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FINAL DRAFT WORK PLAN

RFI/RI WORK PLAN FOR OU 3

ROCKY FLATS PLANT

U S DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

JULY 1991

ADMIN RECORD

FINAL DRAFT WORK PLAN

RFI/RI WORK PLAN FOR OU 3

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ROCKY FLATS PLANT

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

ENVIRONMENTAL RESTORATION PROGRAM

JULY 1991

REVIEWED FOR CLASSIFICATION/UCNI
By V A Muenchow
Date 7/3/91

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LIST OF ACRONYMS

The following is a list of acronyms used throughout this work plan

ac	acre
ACL	Alternative Concentration Limit
AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
ARAR	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factor
Bq/g	Becquerel per gram
BNA	Base-neutral acid extractable organics
BRA	Baseline Risk Assessment Plan
BRAP	Baseline Risk Assessment Plan
CAD	Corrective Action Decision
CCEI	Colorado Committee on Environmental Information
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
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CLP	Contract Laboratory Program
cm	centimeters
CMP	corrugated metal pipe
CMS	corrective measures study
CPOM	coarse particulate organic matter
CWQCC	Colorado Water Quality Control Commission
CRP	community relations plan
CSU	Colorado State University
CWA	Clean Water Act
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyl trichloroethane
DOE	Department of Energy
DQO	data quality objective
DRCOG	Denver Regional Council of Governments
DWR	Colorado Division of Water Resources
EE	environmental evaluation
EEP	Environmental Evaluation Plan
EEWP	Environmental Evaluation Work Plan
EIS	Environmental Impact Statement
EMAD	Environment Monitoring and Assessment Division of RFP
EPA	Environmental Protection Agency
ER	environmental restoration

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ERDA	Energy Research and Development Administration
FIDLER	Field Instrument for Detection of Low Energy Radiation
FS	feasibility study
FSP	field sampling plan
ft	foot/feet
GAC	granular activated carbon
Gbq	gigabecquerel
GC	gas chromatography
GPR	ground penetrating radar
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HEAST	Health Effects Assessment Summary Tables
HSP	Health and Safety Plan
HSU	Hydrostratigraphic unit
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
ICRP	International Commission on Radiological Protection
IM/IRA	Interim Measures/Interim Remedial Action
in	inches
in/hr	inch(es) per hour
IRIS	Integrated Risk Information System
K_d	Distribution coefficient
km	kilometer
La	Lectacne
LANL	Los Alamos National Laboratory
LD_{50}	lethal dose to 50 percent of the population
LLNL	Lawrence Livermore National Laboratory
LOEL	Lowest Observable Effect Level
MATC	Maximum Allowable Tissue Concentration
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mCi/km^2	microcurie per square kilometer
mi	mile
ml	milliliter
µm	micrometers
mm	millimeters
MSL	mean sea level
NAAQSs	National Ambient Air Quality Standards
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NOEL	No Observable Effect Level
NPDES	National Pollution Discharge Elimination System
NRDA	Natural Resource Damage Assessment
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
pCi/g	picocuries per gram

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pCi/l	picocuries per liter
PID	photoionization detector
Pu	Plutonium
PuO_2	Plutonium Dioxide
PNL	(Battelle) Pacific Northwest Laboratory
QAA	Quality Assurance Addendum
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAS	Routine Analytical Services
RBP	Rapid Bioassessment Protocols
RCRA	Resource Conservation and Recovery Act
RFDs	Reference doses
RFEDS	Rocky Flats Environmental Database System
RFI	RCRA facility investigation
RFP	Rocky Flats Plant
RI	remedial investigation (CERCLA)
RMAAP	Radioactive Ambient Air Program
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SAS	Special Analytical Services
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SB	soil boring
SCS	Soil Conservation Service (U.S. Department of Agriculture)
SID	South Interceptor Ditch
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SOPA	Standard Operating Procedure Addendum
SPHEM	Superfund Public Health Evaluation Manual
SS	sediment streams
SS	species specific
TAL	target analyte list
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCL	target compound list
TDS	total dissolved solids
TIC	tentatively identified compounds
TOC	total organic carbon
TVS	Table Value Standards (hardness dependent)
uCi/m^2	microcurie per square meter
USGS	United States Geological Survey
UV	ultraviolet
VOA	volatile organic analysis
VOC	volatile organic compound
WQC	Water Quality Criteria
WQCC	Water Quality Control Commission

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This document presents the work plan for the RCRA Facility Investigation (RFI)/Remedial Investigation (RI) of the Operable Unit Number 3 (OU 3) at the Rocky Flats Plant (RFP), Jefferson County, Colorado This work plan includes a field sampling plan (FSP) that presents the investigation planned to evaluate the presence or absence of contamination at Individual Hazardous Substance Sites (IHSSs) within OU 3 The FSP presented in this work plan is based on the requirements of the Interagency Agreement (IAG) amongst the Department of Energy, Environmental Protection Agency, and the State of Colorado Department of Health Four IHSSs as identified in the IAG are included in OU 3 They are IHSS 199 (contamination of the Land s Surface), IHSS 200 (Great Western Reservoir), IHSS 201 (Standley Lake) and IHSS 202 (Mower Reservoir)

Section 1 0 of this work plan presents introductory information and a general characterization of the region and plant site In addition, the regional geology and hydrology at Rocky Flats are discussed. **Section 2 0** presents descriptions of the site physical characteristics, histories and previous investigations available information concerning the nature and extent of contamination, and conceptual models for each of the 4 IHSSs based on existing data. This initial characterization forms the basis for establishing data needs, data quality objectives (DQOs), and developing an FSP for each IHSS **Section 3 0** presents applicable or relevant and appropriate requirements (ARARs) developed for OU 3 **Section 4 0** outlines RFI/RI tasks to be performed **Section 5 0** establishes data needs and DQOs considering site characteristics and conceptual models of each IHSS in OU 3 A Field Sampling Plan based on the requirements of the IAG, is presented in **Section 6 0** to satisfy the data needs and DQOs identified in Section 5 0 The Human Health Risk Assessment Plan and Environmental Evaluation Plan are presented in **Sections 7 0** and **8 0**, respectively **Section 9 0** presents the general schedule for the RFI/RI tasks. A Quality Assurance Addendum and Standard Operating Procedure Addenda are presented in **Sections 10 0 and 11 0**, respectively A list of references is presented in **Section 12.0**

The IAG also required preparation of separate historical information summaries and preliminary human health risk assessments for IHSS 199 and IHSSs 200 to 202. The Final Past Remedy Report Operable Unit No 3–IHSS 199 (DOE, 1991a) and the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No 3 IHSS 200 to 202 (DOE, 1991b) were submitted to EPA in April 1991 The Final Past Remedy Report Operable Unit No 3-IHSS 199 (DOE, 1991a) has been approved by EPA and CDH The Historical Information Summary and Preliminary

Health Risk Assessment Operable Unit No. 3 IHSS 200 to 202 (DOE, 1991b) currently is undergoing final review by EPA and CDH. These reports describe OU 3 site physical and chemical characteristics, provide synopses of environmental investigations conducted to date at OU 3, formulate conceptual models for contaminant fate and mobility, provide preliminary human health risk assessments based upon existing data, and identify additional data needed to support a detailed site characterization and the Baseline Risk Assessment (Human Health Risk Assessment and the Environmental Evaluation) for OU 3 The information in these preliminary OU 3 reports was used to support the Site Characterization (Section 2.0) and development of DQOs (Section 5.0) in this Work Plan.

DQOs have been developed for this RFI/RI investigation. DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI. The DQO process is divided into three stages. Through application of the DQO process, site-specific RFI/RI goals are established and data needs are identified for achieving these goals.

The following objectives of the OU 3 RFI/RI have been identified:

- Characterize the physical features and ecological characteristics
- Characterize the nature and extent plutonium and americium contamination at each IHSS in each media that is a potential pathway
- Assess the presence or absence of other chemicals that may be in OU 3 in sediments and surface waters
- Collect data to support the Human Health Risk Assessment
- Collect data to support to Environmental Evaluation

Within these broad objectives, site-specific data needs have been identified based on the conceptual models and preliminary identification of contaminant-specific ARARs for OU 3 and data needs for the Baseline Risk Assessment. The FSP is briefly summarized below

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SOIL

Surface soil samples will be collected within a 1,000-meter grid east of Indiana Street Vertical profile soil samples will also be collected in undisturbed areas. Soil samples will be analyzed for radionuclides total organic carbon (TOC) bulk density, and grain size

SEDIMENT

Sediment samples will be collected in the OU 3 drainages and in the three reservoirs Sediment samples will also be collected along the shores of each of the reservoirs Sediment samples will be analyzed for radionuclides, target compound list (TCL) volatiles, target analyte list (TAL) metals, TOC bulk density and grain size

SURFACE WATER

Surface water samples will be collected in the OU 3 drainages and in the three reservoirs. The samples will be analyzed for radionuclides, TCL volatiles TAL metals, cations/anions, dissolved oxygen pH and specific conductance.

GROUNDWATER

Two groundwater monitoring wells will be installed near Great Western Reservoir and two groundwater monitoring wells will be installed near Standley Lake The groundwater samples will be analyzed for radionuclides and cation/anions

AIR

Air samples will be collected in low-lying areas along the shores of Great Western Reservoir and Standley Lake The air samples will be analyzed for plutonium and americium

TERRESTRIAL BIOTA

Qualitative and quantitative field surveys will be conducted Vegetation wildlife/habitat types and wetlands/riparian zones will be identified as part of the qualitative surveys Vegetation

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(aboveground biomass), wetlands vegetation, and small mammals will be sampled as part of the quantitative surveys and analyzed for radionuclides and TAL metals.

AQUATIC BIOTA

Benthic macroinvertebrates, periphyton, and fish will be sampled and analyzed for radionuclides and TAL metals.

Data collected during the OU 3 RFI/RI will be incorporated into the existing Rocky Flats Environmental Database System (RFEDS) database. These data will be used to better define site characteristics, source characteristics, and the nature and extent of contamination, and to support the Baseline Risk Assessment (Human Health and Environmental Evaluation) An RFI/RI Report will be prepared summarizing the data obtained during the field investigation program and containing the Baseline Risk Assessment.

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This document presents the work plan for conducting the RCRA Facility Investigation/Remedial Investigation (RFI/RI) of Operable Unit No 3 (OU 3) at the U S Department of Energy (DOE) Rocky Flats Plant (RFP) Existing information is summarized to characterize OU 3, and a field sampling program is developed to assess the nature and extent of contamination at the four Individual Hazardous Substance Sites (IHSSs, or Sites) which comprise OU 3 IHSS 199 (Contamination of the Land s Surface), IHSS 200 (Great Western Reservoir), IHSS 201 (Standley Lake), and IHSS 202 (Mower Reservoir) The OU 3 RFI/RI is part of an ongoing program of site characterizations, remedial investigations, feasibility studies, and remedial actions at the RFP

1 1 DOE ENVIRONMENTAL RESTORATION PROGRAM

Investigations and remediation of RFP OUs are being conducted under the DOE Environmental Restoration (ER) Program. The ER Program is designed to investigate, and if necessary, remediate contaminated sites at DOE facilities The program involves five major activities.

- **Activity 1—Installation Assessments,** including preliminary assessments and site inspections to assess potential environmental concerns

- **Activity 2—Remedial Investigations,** including the development and implementation of field sampling programs to determine the magnitude and extent of contamination at specific sites, evaluate contaminant fate and mobility in the environment, and perform baseline risk assessments

- **Activity 3—Feasibility Studies** to evaluate remedial alternatives and develop remedial action plans, as necessary, to remediate sites identified during Activity 2

- **Activity 4—Remedial Designs/Remedial Actions,** including design and implementation of site-specific remedial actions selected on the basis of Activity 3 Feasibility Studies

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- **Activity 5—Compliance and Verification** to monitor and assess the performance of remedial actions implemented under Activity 4 and to document their efficacy

Activity 1 has been completed for the Rocky Flats Plant (DOE, 1986). The OU 3 RFI/RI Work Plan falls under Activity 2.

1.2 WORK PLAN SCOPE

The scope of the OU 3 RFI/RI is derived from the Interagency Agreement (IAG) between the U.S Environmental Protection Agency (EPA), the Colorado Department of Health (CDH), and the DOE (EPA, 1991) The IAG describes the general response processes for IHSSs at the RFP These sites are grouped into 16 OUs, one of which is OU 3. The RFI/RI and all response activities performed by the DOE under the IAG are to be consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Resource Conservation Recovery Act (RCRA), the National Contingency Plan (NCP), and the Colorado Hazardous Waste Act (CHWA) Pertinent EPA guidance documents include the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988) and Interim Final RCRA Facility Investigation (RFI) Guidance (EPA, 1989a) RFP OUs are classified under the IAG as:

1 State-lead OUs that CDH will address primarily under RCRA and CHWA (but also will address CERCLA requirements as appropriate)

2. EPA-lead OUs that EPA will address primarily under CERCLA (but also will address RCRA and CHWA requirements as appropriate)

3. Joint EPA-CDH lead OUs, which will incorporate elements of RCRA, CERCLA, and CHWA.

OU 3 has been designated an EPA-lead OU

Section VI of the IAG Statement of Work (Attachment 2 of the IAG) spells out objectives for RFI/RI Work Plans at the RFP The primary objective of the OU 3 RFI/RI is to conduct a detailed site characterization which meets the following goals:

- Define OU 3 site physical characteristics

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- Define sources of contamination

- Describe the nature and extent of contamination

- Describe contaminant fate and transport

- Provide data to support a Baseline Risk Assessment (BRA) to establish the baseline risk for the OU and to evaluate the need for Interim Measures/Interim Remedial Actions (IM/IRAs)

This work plan is organized into the following sections

- **Section 1 0** provides introductory information and a general characterization of the RFP and the surrounding region

- **Section 2.0** presents a characterization of OU 3 site conditions, previous environmental investigations, available information regarding the nature and extent of contamination and conceptual models for the soils (IHSS 199) and the reservoirs (IHSSs 200 201, and 202)

- **Section 3 0** identifies potential Applicable or Relevant and Appropriate Requirements (ARARs) for OU 3

- **Section 4 0** identifies specific RFI/RI tasks to be performed

- **Section 5.0** establishes data needs and Data Quality Objectives (DQOs) based upon the site characterization information presented in Section 2.0

- **Section 6 0** presents a Field Sampling Plan (FSP) to satisfy the data needs and DQOs identified in Section 5 0

- **Section 7 0** presents the Human Health Risk Assessment Plan for OU 3

- **Section 8 0** presents the Environmental Evaluation Work Plan (EEWP) for OU 3

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- **Section 9 0** provides a schedule for completion of the RFI/RI tasks identified in Section 4 0 in accordance with the scheduling requirements of the IAG

- **Section 10 0** provides a Quality Assurance Addendum (QAA) for quality assurance issues specifically related to the OU 3 RFI/RI (submitted to EPA separately)

- **Section 11 0** provides Standard Operating Procedure Addenda (SOPA) for procedures specific to the OU 3 RFI/RI

- **Section 12.0** provides references.

Included in the IAG required actions for OU 3 are the preparation of historical information summaries and preliminary human health risk assessments for offsite soils (IHSS 199) and offsite reservoirs (IHSSs 200, 201, and 202) The two reports currently are undergoing final review by EPA and CDH (DOE, 1991a; DOE, 1991b) These reports describe OU 3 site physical and chemical characteristics, provide synopses of environmental investigations conducted to date at OU 3, formulate conceptual models for contaminant fate and mobility, provide preliminary human health risk assessments based upon existing data, and identify data gaps which must be filled in order to support a detailed site characterization and baseline risk assessment under the OU 3 RFI/RI. The information in these preliminary OU 3 reports was used to support the Site Characterization (Section 2.0) and development of DQOs (Section 5.0) in this Work Plan

1 3 REGIONAL AND RFP SITE BACKGROUND INFORMATION

The following subsections provide general information on the RFP and the surrounding region, including RFP history, regional land use and population data, and site conditions.

1 3.1 RFP Mission and History

The RFP is part of a nationwide nuclear weapons complex owned by DOE. The facility is contractor-operated by EG&G Rocky Flats, Inc (EG&G) as a nuclear weapons research, development, and production complex. The RFP fabricates components for nuclear weapons from plutonium, uranium, beryllium, and stainless steel. Support activities include chemical recovery and purification of recyclable transuranic radionuclides, and research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics (DOE, 1988)

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Construction of the RFP began in 1951, and the first production activities commenced the following year Operation of the RFP fell under the administration of the U S Atomic Energy Commission (AEC) from 1951 until the AEC was dissolved in January 1975 Responsibility for the plant was then transferred to the Energy Research and Development Administration (ERDA), which was succeeded in 1977 by DOE Dow Chemical USA was the prime operating contractor of the facility from 1951 until 1975 Rockwell International succeeded Dow Chemical USA from 1975 through 1989, when EG&G assumed RFP operations

1 3 2 Physical Setting

The RFP is situated on 6,550 acres (ac) (2,650 hectares [ha]), of federal property in Jefferson County, Colorado, 16 miles (mi) (26 kilometers [km]) northwest of downtown Denver The 385 ac (156 ha) main production facility of the RFP, within the plant's controlled area, is surrounded by a 6,150 ac (2,491 ha) buffer zone which delineates the RFP boundary (Figure 1-1)

1 3 2.1 Climatology

The RFP area has a semiarid climate typical of the Rocky Mountain region Local climatology is controlled in large part by the nearby slopes of the Front Range

Winds in the area are variable in direction but are predominantly from the west (westerly) Stronger winds occur during the winter months and the area occasionally experiences gusts in excess of 100 miles per hour Area temperatures are moderate, extreme hot or cold weather typically is of short duration Average summer temperatures range from 55 to 85 degrees Fahrenheit (°F), or 13 to 29 degrees Celsius (°C), while winter temperatures typically range from 20° to 45°F (-6° to 7°C) (DOE, 1980)

Average total precipitation for the RFP area is approximately 15 inches per year (in/yr) (38 cm/yr), with 40 percent of this falling during the spring Snowfall averages 85 in/yr (216 cm/yr) (DOE, 1980) Rainfall intensity and duration vary widely During a 3-year hydrological study of the RFP between 1972 and 1975, rainfall intensities varied from <0 1 in/hr (<0 25 cm/hr) to approximately 0 5 in/hr (1 25 cm/hr) (USGS, 1976) Frontal storms with long, low-intensity rainfall durations occur in the autumn and early spring while short intense cloudbursts are frequent in the late spring and summer months

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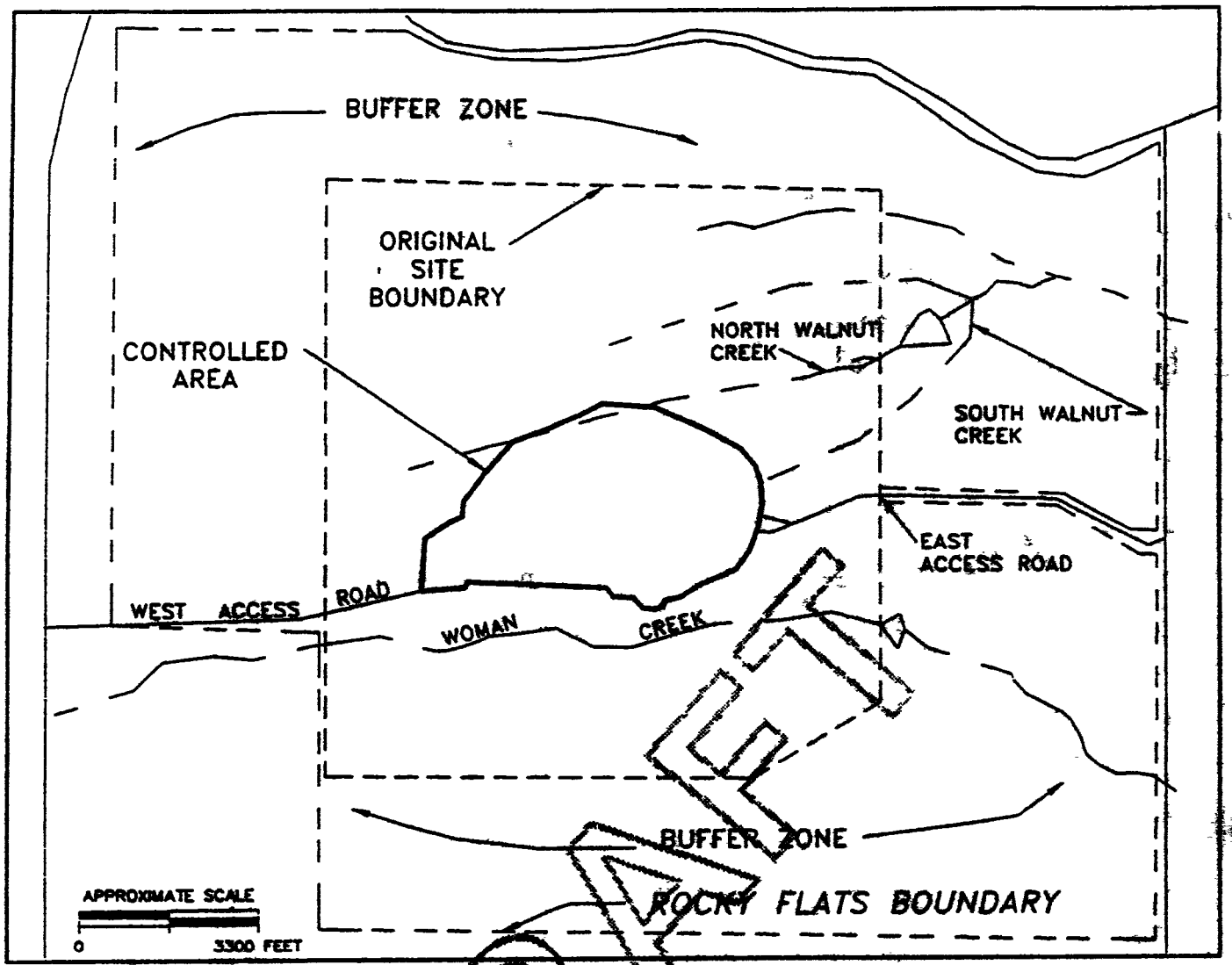

