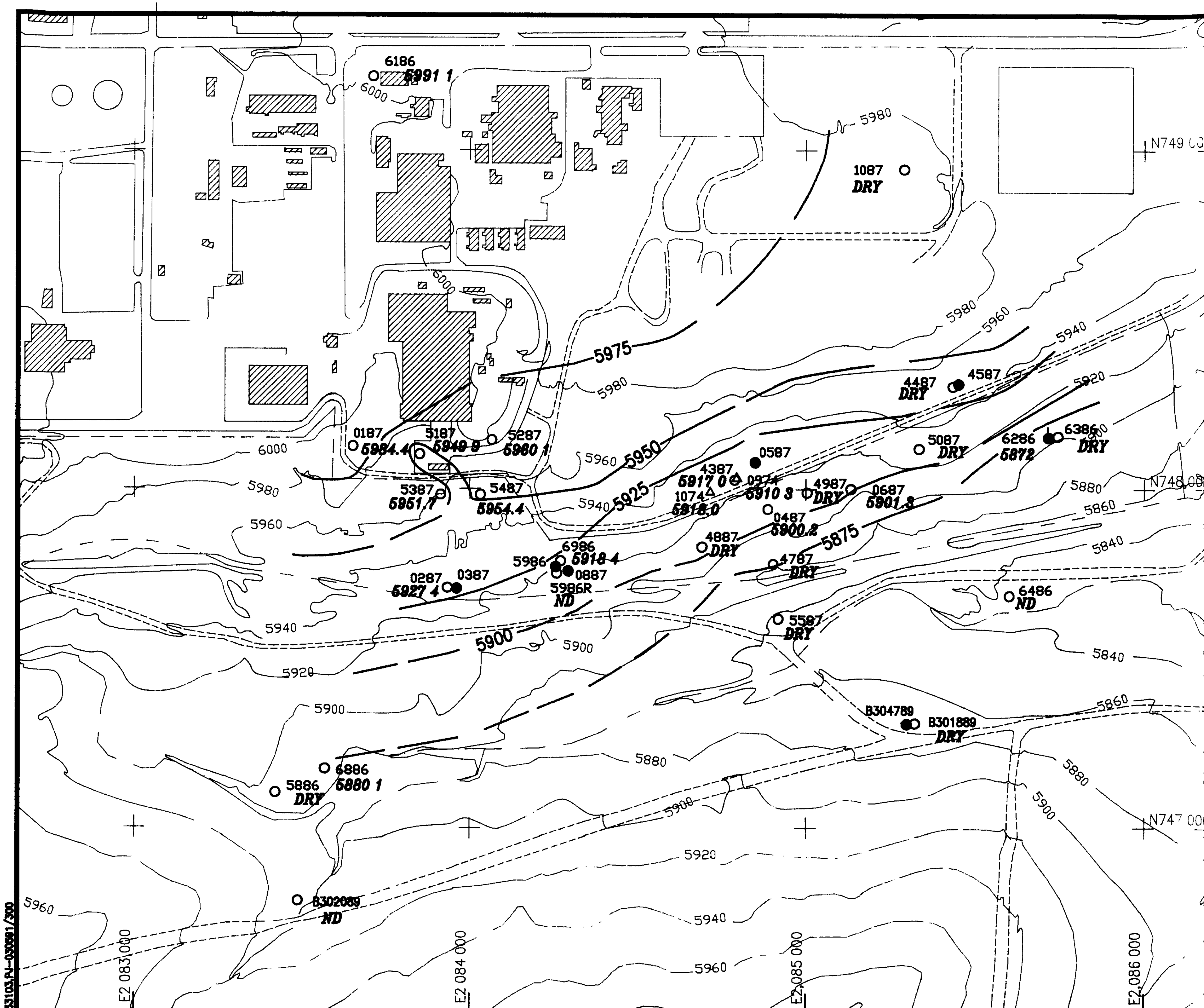
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

ELEVATION OF WATER TABLE
May 1989

FIGURE 2-6

March 1991



EXPLANATION

B301889	O	Alluvial Monitoring Well
B304789	●	Bedrock Monitoring Well
0271	△	Pre-1986 Well
5851		Water Table Elevation (feet above mean sea level)
5920		Line of Equal Water Table Elevation (feet above sea level – dashed where approximately located)
ND		No Data

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

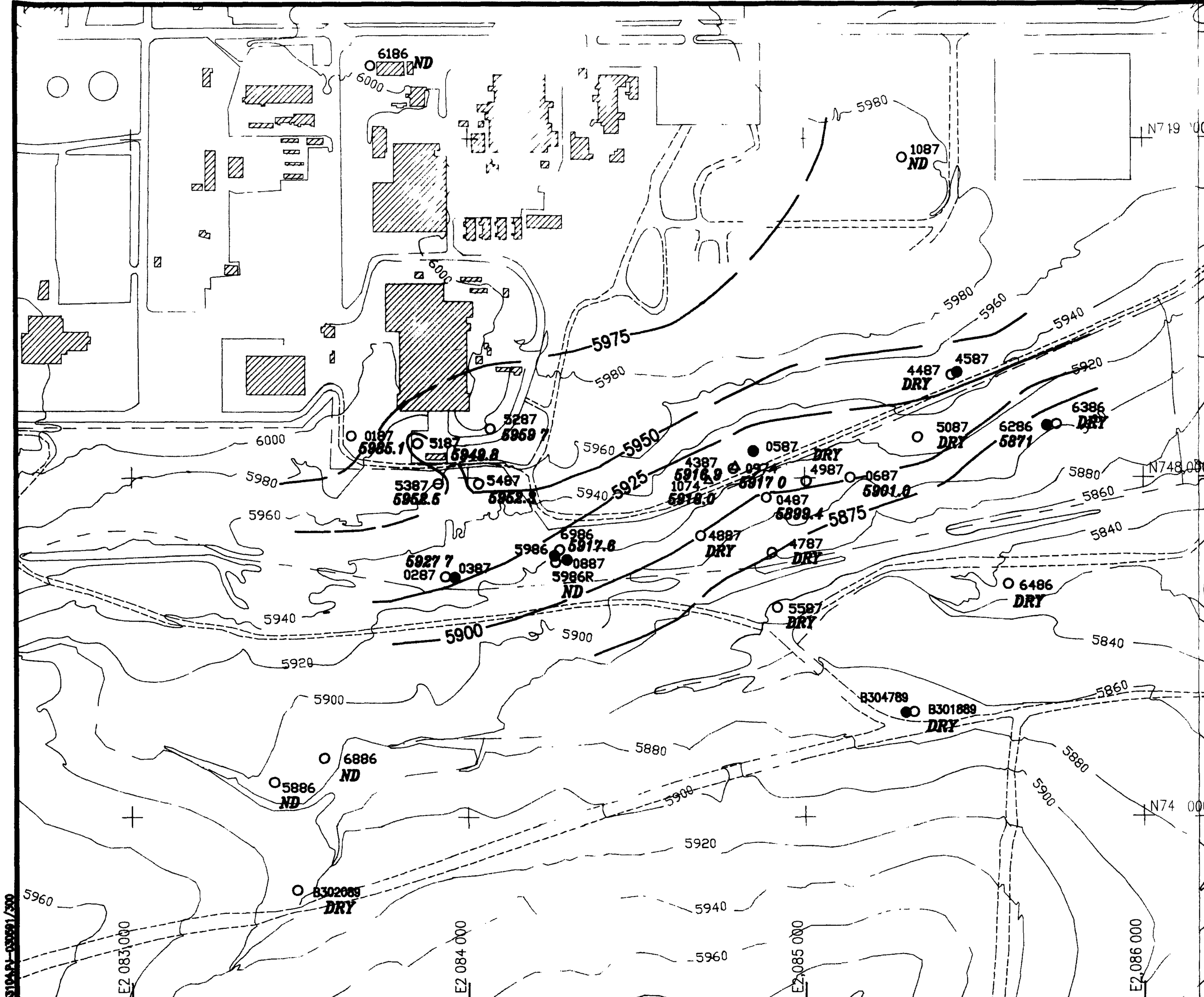
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

ELEVATION OF WATER TABLE
August 1989

FIGURE 2-7

March, 1991



EXPLANATION

B301889	○	Alluvial Monitoring Well
B304789	●	Bedrock Monitoring Well
0271	△	Pre-1986 Well
5851		Water Table Elevation (feet above mean sea level)
5920		Line of Equal Water Table Elevation (feet above sea level – dashed where approximately located)
ND		No Data