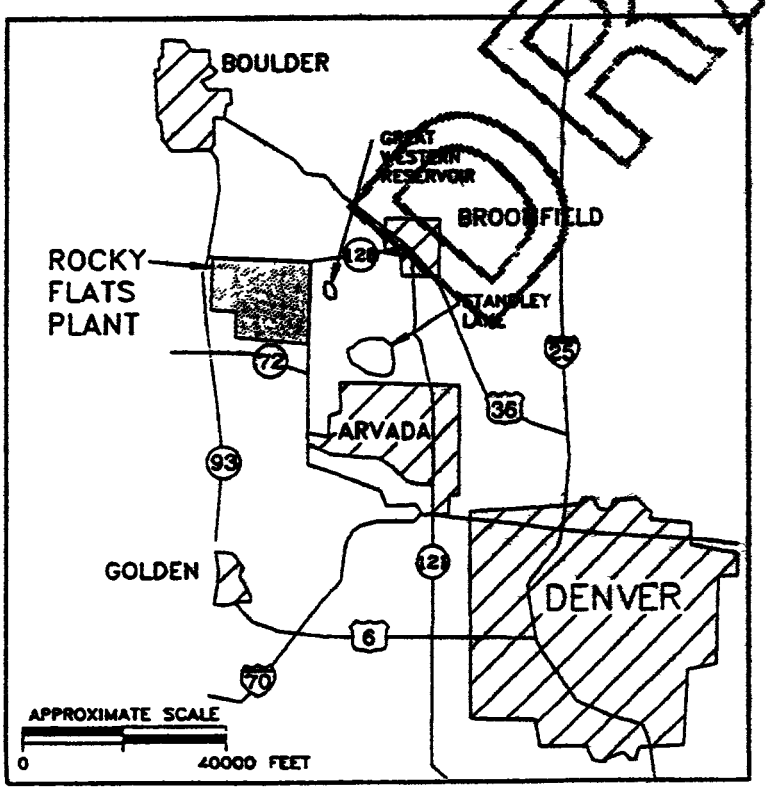

Figure 1-1
ROCKY FLATS LOCATION MAP

ADAPTED FROM FIG 1-1 E.G. & G. DRAFT GEOLOGIC CHARACTERIZATION REPORT JAN 3, 1990.

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1 3 2.2 Physiography

The RFP is situated at an elevation of approximately 6000 feet (ft), or 1830 meters (m), above mean sea level, on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Fenneman, 1931) The site is located where the Colorado Piedmont is terminated abruptly by the Front Range section of the southern Rocky Mountains The Front Range rises to elevations of 12,000 to 14,000 ft (3,660 to 4,270 m) to the west of the RFP site

The Colorado Piedmont represents an old erosional surface along the eastern margin of the Rocky Mountains. It is underlain by gently dipping sedimentary rocks which are abruptly upturned at the Front Range to form hogback ridges parallel to the mountain front. The piedmont surface is broadly rolling and slopes gently to the east with a topographic relief of several hundred feet (approximately 100 m) This relief is attributed both to resistant bedrock units that rise above the landscape and to incised stream drainages. Major stream valleys run predominantly from west to east in the area. Numerous local valleys from minor tributaries also exist (DOE, 1980)

In the RFP area, a series of Quaternary pediments have been deposited across the gently rolling piedmont surface and incised by several minor drainages The RFP is located on a relatively flat surface formed by one such pediment. The pediment has been eroded by creeks on the north and south to form a terrace that ranges in height from 50 to 150 ft (15 to 46 m) The grade of the dissected pediment surface ranges from 0.7 percent at the RFP to approximately 2 percent just east of the plant (DOE 1990)

1 3 3 Geologic Setting

The Rocky Flats Plant is located on the northwestern flank of the Denver Basin, an asymmetric syncline that formed during the late Cretaceous Laramide Orogeny The western limb of the basin dips steeply to the east, while the eastern limb dips gently to the west. The axis of the basin is located approximately 10 miles (16 km) east of the RFP

1 3 3 1 Bedrock

The Cretaceous-age Arapahoe Formation underlies surficial deposits in the RFP area. The maximum thickness of the formation in the area is approximately 270 ft (82 m) The Arapahoe Formation consists of fluvial claystones with interbedded, discontinuous sandstone and siltstone lenses and

channels. The lower half of the formation contains more sandstones than the upper half The upper sandstones were deposited by a complex system of meandering streams flowing generally west to east off of the Front Range (USGS, 1976) Bedrock dips beneath the RFP are approximately 2 degrees to the east (EG&G, 1990a)

A major erosional surface developed in the RFP area during late Tertiary time, completely removing two formations overlying the Arapahoe Formation and eroding into the Arapahoe. Weathering penetrates the Arapahoe Formation beneath surficial deposits to a depth of 10 to 40 ft (3 to 12 m) (DOE, 1990) Drainages eroded into the formation were infilled by later surficial deposits. The top of the bedrock surface beneath the surficial deposits generally parallels the ground surface topography, with bedrock lows along existing drainageways and creeks (EG&G, 1990a)

The Arapahoe Formation is directly underlain by the Laramie Formation, a fluvial sequence of sandstones, siltstones, claystones, and coal. The upper Laramie Formation, which subcrops immediately west of the RFP, consists of some 750 ft (230 m) of claystone. Underlying the Laramie Formation are up to 10,000 ft (3,280 m) of Paleozoic and Mesozoic sedimentary rocks. To the west of the RFP, resistant sedimentary units form ridges where they are upturned along the flank of the Front Range.

1.3.3.2 Surficial Deposits

Surficial deposits in the RFP area consist of unconsolidated Quaternary-age units, which unconformably overlie the Arapahoe Formation and other subcropping bedrock units. The RFP is located on a terrace capped by Rocky Flats Alluvium, which is the oldest and topographically highest of the surficial deposits in the area. The Rocky Flats Alluvium is a series of laterally coalescing fans deposited by streams. Bedding is uncommon. The unit consists of sand, clay, silt, gravel, cobbles, and occasional boulders, and is weakly to moderately cemented with caliche (calcium carbonate) in some areas.

Younger alluvial deposits existing topographically below the Rocky Flats Alluvium include the Verdos and Slocum Alluviums. These deposits consist largely of drainage infilling with reworked Rocky Flats Alluvium. In addition, active deposition of valley fill alluvium is occurring within existing drainages in the RFP area (DOE, 1990)

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1 3 4 Hydrology

The following sections contain general information about the surface water and groundwater systems in the RFP area.

1 3 4 1 Surface Water

Several ephemeral streams flow through the RFP area. Three of these streams (North Walnut Creek, South Walnut Creek, and Woman Creek) originate within the RFP boundary and flow generally eastward from the plant site The Walnut Creek and Woman Creek drainages within the boundary of the RFP are being investigated under the IAG as OU 5 and OU 6, respectively A fourth ephemeral stream, Rock Creek, originates in the Buffer Zone northwest of the main production facility and flows northwest from the RFP (Figure 1-2) Other surface water features in the vicinity of the plant include a complex network of manmade diversions and impoundments. RFP surface water features are shown in Figures 1-2 and 1-3 Flow into and within these features results from direct surface runoff, baseflow from groundwater, and diversions and wastewater from human-related activities A sitewide study of the hydrology of the RFP determined that surface runoff in the Woman Creek basin averages only 1 4 percent of rainfall, indicating either a high soil infiltration rate or high surface retention capacity This figure was based on records for long-duration, low-intensity precipitation, runoff may be much higher for a short-duration, high intensity event (USGS, 1976)

1 3 4.2 Groundwater

Two hydraulically-connected groundwater systems exist in the RFP area. An unconfined system which is present in saturated surficial deposits (the upper hydrostratigraphic unit) in many areas of the RFP, and a confined system in claystones and sandstones of the underlying Arapahoe Formation (the lower hydrostratigraphic unit) (USGS, 1976) The shallow unconfined system is recharged by infiltration from incident precipitation and from surface and baseflow water (such as drainages and reservoirs) Groundwater flow is generally to the east and towards drainages Groundwater locally discharges as seeps or springs in drainages, especially where the surficial deposit/bedrock contact is exposed Large water table fluctuations may occur in the shallow system in response to seasonal variations in recharge and discharge, with the highest water levels generally occurring during the months of May and June and the lowest water levels generally occurring in January and February As a result of these fluctuations the lateral and vertical extent of saturated surficial deposits varies seasonally Several past studies have measured hydraulic conductivity in the upper

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and lower hydrostratigraphic units using drawdown-recovery tests, pump tests, packer testing and slug testing on selected wells (USGS, 1976, Hydro-Search, 1985, Rockwell, 1988a) Recent work has estimated hydraulic conductivities for RFP geologic units at 10^{-5} cm/sec in the Rocky Flats Alluvium, 10^{-5} cm/sec in subcroppings Arapahoe Formation sandstones, 10^{-6} cm/sec in unweathered Arapahoe Formation sandstones, and 10^{-7} cm/sec in both weathered and unweathered Arapahoe Formation claystones (EG&G, in press)

Confined groundwater in the lower hydrostratigraphic unit exists primarily in lenticular sandstone bodies within claystone. Groundwater flow in the upper hydrostratigraphic unit occurs in the unconsolidated Quaternary surficial deposits and the shallow sandstone within the bedrock. Recharge to this unit consists of infiltration from streams and precipitation. The lower hydrostratigraphic unit is found in the deeper bedrock sandstones which exhibit confined conditions. Recharge to this unit occur primarily from baseflow and leakage from the overlying claystone. Groundwater in the lower hydrostratigraphic unit flows east towards a regional discharge area along the South Platte River, some 20 miles (32 km) east of the RFP Local seeps occur along the sides of drainages where the bedrock crops out. Calculated horizontal linear flow velocities for the system average 0 1 ft/day (0.03 m/day) in the sandstones and approximately 9×10^{-4} ft/day (2.7×10^{-4} m/day) in the claystone (USGS, 1976; Hydro-Search, 1985)

1.3.5 Ecology

The ecosystems in the RFP area and surrounding region are typical for foothill ravine and high plains portion of Colorado and include aquatic and terrestrial ecosystems. The aquatic ecosystems include perennial and intermittent streams, and manmade ditches, canals, ponds and reservoirs. Terrestrial ecosystems occur on all drainages, slopes, and uplands. Many of the natural ecosystems have been converted to other uses such as commercial and residential development, agriculture and rangeland grazing and water control and storage. The remaining ecosystems have experienced some effects from surrounding land use and few or no pristine areas exist in the vicinity of the RFP However, some areas within the RFP buffer zone have not been disturbed for 20 or more years.

The principal components of the aquatic ecosystems are the periphyton, phytoplankton, benthic macroinvertebrates, amphibians, and fish. The type of aquatic communities and diversity of species in each of these components is dependent on the type of substrate, water characteristics (such as depth and flow regime, water quality, creek or pond morphology), water management practices, and

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season Fish species are most abundant in the larger ponds and reservoirs, and are mostly absent in the intermittent streams

Vegetation in the terrestrial ecosystems are representative of high plains and foothill ravine regions, and include native grassland with tall and short prairie grass species and associated shrubs and forbs Riparian and wetland vegetation occurs along drainages and around springs and seeps Portions of the grasslands and riparian vegetation have been converted to other land uses, and the grasslands have been and are being grazed as rangeland

Flora in the RFP area are representative of lower mountainous and foothill ravine regions and include species of tall and short prairie grass. Riparian vegetation occurs along drainages and in wetlands. None of the vegetative species present at the RFP are reported to be on the endangered species list (EG&G, 1991a) Many of the disturbed areas of the RFP have been revegetated since establishment of the plant using native or introduced species.

The fauna inhabiting the RFP area are typical of western prairie regions. The most common large mammal is the mule deer There are a number of small carnivores, such as the coyote, red fox, striped skunk, and long-tailed weasel Numerous small herbivores are found throughout the area, including the prairie dog pocket gopher, white-tailed jackrabbit, and the meadow vole Birds common to the area include the western meadowlark, horned lark, mourning dove, and vesper sparrow Killdeer, red-winged blackbirds and a variety of ducks are seen near ponds. Mallards and other ducks frequently nest and breed on RFP ponds Birds of prey in the area include the marsh hawk, red-tailed hawk, ferruginous hawk, rough-legged hawk, and great horned owl Bull snakes and rattlesnakes are the most frequently observed reptiles Eastern yellow-bellied racers are also observed. The eastern short-horned lizard has been reported on the RFP, but these and other lizards are not commonly observed The western painted turtle and the western plains garter snake are found in and around ponds in the area (DOE 1980)

The U S Fish and Wildlife Service has indicated that the two endangered species of interest in the RFP are the bald eagle and the black-footed ferret (Rockwell, 1988c) Prairie dog towns provide the food source and habitat for ferrets

1 3.6 Demographics

The population economics, and land use of the areas surrounding the RFP are described in a 1989 Rocky Flats vicinity demographics report by DOE (DOE, 1991d) This report divides general use of areas within zero to 10 mi (zero to 16 km) of the RFP into residential, commercial, industrial, parks and open spaces, agricultural and vacant, and institutional classifications, and considers current and future land use near the plant.

1.3 6.1 Current Population and Land Use

The majority of residential use within 5 miles (8 km) of the RFP is located immediately north and southwest of Standley Lake (IHSS 201) Single (unincorporated) residents are located immediately east and south of the RFP Figure 1-4 shows the 1989 population distribution within areas up to 5 miles from the RFP Commercial development is concentrated near the residential developments north and southwest of Standley Lake, and around the Jefferson County Airport approximately 3 miles (4.8 km) northeast of the RFP Industrial land use within 5 miles (8 km) of the plant is limited to quarrying and mining operations. Open Space lands are located northeast of the RFP near the City of Broomfield, and in small parcels adjoining major drainages and small neighborhood parks in the cities of Westminster and Arvada. Standley Lake is surrounded by Standley Lake Park. Irrigated and nonirrigated croplands, producing primarily wheat and barley, are located northeast of the RFP near the cities of Broomfield, Lafayette, and Louisville, north of the RFP near Louisville and Boulder, and in scattered parcels adjacent to the eastern boundary of the plant. Several horse operations and small hay fields are located south of the RFP The demographics report characterizes much of the vacant land adjacent to the RFP and the reservoirs as rangeland (DOE, 1991d).

1.3.6.2 Future Population and Land Use Projections

Future land use in the vicinity of the RFP most likely involves continued suburban expansion, increasing the density of residential, commercial, and perhaps industrial land use in the areas. The expected trend in population growth in the vicinity of the RFP is addressed in the DOE demographics study (DOE, 1991d) This report considers expected variations in population density by comparing the current (1989) setting to population projections for the years 2000 and 2010. A 21-year profile of projected population growth in the vicinity of the RFP can thus be examined. The DOE projections are based primarily upon long-term population projections developed by the Denver Regional Council of Governments (DRCOG) Expected population density and distribution

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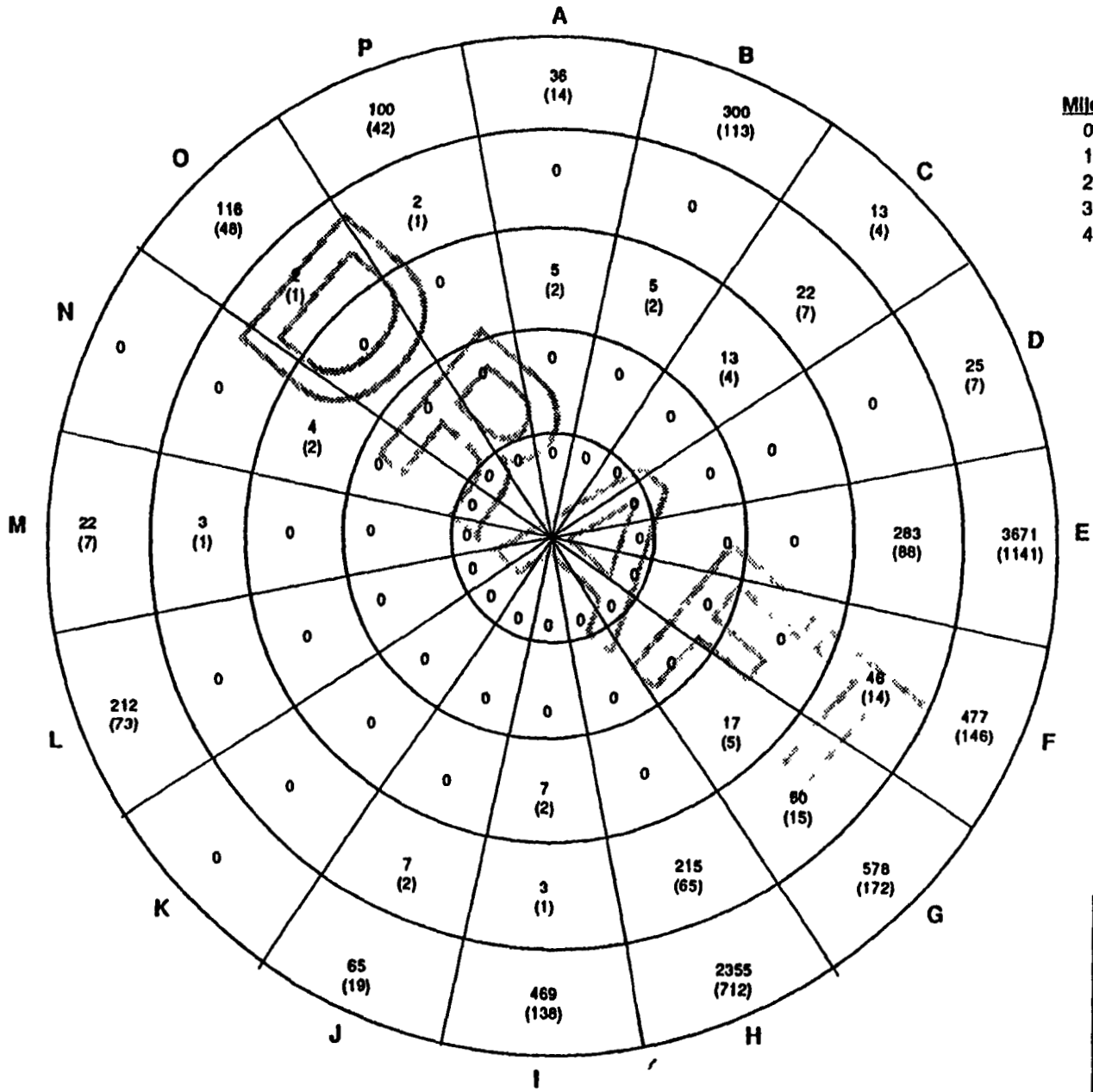

Miles	Sector Name
0 1	Sector 1
1 2	Sector 2
2 3	Sector 3
3 4	Sector 4
4 5	Sector 5

SOURCE DOE 1989 POPULATION ECONOMIC AND LAND USE DATA BASE FOR ROCKY FLATS PLANT (IN PRESS)

Figure 1-4
1989 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5

around the RFP for the years 2000 and 2010 are shown in Figures 1-5 and 1-6, respectively Table 1-1 summarizes the population data presented in Figures 1-4, 1-5, and 1-6.

1.3.7 RFP Hazardous Substances

RFP operations generate nonhazardous, hazardous, radioactive, and mixed radioactive waste streams (DOE, 1988) Hazardous substances which have been detected in the environment on the RFP as a result of RFP operations include various radionuclides, nonradioactive metals, Volatile Organic Compounds (VOCs), semi-volatile organic compounds, and inorganic ions. These substances have been detected through routine environmental monitoring conducted by the RFP (see Subsection 1.3.8) and/or during investigations of RFP OUs. Herbicides which have been applied in the past at various locations on the RFP have also been detected.

The IAG identifies 117 IHSSs at the RFP, 113 of which are within the RFP boundary As mentioned in Subsection 1.2, these IHSSs have been grouped into sixteen OUs. A number of the IHSSs consist of multiple release locations which are grouped together as a single IHSS because of similar contaminant characteristics. RFP IHSSs have been identified primarily on the basis of RFP records and employee interviews. RFI/RI field activities have not yet commenced at most of the sixteen RFP OUs, meaning that most of the IHSSs have been characterized only on the basis of historical information, and that detailed information regarding the existence, concentration and extent of contamination is not available for most IHSSs.