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

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

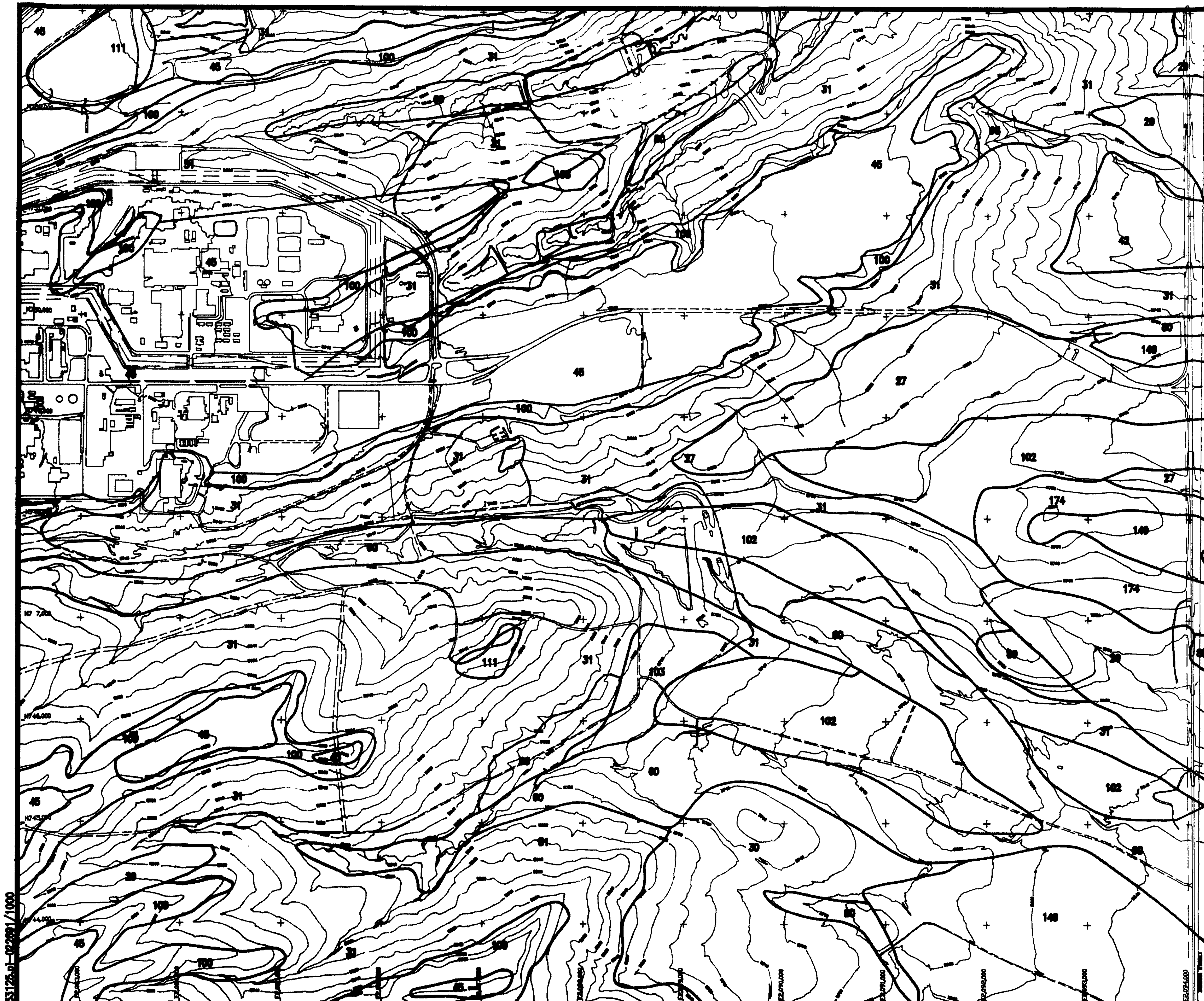
OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

ELEVATION OF WATER TABLE
October 1989

FIGURE 2-8

March, 1991

R53104A.P1-030591/300



EXPLANATION

98 SOIL TYPE BOUNDARY AND NUMBER

SOURCE. U.S. DEPARTMENT OF AGRICULTURE, 1980

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

N

1 = 1000

0' 500' 1000'

CONTOUR INTERVAL = 20'

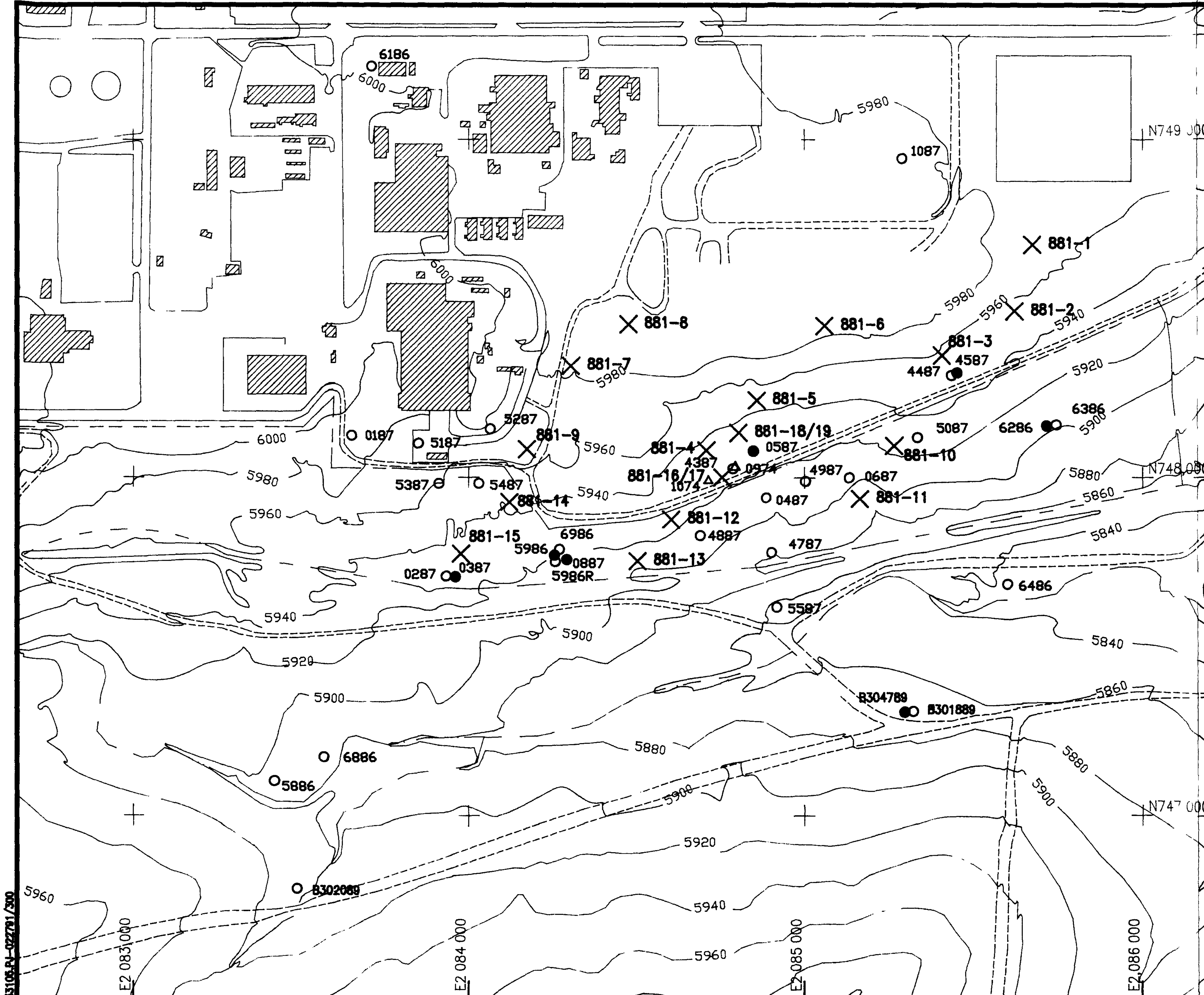
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

SURFACE SOILS MAP

FIGURE 2-9

March, 1991



EXPLANATION

- B301889 ○ Alluvial Monitoring Well
- B304789 ● Bedrock Monitoring Well
- 0271 △ Pre-1986 Well
- × 881-1 Approximate Surface Soil Scrape Location

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

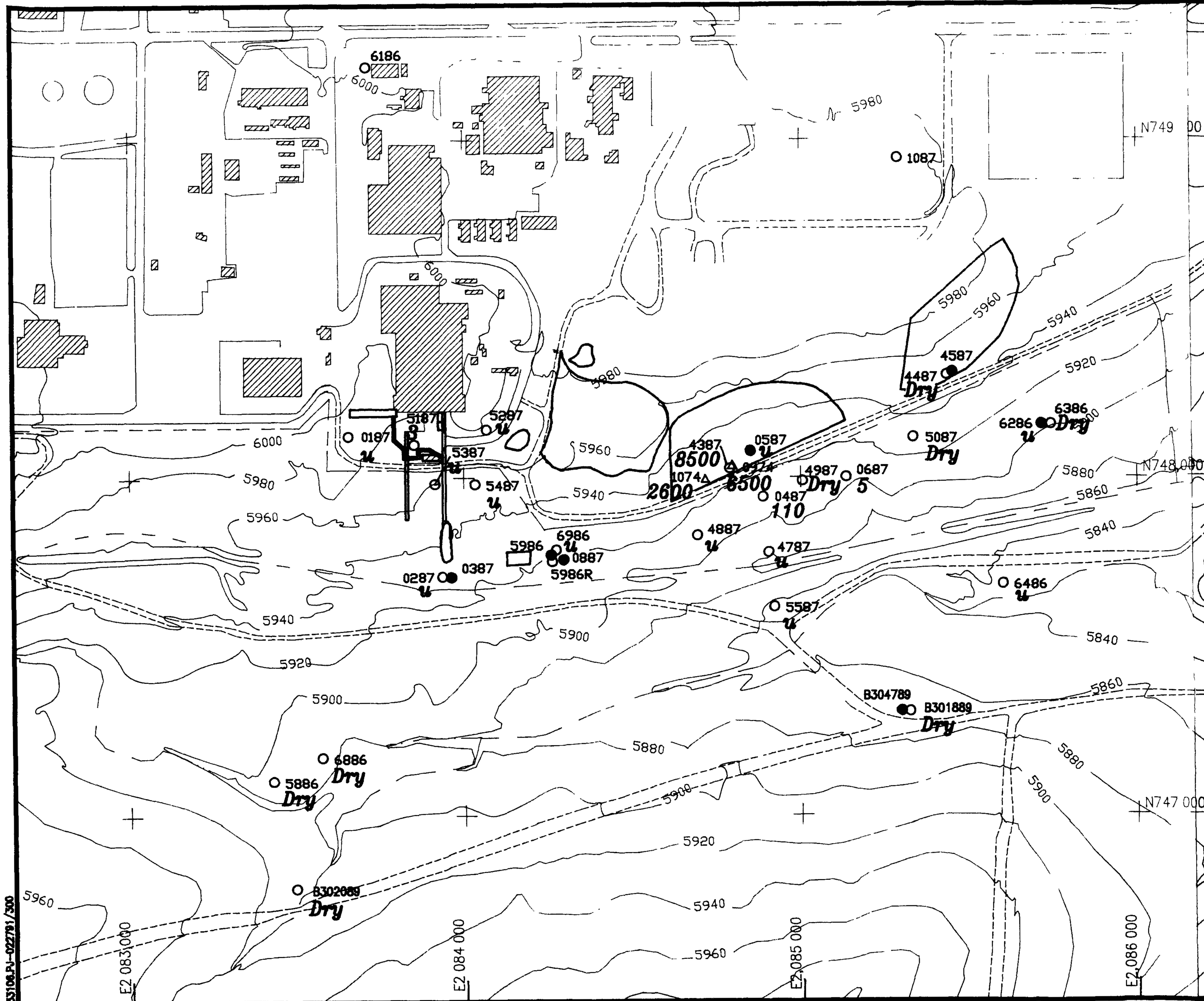
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

SURFACE SCRAPE SAMPLING LOCATIONS
September, 1988

FIGURE 2-10

March, 1991



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Trichloroethene Concentration

35 Data in $\mu g/l$

u Analyzed but not Detected

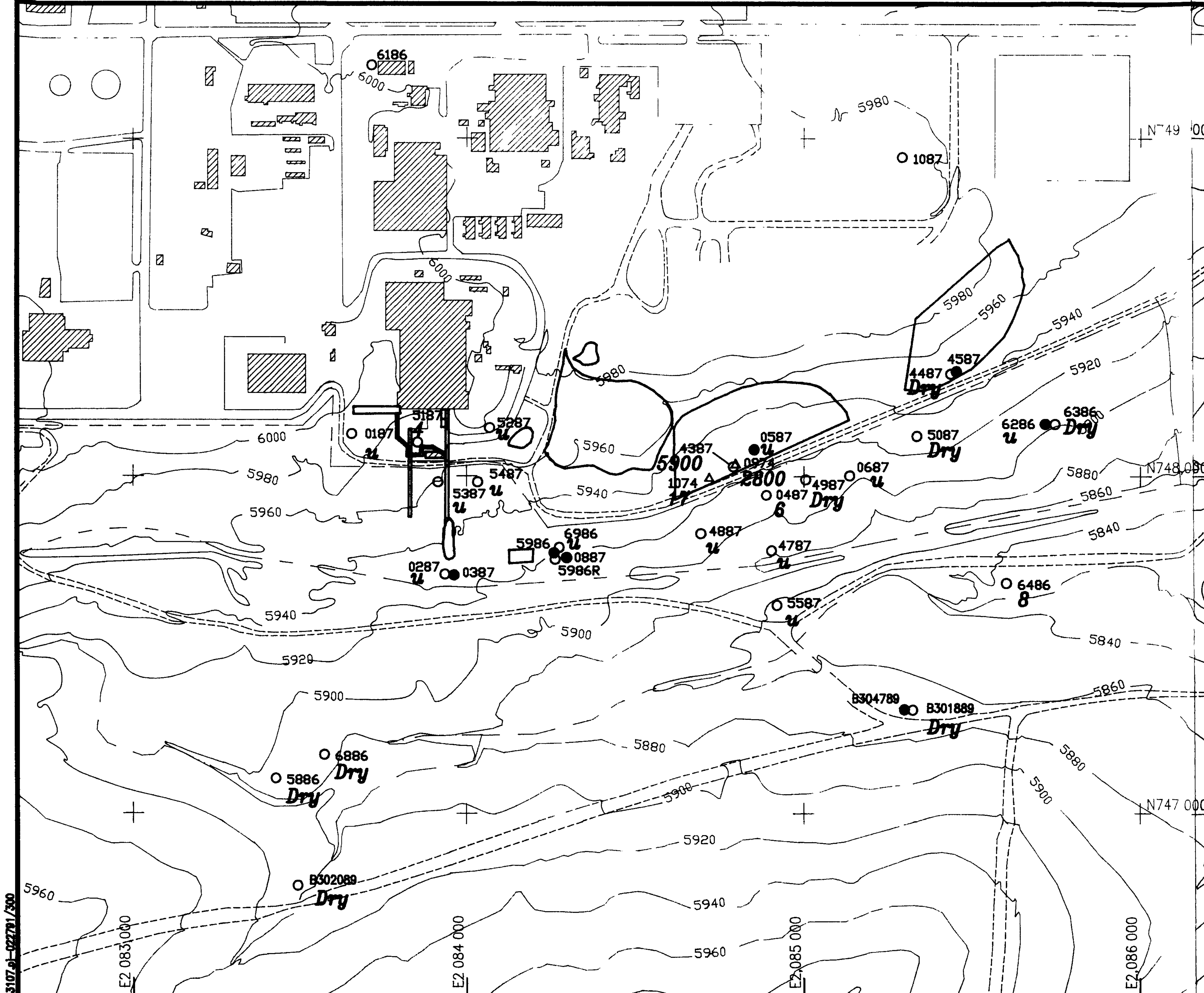
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

TRICHLOROETHENE CONCENTRATIONS IN THE UNCONFINED GROUND-WATER FLOW SYSTEM Second Quarter 1989

FIGURE 2-11

March, 1991



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Tetrachloroethene Concentrations

6 Data in µg/l

u Analyzed but not Detected

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

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

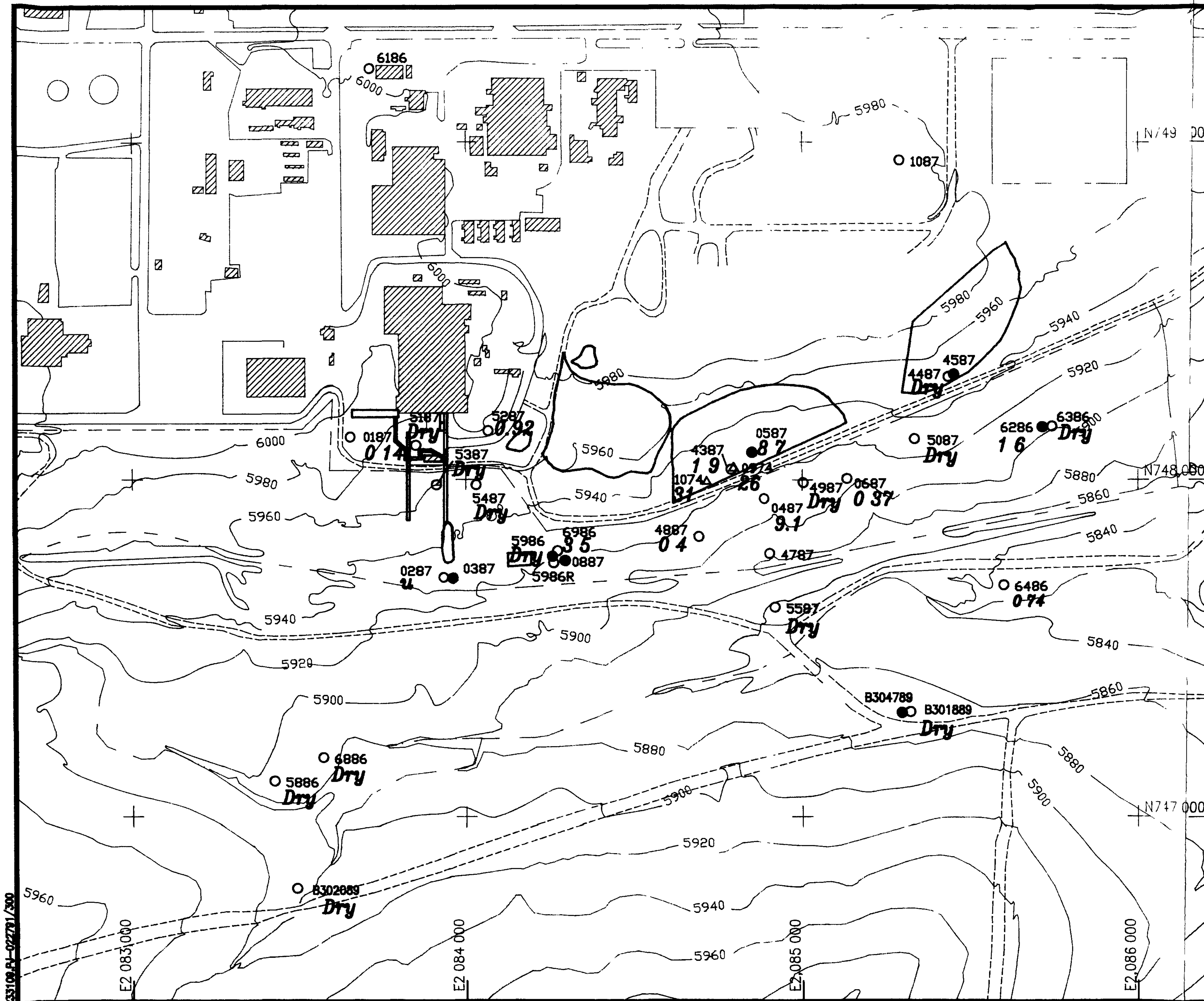
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