1.3.8 RFP Environmental Monitoring

The RFP conducts routine radiological and nonradiological environmental monitoring of effluent air, ambient air, surface water, groundwater, tap water, stream sediments, and soil at locations on and in the vicinity of the RFP. Results from these monitoring programs are published monthly and/or annually in RFP environmental monitoring reports (Dow et al., 1971 to date) Ambient air, soil, and surface water quality are also monitored in locations around the RFP by CDH and by cities utilizing Great Western Reservoir and Standley Lake as municipal water supplies. The following information about these programs is taken primarily from RFP monthly and annual environmental reports.

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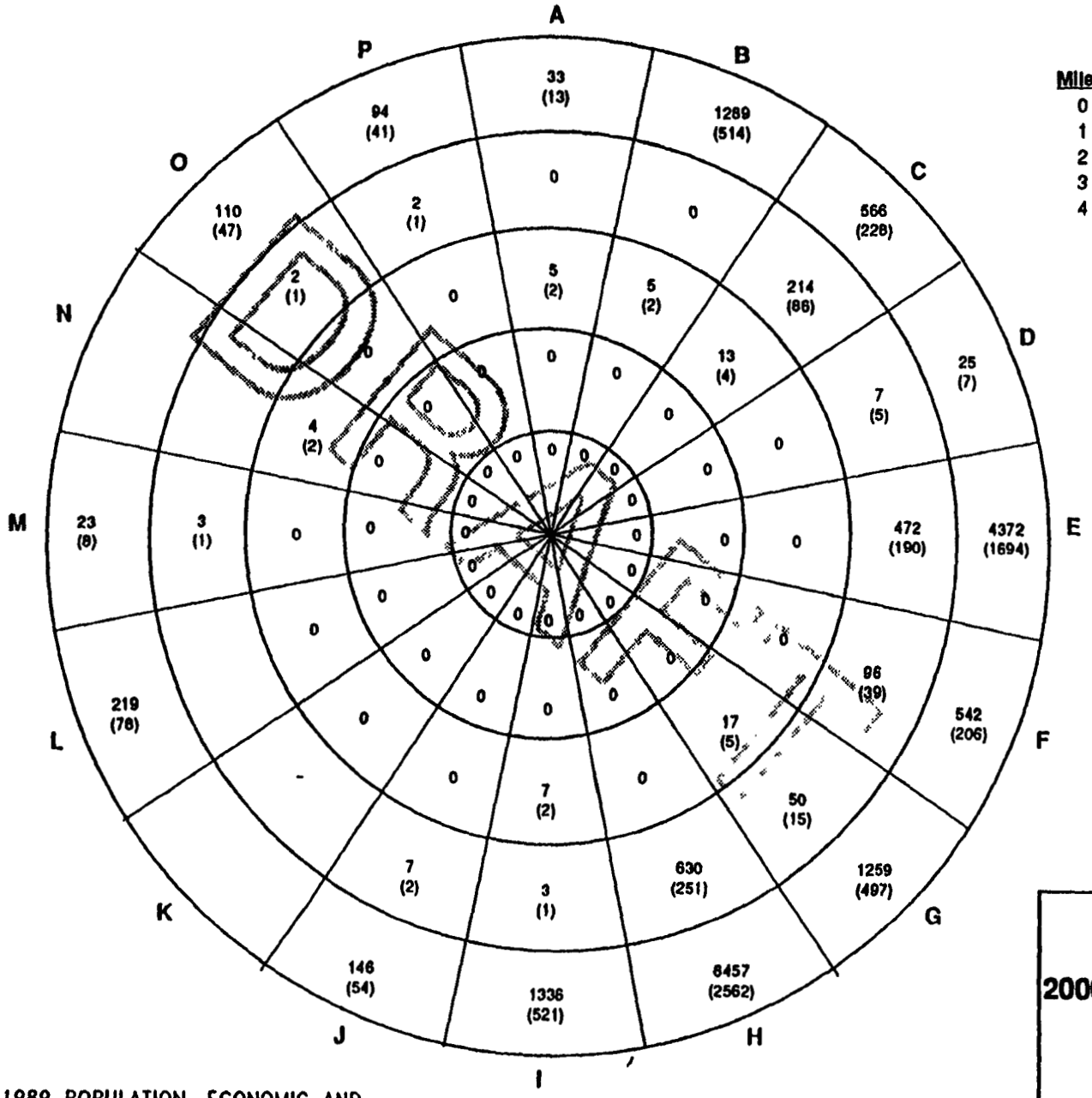
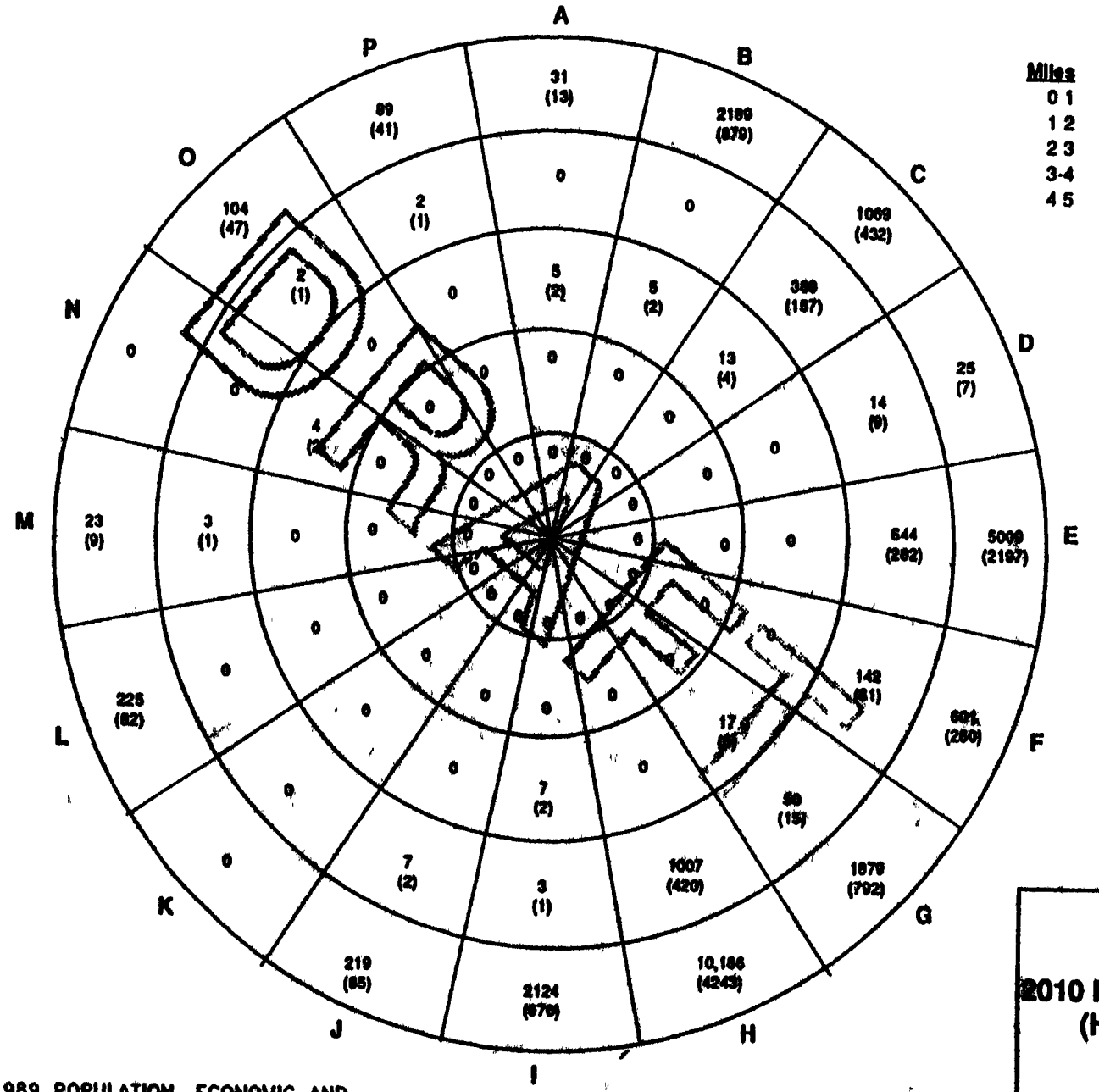


Miles	Sector Name
0 1	Sector 1
1 2	Sector 2
2 3	Sector 3
3 4	Sector 4
4 5	Sector 5

SOURCE DOE 1989 POPULATION ECONOMIC AND LAND USE DATA BASE FOR ROCKY FLATS PLANT (IN PRESS)

Figure 1-5
2000 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5



Miles	Sector Name
0 1	Sector 1
1 2	Sector 2
2 3	Sector 3
3-4	Sector 4
4 5	Sector 5

SOURCE: DOE "1989 POPULATION, ECONOMIC AND LAN[illegible] DATA BASE FOR ROCKY FLATS PLANT", (IN [illegible])

Figure 1-6
2010 POPULATIONS AND (HOUSEHOLDS), SECTORS 1-5

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TABLE 1-1

CURRENT AND PROJECTED POPULATION IN THE VICINITY OF THE ROCKY FLATS PLANT

	Segment							
Sector	B	C	D	E	F	G	H	Sum
Year 1989								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	5	13	0	0	0	17	0	35
4	0	22	0	283	46	50	215	616
5	300	13	25	3,671	477	578	2,355	7,419
SUM	305	48	25	3 954	523	645	2,570	8 070
Year 2000								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	5	13	0	0	0	17	0	35
4	0	214	7	472	96	50	630	1 469
5	1,289	566	25	4,372	542	1,259	6 457	14,510
SUM	1,294	793	32	4 844	638	1 326	7 087	16,014
Year 2010								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	5	13	0	0	0	17	0	35
4	0	389	14	644	142	50	1 007	2,246
5	2,189	1 069	25	5 009	601	1 879	10,186	20 958
SUM	2,194	1,471	39	5,653	743	1,946	11,193	23,239

Source DOE (in press)

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1.3.8.1 Ambient Air Monitoring

The RFP maintains a network of continuously operating ambient air samplers on and in the vicinity of the plant site These samplers trap influent particulates on a filter element. Specific information regarding sampler types and locations, analytical protocols, and analytical results have been summarized since 1971 in the RFP annual environmental monitoring reports (Dow et al., 1971 to date) There currently are 53 samplers in the ambient air sampling network, of which 25 are located on the RFP site (Figure 1-7), 14 are located along the RFP boundary (Figure 1-7), and 14 are located within nearby communities (Figure 1-8) The RFP has conducted onsite ambient air monitoring since the plant opened in 1951 The original network of low-volume (approximately 2 cubic feet per minute [cfm]) air samplers was upgraded in 1974 to 1975 to the high-volume (approximately 25 cfm) samplers currently in use Offsite (community) samplers were added to the network at this time.

Sampling and analytical protocols have varied throughout the history of the ambient air monitoring program. Plutonium analysis of selected ambient air samples begin in 1975, prior to this, onsite ambient air samples were analyzed for total long-lived alpha radiation only. Under the current protocol, onsite samples are collected biweekly and analyzed for isotopic plutonium. As of December 1990, the biweekly onsite samples are composited into a single monthly sample. Samples from the RFP perimeter and from nearby communities are collected biweekly and composited into single monthly samples from each sample station, which are analyzed for plutonium. The CDH also maintains offsite air samplers for measuring plutonium concentration in ambient air in the vicinity of the RFP (CDH, 1970 to date)

Starting in the early 1980s, the RFP conducted onsite monitoring for EPA criteria pollutants (total suspended particulates, ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, and lead) utilizing a mobile ambient air monitoring unit. This mobile unit was replaced in mid-1986 with a permanent monitoring station located just inside the RFP east gate Starting in 1989, this program was scaled back to include total suspended particulates and respirable particle fraction (those particles smaller than or equal to 10 microns in size) only

In 1976, nine ambient air monitoring stations were installed by the RFP at and near IHSS 199 acreage which was the subject of a lawsuit by owners of land adjacent to the plant. These stations were operated from November 1976 through July 1978 specifically to collect monthly airborne plutonium concentration data for the lawsuit. It was determined in 1978 that data collected from the lawsuit-

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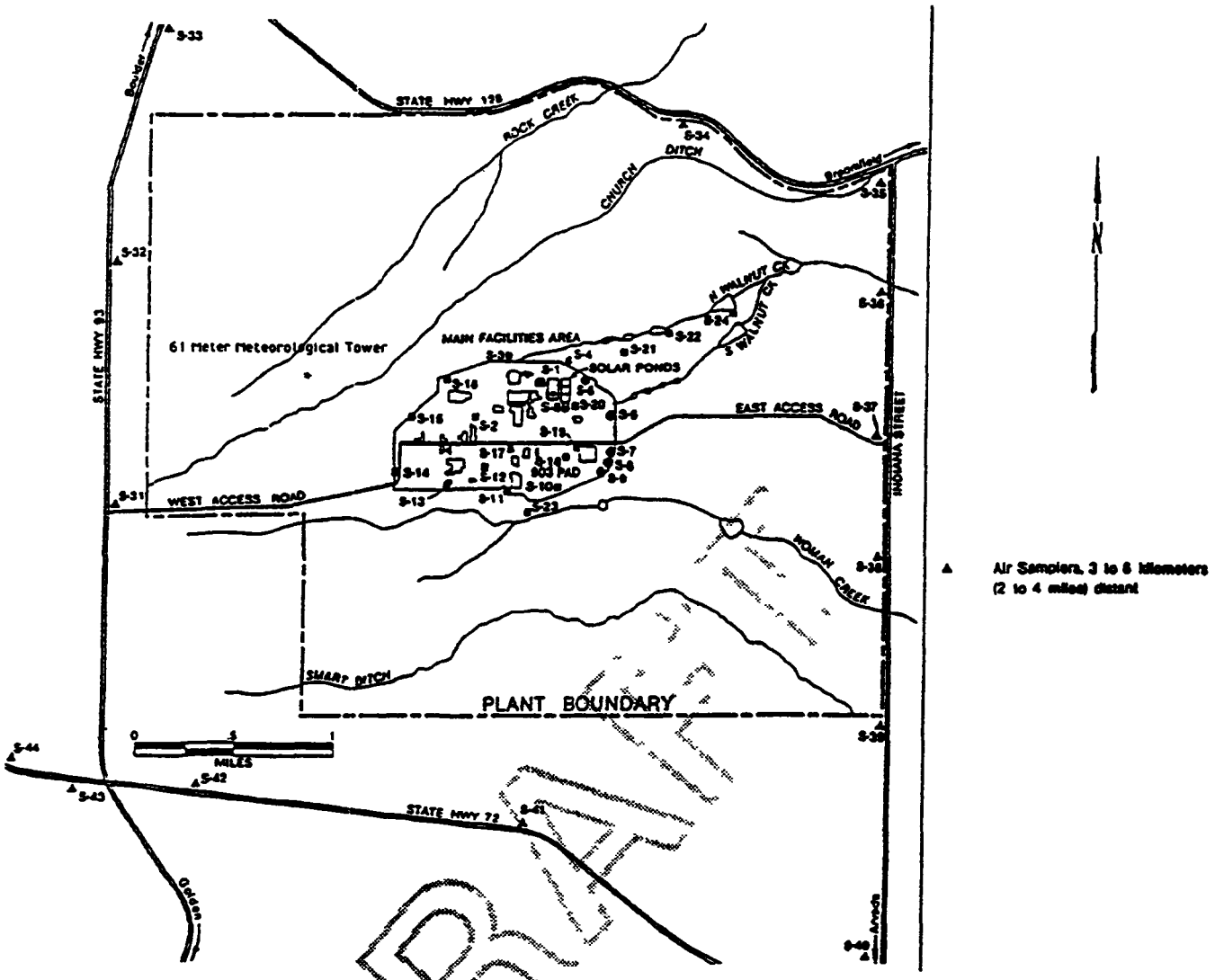

NOTE PORTIONS OF FIGURE ARE NOT TO SCALE

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Figure 1-7
LOCATION OF ONSITE AND PLANT PERIMETER AMBIENT AIR SAMPLERS

SOURCE EG&G ROCKY FLATS "ROCKY FLATS PLANT MONTHLY ENVIRONMENTAL MONITORING REPORT"

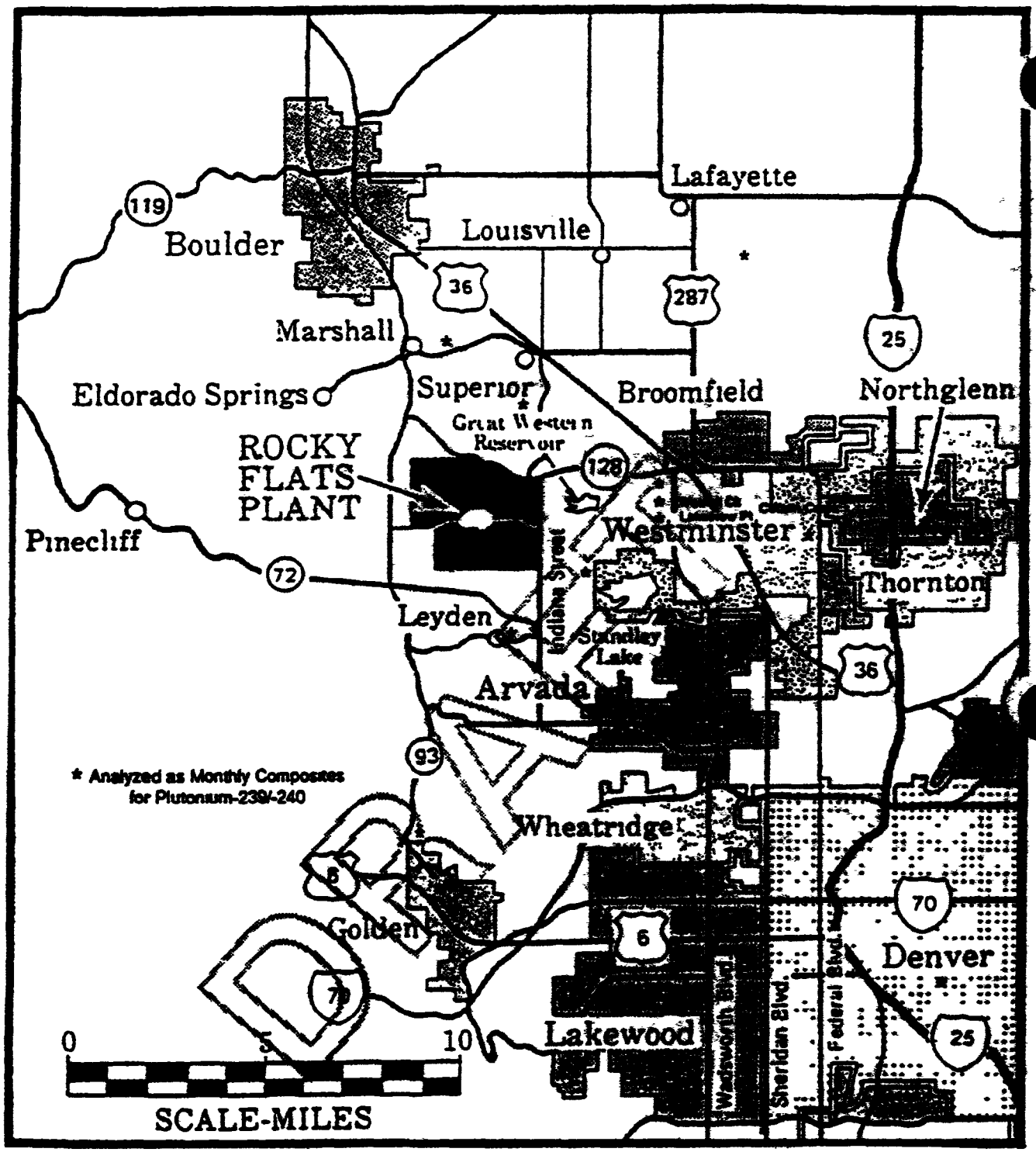

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Figure 1-8
LOCATION OF COMMUNITY AMBIENT AIR SAMPLERS

SOURCE EG&G ROCKY FLATS "ROCKY FLATS PLANT MONTHLY ENVIRONMENTAL MONITORING REPORT"

specific stations did not significantly differ from nearby ambient air monitoring program sampler data, and the lawsuit-specific stations were therefore removed (Rockwell, 1978)

Airborne plutonium concentrations were monitored by the RFP immediately downwind of the remedy acreage during court-ordered tilling to supplement data obtained from permanent stations downwind of the acreage A tabulation of the 1987 remedy-specific monitoring data is included in Rockwell (1988b) A summary of average annual ambient air plutonium concentrations from selected monitoring stations near the remedy acreage during the period of remedial activity (1985 to 1988) is provided in Rockwell (1989a)

1 3 8 2 Effluent Air Monitoring

RFP effluent air has been monitored since RFP opened in 1951 Effluent air monitoring is addressed in detail in RFP monthly and annual environmental monitoring reports (Dow et al , 1971 to date) and in the RFP Environmental Impact Statement (DOE, 1980). Continuous effluent air samplers are located in the ventilation exhaust systems of each production and research building at the RFP As is the case with the ambient air monitoring program, the sampling and analytical protocols for effluent air monitoring have varied throughout the history of the RFP Plutonium analysis of selected effluent air samples began in 1975, prior to this, airborne effluents were analyzed for total long-lived alpha radiation only Under current protocol effluent air samples are analyzed at regular intervals for total long-lived alpha activity Individual samples from each exhaust system are composited monthly into area-specific samples, which are analyzed for plutonium, americium, uranium, and beryllium Exhaust streams known to potentially contain tritium are also analyzed for tritium concentration three times each week.