TETRACHLOROETHENE CONCENTRATIONS IN THE UNCONFINED GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-12

March, 1991

r33107.pl-022791/300



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Nitrate Concentrations

8 7 Data in mg/l

u Analyzed but not Detected

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

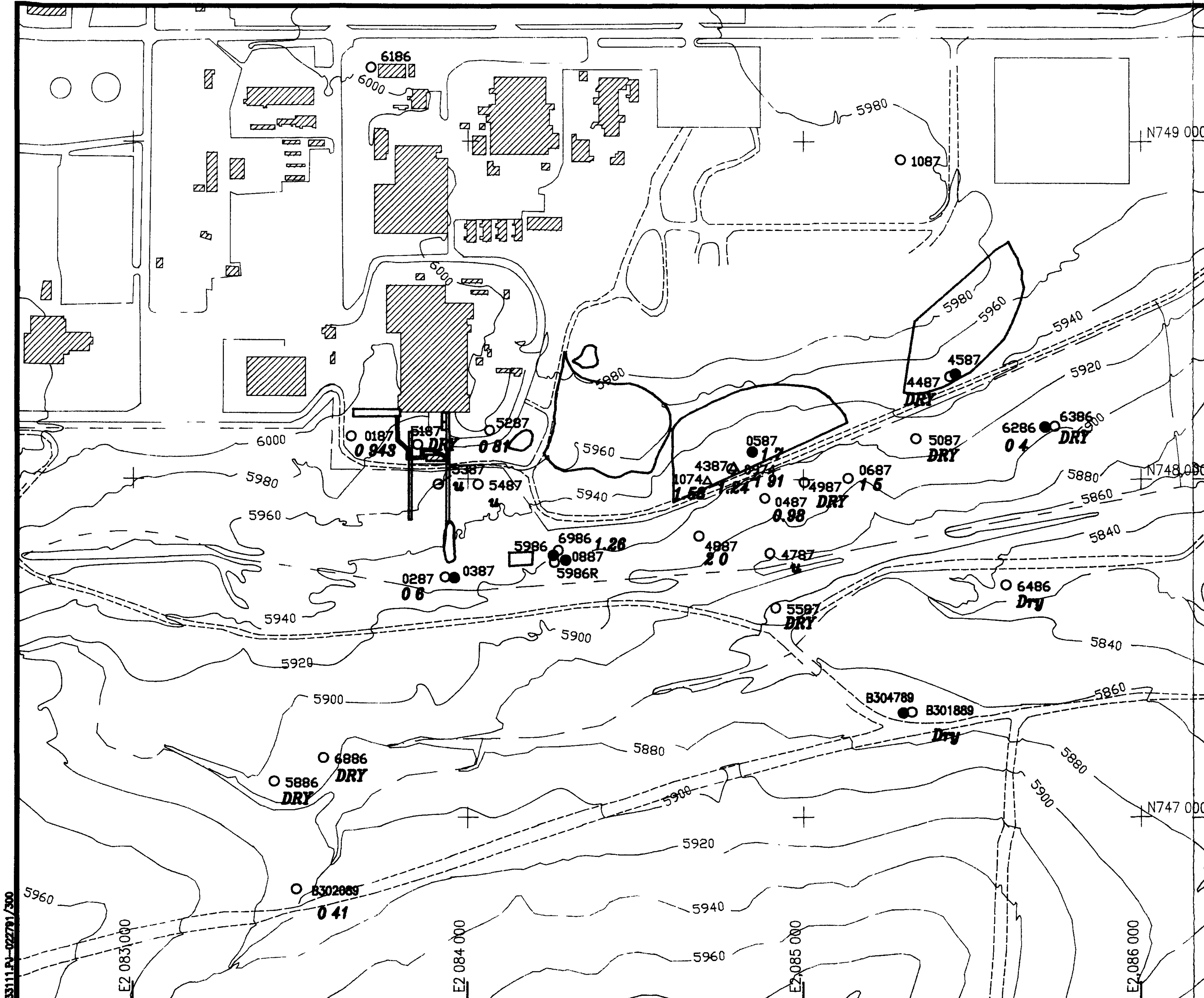
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

NITRATE CONCENTRATIONS IN THE UNCONFINED GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-14

March, 1991



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Strontium Concentration

1 5 Data in mg/l

u Analyzed but not Detected

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

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

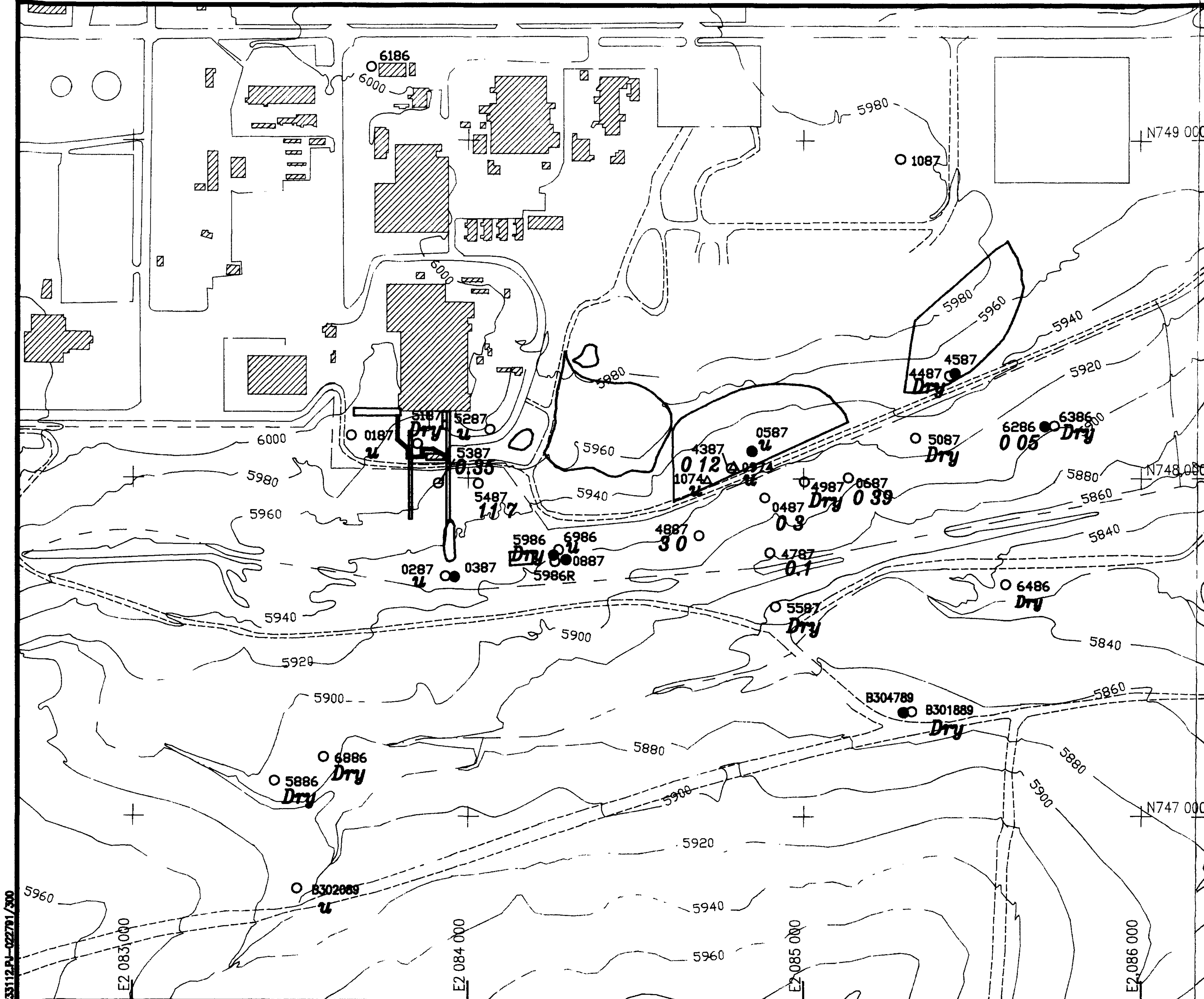
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

STRONTIUM CONCENTRATIONS IN THE UNCONFINED GROUND-WATER FLOW SYSTEM Second Quarter 1989

FIGURE 2-16

March, 1991

R33111.PJ-022791/300



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Nickel Concentrations

0 6 Data in mg/l

u Analyzed but not Detected

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

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

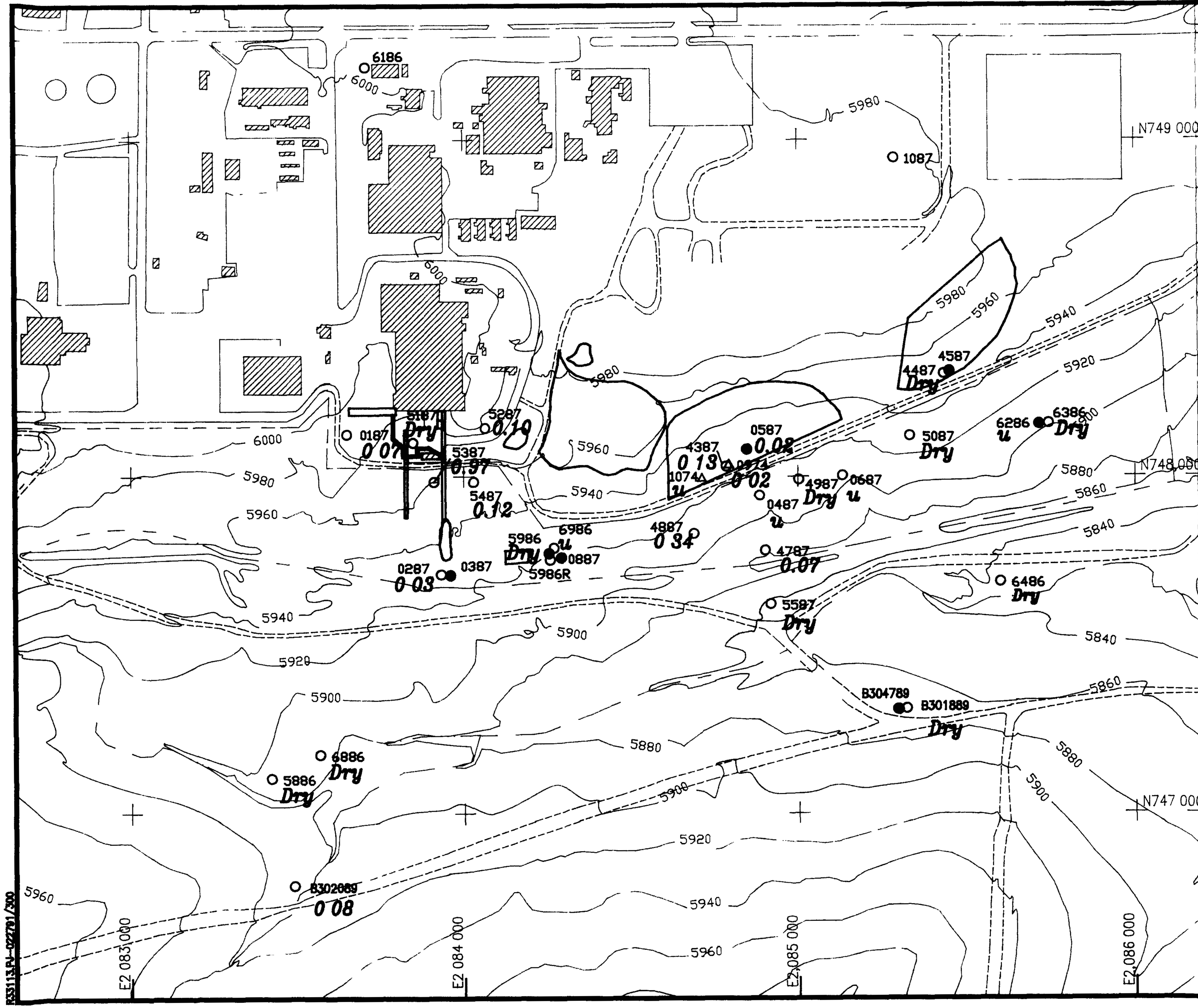
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

NICKEL CONCENTRATIONS IN THE UNCONFINED GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-17

March, 1991

R33112.PJ-022791/300



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Zinc concentrations

0 02 Data in mg/l

u Analyzed but not Detected

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

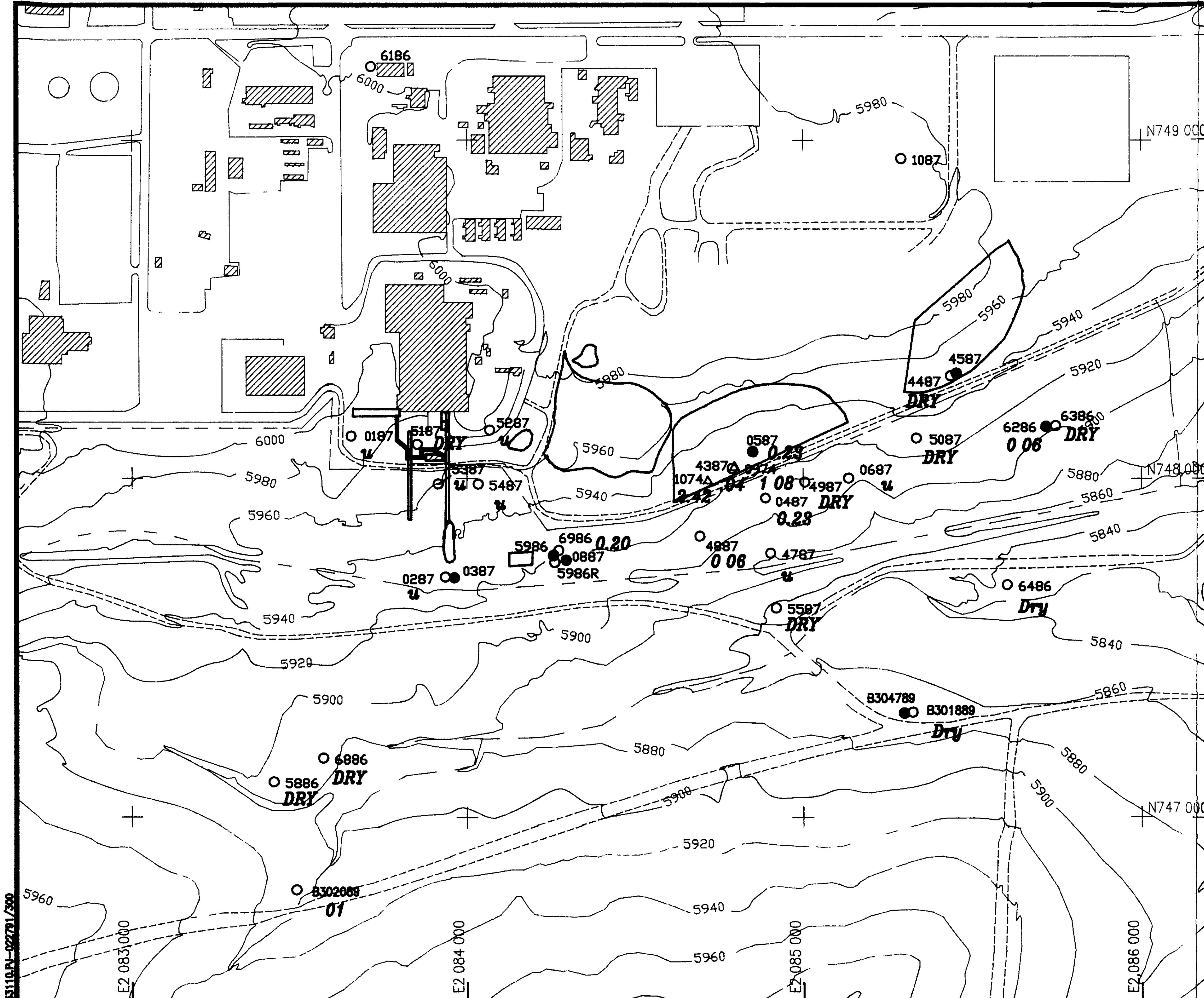
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

ZINC CONCENTRATIONS IN THE UNCONFINED GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-18