1 3 8 3 Soil Monitoring

Beginning in 1984, soil samples have been collected annually by the RFP to evaluate changes in soil plutonium concentrations. The soil monitoring program is addressed in detail in the RFP annual environmental monitoring reports (Dow et al , 1971 to date) Under current protocol, soils samples are collected once per year from 40 sites located on concentric circles 1 and 2 miles (1 6 and 3 2 km) from the center of the RFP and are analyzed for plutonium A similar soil sampling program was conducted in 1977, with the addition of 17 samples collected from locations on a circle 5 miles (8 km) from the RFP center

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The CDH also monitors soil plutonium concentrations in areas near the RFP (CDH, 1990a) Under this program, five subsamples are collected within each of 13 predefined sectors near the RFP and composited into a single sample, which provides an average soil plutonium concentration within the sector Soil samples also are collected from eight Colorado locations remote from the RFP in order to assess soil plutonium concentrations due to worldwide atmospheric fallout. The CDH soil sampling program was conducted annually between 1970 to 1978, and in 1980, 1981, 1986, and 1989. Results are published in RFP environmental surveillance reports prepared monthly by CDH, (CDH, 1970 to date) A summary table of results between 1970 to 1986 is included in CDH (1990) Several of the past sampling programs, including the 1989 program, have included analysis of selected radionuclides other than plutonium and of beryllium (CDH, 1990a)

1 3.8.4 Surface Water Monitoring

Routine monitoring of surface water within and around the RFP, of all effluent streams leaving RFP, and of tap water in municipalities around the RFP has been conducted since shortly after RFP opened in 1951 Specific sampling and analytical protocols have varied throughout the history of the surface water monitoring program. Information regarding sample locations, analytical protocols, analytical results, and compliance with applicable state and federal water quality standards has been summarized since 1971 in the RFP monthly and annual environmental monitoring reports (Dow et al., 1971 to date). The surface water monitoring program is also summarized in the environmental impact statement for the RFP (DOE, 1980)

Water quality in Great Western Reservoir and offsite reaches of Walnut Creek is routinely monitored by the City of Broomfield and CDH. Broomfield samples Walnut Creek at a location immediately east of the RFP on a monthly basis and tests for eight volatile organic compounds (VOCs) An automatic sampler at the same location collects a composite water sample each week for gross alpha and gross beta analysis. Weekly samples also are collected by Broomfield from Walnut Creek below Great Western Reservoir and analyzed for gross alpha and gross beta. Water entering the Broomfield water treatment plant from the reservoir is monitored monthly for eight VOCs. Treated Broomfield tap water is also monitored weekly for gross alpha and gross beta, and monthly for eight VOCs (CDH, 1989) CDH conducts quarterly sampling of Great Western Reservoir for selected herbicides, pesticides, metals, base neutral acids (BNAs), and radionuclides. Broomfield water treatment plant influent from Great Western Reservoir is analyzed weekly by CDH for selected radionuclides (CDH, 1990b)

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The cities of Northglenn Thornton, and Westminster each monitor raw water influent from Standley Lake at their respective water treatment plants for VOCs gross alpha, and gross beta. Westminster also monitors treated tap water for gross alpha and gross beta. Woman Creek is sampled immediately east of the RFP boundary once each month by the City of Thornton and is analyzed for 59 VOCs. Another location along Woman Creek is sampled weekly for gross alpha and gross beta analysis Standley Lake water is sampled monthly near the Westminster treatment plant inlet and analyzed for 59 VOCs Water is also sampled monthly near the Standley Lake dam at six different depths and analyzed for gross alpha and gross beta (CDH, 1989) CDH conducts quarterly sampling of Standley Lake for analyses of selected herbicides, pesticides, metals, BNAs, and radionuclides Westminster water treatment plant influent from Standley Lake is analyzed weekly by CDH for selected radionuclides (CDH, 1990b)

The RFP, CDH, and municipal monitoring programs have produced a large volume of data to assess the potential impacts from RFP releases on surface water. The monitoring is conducted in part to ensure that the RFP meets applicable state and federal water quality standards. Applicable standards have varied since the opening of the RFP in 1951 Currently applicable standards for the RFP include

- **The National Pollution Discharge Elimination System (NPDES) standards** for the RFP, first issued in 1974, which limit nonradioactive discharges from the plant

- **State drinking water standards** for radioactive contaminants in community water systems, promulgated in 1977

- **Colorado Water Quality Control Commission (CWQCC) water quality standards** for both radioactive and nonradioactive contaminants, which were adopted in July 1989 for the upper segments of Big Dry Creek basin

Descriptions of these standards, and information about RFP compliance with the standards, are contained in the RFP monthly and annual environmental monitoring reports (Dow et al, 1971 to date)

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1 3 8.5 Groundwater Monitoring

A total of 56 groundwater monitoring wells were installed at the RFP between 1960 and 1985 Most of these wells were located within the controlled area of the plant (Figure 1-1) and targeted specific sites of suspected groundwater contamination. Limited completion data and sampling data are available for these pre-1986 wells. The sampling frequency for these wells varied from quarterly to biannually Until 1985, samples were analyzed for selected radionuclides only; beginning in 1985, other chemical parameters (volatile organic compounds, metals, and inorganics) were added (Rockwell, 1989b)

In 1986 and 1987, 136 monitoring wells were installed as part of the DOE Comprehensive Environmental Assessment and Response Program (CEARP) for the RFP CEARP later became the ER Program (Subsection 1 1) These wells were drilled in part to meet RCRA requirements for the four regulated units at the RFP, and also targeted other known IHSSs at the plant. The 1986 wells included four wells along the eastern boundary of the RFP (downgradient of the main production facility) to assess potential contaminant movement offsite through groundwater Also included were background characterization wells in onsite areas believed to be unaffected by releases from the RFP (Rockwell, 1989b) An additional 153 wells were installed in 1989 to further characterize the hydrogeology of the RFP, including three additional wells along the eastern RFP boundary (EG&G, 1990b)

The current network of 346 monitoring wells is sampled quarterly and analyzed for selected radionuclides, metals, organics, and anions, and for total dissolved solids. Monthly and/or quarterly water level measurements are taken in selected wells to assess groundwater flow direction. More detailed information regarding the RFP groundwater monitoring program is provided in the RFP annual environmental monitoring reports (Dow et al., 1971 to date). Groundwater monitoring results for RCRA-regulated units at the RFP have been provided since 1988 in annual RCRA groundwater monitoring reports (Rockwell, 1989b, EG&G, 1990b)

1 3.9 Other OU Activities

Sixteen operable units have been identified at the Rocky Flats Plant under the Rocky Flats IAG as in Subsection 1.2. Under the IAG, DOE is required to conduct RI/FS/RFI/CMSs for the operable units. The operable units that OU 3 will interact with include OUs 2, 5, and 6.

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OU 2 studies are investigating Pad 603 which is believed to be the source area for contamination associated with OU 3 OUs 5 and 6 studies are investigating Woman Creek and Walnut Creek respectively The drainages from these creeks flow offsite and into OU 3 Work efforts for OU 3 will be coordinated with efforts at OUs 2, 5 and 6 As information from other OUs becomes available the data will be reviewed and incorporated into OU 3 work, as appropriate

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OU 3 is unique among RFP OUs in that it is located outside the RFP boundaries The locations of each of the four IHSSs (Sites) in OU 3 relative to the RFP are shown in Figure 2-1 Subsections 2.1 through 2.4 describe site conditions, previous environmental investigations, and available information regarding the nature and extent of contamination for IHSSs 199 through 202, respectively Conceptual models for contaminant fate and mobility in soils (IHSS 199) and reservoirs (IHSSs 200 to 202) are developed in Subsection 2.5

2.1 IHSS 199 (CONTAMINATION OF THE LAND'S SURFACE)

IHSS 199, Contamination of the Land's Surface, specifically targets offsite soil contamination as a result of RFP releases Included within IHSS 199 are approximately 350 ac (142 ha) of land which were the subject of a 1975 lawsuit filed in U S District Court (Civil Action No 75-M-1162) by the land owners against the United States and other defendants (hereafter referred to as the lawsuit), alleging contamination of the land surface by releases from the RFP during its operating history Several technical investigations and studies of the lawsuit acreage were conducted by the various parties to the lawsuit to provide supporting evidence in the case A Settlement Agreement finalized in July 1985 (the Settlement Agreement) (U S. District Court, 1985a) required that the RFP undertake remedial action on those portions of the land (hereafter referred to as the remedy acreage) containing plutonium at concentrations exceeding an action level adopted by the court from a CDH special construction standard for plutonium in soil of 0 9 pCi/g (0 03 Bq/g) Two contiguous tracts of land, which currently are owned by the City of Broomfield and Jefferson County, were targeted for remediation based upon the CDH standard To date, remedial activities have been undertaken on 120 ac (49 ha) of Jefferson County remedy acreage (Subsection 2.1 2.2)

2.1 1 Location and Description

As presently defined IHSS 199 includes all soils outside of the RFP boundary which are contaminated by releases from the RFP The IHSS 199 boundary, therefore, is delineated by the extent of offsite contamination, which has not been conclusively defined Previous work which has attempted to determine this extent is detailed in Subsection 2.1 4 2 Past attempts to define the presence and

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extent of offsite soil contamination have focused almost exclusively on airborne plutonium emissions from the RFP

The remedy acreage is located on two contiguous tracts of land totalling 350 ac (142 ha) in the southern half of Section 7 and the western half of Section 18, Township 2 South Range 69 West (T2S, R69W) Both areas are just outside the eastern boundary of the RFP, approximately 1 5 miles (2.4 km) east of the main production area of the plant (Figure 2-1) Both are generally downwind and downgradient of the RFP

2 1 2 History of IHSS 199

Under the terms of the 1985 Settlement Agreement with landowners a 250-ac (101 hectare) tract of land was transferred to Jefferson County for use in its Open Space program, and 100 adjoining ac (41 ha) were allotted to the City of Broomfield for future expansion of Great Western Reservoir These lands were deeded with the understanding that the RFP would implement remedial activities on these 350 ac (142 ha) as specified in the Settlement Agreement, at the request of the owners Jefferson County requested in 1986 that remediation commence on the portions of their acreage targeted for remediation To date, the remedy has been implemented on 120 of the 250 ac of Jefferson County land Rather than allow immediate use of the acreage as Open Space, the county has chosen to not allow public access to this land until the remediation is completed To date, Broomfield has not requested that the RFP begin remediation on their affected acreage, and has not proceeded with plans to expand Great Western Reservoir Broomfield does not allow public access to this land

The following sections summarize the legal history of IHSS 199 and describe the remedial actions undertaken to date at the site as a result of the Settlement Agreement

2.1 2.1 History of Litigation

In May 1975, a lawsuit was filed against Rockwell International Corporation, Dow Chemical Company, and the United States of America by the Church (McKay) plaintiffs and Great Western Venture partnership (U S District Court, 1985b) The plaintiffs holdings consisted of approximately 2,000 ac (810 ha) to the west south and east of the RFP The plaintiffs alleged that their lands were damaged by releases of plutonium and other radioactive materials from the RFP The plaintiffs claimed that these materials had rendered their land unfit for human habitation and had diminished

the market value of their properties for commercial, residential or other nonagricultural uses. The plaintiffs further claimed that the mere presence of the RFP next to their property further diminished the value of their properties. The defendants acknowledged that releases of radioactive materials occurred at various times from the 1950s through the late 1960s, but contended that the releases had not violated applicable regulations established for the protection of the public (U S District Court, 1985b)

On the basis of scientific exhibits presented early in the proceedings and objections raised during the hearings, the parties agreed to conduct a field investigation on the plaintiffs' lands that would include collection and analysis of soil samples for plutonium and americium. Prior to commencement of the field investigation, the parties agreed to specific methodologies for collecting, preparing, and analyzing the soil samples (Rockwell, 1979) The field investigation program commenced in 1977 and continued through 1979. Results of the program indicated plutonium concentrations on the plaintiffs' properties ranging from <0 01 to 3.4 pCi/g (3.7×10^{-4} to 0.13 Bq/g) (CDH, 1977; Rockwell, 1979a; Rockwell, 1979b) After additional testing, the parties agreed to accept some of the data as evidence for the trial (U S. District Court, 1985b).

In March 1978, the Ackard-Butler interests intervened in the legal proceeding and were added to the lawsuit as plaintiffs. Church and Ackard-Butler added, by amended complaint, the State of Colorado and Jefferson County, Colorado as defendants in 1982, claiming that if the government defendants prevailed in this litigation, then the State and County had acted unlawfully in precluding development of plaintiffs' lands. In 1982, the court dismissed the plaintiffs' claims for lack of jurisdiction, ruling that the issues were not determinable under Rule 56. In 1983, the Tenth Circuit Court of Appeals reversed this ruling, stating that the plaintiffs were entitled to a trial or trials on some of their claims.

In December 1984, a settlement was reached between the defendants and plaintiffs (U S District Court, 1985a) The Settlement Agreement, as amended on July 2, 1985, called for ripping, plowing and discing (referred to generically in this report as "tilling") of affected soils to reduce plutonium concentrations to less than the CDH special construction requirements standard of 0.9 pCi/g (0 03 Bq/g) Historical incidents (such as in Palomares, Spain, circa 1960) established a precedent for tilling plutonium contaminated lands, which reduces the concentration of plutonium by dispersing it throughout the soil (Lawton, 1990) Results of soil sampling during 1977 indicated that plutonium levels in several tilled wheat fields on the plaintiffs' property were consistently lower than levels on adjacent undisturbed ground. The agreement required the RFP to conduct additional soil sampling

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to verify that plutonium concentrations were reduced, and to revegetate the tilled soils to provide stabilizing vegetation Specific standards for evaluating the success of revegetation were not included in the agreement. The option of remediating the land through "other processes" was left open in the agreement. The selected remedial actions were jointly agreed upon by Rockwell International, DOE and CDH One of the conditions of the agreement was the preparation and dissemination by the RFP of an annual status report on remediation progress. The RFP currently provides semiannual status reports The Settlement Agreement also made provisions in the event there are any future release(s) from the RFP If a release occurs, the RFP must demonstrate that contaminants on affected properties do not exceed applicable standards

Court-supervised soil sampling was conducted in 1985 on the affected lands according to CDH sample collection protocol (Rockwell, 1985a, Rockwell, 1985b) Approximately 350 ac (142 ha) of land with concentrations of plutonium greater than 0 9 pCi/g (0 03 Bq/g) were delineated by the sampling program. These areas, which were subsequently transferred to Jefferson County and the City of Broomfield, are the only land to which the Court-ordered remedial action applies. Another 490 ac (198 ha) pertinent to the settlement did not exceed the soil plutonium concentration limit and therefore were not targeted for remedial action.

The 1985 sampling data corroborated earlier observations that areas originally cultivated with wheat contained substantially lower concentrations of near-surface plutonium It was also noted that average plutonium concentrations in the surficial soil appeared to have decreased significantly between 1977 and 1985 This apparent decrease may have been due to plutonium migration (see discussion in Subsection 2.5 1 4) The lower values may also have resulted from (1) the use of different laboratories utilizing differing analytical techniques, (2) the significantly larger area represented by the 1985 samples (10 ac [4 ha] per sample) as compared to the 1977 samples (0 2 ac [0 08 ha] per sample) (Rockwell, 1987a), or, (3) soil sampling techniques used during the two studies

On May 28, 1986, Jefferson County requested that the remedial actions be undertaken on their lands (Rockwell, 1988c) To date, the City of Broomfield has not requested that their lands be remediated

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2.1.2.2 Remediation of Jefferson County Lands

Soil remediation currently is underway on approximately 250 ac (101 ha) of Jefferson County lands The following sections address the scope of the remedial activities and the history and present status of the remediation

2.1.2.2.1 Scope of Soil Remediation. The July 1985 amended Settlement Agreement outlines a specific course of remedial action for plutonium contaminated lands. The nature and scope of remedial actions were developed and agreed upon by Rockwell International, DOE, and CDH. Recommendations concerning erosion control and revegetation were provided by the U S Department of Agriculture Soil Conservation Service (SCS) on behalf of Rockwell. It should be noted that, because of concerns over soil stabilization, the SCS concluded that it would be best to leave the affected lands undisturbed rather than to attempt remediation (SCS, 1985)

The Settlement Agreement specifies the following remedial actions (U.S. District Court, 1985b)

- Spring ground preparation (plowing and discing ["tilling"] to reduce plutonium concentrations through mixing and dilution) plus a summer (June) cover crop
- Drilling grass seed into cover crop stubble in the fall
- Supplemental mulch
- Timely irrigation during the establishment period
- Weed control to ensure successful establishment of grasses

More specifically, the Settlement Agreement requires that the remediation shall consist of the following remedial actions, any of which may be modified by agreement between the owner of the land and the RFP·

- **Erosion Control**–Small areas of land may be worked on all at once, but larger areas will require a phased approach. Land shall be broken out in alternating strips perpendicular to the prevailing winds or, on long slopes, on the contour Strip widths shall be determined by a number of site-specific variables, including soil

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characteristics, slope length and gradient, vegetative cover, and field width Work on the other set of strips shall not begin until the first set is successfully reestablished in grass Properly done, this will minimize erosion in "normal weather There shall be some standby provisions for emergency erosion control such as extra mulching and sediment-trapping diversions, in the event of unusual weather

- **Soil Preparation**—May is the logical time for the plowing, discing, chiseling, and harrowing operations necessary to satisfy the soil mixing objective of the remedial action plan and to prepare a seedbed for the cover crop The frequency of tillage required depends on successful reduction of soil plutonium concentrations to the remedy action level Additions of nitrogen and phosphorous shall be made as necessary

- **Cover Crop**—The revegetation scheme utilizes a cover crop (forage sorghum) which will be planted in June when the soil has warmed to 60°F (16°C)

- **Grass Seeding**—Grass shall be drilled into the ground after November 1

- **Mulch**—The cover crop should leave adequate residue for soil protection. If it is insufficient in some areas, mulch will be needed.

- **Supplemental Irrigation**—Timely irrigation through establishment of the grass seed mix shall be used to improve the chances for a successful planting Supplemental irrigation may also be required during establishment of the cover crop

- **Special Conditions**—In order to prevent possible resuspension of plutonium on the soil surface, the mixing operation will be conducted only when the soil moisture content is greater than 15 percent and the wind velocity is less than 15 mph (24 km per hour) Portable air samplers will be operated downwind from the soil mixing operations during all phases of the program The samples will be analyzed for plutonium and all activities will be shut down if the plutonium concentration in the air exceeds a control level of 0 02 pCi/cubic meter (7 4 x 10^{-4} Bq per cubic meter)

- **Maintenance**—Areas that do not develop satisfactory ground cover in a reasonable length of time (two growing seasons) would be reseeded after an evaluation of the

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circumstances by representatives of Rockwell (now EG&G) and the land owners involved.

2.1.2.2.2 **Effectiveness of the Remedy Implementation.** Court-ordered remedial actions taken to date on the Jefferson County remedy acreage are summarized in Table 2-1 These actions are addressed in much greater detail in the remedy status reports prepared by the RFP under the terms of the Settlement Agreement. Six remedy status reports have been prepared to date (Rockwell, 1987a, Rockwell, 1987b, Rockwell, 1988d, Rockwell, 1989c; EG&G, 1990c; EG&G, 1991c)

As indicated in Table 2-1, remedy actions have been implemented on two plots of Jefferson County remedy acreage, a 20 ac (8 ha) plot in Section 18, T2S, R69W (the southern area) and a 100-ac (41 hectare) plot in Section 7, T2S, R69W (the northern area). The southern and northern areas have been tilled in strips as an erosion control measure, as shown in Figures 2-2 and 2-3, respectively Tilling of these 120 ac appears to have successfully reduced soil plutonium concentrations to below the 0.9 pCi/g (0.03 Bq/g) CDH standard adopted by the court as a remedy action level. Attempts to stabilize the tilled soils through revegetation have met with mixed success to date. The outcome of the revegetation effort appears to result from the following factors (EG&G, 1990c; EG&G, 1991c)

- Insufficient amounts and/or seasonal distribution of precipitation
- Extremely rocky surfaces or clayey soils
- Intense competition from weeds
- An expanding prairie dog population
- The effects of slope on soil moisture.

The 1990 remedy status report (EG&G, 1990c) proposed specific actions to improve the revegetation effort, which at the time was estimated to be only 10 percent successful. Between 1988 and 1990, the RFP operating contractor changed from Rockwell International to EG&G, and several key personnel changes occurred within the EG&G group responsible for implementation of the remedy As a result, the remedy actions proposed in the 1990 report were not implemented.