March, 1991



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Selenium Concentrations

0 5 Data in mg/l

u Analyzed but not Detected

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

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

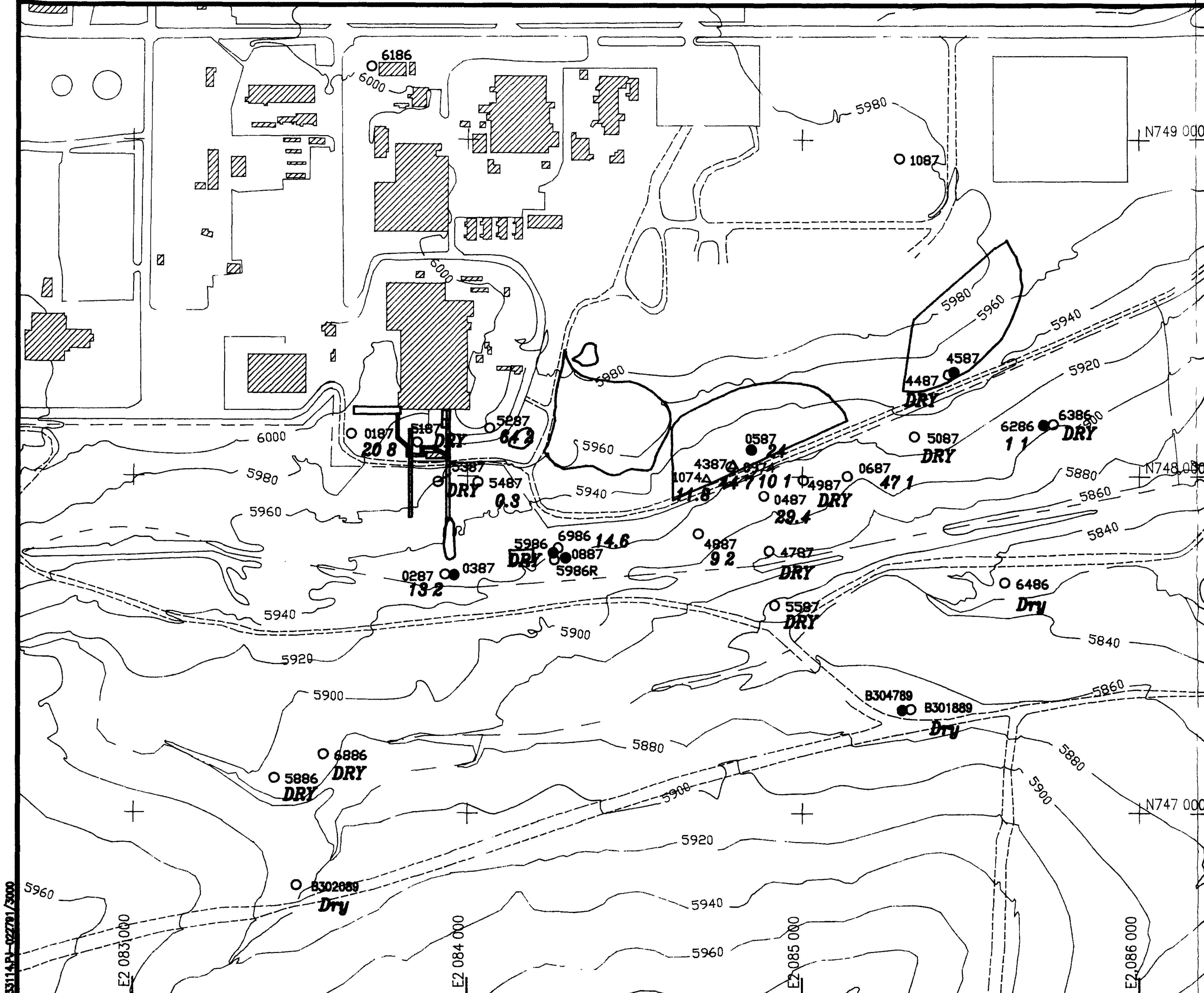
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

SELENIUM CONCENTRATIONS IN THE UNCONFINED GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-15

March, 1991

R33110.PJ-022791/300



EXPLANATION

Individual Hazardous Substance Site (IHSS)

B301889 ○ Alluvial Monitoring Well

B304789 ● Bedrock Monitoring Well

0271 △ Pre-1986 Well

Uranium Concentrations

1 1 Data in pCi/l

ND No Data

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

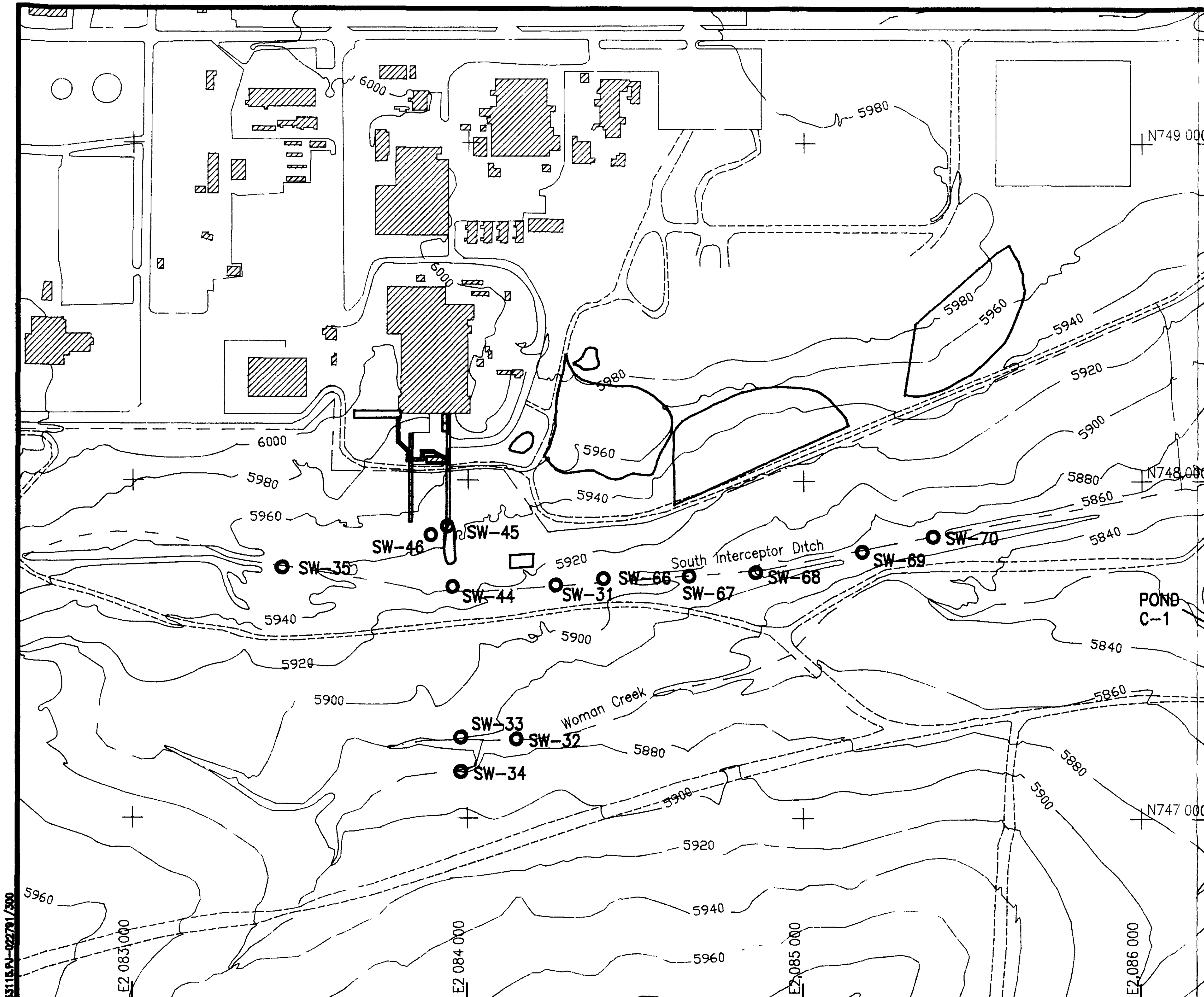
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

TOTAL DISSOLVED URANIUM IN THE UNCONFINED GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-19

March, 1991



R33115.PJ-022791/300

EXPLANATION

Individual Hazardous Substance Site (IHSS)

SW-35 O Surface Water Monitoring Station

Scale 1 = 300

0' 150' 300'

CONTOUR INTERVAL = 20'

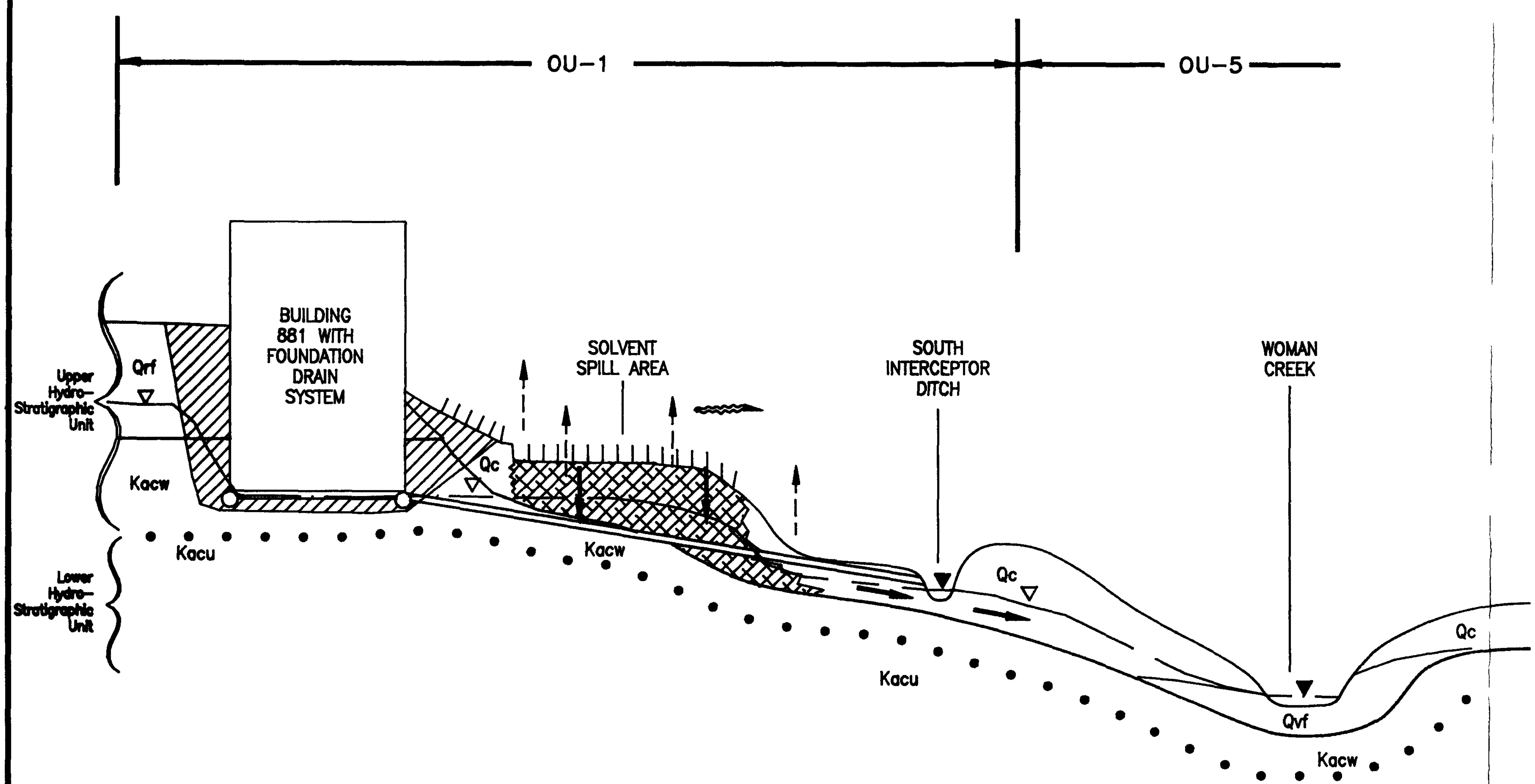
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant Golden Colorado

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

SURFACE WATER MONITORING STATION LOCATIONS

FIGURE 2-20

March, 1991



EXPLANATION

- Contact Between Surficial Materials
- Base of Weathering and Boundary between Hydrostratigraphic UKnits
- Volatile Organic Contaminant Plume
- Disturbed Ground
- Volatization
- Potential Ground-water Pathway
- Potential Radionuclide Contaminated Soils
- Wind Blown Pathway
- Stream Surface
- Groundwater Surface

CRETACEOUS ARAPAHOE FORMATION

Kacu Unweathered Claystone/Siltstone
Kacw Weathered Claystone/Siltstone

QUATERNARY UNITS

Qrf Rocky Flats Alluvium
Qc Colluvium Deposits
Qvf Valley Fill Alluvium

SCHEMATIC CROSS-SECTIONAL VIEW

NOT TO SCALE

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

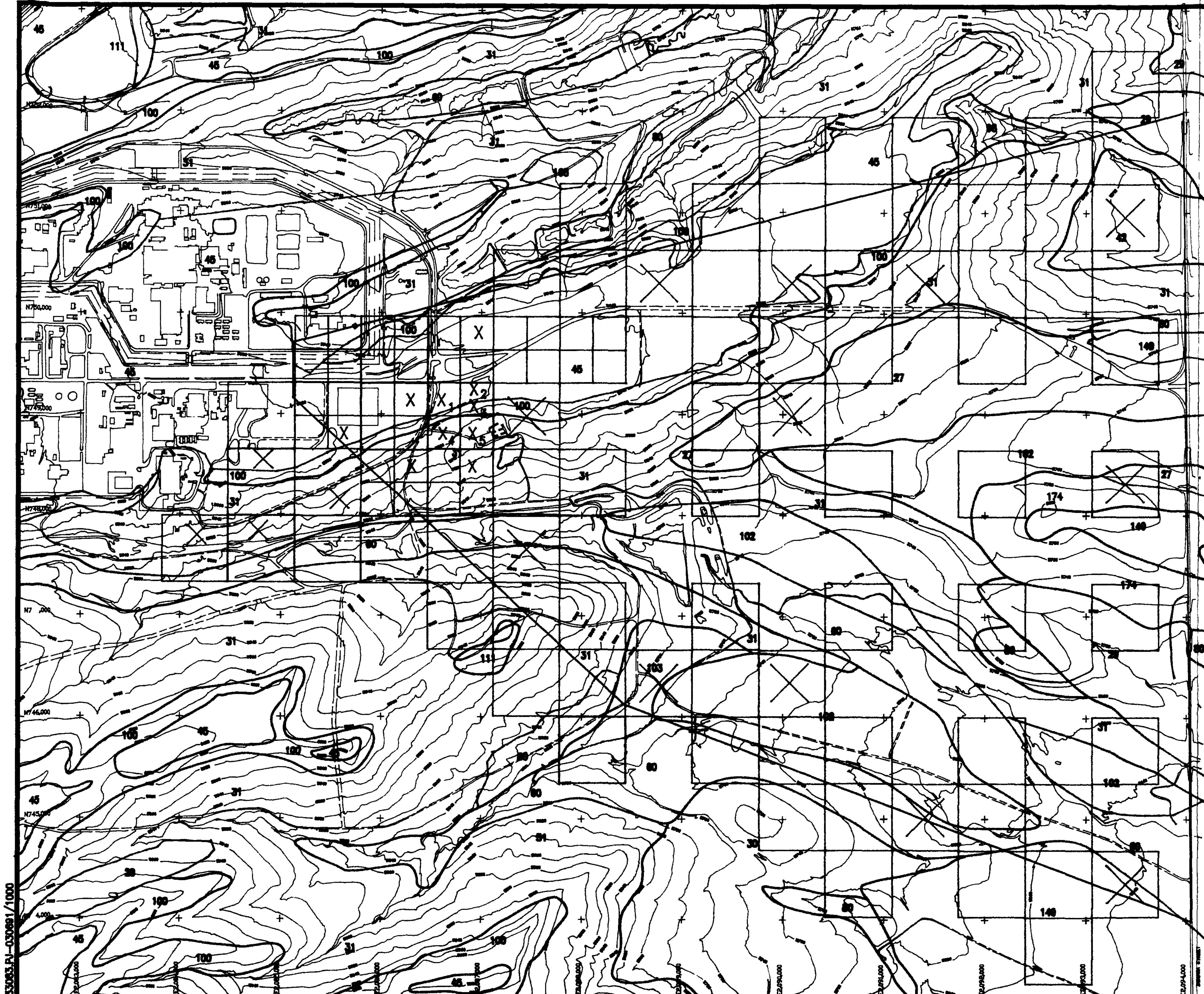
OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

SITE CONCEPTUAL MODEL

FIGURE 2-24

March, 1991

R33126.PJ-030691



EXPLANATION

ESTIMATED MAXIMUM EXTENT OF SURFICIAL SOILS CONTAINING TWO dpm/g ACTIVITY BY CDH PROTOCOL

10 ACRE SAMPLING PLOT LOCATIONS

2.5 ACRE SAMPLING PLOT LOCATIONS

SOIL PROFILE SAMPLING LOCATIONS

X_1 to X_5 LOCATION OF SOIL SOLUTION SAMPLERS

98 SOIL TYPE BOUNDARY AND NUMBER

SOURCE. U.S. DEPARTMENT OF AGRICULTURE, 1980

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

N

1 = 1000

0' 500' 1000'

CONTOUR INTERVAL = 20'