The January 1991 remedy status report (EG&G, 1991c) provides the latest available assessment of the revegetation effort. This report indicates that, after a successful 1990 growing season, planted grasses have become established on approximately 50 percent of the northern (Section 7) acreage,

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TABLE 2-1

IHSS 199 REMEDY ACTIONS

Dates	Activity	Result
June 1986	Soil tilling and subsequent seed bed preparation of the northern area (approximately 100 ac) in Section 7	Partial success, approximately 80 ac were successfully remediated and approximately 20 ac exceeded the plutonium concentration standard
July 1986	Initiated application of sorghum seed on the approximately 80 ac successfully remediated in Section 7	First sprouts appeared 08/04/86
July 1986	Second tilling operation of the approximately 20 ac in Section 7 where the initial effort was unsuccessful This operation consisted of tilling the area three more times.	Unsuccessful, plutonium concentration exceeded the standard
July 1986	Third tilling operation of the approximately 20 ac in Section 7 This operation consisted of deep plowing an additional three times and one application of a Vibrashank ripper	Successfully remediated
August 1986	Planted the additional 20 ac in Section 7 with sorghum seed	Sorghum stopped growing in October and wilted after the first frost.
October to November 1986	Applied wild grass seed to the approximately 20 ac in Section 7	Failure
June 1987	Ripped the approximately 100 ac in Section 7 and replanted sorghum seed	Successful, sorghum came up well
June to July 1987	Plowed and ripped the southern area (approximately 20 ac) in Section 18	Partial success, approximately 15 ac were successfully remediated and the remaining approximately 5 ac exceeded the plutonium concentration standard
July 1987	Replowed and ripped approximately 5 of the 20 ac in Section 18 which exceeded the plutonium concentration standard	Successfully remediated
November 1987	Conducted weed control on the approximately 100 ac in the North Area in Section 7 that were remediated. The area was sprayed with Roundup herbicide The primary target was cheatgrass	Very successful
November 1987	Conducted weed control by discing the approximately 20 ac of remediated land in the South Area in Section 18	Unknown

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TABLE 2-1

IHSS 199 REMEDY ACTIONS
(Concluded)

Dates	Activity	Result
November to December 1987	Performed erosion control measures consisting of planting winter wheat and the placement of mulch on the surface of the 20 ac of remediated land in Section 18.	Successful, subsequent inspections revealed little erosion was occurring.
April 1988	Reseeded grasses on the approximately 120 ac of remediated land in Sections 7 and 18	Poor to marginal success, native grasses successfully established on only about 10 percent of the area.[a]
January 1991	Collected soil samples from both tilled and untilled areas in the Jefferson County acreage. This was performed because soil samples collected in 1986 and 1987 do not meet current quality assurance protocols.	Analytical results pending.

[a]Past Remedy Report, Operable Unit No. 3, IHSS 199 (Appendix D, Document D-16) (DOE, 1991a) indicates that a successful 1990 growing season significantly reduced the amount of area requiring reseeding.

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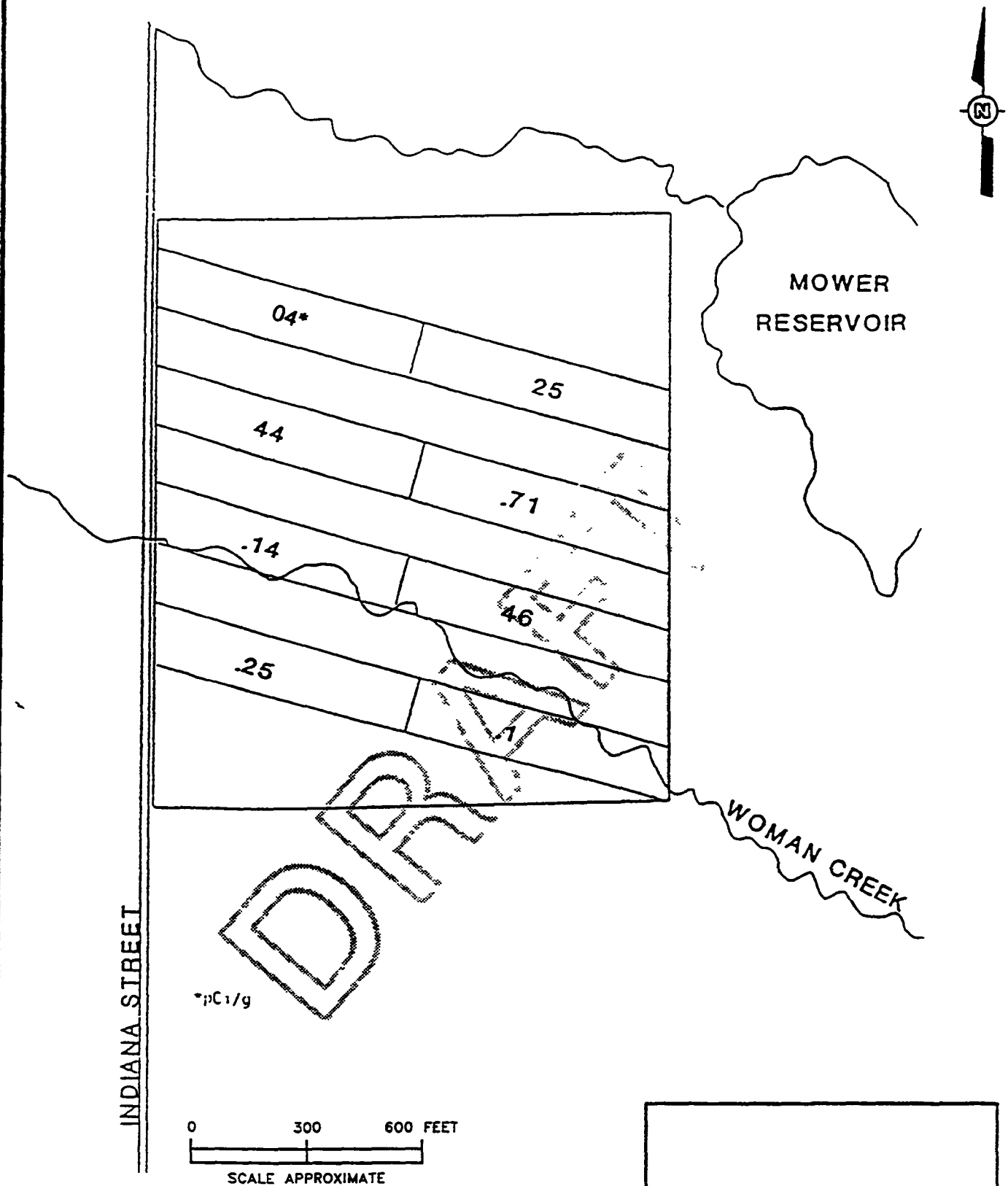

NOTE.
VALUES SHOWN IN STRIPS ARE AVERAGE SOIL PLUTONIUM CONCENTRATION IN pCi/g AND REPRESENT POST-TILLING CONDITIONS.

SOURCE ROCKWELL INTERNATIONAL, "REMEDIAL ACTION PROGRAM ON JEFFERSON COUNTY OPEN SPACE LAND STATUS REPORT FOR PERIOD JANUARY 15 1987 TO OCTOBER 15 1987"

Figure 2-2
REMEDY ACREAGE TILLED STRIPS - SECTION 18

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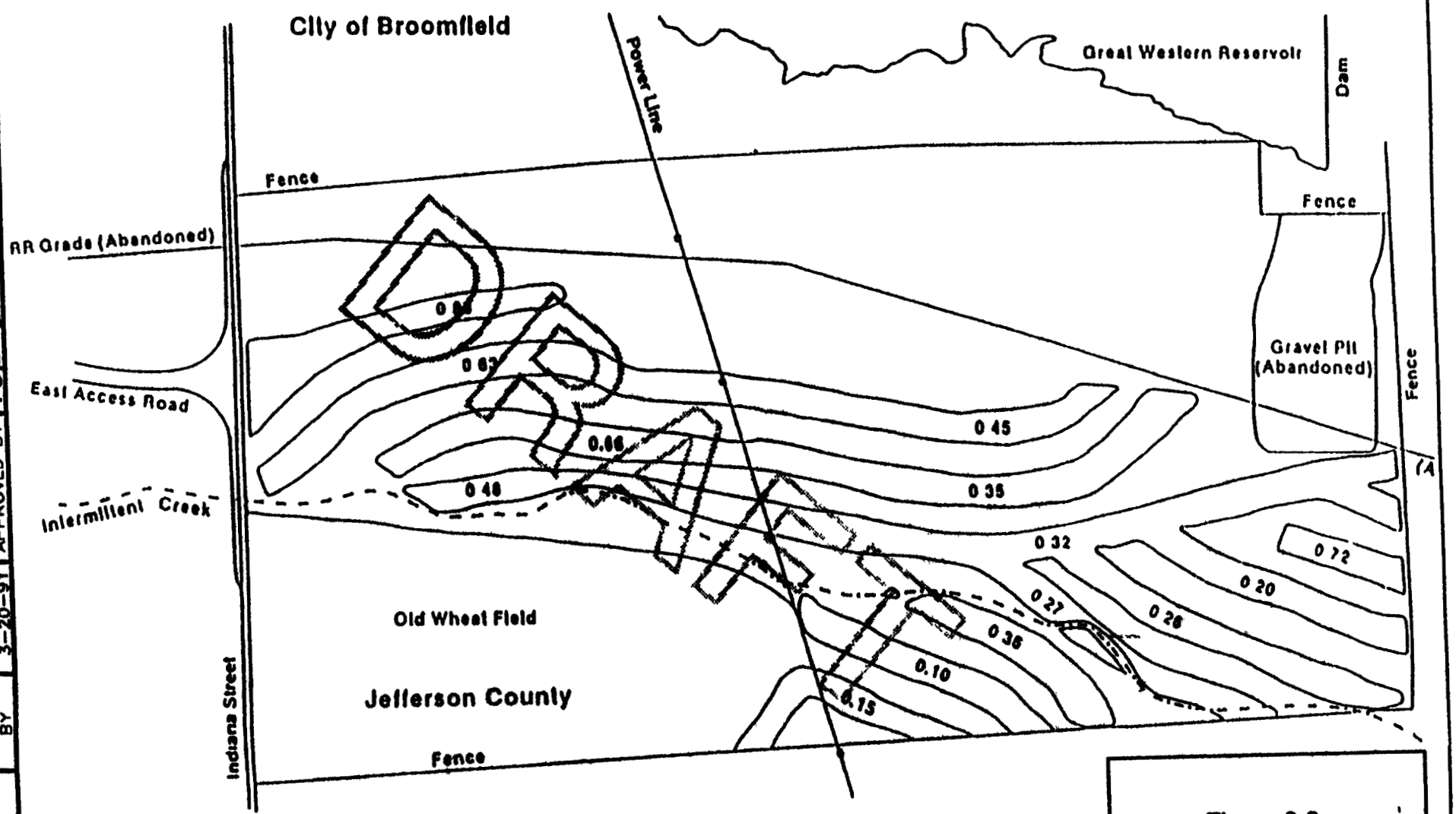

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NOTE:
VALUES SHOWN IN STRIPS ARE AVERAGE SOIL PLUTONIUM CONCENTRATION IN pCi/g AND REPRESENT POST-TILLING CONDITIONS.

SOURCE ROCKWELL INTERNATIONAL, "REMEDIAL ACTION PROGRAM ON JEFFERSON COUNTY OPEN SPACE LAND STATUS REPORT FOR PERIOD JANUARY 15, 1987 TO OCTOBER 15, 1987"

0 300 600 900 1200 FEET
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Figure 2-3
REMEDY ACREAGE
TILLED STRIPS
- SECTION 7

significantly reducing the amount of land requiring reseeding The January 1991 report proposes the following actions to facilitate revegetation of the remaining acreage

- Weed control
- Prairie dog suppression
- Change of seed mixture

Irrigation of the revegetated areas, which was proposed in the 1990 Remedy Status Report (EG&G, 1990c), is not being considered because of water quality issues in using RFP water for irrigation and concerns over surface runoff transport of contaminants from the remedy acreage

Because soil samples collected from the remedy acreage in 1986 and 1987 (Table 2-1) do not meet current quality assurance protocols, soil samples were collected again in January 1991 from both tilled and untilled Jefferson County acreage to confirm the soil plutonium concentrations on these lands. These samples will be analyzed for plutonium and americium, and the results reported as soon as they are available (EG&G, 1991c)

2.1 3 IHSS 199 Conditions

The following sections address the soils, hydrology, and biota of IHSS 199 Because IHSS 199 boundaries have not been conclusively defined, and because site conditions at the IHSS 199 remedy acreage adjoining the RFP have been studied in detail, the following descriptions focus primarily upon studies of the remedy acreage

2.1 3 1 Soils

A general description of the soils in the IHSS 199 areas east and south of the RFP is provided in the SCS Soil Survey of the Golden Area, Colorado (SCS, 1980) According to this survey, soils in the area are characteristically well drained, clayey and loamy soils on high terraces, hill slopes, and fans. The primary soil type in this area is mapped by the SCS as Nunn-Denver complex, comprised of approximately 45 percent Nunn, 25 percent Denver, and 30 percent other soil types and Urban land Nunn and Denver soils are deep and well drained, and form from clayey material derived predominantly from mudstone and shale The surface layer is a clay loam The Nunn subsoil is a clay loam to a depth of 60 in (152 cm), while the Denver subsoil is clay to the same depth The

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SCS also notes that Primen and Leyden soil units occur within the area on gravelly and cobbly hill slopes.

Soil characteristics in the IHSS 199 remedy acreage were considered by the SCS in providing erosion control and revegetation recommendations for the remedy (SCS, 1985) The soils were characterized as Denver-Kutch-Midway clay loams, estimated at 50 percent Denver, 30 percent Kutch, and 20 percent Midway, with Denver and Kutch soils on hill slopes and Midway soils on ridge crests. Establishment and maintenance of grasses and other vegetation in the Denver-Kutch-Midway soil complex are restricted by the slope, the clay loam surface layer and clayey subsoil, and, on the Midway soil, shallow depth to bedrock. The complex is described as generally unsuitable for cultivation due to the high risk of erosion. When attempting to vegetate the soil, supplemental irrigation at planting time and during dry periods is recommended (SCS, 1980)

The SCS estimated annual soil loss rates because of water and wind erosion for northeast-facing slopes at the remedy acreage under worst-case conditions (such as bare soil) and under remedial activity conditions (such as tilled, with a cover crop). Total annual loss through water and wind erosion may range from 93 to 143 tons per ac (209 to 321 metric tons per ha) under worst-case conditions. This loss would be reduced to 13 to 22 tons per ac (29 to 49 metric tons per ha) under remediation without using protective mulch between plowing and establishment of a cover crop. If such a mulch was used, the loss due to erosion is predicted to be 1 to 3 tons per ac per year (2.2 to 6.7 metric tons per ha per year), almost exclusively attributable to water erosion. Gullying, which might increase the total loss in the worst-case scenario, was identified as a likely problem if the land was not adequately protected during remedial activities (SCS, 1985)

Soil conditions may have changed on the remedy acreage as a result of court-ordered remediation. In particular, the following changes may have occurred as a result of tilling:

- Increased erosion potential due to vegetation loss
- Mixing of soil horizons and redistribution of rock fragments
- Loss of plant nutrients, particularly nitrogen, through leaching
- Loss of organic matter through increased oxidation
- Loss of soil structure

It should be noted that water erosion does not appear to be a common or significant problem on undisturbed soil surfaces in and around the IHSS 199 remedy acreage. It is believed, therefore, that

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successful revegetation of the remedy acreage will greatly reduce the contribution of surface runoff and erosion to plutonium transport at IHSS 199

Revegetation of IHSS 199 remedy acreage has been hampered by abundant cobbles in the soil, which were brought to the surface by tilling Surface accumulations of cobbles are estimated to cover some 30 percent of the 120 tilled ac and in some areas cover nearly 90 percent of the surface (EG&G, 1990c, EG&G, 1991b) An inactive gravel pit is located in the northeastern corner of the Section 7 remedial acreage It can be inferred from these observations that the rock fragment content of some portions of the remedy acreage soil is appreciable perhaps 15 to 20 percent or more by volume

2.1 3 2 Surface Water

The City of Broomfield remedy acreage in Section 7 abuts Great Western Reservoir to the north The Jefferson County remedy acreage in Section 18 surrounds Mower Reservoir (IHSS 202) Mower Reservoir is fed by a diversion from Woman Creek, which flows from the southern part of the RFP Outflow from Mower Reservoir discharges to the east, eventually entering Standley Lake. Woman Creek itself traverses the southern end of the Jefferson County remedy acreage before discharging to Standley Lake (IHSS 201)

Existing slopes at and near the remedy acreage are 2 to 15 percent, generally to the east. Slopes to the west also are present (SCS, 1985) Most of the remedy acreage drains into two ephemeral channels which flow southeast from the acreage into Standley Lake (IHSS 201) (USGS, 1980) Portions of the northernmost City of Broomfield remedy acreage in Section 7 drain north into Great Western Reservoir (IHSS 200) The southernmost Section 18 remedy acreage drains directly into Woman Creek.

The frequency and amount of surface runoff depend upon several factors, including soil infiltration capacity, surface vegetation, and slope The clay loam soils at IHSS 199 are assumed to have relatively low infiltration capacity because of clay content, except where fractures may have significantly increased vertical permeability Vegetation cover, addressed in more detail in Subsection 2.1 3 4, is somewhat sparse, consisting mostly of native grasses and weeds. Parts of the 120 ac of remedy acreage tilled during 1986 to 1987 contain adequate to marginal ground cover of perennial grasses and weeds Some surfaces of the remedy acreage are poorly vegetated because of prairie dog

colonies and cobbles brought to the surface by tilling Application of mulch on this surface (see Subsection 2.1 2.2.2) would reduce the likelihood of surface runoff

2.1 3.3 Groundwater

Currently, there are no dedicated groundwater monitoring wells outside of the RFP eastern boundary Numerous privately-owned water wells, however, have been drilled just east of the RFP Limited information was obtained from drilling and filing records held by the Colorado Division of Water Resources. These records suggest that the thickness of surficial deposits ranges from 15 to 50 ft (4 6 to 15 m) and averages approximately 25 ft (7.6 m) near the remedy acreage. Surficial deposits typically are described in the well records as clay, sandy clay, or clay with gravel and boulders, locally capped by 5 or 6 feet of topsoil. The underlying bedrock is described in the well records as alternating layers of shale and sandstone, which is assumed to be a very generalized description of the Arapahoe Formation. Most of the wells studied were completed in sandstones at depths ranging from 35 to 275 ft (10.7 to 84 m) Static water levels averaged 10 to 50 ft (3.0 to 15 m) higher than the screened interval, indicating moderate pressure head in the sandstones. The static water level was 20 ft (6.1 m) in one well completed in the shallow aquifer (alluvium) in the southwest corner of Section 6, just north of the IHSS 199 remedy acreage (DWR, 1990).

2.1.3.4 Biota

Much of the land surface in OU 3 has been converted to land uses that no longer have native species or natural ecosystems. Disturbed land surfaces include cultivation for agricultural crops, roads and right-of-way, development for housing and commerce, and canals and reservoirs for water control and storage. Much of this land surface has secondary growth of vegetation including managed lawns and grasses, but most vegetated by is weedy and introduced species of plants that invade after disturbance Grazing is common on grasslands except the open space property of Jefferson County and the City of Broomfield.

IHSS 199 vegetation consists of native grasses and weeds, with various shrubs and small trees along drainages. Native grasses common to the area include western wheatgrass, green needlegrass, blue grama, and sideoats grama (SCS, 1980) Lands which have been tilled and seeded as part of remediation have been dominated in the early stages of regrowth by weeds, including Canadian, Russian and musk thistles, mustards, bindweed, and cheatgrass (Rockwell, 1989c) Although these weeds compete with the grasses planted at the remedy acreage, they provide fair

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but unreliable stabilization of soils As of late 1990, planted grasses have become established on approximately 50 percent of the northern (Section 7) remedy acreage and provide excellent soil stabilization Planted grasses were characterized as marginally established on 15 to 20 percent of the northern acreage and unestablished on 30 to 35 percent of the acreage owing primarily to surface cobbles and competition from weeds (EG&G, 1991c) The seed mix mandated by the Settlement Agreement includes western wheatgrass, sideoats grama, pubescent wheatgrass, and smooth brome (SCS, 1985) Winter wheat and sorghum also have been planted on these lands as winter cover to help prevent soil erosion during remediation

Fauna indigenous to IHSS 199 are believed to be similar to those described in Subsection 1 3 5 for the RFP area as a whole It has been noted that a significant prairie dog population has become established on the remedy acreage (EG&G, 1990c, EG&G, 1991c) The U S Fish and Wildlife Service has indicated that there are two endangered species of interest in the RFP--the bald eagle and the black-footed ferret (Rockwell International, 1988c) Prairie dog towns provide the food source and habitat for ferrets Bald eagles are common winter visitors in the areas near the reservoir

2.1 4 Nature of Contamination

Numerous studies have attempted to define the presence and extent of contamination at IHSS 199 as a result of RFP releases, and to identify prospective RFP source(s) of the contaminants As mentioned in Subsection 2.1 1, these past studies have focused almost exclusively on airborne plutonium releases from the RFP The OU 3 RFI/RI will investigate contaminants other than plutonium, as reflected in the Field Sampling Plan presented in Section 6 0 of this document.

2 1 4 1 RFP Contamination Sources

Krey and Hardy (1970) sought, among other goals, to identify onsite sources of the plutonium found in offsite soils These investigators focused on four sources which might conceivably have resulted in offsite contamination (1) a September 11, 1957 fire in Building 771 (Dow, 1973), (2) a May 11, 1969 fire in Building 776 (USAEC 1969, CCEI, 1970), (3) leaking drums of plutonium-contaminated lathe coolant at the 903 Pad a drum storage area in the southeastern part of the RFP main production area, and, (4) chronic low-level stack effluent. Based on the particle size of the contaminated soil fraction, meteorological data, and RFP monitoring records, the Krey and Hardy investigation concluded that the great majority of the plutonium at IHSS 199 originated as windborne

particulates from the 903 Pad, and largely dismissed the contributions of the 1957 and 1969 fires and chronic stack emissions. Contamination at the 903 Pad resulted from 55-gallon drums of plutonium-contaminated lathe coolant which corroded and leaked over a 10-year period starting in 1958 The 903 Pad was capped with asphalt in November 1969 effectively eliminating it as a direct source of contamination to IHSS 199 Numerous other investigations focusing on plutonium in offsite soils since the Krey and Hardy study have reinforced the conclusion that the 903 Pad was the primary source of offsite soil plutonium contamination from the RFP (Dow, 1971, Dow, 1972; CDH, 1977, Rockwell, 1979a, Rockwell, 1979b)

As discussed in Subsection 1.3.7, contaminants other than plutonium have been detected in the environment as a result of RFP releases. Available information on RFP IHSSs suggests that some of these other contaminants could potentially have impacted IHSS 199 through airborne transport from the RFP Possible sources include the on-site burning of wastes, including waste oils contaminated with trace amounts of uranium (IHSSs 128, 153, 154, and 171). A fire which breached the exhaust filters of a beryllium-machining building, possibly releasing airborne beryllium to the environment, has also been documented but has not resulted in the designation of an IHSS. A less plausible potential source is wind stripping of waste water from the solar evaporation ponds (IHSS 101, see Figure 2-1), incidences of which are documented in records from the Dow Chemical Waste Disposal Coordination Group Water from the solar ponds would have possibly contained trace amounts of radionuclides, nonradioactive metals, and inorganic ions. Knowledge of the fate and mobility of these potential contaminants in air and surface soils is critical in determining whether they could reasonably have impacted IHSS 199 and, if so, whether they still exist at the site today Contaminant fate and mobility are addressed in the conceptual model for off-site surface soils (Subsection 2.5.1) Available information from on-site and off-site RFP environmental monitoring (Subsection 1.3.8) and RFP OU investigations can be used to verify the predictions of the conceptual model and focus the selection of contaminants of concern (Subsection 6.2)

It is possible that onsite soils contaminated by the 903 Pad could in turn generate windborne particulates which might impact IHSS 199, as could any abnormal airborne emission from the RFP, including those generated by soil remediation and similar activities at onsite RFP OUs. Results from offsite air monitoring stations (Rockwell, 1989a) suggest that IHSS 199 has not been measurably impacted by airborne emissions from the RFP since the offsite air monitoring system was established in 1975. It is reasonable to expect that any future RFP emission potentially impacting IHSS 199 will also impact onsite soils and ambient air, and that the contamination will be detected through routine onsite air and soil monitoring (Subsections 1.3.7 1 and 1.3.7 3)

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2 1 4 2 IHSS 199 Contamination

In an attempt to delineate offsite plutonium contamination around the RFP Krey and Hardy (1970) established contours, in millicuries per square kilometer (mCi/km^2) for plutonium in soil around the RFP, based upon analytical results from 33 soil samples collected from locations up to 40 miles (64 km) from the plant (Figure 2-4) Dow (1971) based similar contours (Figure 2-5) on results from 135 soil samples Dow's 1972 Rocky Flats Annual Environmental Monitoring Report (Dow et al, 1971 to date) included soil plutonium contours, in microcuries per square meter (uCi/m^2), based on over 300 soil samples (Figure 2-6) The differences in the results of these studies help to illustrate the inherent difficulty in drawing conclusions about IHSS 199 contamination based upon existing data. Results, and hence conclusions, vary widely depending upon sampling methods, analytical methods and uncertainty definition of "background" concentrations, and units of measurement. Most of the data collected since 1972 have focused specifically on characterizing the lawsuit acreage rather than defining IHSS 199 as a whole (Rockwell, 1979a Rockwell, 1979b Rockwell, 1985a, Rockwell 1985b Rockwell, 1987a, Rockwell, 1987b) because the investigations preceded the designation of the offsite soils as IHSS 199 Very few data exist for contaminants other than plutonium which could affect offsite soils as a result of RFP releases

In short, the extent of offsite soil contamination as a result of RFP releases, which will delineate the boundaries of IHSS 199, has not been conclusively defined Studies conducted to date, however, do point to the following delimitations

- IHSS 199 is most likely limited to areas downwind of the RFP, namely to the north-east, east, and southeast of the plant

- The 350 ac of lawsuit acreage targeted for remediation were shown to have the highest concentrations of plutonium in soil of all lawsuit acreage, which adjoined most of the eastern and southern boundaries of the RFP (Rockwell 1979b) "Hot spots" may occur which were not detected through lawsuit acreage sampling however, because other IHSS 199 lands downwind of the RFP are further from the plant than the remedy acreage, it is reasonable to expect that these lands contain lower concentrations of plutonium than the remedy acreage

- The most likely pathways of plutonium migration from IHSS 199 are wind and water erosion of surface soil (SCS, 1985)

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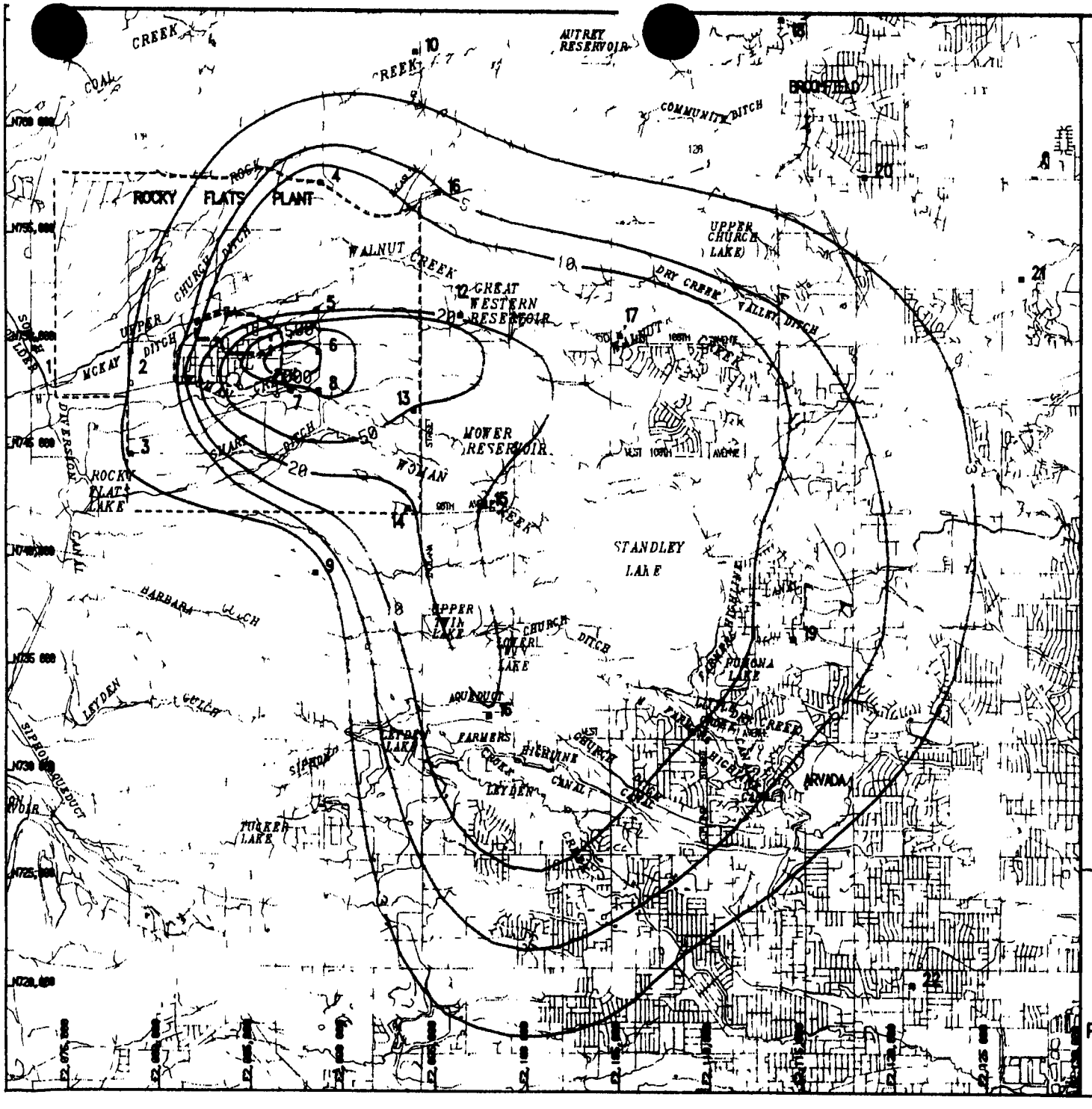

MAP LEGE

RFP BOUNDARY AND PSZ

CONTOUR VALUES IN mCi per km2

NUMBERED SAMPLING SITES

N

0 feet 3000 6000

Figure 2 4

PLUTONIUM-239 CONTOURS IN THE VICINITY OF THE ROCKY FLATS PLANT KREY AND HARDY (1970)

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		APPROVED BY TDK	3-22-91	

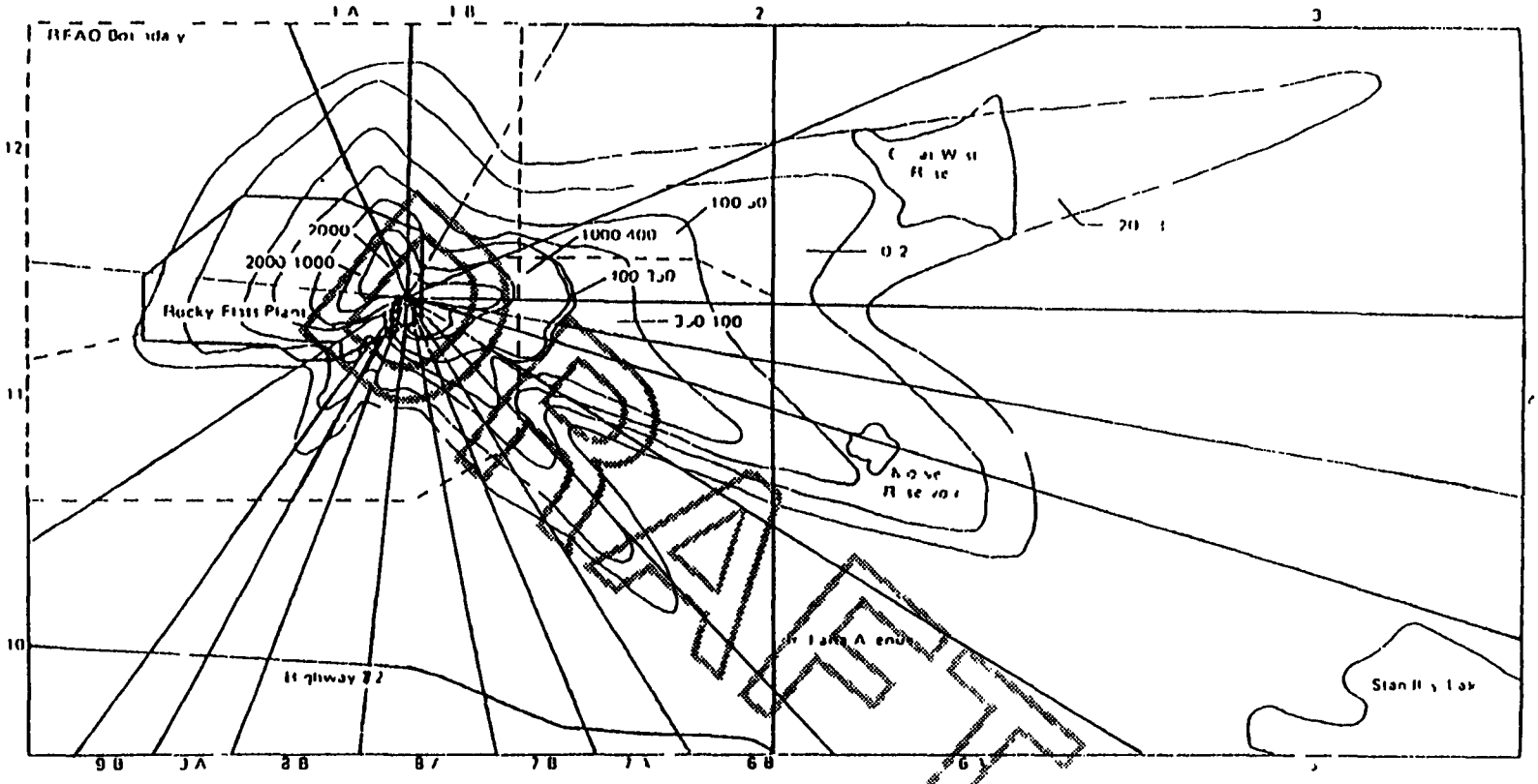

Figure 7 1 An Outline of Rocky Flats Showing the Levels of Plutonium Activity in the Soil in mCi/km² Soil Sample Data for the Contours were Evaluated per Sector of the Outline One inch of the Outline is about 3600 Feet

SOURCE FIGURE 7-1, J R SEED et al, DOW CHEMICAL COMAPANY COMMITTEE EVALUATION OF PLUTONIUM LEVELS IN SOIL WITHIN AND SURROUNDING USAEC INSTALLATION AT ROCKY FLATS COLORADO" JULY 9 1971

Figure 2-5
PLUTONIUM CONTOURS AROUND ROCKY FLATS PLANT DOW (1971)

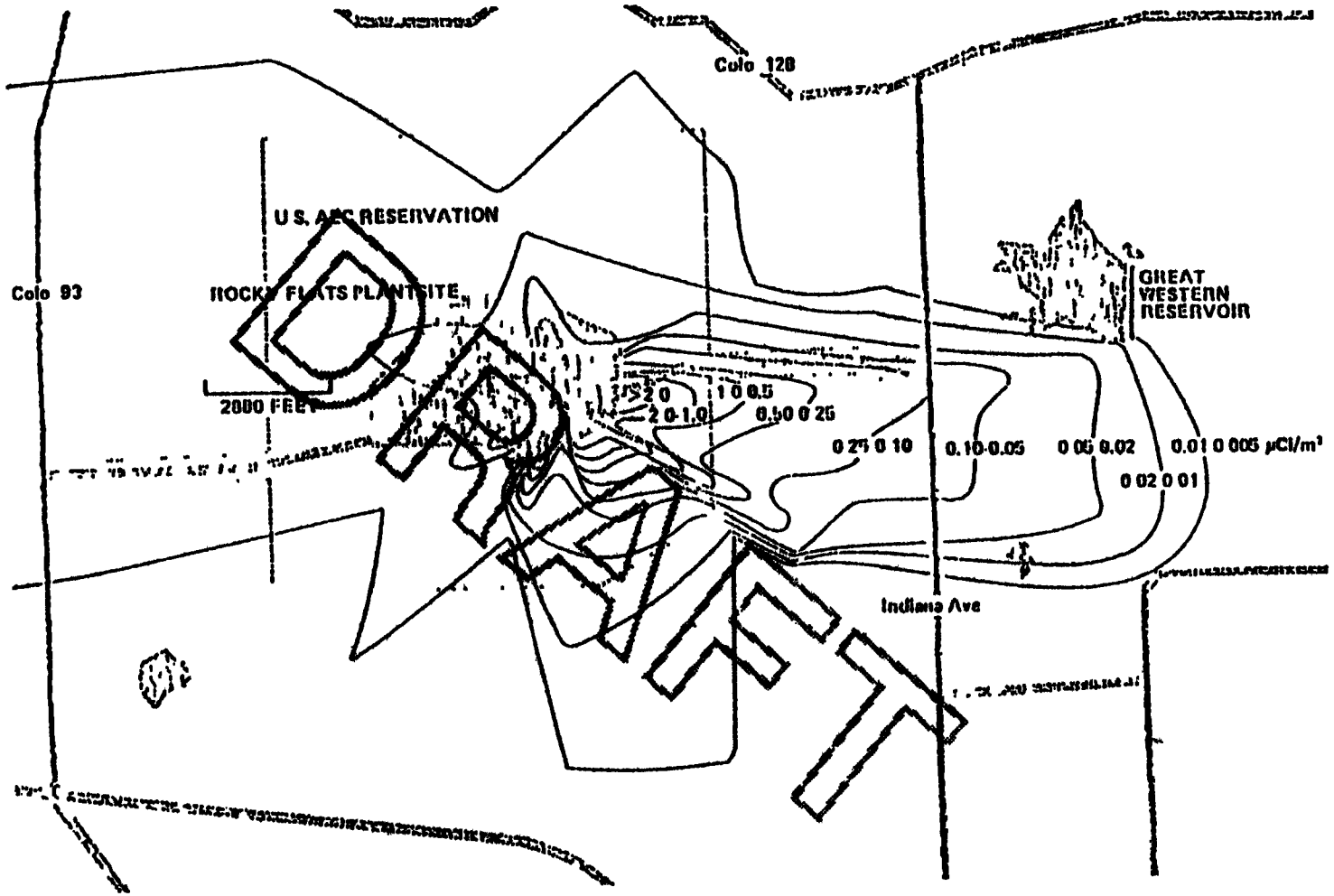

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Figure 2-6
PLUTONIUM CONTOURS AROUND ROCKY FLATS PLANT DOW et al (1972)

SO[illegible] DOW CHEMICAL COMAPANY, "ANNUAL ENVIRONMENTAL REPOR[illegible]
RO[illegible]LATS PLANT JANUARY-DECEMBER 1972

Existing IHSS 199 soil plutonium data are summarized in Table 2-2

Very limited data exist for contaminants other than plutonium which could affect offsite soils as a result of RFP releases In 1976 and 1977, the RFP tested lawsuit acreage soils for isotopes of americium, cesium, thorium, neptunium, cerium, radium and potassium in addition to plutonium The sampling program also included five sites remote from the RFP in order to determine representative background concentrations (Rockwell, 1979a Rockwell, 1979b) The Rockwell International Disclosure to the City of Broomfield following the lawsuit (Rockwell, 1985a) based the following conclusion on the results of the 1976-1977 sampling

> "Analysis of 25 soil samples from plaintiffs lands and samples from each of the five background locations used in the testing program show that with respect to radionuclides other than plutonium and americium, the levels of these radionuclides on plaintiffs lands are consistent with background levels "

As indicated in this passage, americium-241, a daughter product of plutonium-241 decay, was detected in IHSS 199 soils above the background concentrations recorded at the five remote sampling locations However, neither Rockwell (1985a) nor Rockwell (1979b), which also refer to americium data from the 1976-1977 sampling program provide the analytical results for americium Poet and Martell (1972) measured americium-241 and strontium-90 concentrations in soil samples collected in 1969 from several locations around the RFP This study calculated that americium contributed 3-15 percent as much alpha activity as did plutonium in the areas sampled, and estimated that the americium contribution to alpha activity would eventually approach that of plutonium as decay of plutonium-241 into americium-241 progressed The RFP soil sampling program conducted by CDH (see Subsection 1 3 7 3) has periodically included analyses for cesium-137 and uranium These limited efforts represent the only known characterizations of radionuclides other than plutonium at IHSS 199 Possible contaminants other than radionuclides present in IHSS 199 soils as a result of RFP releases have not been characterized, with the exception of beryllium measurements in 1971 under the CDH soil monitoring program (CDH, 1990a)

Ongoing studies of RFP OU 2 will provide more detailed characterizations of soil contamination between the 903 Pad and the RFP eastern boundary Studies are also underway to define background concentrations in soil of potential RFP contaminants including background" plutonium and americium resulting from atmospheric testing of nuclear weapons The relevance of these