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

OPERABLE UNIT NO 1
PHASE III RFI/RI WORK PLAN

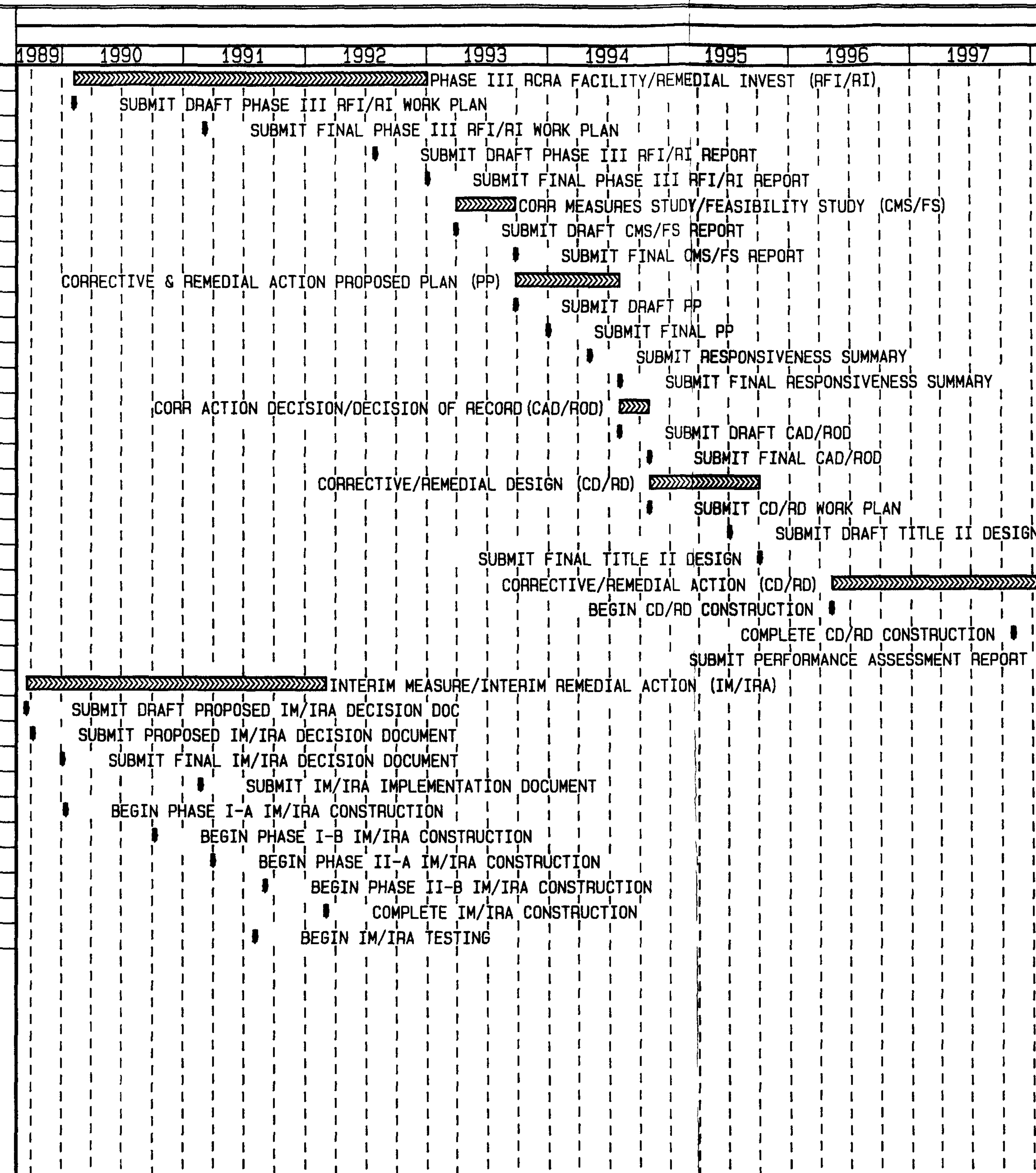
PROPOSED SURFICIAL SOIL SAMPLING LOCATIONS

FIGURE 5-3

March, 1991

R33083.PJ-030891/1000

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH
10 00	PHASE III RCRA FACILITY/REMEDIAL INVEST (RFI/RI)	6FEB90	4JAN93
10 10	SUBMIT DRAFT PHASE III RFI/RI WORK PLAN	6FEB90	
10 20	SUBMIT FINAL PHASE III RFI/RI WORK PLAN	8MAR91	
10 30	SUBMIT DRAFT PHASE III RFI/RI REPORT	30JUL92	
10 40	SUBMIT FINAL PHASE III RFI/RI REPORT		4JAN93
20 00	CORR MEASURES STUDY/FEASIBILITY STUDY (CMS/FS)	31MAR93	27SEP93
20 10	SUBMIT DRAFT CMS/FS REPORT	31MAR93	
20 20	SUBMIT FINAL CMS/FS REPORT		27SEP93
30 00	CORRECTIVE & REMEDIAL ACTION PROPOSED PLAN (PP)	27SEP93	3AUG94
30 10	SUBMIT DRAFT PP	27SEP93	
30 20	SUBMIT FINAL PP	4JAN94	
30 30	SUBMIT RESPONSIVENESS SUMMARY	6MAY94	
30 40	SUBMIT FINAL RESPONSIVENESS SUMMARY		3AUG94
40 00	CORR ACTION DECISION/DECISION OF RECORD (CAD/ROD)	3AUG94	1NOV94
40 10	SUBMIT DRAFT CAD/ROD	3AUG94	
40 20	SUBMIT FINAL CAD/ROD		1NOV94
50 00	CORRECTIVE/REMEDIAL DESIGN (CD/RD)	1NOV94	3OCT95
50 10	SUBMIT CD/RD WORK PLAN	1NOV94	
50 20	SUBMIT DRAFT TITLE II DESIGN	5JUL95	
50 30	SUBMIT FINAL TITLE II DESIGN		3OCT95
60 00	CORRECTIVE/REMEDIAL ACTION (CD/RD)	7MAY96	10FEB98
60 10	BEGIN CD/RD CONSTRUCTION	7MAY96	
60 20	COMPLETE CD/RD CONSTRUCTION	4NOV97	
60 30	SUBMIT PERFORMANCE ASSESSMENT REPORT		10FEB98
70 00	INTERIM MEASURE/INTERIM REMEDIAL ACTION (IM/IRA)	18SEP89	2MAR92
70 05	SUBMIT DRAFT PROPOSED IM/IRA DECISION DOC	18SEP89	
70 10	SUBMIT PROPOSED IM/IRA DECISION DOCUMENT	6OCT89	
70 20	SUBMIT FINAL IM/IRA DECISION DOCUMENT	5JAN90	
70 30	SUBMIT IM/IRA IMPLEMENTATION DOCUMENT	22FEB91	
70 40	BEGIN PHASE I-A IM/IRA CONSTRUCTION	15JAN90	
70 50	BEGIN PHASE I-B IM/IRA CONSTRUCTION	8OCT90	
70 60	BEGIN PHASE II-A IM/IRA CONSTRUCTION	1APR91	
70 70	BEGIN PHASE II-B IM/IRA CONSTRUCTION	3SEP91	
70 80	COMPLETE IM/IRA CONSTRUCTION		2MAR92
70 90	BEGIN IM/IRA TESTING	5AUG91	



LEGEND
Activity Bar/Early Dates
Critical Activity
Progress Bar
SUMMARY ACTIVITY
MILESTONE

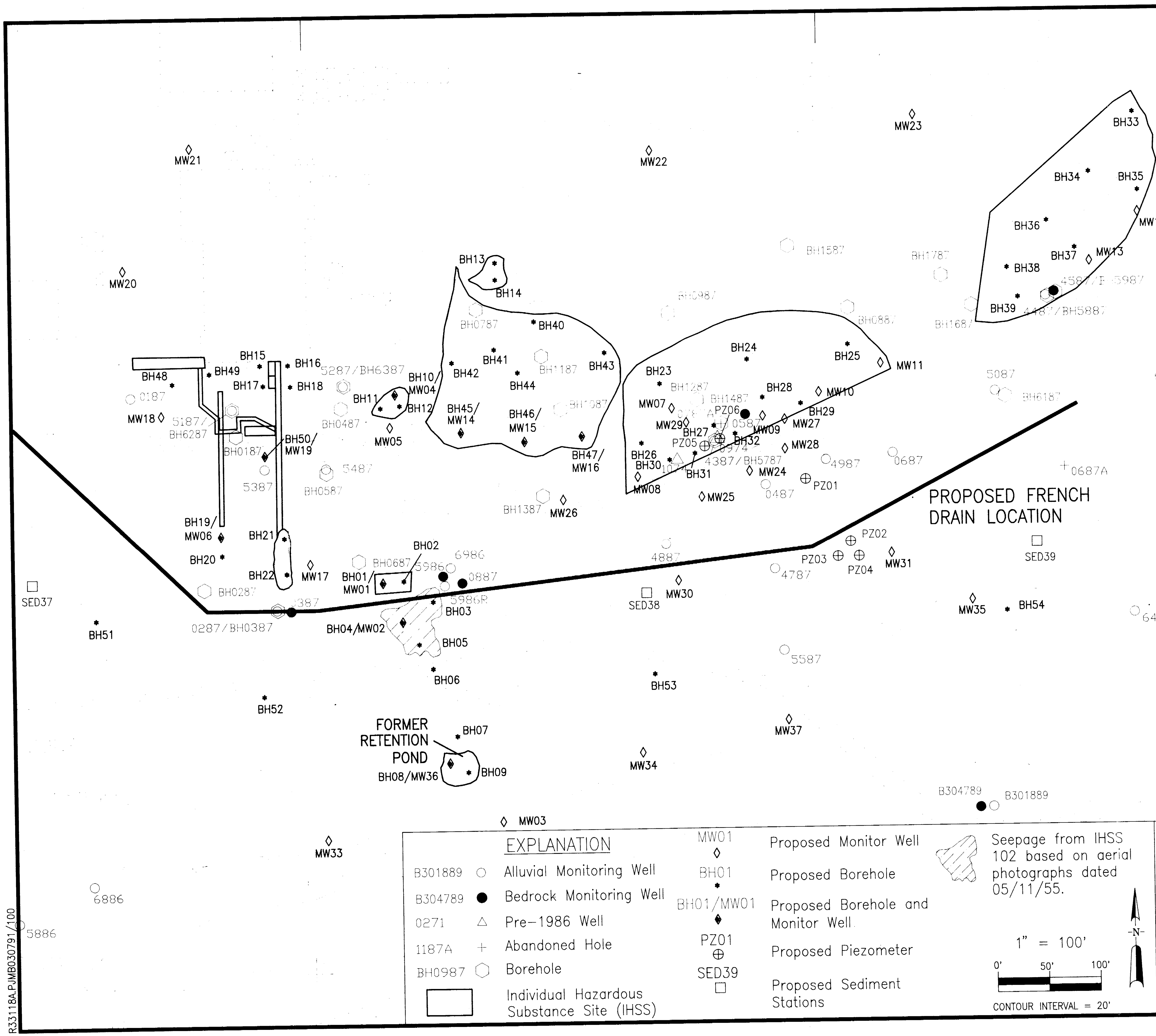
Primavera Systems Inc 1984 1990

FIGURE 8-1
OPERABLE UNIT NO 1
RFI/RI AND CMS/FS SCHEDULE
Sheet 1 of 1

Project Start 17AUG89
Project Finish 10FEB98
Data Date 17AUG89
Plot Date 6MAR91

SCHEDULE OF SUMMARY ACTIVITIES AND MILESTONES

Date	Revision	Checked	Approved



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

OPERABLE UNIT NO. 1
PHASE III RFI/RI WORK PLAN

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

PLATE 1

March, 1991