TABLE 2-2

SUMMARY OF IHSS 199 HISTORICAL PLUTONIUM IN SOIL DATA

Data Source	Range (pCi/g unless otherwise noted)	Average (pCi/g unless otherwise noted)	No. of Data Points	Comments
"Plutonium in Soil Around the Rocky Flats Plant, by P W Krey and E.P Hardy 1 August 1970	0.0007-0.963	0.065	27	1,23
"Committee Evaluation of Plutonium Levels in Soil Within and Surrounding USAEC Installation at Rocky Flats, Colorado by J.R. Seed et al., 9 July 1971	0.045-139 7	5.0	123	1, 2, 4
"Soil Sampling East of Indiana Avenue," by R.W Loser and R.L. Tibbels, 29 November 1972	2.7-594 mCi/km^2	99.3 mCi/km^2	14	1 5
"Results of Special Soil Samples Collected Adjacent to the Rocky Flats Plant Site," by C.T Illsley, 7 September 1977 (revised 30 November 1979)	0.01-1 46	0.207	20	1 2
"Radioactive Soil Contamination (Cesium-137 and Plutonium) in the Environment Near the Rocky Flats Nuclear Weapons Plant," by CDH, September 1977	Data contained in this report are included in the 1970-1989 CDH report below			
"Plutonium Concentrations in Soil on Lands Adjacent to the Rocky Flats Plant," by C.T Illsley and M.W Hume, 16 March 1979	0.009-3.42	0.19	160	1, 2
"Disclosure to the City of Broomfield," by Rockwell International, 22 January 1985	0.06-7 7	N/A	N/A	1, 2, 6
"Soil Sample Collection and Analysis for Plutonium on Lands Adjacent to Great Western Reservoir for the City of Broomfield," by C.T Illsley, 15 January 1987	0.04-8.8	1.2	15	1 2
"Remedial Action Program on Jefferson County Open Space Land in Section 7 T2S, R69W, South of Great Western Reservoir," by C.T Illsley, 15 October 1987	1977 0.06-7 7	1.55	22	1, 7
	1985 0.06-5.6	1 70	24	
"Rocky Flats Surface Soil Survey 1970-1989," by CDH, February 1990	1970 0.01-11.0	1.2	13	1 2, 4
	1971 0.03-30 1	2.6	13	1 2, 4
	1972 0.02-25 1	2.1	13	1 2, 4
	1973 0.03-0.38	0 12	5	1 2
	1974 0.02-12.7	1.2	13	1 2, 4

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TABLE 2-2

SUMMARY OF IHSS 199 HISTORICAL PLUTONIUM IN SOIL DATA (Concluded)

Data Source	Range (pCi/g unless otherwise noted)	Average (pCi/g unless otherwise noted)	No. of Data Points	Comments
	1975 0 01-4 30	1 1	10	1 2
	1976 0 02-3 50	0 4	13	1 2
	1977 0 03-4.20	0 5	13	1 2
	1978 0 03-0.25	0 09	6	1 2
	1980 0.01-3 1	0 3	13	1 2
	1981 0 18-2.2	0 3	12	1 2
	1986 0 01 1.5	0.2	13	1 2

Notes

[1] Data do not meet EPA useability criteria for risk assessment (EPA, 1990b).
[2] Values originally expressed in dpm/g converted to pCi/g using 0.45 multiplier
[3] Included multiple analyses by various laboratories some data points have multiple values
[4] Some data points are within the present RFP boundary sample locations are not defined clearly enough to separate these from data points outside the RFP boundary.
[5] Document lacks adequate description of sampling and analytical methodology and contains inconsistent definition of sample locations Because conversion of mCi/km^2 to pCi/g requires detailed knowledge of methodology and properties of the medium sampled, this conversion could not reliably be performed however reported values appear to be much higher than those recorded in other sampling programs in this area. Very low confidence in these values
[6] Document presents high low and average values from Broomfield remedy acreage sampling between 1977-1985
[7] 1977 data do not include Broomfield remedy acreage

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background concentrations to IHSS 199 will be addressed in future RFI/RI activities. Cumulative depositions of plutonium because nuclear testing on ground surfaces in the United States range from 0 001 to 0 003 uCi/m² (EPA, 1990a) Data on RFP climatology also are available (Subsection 1 3.2.1) It is believed that geostatistical methods incorporating these various data can be utilized during future RFI/RI activities at IHSS 199 to help focus efforts to define the site boundary by selecting appropriate sample locations and sampling density

2.2 IHSS 200 (GREAT WESTERN RESERVOIR)

IHSS 200 encompasses Great Western Reservoir, offsite reaches of Walnut Creek (which formerly flowed into the reservoir from the RFP), and downstream surface water features possibly impacted by outflow from the reservoir (Figure 2-1) Portions of Walnut Creek within the boundaries of the RFP will be investigated as RFP OU 6 and are not included in IHSS 200.

2.2.1 Location and Description

Great Western Reservoir is located approximately 1 5 mi (2 4 km) east of the RFP's eastern boundary in Sections 6 and 7 of Township 2 South, Range 69 West (T2S, R69W) (Figure 2-1) The reservoir is owned by the City of Broomfield and is utilized solely for the city's municipal water supply Public access to Great Western Reservoir and the surrounding area is fenced and posted to exclude public access (Broomfield, 1990)

Preconstruction information for the Great Western Reservoir site is not given in available references. The original reservoir was built in 1904 as an irrigation water supply. The dam has been enlarged on several occasions, most recently in 1958. The maximum height of the dam is 69 feet (ft) (21 meters [m]) (Hydro-Triad, 1991). The present reservoir volume is 3,250 acre-feet (401 hectare-meters) The bottom and sides of the reservoir are unlined, meaning that the reservoir may or may not be hydraulically connected to the groundwater system in the area (Miller, 1990)

2.2.2 IHSS Conditions

Although little site-specific information is available concerning the geology and groundwater hydrology of IHSS 200, plantwide hydrogeologic studies give an indication of conditions in the vicinity of the RFP The following sections summarize relevant results of these studies and provide site-specific information where available

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2.2.2 1 Geology and Groundwater Hydrology

The U S Army Corps of Engineers utilized data from two existing boreholes near Great Western Reservoir as part of a 1989 evaluation for a surface water interceptor system for the reservoir In these boreholes alluvium surficial deposits are underlain by Arapahoe Formation bedrock at depths of 5 and 16 ft (1 5 and 4 9 m) Bedrock consists of claystone with minor interbedded sandstone and siltstone lenses, and dips slightly to the east (Corps of Engineers 1989) The precise locations of these boreholes are not given in this document The Arapahoe Formation averages 250 ft (76 m) in thickness in the RFP area, and is underlain by several hundred feet (approximately 100 m) of shale comprising the upper portion of the Laramie Formation (USGS, 1976) It is expected that a similar stratigraphic sequence underlies Great Western Reservoir

A general description of groundwater hydrogeology in the vicinity of the RFP is given in Subsection 1 3 4 2. Specific groundwater hydrogeologic information for Great Western Reservoir is limited to drilling records from privately-owned water wells in the vicinity of the reservoir (DWR 1990) The description of these records given in Subsection 2.1 3 3 for IHSS 199 also applies to Great Western Reservoir and the surrounding area.

2.2.2.2 Surface Water

Great Western Reservoir is fed primarily by Clear Creek via Lower Church Ditch (Figure 2-1) Until recently, the reservoir also received influent from the north and south branches of Walnut Creek, both of which flow from the RFP The two branches merge into a single drainage within the RFP boundary (Figure 2-1) A chromic acid release at the RFP in 1989 prompted construction of a Walnut Creek diversion around Great Western Reservoir, known as the Broomfield Diversion Ditch (Figure 1-3) Surface water affected by the chromic acid was diverted around Great Western Reservoir and did not impact the reservoir (Dow et al , 1971 to date) Walnut Creek flow from the RFP is now treated and diverted south around Great Western Reservoir into the drainage below the reservoir outlet, where it combines with outflow from the reservoir The Broomfield Diversion Ditch prevents surface water from the RFP from reaching Great Western Reservoir Walnut Creek continues below Great Western Reservoir and eventually discharges to Big Dry Creek several miles downstream from the reservoir (USGS, 1980)

Within the RFP boundary the North and South Walnut Creek drainages contain the A and B-series holding ponds, respectively In North Walnut Creek, there are four ponds designated A 1, A-2, A-3

and A-4, from west to east (Figures 1-2 and 2-1) Ponds A-1 and A-2 are used only for spill control, and North Walnut Creek stream flow is diverted around them through an underground pipe. Pond A-3 receives North Walnut Creek stream flow and runoff from the northern portion of the RFP Pond A-4 is utilized for surface water control and for overflow from Pond A-3 (DOE, 1988)

Five retention ponds located along South Walnut Creek are designated B-1, B-2, B-3, B-4 and B-5, from west to east (Figures 1-2 and 2-1) Ponds B-1 and B-2 are reserved for spill control. Pond B-3 receives treated effluent from the RFP sanitary sewage treatment plant. Ponds B-4 and B-5 receive surface runoff from the central part of the plant and routinely receive discharge from Pond B-3. Pond B-5 also collects overflow from Pond B-4 (DOE, 1988)

2.2.2.3 Biota

The aquatic biota is this reservoir consists of the common species of periphyton and macroinvertebrates, and a fairly large and stable population of fish since this reservoir is not fished nor used for recreation. Rooted aquatic vegetation around this reservoir is minimal because of fluctuating shoreline and subsequent denudation by wave action. Studies to characterize the aquatic biota in this reservoir have not been undertaken.

2.2.3 Nature of Contamination

From the opening of the RFP in 1952 through approximately 1979, water containing decontaminated process and laundry effluent was discharged through the B-series ponds to South Walnut Creek (DOE, 1988; Dow, 1973). Cooling tower blowdown and treatment system steam condensate were discharged to the A-series ponds, which feed into North Walnut Creek. These discharges contained radionuclides which accumulated in varying amounts in the sediments of the holding ponds, Walnut Creek, and Great Western Reservoir (DOE, 1980) The EPA (1975) concluded that historic releases of contaminants from the RFP to Great Western Reservoir resulted primarily from the following activities:

- Early operational practices at the plant (1950s and 1960s)

- Reconstruction of the holding ponds between 1970 to 1973, which resuspended pond sediments and released some of this material to Great Western Reservoir

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- A 1973 tritium release from the RFP (Subsection 2.2 3 2)

- Airborne transfer of radionuclides (primarily plutonium)

Available data from on-site RFP OUs, particularly OU 6 (Walnut Creek Drainage), suggests that contaminants other than plutonium could conceivably have impacted Great Western Reservoir through surface water transport from the RFP Leakage from the solar evaporation ponds (IHSS 101, see Figure 2 1) is known to have contaminated groundwater and surface water in the Walnut Creek drainage, primarily with nitrate and other inorganic ions Inorganic ions, nonradioactive metals VOCs, and uranium have been detected in the Walnut Creek holding ponds Herbicides which have been applied in the past at various locations on the RFP have also been detected in RFP surface water Knowledge of the fate and mobility of these potential contaminants in surface water and sediments is critical in determining whether they could reasonably have impacted Great Western Reservoir and if so, whether they still exist at the site today Contaminant fate and mobility are addressed in the conceptual model for reservoirs (Subsection 2.5.2) Available information from on-site and off-site RFP environmental monitoring (Subsection 1 3 8) and RFP OU investigations can be used to verify the predictions of the conceptual model and focus the selection of contaminants of concern (Subsection 6 2)

The following sections present chronological summaries of environmental studies conducted to date of IHSS 200 Analytical results from these studies are summarized in Table 2-3 The studies are incorporated by reference to the list of references in Section 12.0

2.2.3 1 Reservoir and Drainage Sediments

The EPA conducted the first extensive sampling of bottom sediments in Great Western Reservoir in February and September 1970. The results indicated that a layer of sediment containing plutonium above the EPA estimated baseline (worldwide atmospheric fallout) level of $\leq$0 1 picocurie per gram (pCi/g), or 0 0037 becquerel per gram (Bq/g) was present in the bottom of the reservoir The thickness of the plutonium-bearing sediments was 2 in (5 cm) or more at all sampling locations. The highest concentrations of plutonium were detected in sediments in the Walnut Creek inlet area and the central section of the reservoir (leading to the dam inlet) The lowest concentrations were found in the south arm, the shoreline area between the south arm and the dam, and the western portion of the north arm (EPA, 1971, EPA, 1973)

TABLE 2-3

GREAT WESTERN RESERVOIR
PLUTONIUM ANALYTICAL DATA

Data Source	Range (pCi/g or l)	Average (pCi/g or l)	Number of Data Points
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Golden, Colorado, 1970," April 1971, by EPA (Appendix D, Document D-1)	Surf Sed[1] 0.10-0 13	0 11	3
	Water 0 03	0.03	1
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Colorado, 1970, Part II," December 1973, by EPA (Appendix D, Document D-2)	Surf Sed. 0.08-0.86	0.34	20
	Sed Core: 0.03-1 0	0.24	12
	Water <0.02	<0.02	1
"Plutonium Levels in the Sediment of Area Impoundments Environs of the Rocky Flats Plutonium Plant– Colorado," February 1975, by EPA (Appendix D, Document D-3)	Surf Sed <0.08-4.1	1.4	20
	Sed Core: <0.02-4.5	0.97	15
"Survey of Reservoir Sediments," August 1974, by Dow Chemical (Appendix D, Document D-4)[2]	Surf Sed: 0.68-7 9	3.4	5
	Sed Core: 0.001-5.3	0.42	13
"Radionuclide Concentrations in Reservoirs, Streams and Domestic Waters Near the Rocky Flats Installation," April 1981, by Battelle PNL (Appendix D, Document D-5)[3]	Sed Core: 0.01-8.2	2.7	7
"Great Western Reservoir Spillway Sediment Sampling Program Phase I Report," May 1979, by Rockwell International (Appendix D, Document D-7)[4]	Surf Sed: 0.013-0.083	0.04	14
	Sed Core: 0.007-0.192	0 074	14
"Great Western Reservoir Spillway Sediment Sampling Program Phase II Report," August 1980, by Rockwell International (Appendix D, Document D-8)[4]	Sed Core: 0.006-0.07	0.04	7
	Surf Sed: 0.2-6.1	3.5	48
"Great Western Reservoir Sediment Cores," February 1985, by Rockwell International (Appendix D, Document D-9)	Sed Core 0.013-5.4	1.2	4

[1]Surface sediment grab sample–typically represents upper 5 cm of sediments.
[2]Results are for samples collected in 1973 by EPA and split with DOE. Surface sediment grabs analyzed by Rocky Flats laboratory; sediment cores analyzed by Battelle Pacific Northwest Laboratory and Lawrence Livermore National Laboratory
[3]Collected numerous water and sediment samples in which plutonium concentrations were not measured.
[4]Great Western Reservoir spillway sediments, sampled prior to removal and disposal.

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EPA resumed their investigation of plutonium in surface water sediments east of the RFP in September 1973 This phase of the study further documented plutonium concentrations in Great Western Reservoir Sediment samples collected both by dredging and coring indicated that plutonium above expected baseline concentrations was present over almost the entire bottom of Great Western Reservoir as a result of releases from the RFP The maximum plutonium concentration detected was 4 5 pCi/g (Table 2-3) The results confirmed the areal distribution of plutonium delineated by the 1970 study, except that the highest concentrations were found in the deepest areas of the reservoir rather than in the Walnut Creek inlet area. It was also observed that plutonium-239 concentrations in the uppermost sediment layer increased substantially in the three years between the studies. This increase was traced to an influx of sediment resuspended from the RFP holding ponds during pond reconstruction activities. This study also measured concentrations in Great Western Reservoir sediments of selected radionuclides other than plutonium and of beryllium No significant variations in the concentrations of these potential RFP contaminants were observed throughout the reservoir or between Great Western Reservoir and Standley Lake (IHSS 201) (EPA, 1975)

The 1970 and 1973 EPA studies also sought to confirm the estimated plutonium baseline (background) level by sampling sediments from Front Range reservoirs believed to be unaffected by the RFP During the 1970 study, sediment samples were collected from Calkins Lake and Autrey Reservoir (EPA, 1971, EPA, 1973) During the 1973 study, samples were collected from Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir (EPA, 1975) With one exception, analysis of samples from these reservoirs yielded plutonium-239 levels below $\leq$0 1 pCi/g (0 0037 Bq/g), substantiating EPA s estimated baseline concentration

An accidental release of tritium from the RFP into Walnut Creek and Great Western Reservoir occurred in 1973 (EPA, 1974) Subsequent studies measured tritium concentrations in reservoir water as a result of the release. Tritium contamination in reservoir sediments has not been studied, however, tritium would not be expected to concentrate in sediments because of its high mobility in the environment (Rockwell, 1988c)

In 1974, Battelle Pacific Northwest Laboratories conducted an investigation of radionuclide concentrations in reservoir and stream sediments near the RFP Concentrations of plutonium-239, plutonium-240 and americium-241 in the sediments of Great Western Reservoir and Walnut Creek were found to exceed "baseline levels" (presumably the EPA baseline of $\leq$0 1 pCi/g [0 0037 Bq/g]) The study estimated the total inventories of plutonium and americium in Great Western Reservoir sedi-

ments at 244 millicurie (mCi) and 73 mCi (9 02 and 2.7 gigabecquerel [GBq]), respectively Concentrations of cesium-137 were at or below expected baseline concentrations. Age-dated sediment cores (using cesium-137 as an age-dating marker) collected during this study from Great Western Reservoir demonstrated two separate periods of plutonium deposition, 1968 to 1969 and 1959 to 1964, both of which coincide with recorded, controlled waterborne releases from the RFP Worldwide fallout from atmospheric nuclear weapons testing may also have contributed to the plutonium in the 1968 to 1969 sediment layer (Battelle, 1981) The 1968 to 1969 peak detected in the Battelle study also corresponds to a period of windborne releases from the 903 Pad, a former drum storage area near the eastern end of the RFP controlled area (Figure 2-1) (DOE, 1991a)

Also in 1974, Colorado State University (CSU) conducted a study of plutonium in aquatic systems of the RFP environs. This study concluded that the clay fraction of RFP sediments has an extremely high affinity for plutonium and, left undisturbed, provides an excellent retention mechanism for plutonium in the aquatic system. Laboratory studies related to this investigation showed that the adsorbtion of plutonium onto the sediments was rapid and essentially irreversible (CSU, 1974)

Results of studies conducted through 1974 were summarized in a 1975 report by Dow Chemical. According to this report, the studies demonstrated that plutonium in surface water impoundments is not readily transported from the impoundments. Consequently, the majority of the plutonium released through RFP surface waters was contained in the onsite holding ponds. Plutonium concentrations in Walnut Creek sediments increased downstream, suggesting downstream migration of plutonium released at an earlier time (Dow, 1975).

In 1979 and 1980, Rockwell International measured plutonium and americium concentrations in sediments on the Great Western Reservoir overflow spillway prior to removal and disposal of the sediments by the City of Broomfield. Levels of plutonium-239, plutonium-240 and americium-241 in spillway sediment samples were near regional atmospheric fallout background concentrations. Plutonium concentrations averaged 0.04 pCi/g and peaked at 0.19 pCi/g in the spillway sediments. Plutonium and amencium concentrations in the spillway sediments varied little with depth, supporting the conclusion that the sediments accumulated through a combination of hillslope erosion, wave action and sediment mixing, rather than the continuous lacustrine deposition typical of the reservoir bottom sediments (Rockwell, 1979c; Rockwell, 1980)

In 1983, Rockwell International collected 48 sediment surface grab samples and four sediment cores during an extensive Great Western Reservoir geochemical sampling project. Duplicate cores were

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collected at three locations for joint analysis by the City of Broomfield The results of this study were not published in report form, but were summarized in public meetings Maximum recorded plutonium concentrations in these cores were 5 4 pCi/g (Rockwell) and 4 9 pCi/g (Broomfield), occurring at depths of 17 in (43 cm) and 7 5 in (19 cm), respectively The study indicated that plutonium existed in a discrete sediment horizon corresponding with historical releases from the RFP and that this horizon had been buried to varying depths by subsequent sedimentation Sedimentation rates based on core samples were determined to vary from >1 4 in/yr (>3 5 cm/yr) in the eastern, deeper areas of the reservoir to <0 1 in/yr (<0 25 cm/yr) in the shallower areas (Rockwell, 1985c) It was also concluded that no evidence of plutonium migration through the sediment column existed (Rockwell, 1988c)

Numerous studies have focused on surface soil plutonium contamination east of the RFP (DOE, 1991a) Elevated plutonium concentrations have been measured in surface soils north, west, and south of Great Western Reservoir as a result of windborne releases from the 903 Pad, a former drum storage area within the RFP (Figure 2-1) The distribution of surface soil plutonium contamination around the reservoir suggests that windborne particulates have contributed to the plutonium in Great Western Reservoir sediments

2.2.3.2 Reservoir and Drainage Water Quality

Surface water quality in North and South Walnut Creeks and in Great Western Reservoir has been monitored since shortly after the RFP opened in 1951 Tap water is also monitored for prospective RFP-derived contaminants in a number of municipalities around the RFP, including the City of Broomfield, which is supplied by Great Western Reservoir (see Subsection 1 3 7) In addition, a number of historical studies have focused on potential impacts to IHSS 200 water quality as a result of RFP releases

A 1973 EPA study concluded that dissolved plutonium concentrations in water samples from Great Western Reservoir and Walnut Creek were less than atmospheric fallout-derived baseline concentrations of <0 03 picocuries per liter (pCi/l) (<0 001 Bq/l) Dissolved uranium concentrations were less than the expected natural background of 2.5 micrograms per liter (EPA, 1975)

An accidental release of tritium in 1973 from the RFP into Walnut Creek and Great Western Reservoir was the focus of another EPA study EPA estimated that the release resulted in a total committed dose of 4 millirem (0 04 millisievert) to the average individual using the reservoir as a

source of drinking water EPA found that this dose had minimal impact on public health and did not recommend any mitigative actions (EPA, 1974) Tritium concentrations in Great Western Reservoir waters returned to approximately background levels by 1977 (Rockwell, 1988c) Tritium is one of the radionuclides routinely monitored in RFP surface water effluents and nearby public water supplies (Dow et al., 1971-date)

In 1974, Battelle conducted an investigation of radionuclide concentrations in reservoirs, streams and domestic tap waters near the RFP Plutonium-239, plutonium-240, and americium-241 concentrations in Great Western Reservoir and Walnut Creek water were slightly above the expected atmospheric fallout background, which was not specifically quantified in this study Concentrations of these three radionuclides in Broomfield tap water were slightly above the detection limit of 4.5×10^{-4} pCi/l (1.7×10^{-5} Bq/l) but were orders of magnitude lower than the EPA National Primary Drinking Water Regulation of 15 pCi/l (0.55 Bq/l) for total long-lived alpha activity (exclusive of radon and uranium) (Battelle, 1981)

A 1981 Rockwell International study statistically compared available gross alpha and plutonium monitoring data for Great Western Reservoir water and Broomfield tap water with plutonium and gross alpha data for other regional water bodies and supplies. All of the comparisons (with the exception of those for Ralston Reservoir water, in which very low plutonium concentrations were found) indicated that concentrations of plutonium and gross alpha in the regional waters did not statistically differ from those in Great Western Reservoir water and Broomfield tap water (Rockwell, 1981)

Water from Great Western Reservoir is filtered at the Broomfield Water Treatment Plant. The filters are routinely backwashed into a settling lagoon at the plant. Accumulated backwash sludge is periodically removed from the lagoon and analyzed for a variety of parameters, including plutonium, prior to disposal. Plutonium above background concentrations has not been detected in the sludge in past analyses. Filter sludge was last analyzed and removed from the lagoon approximately 5 years ago (Broomfield, 1990) Filter sludge was also analyzed at the Broomfield plant by the EPA (1971) and Battelle (1981b)

2.3 IHSS 201 (STANDLEY LAKE)

IHSS 201 encompasses Standley Lake, offsite reaches of Woman Creek (which flows into the reservoir from the RFP), and downstream surface water features possibly impacted by outflow from the

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reservoir (Figure 2-1) Portions of Woman Creek within the boundaries of the RFP will be investigated as RFP OU 5 and are not included in IHSS 201

2 3 1 Location and Description

Standley Lake is a large reservoir located approximately 2 mi (3 2 km) southeast of the RFP s eastern boundary (Figure 2-1) in Sections 16, 17, 20, 21, 22 and 28, T2S R69W Uses of the reservoir include municipal water supply and recreation The reservoir has been owned by The Farmers Reservoir and Irrigation Company of Brighton, Colorado, since its construction between 1909 to 1919 Although the dam has undergone periodic maintenance and reconstruction, most recently in 1978, Standley Lake s present volume of 43,000 acre-feet (5,300 hectare-meters) has remained relatively unchanged since its construction Approximately 67 percent of the reservoir water is used as municipal water supply for the cities of Westminster, Northglenn and Thornton The remaining 33 percent is transported through irrigation ditches to agricultural areas northeast of the lake, primarily between Broomfield and Fort Lupton Standley Lake receives approximately 96 percent of its water from Clear Creek via an irrigation ditch, but is also fed by Woman Creek (Figures 1-3 and 2 1), which drains the southern side of the RFP (Farmers, 1990)

2.3 2 IHSS Conditions

Although little site-specific information is available concerning the geology and groundwater hydrology of IHSS 201 plantwide hydrogeologic studies give an indication of conditions in the vicinity of the RFP The following sections summarize relevant results of these studies and provide site-specific information where available

2.3.2.1 Geology and Groundwater Hydrology

A geologic characterization of Standley Lake was performed by Mineral Systems, Inc in 1982 to provide data for the enlargement of the dam and reservoir Bedrock outcrops at various locations around the lake consist of claystone with interbedded sandstone lenses, probably of the Arapahoe Formation These units dip gently to the northeast Overlying the bedrock are surficial deposits averaging 15 to 20 ft (5 to 7 m) thick consisting of a series of alluvial terraces, colluvium, and minor other deposits No faults have been identified in the area (Hydro-Triad, 1982) Although other site-specific information concerning Standley Lake geology and groundwater hydrology are lacking it is

expected that conditions in the immediate vicinity of the reservoir are similar to those described in Subsection 2.2.2.1 for Great Western Reservoir

2.3 2.2 Surface Water

Within the RFP boundary, the Woman Creek drainage contains the two C-series holding ponds, Ponds C-1 and C-2 (south and east of the main production area, respectively) (Figures 1-2 and 2-1) Pond C-1 receives flow from Woman Creek. This flow is diverted around Pond C-2 and back into the Woman Creek channel downstream of Pond C-2. Pond C-2 receives surface runoff from the South Interceptor Ditch which collects surface runoff from the southern portion of the RFP main production area (Rockwell, 1988a) The South Interceptor Ditch runs along the south (downgradient) side of the main production area, between the controlled area and Woman Creek (Figure 1-2). Pond C-2 water formerly was discharged into Woman Creek in accordance with the NPDES permit for the RFP More recently, water was pumped from Pond C-2 into a treatment facility, then through an aboveground pipeline to the Broomfield Diversion Ditch, where it was discharged in accordance with applicable regulations and by agreement with the City of Broomfield. Options to discharge Pond C-2 water to the Broomfield Diversion Ditch or to Ponds A4/B5 are being completed. Treatment of this water will be provided on a contingency basis, as required to meet applicable regulations. Surface water controls within RFR allow the RFP to effectively prevent runoff from the RFP's main production facility (the controlled area shown in Figure 2-1) from reaching Standley Lake.

2.3.2.3 Biota

The aquatic biota in this reservoir are typical for large bodies of water in this area, but an inventory and characterization have not been published. Colorado Department of Health fish toxicity monitoring in Standley Lake has determined that the fish were safe for human consumption. The species analyzed were walleyes, channel catfish, smallmouth bass and rainbow trout. Other species of fish may occur in this reservoir but were not sampled. Bald eagles have been sighted at Standley Lake, especially during the winter and spring, and they prey on fish in the lake.

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2 3 3 Nature of Contamination

Radioactive materials released from the RFP may have been transported to Standley Lake through surface water (primarily in suspended sediments) and/or airborne particulates (fugitive dust) Between 1952 and 1973 the RFP discharged water treatment facility filter backwash into Pond C-1, which discharges into Woman Creek (Rockwell, 1988c) At present, only buffer zone surface runoff and natural groundwater seepage flow into the Woman Creek drainage within the RFP boundary (Dow et al , 1971 to date)

Prospective RFP sources of contaminants other than plutonium to Standley Lake, particularly VOCs and uranium, exist in OU 1 (881 Hillside) and OU 2 (903 Pad, Mound, and East Trenches) Herbicides which have been applied in the past at various locations on the RFP have also been detected in RFP surface water The fate and mobility of these potential contaminants are addressed in the conceptual model for reservoirs (Subsection 2 5 2) Available information from on-site and off-site RFP environmental monitoring (Subsection 1 3 8) and RFP OU investigations can be used to verify the predictions of the conceptual model and focus the selection of contaminants of concern (Subsection 6 2)

The following sections present chronological summaries of environmental studies conducted to date of IHSS 201 Analytical results from these studies are summarized in Table 2-4 Many of the studies conducted at Great Western Reservoir (Subsection 2.2.3) also included Standley Lake Reports associated with these studies are incorporated by reference to the list of references in Section 12.0 in this document.

2.3 3 1 Reservoir and Drainage Sediments

The EPA collected four surface grab samples and two cores of bottom sediments from Standley Lake in 1970 The results indicated possible plutonium contamination above the estimated $\leq$0 1 pCi/g (0 0037 Bq/g) baseline concentration (worldwide atmosphere fallout) in the deeper areas of the reservoir EPA concluded that elevated plutonium in Standley Lake resulted from unspecified releases from the RFP, and speculated that these releases occurred from surface water erosion and transport of plutonium-contaminated soil (EPA, 1971 EPA, 1973)

EPA resumed their investigation of plutonium in surface water sediments east of the RFP in 1973 Analysis of 17 surface grab samples and 8 cores of Standley Lake sediments yielded plutonium

TABLE 2-4

STANDLEY LAKE
PLUTONIUM ANALYTICAL DATA

Data Source		Range (pCi/g or l)	Average (pCi/g or l)	Number of Data Points
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Golden, Colorado, 1970," April 1971, by EPA (Appendix D, Document D-1)	Surf Sed[1]	0.04-0.05	0.045	2
	Water	<0.02	<0.02	1
"Radioactivity Levels in the Environs of the Rocky Flats Plutonium Plant, Colorado, 1970, Part II," December 1973, by EPA (Appendix D, Document D-2)	Surf Sed:	0.05-0.21	0.13	2
	Sed Core	0.09-0.37	0 19	2
	Water	<0.02	<0.02	1
"Plutonium Levels in the Sediment of Area Impoundments Environs of the Rocky Flats Plutonium Plant–Colorado," February 1975, by EPA (Appendix D, Document D-3)	Surf Sed:	<0.02-0.17	0.07	17
	Sed Core:	<0 03-0.16	0.07	8
"Survey of Reservoir Sediments," August 1974, by Dow Chemical (Appendix D, Document D-4)[2]	Surf Sed:	0.13-3.16	1.3	6
	Sed Core:	0.00007-0.109	0.016	8
"Radionuclide Concentrations in Reservoirs, Streams and Domestic Waters Near the Rocky Flats Installation," April 1981, by Battelle PNL (Appendix D, Document D-5)[3]	Surf Sed:	0.15-0.29	0.22	3
	Water	0.0015	0.0015	1
"Time Pattern of Offsite Plutonium Contamination from Rocky Flats Plant by Lake Sediment Analyses," July 1978, by DOE (Appendix D, Document D-6)	Sed Core	0.03-0.56	0.15	2
"Standley Lake Sediment Sample Collection Summary," September 1984, by Rockwell International (Appendix D, Document D-10)	Surf Sed:	ND[4]-0.55	0.04	63
	Sed Core	0.052-0.61	0.12	2

[1]Surface sediment grab sample–typically represents upper 5 cm of sediments.
[2]Results are for samples collected in 1973 by EPA and split with DOE. Surface sediment grabs analyzed by Rocky Flats laboratory; sediment cores analyzed by Battelle Pacific Northwest Laboratory and Lawrence Livermore National Laboratory Reported values from Rocky Flats laboratory are much higher than those recorded in other Standley Lake sampling programs. Very low confidence in these values.
[3]Collected numerous water and sediment samples in which plutonium concentrations were not measured.
[4]ND = below 1984 Rocky Flats laboratory detection limit of 0 002 pCi/g.

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concentrations above estimated baseline concentrations in only two of the surface grab samples Plutonium concentrations in the cores taken at the locations of these grab samples were similar to baseline concentrations (≤ 0 1 pCi/g) EPA believed the cores to be more representative of actual conditions at the two locations and concluded that the collective sampling effort did not indicate any discernable plutonium contamination in Standley Lake sediments attributable to RFP releases (EPA, 1975)

During a 1974 investigation of radionuclides in the sediments of reservoirs and streams near the RFP, Battelle Pacific Northwest Laboratories collected eight surface sediment grab samples and a single sediment core from Standley Lake Several samples contained plutonium above EPA estimated baseline levels of ≤0 1 pCi/g (0 0037 Bq/g) Based upon the single core sample, Battelle extrapolated total plutonium and americium inventories for Standley Lake sediments at 60 and 18 mCi (2.2 and 0 7 GBq/g), respectively The core also suggested that cesium-137 levels in Standley Lake sediments were typical of atmospheric fallout baseline levels. The Battelle study did not attempt to define the historical source of Standley Lake plutonium contamination (Battelle, 1981)

Separate studies of plutonium in the surface water systems in the vicinity of the RFP concluded that. (1) plutonium rapidly and almost irreversibly attaches itself to clay sediments (CSU, 1974), and, (2) plutonium in surface water impoundments does not move very far or very rapidly through subsurface waters, meaning that the majority of the plutonium released through RFP surface waters was contained in the onsite holding ponds (Dow, 1975).

The DOE collected two sediment cores from Standley Lake in August 1976, and determined through correlation of peak radionuclide concentrations in the longer core that it represented approximately 14 years of sedimentation (1962 to 1976) This dating enabled DOE to calculate an average sedimentation rate for the core location of 1 3 in/yr (3 4 cm/yr), and to conclude that plutonium concentrations in the core location exceeded baseline levels since 1966, peaked in 1969, and declined after 1969 The report attributed 70 percent of the plutonium in Standley Lake to releases from the RFP and speculated that this plutonium was transported both by airborne particulates and by soil erosion within the lake drainage basin (such as surface water) The time correlation of plutonium deposition in the core corresponded with the known period of windborne plutonium release from the 903 Pad at the RFP (Figure 2-1) (DOE, 1978)

Rockwell International conducted an extensive sediment sampling program at Standley Lake in 1984 to evaluate sediment plutonium concentrations and to compare the results with previous work A

total of 63 surface sediment grab samples and four sediment cores were collected by Rockwell, of which seven grab samples and two cores were collected jointly with the City of Westminster The results of this study were not published in report form, but were summarized in public meetings. A maximum concentration of 0.61 pCi/g (0.02 Bq/g) was detected at a depth of 6.3 to 7 1 in (16 to 18 cm) in one core. The maximum plutonium concentration measured in the surface sediment grab samples, which potentially represented a sediment depth of several inches, was 0.55 pCi/g (0 018 Bq/g) (Rockwell, 1984)

In 1989, the CDH analyzed various species of fish collected from Standley Lake to determine if they were safe for human consumption. The fish were analyzed for selected metals, radionuclides (including plutonium-239, plutonium-240, and cesium-137), and priority organic pollutants. No radionuclides were detected in the fish; however, low concentrations of cadmium, mercury, selenium, and the pesticides DDT, DDE, DDD, and malathion were detected. The report stated that the source(s) of these contaminants was indeterminate, but that none of the contaminants detected were unique to the RFP It was concluded that the contaminants may have originated from a variety of sources in the watershed, including water diverted from Clear Creek, which contributes 96 percent of the influent to Standley Lake (CDH, 1990c)

2.3.3.2 Reservoir and Drainage Water Quality

Surface water quality in Woman Creek and Standley Lake has been monitored since shortly after the RFP opened in 1951 Tap water is also monitored for prospective RFP-derived contaminants in a number of municipalities around the RFP, including the cities of Westminster, Thornton, and Northglenn, which are supplied by Standley Lake (see Subsection 1.3.7) In addition, several historical studies have focused on potential impacts to Standley Lake water quality as a result of RFP releases.

A 1973 study by the EPA concluded that dissolved plutonium concentrations in water samples from Standley Lake were less than atmospheric fallout-derived baseline concentrations of <0.03 pCi/l (0 001 Bq/l) Dissolved uranium concentrations were less than the expected natural background of 2.5 micrograms per liter (EPA, 1975)

Battelle Pacific Northwest Laboratories analyzed Standley Lake water as part of their investigation of radionuclide concentrations in reservoirs, streams and domestic waters near the RFP Plutonium-239, plutonium-240, and americium-241 concentrations in Standley Lake water were above the

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expected atmospheric fallout background, which was not specifically quantified in this study, but were orders of magnitude lower than the EPA National Primary Drinking Water Regulation of 15 pCi/l (0 55 Bq/l) for total long-lived alpha activity (exclusive of radon and uranium) Concentrations of these three radionuclides were below detection limits of 4 5x10^{-4} pCi/l (1 7x10^{-5} Bq/l) in Westminster tap water (Battelle, 1981)

Filtration of Standley Lake influent occurs at the Northglenn, Thornton and Westminster water treatment plants Discussions with personnel at each of these facilities indicate that filter backwash sludge is not and has not previously been analyzed for plutonium or gross alpha activity

2.4 IHSS 202 (MOWER RESERVOIR)

IHSS 202 encompasses Mower Reservoir, offsite reaches of the irrigation ditch which feeds the reservoir from Woman Creek, and downstream surface water features possibly impacted by outflow from the reservoir (Figure 2-1) Portions of this irrigation ditch within the boundaries of the RFP are part of RFP OU 6 and are not included in IHSS 202.

2.4 1 Location and Description

Very little documentation exists for Mower Reservoir, a small, privately-owned impoundment located just southeast of the RFP in Section 18, T2S R69W The reservoir is fed by Woman Creek via Mower Ditch an irrigation ditch that originates within the RFP boundary (Figure 1-3) Mower Reservoir is used for agricultural purposes, primarily cattle watering and irrigation, and fluctuates in capacity depending upon water supply and demand. It covers an area of approximately 9 ac (3 6 ha) and is roughly 50 ft (15 m) deep at its deepest point (Personal communication, 1990) Outflow from Mower Reservoir flows southeast from the reservoir, eventually discharging to Standley Lake (Figure 1-3) Mower Reservoir is located on land which was the subject of a lawsuit against the RFP by several landowners, alleging contamination of the land surface by releases from the plant (DOE, 1991a)

2.4.2 IHSS Conditions

No site-specific information is available for geologic and groundwater conditions at Mower Reservoir The geology and groundwater hydrology of Mower Reservoir are expected to be similar to those described for Great Western Reservoir (Subsection 2.2.2 1) Because Mower Reservoir is fed by a

diversion from Woman Creek, surface water pathways from the RFP to Mower Reservoir are similar to those described for Standley Lake (Subsection 2.3 2.2) Biota at Mower Reservoir are expected to be similar to those at Great Western Reservoir (Subsection 2.2.2.3) and Standley Lake (Subsection 2.3.2.3)

The DOE recently examined the possibility of discharging water from RFP holding Pond C-2 to Mower Reservoir via Woman Creek and Mower Ditch (Figure 2-3) The following conditions would have to be met in order to discharge Pond C-2 water to Mower Reservoir

- All site-specific CWQCC discharge standards would have to be met by the RFP (see Section 2.2.2.2 of this document)
- Permission would have to be obtained from the owner of Mower Reservoir
- Assurance would have to be obtained from the reservoir owner that the water would be used only for agricultural purposes

2.4.3 Nature of Contamination

In contrast to the extensive historical sampling data available for Great Western Reservoir and Standley Lake, only very limited data have been collected to characterize Mower Reservoir Because the reservoir is not a public water supply, its water quality is not monitored and has not previously been evaluated. RFP-derived contaminants in Mower Reservoir are believed to have been transported primarily as airborne particulates, and to a lesser degree by surface water through the Woman Creek drainage, which may have contributed to plutonium concentrations in Standley Lake sediments (see Subsection 2.3.3). It can be inferred that contaminant concentrations resulting from releases into Woman Creek would be similar for Mower Reservoir and Standley Lake, while concentrations resulting from airborne releases, and from erosion and transport of contaminated soils by surface runoff, would be similar for Mower Reservoir and Great Western Reservoir

Mower Reservoir sediments were sampled in 1970 during EPA's initial study of radioactive contamination in the aquatic environs of the RFP A total of four surface sediment grab samples were collected. Plutonium concentrations in these samples ranged from 0.09 to 0.18 pCi/g and averaged 0.14 pCi/g, slightly exceeding EPA's estimated baseline concentration of $\leq$0.1 pCi/g (EPA, 1971,

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EPA, 1973) No further characterization of Mower Reservoir contamination has been conducted since this 1970 sampling effort

Numerous investigations have focused on elevated plutonium concentrations in surface soils around Mower Reservoir (DOE, 1991a) These studies have concluded that the primary source of the plutonium was windborne particulates from the 903 Pad (Figure 2-1) It is expected that Mower Reservoir received similar amounts of plutonium through airborne transport as the nearby land surface

2.5 CONCEPTUAL MODELS

Utilizing the information obtained in past studies of OU 3, conceptual models of contaminant exposure pathways for off-site soils (IHSS 199) and reservoirs (IHSS 200, 201 and 202) are presented here for use in the evaluation of the potential risks of OU 3 contamination to human health and the environment

The primary purpose of the conceptual models is to aid in identifying exposure pathways by which populations may be exposed to contaminants from the IHSSs. The EPA defines an exposure pathway as " a unique mechanism by which a population may be exposed to the chemicals at or originating from the site " (EPA, 1989c) As shown in Figure 2-7, an exposure pathway must include a contaminant source, a release mechanism, a transport medium, an exposure route and a receptor An exposure pathway is not complete without each of these five components. The individual components of the exposure pathway are defined as follows

- Contaminant Source For purposes of the OU 3 conceptual models the contaminant sources are the media in each IHSS which are known to have been or which potentially have been directly affected by releases from the RFP These source media are the surface soils at IHSS 199 and the sediment and surface water of IHSS 200, 201, and 202. Because known contaminants at OU 3 have been traced to past releases from the RFP the plant is shown in the models as a historical contaminant source to the IHSSs

- Release Mechanism Release mechanisms are physical and/or chemical processes by which contaminants are released from the source The conceptual models identify mechanisms which release contaminants directly from the source and those which release contaminants from transport media (i e, secondary release

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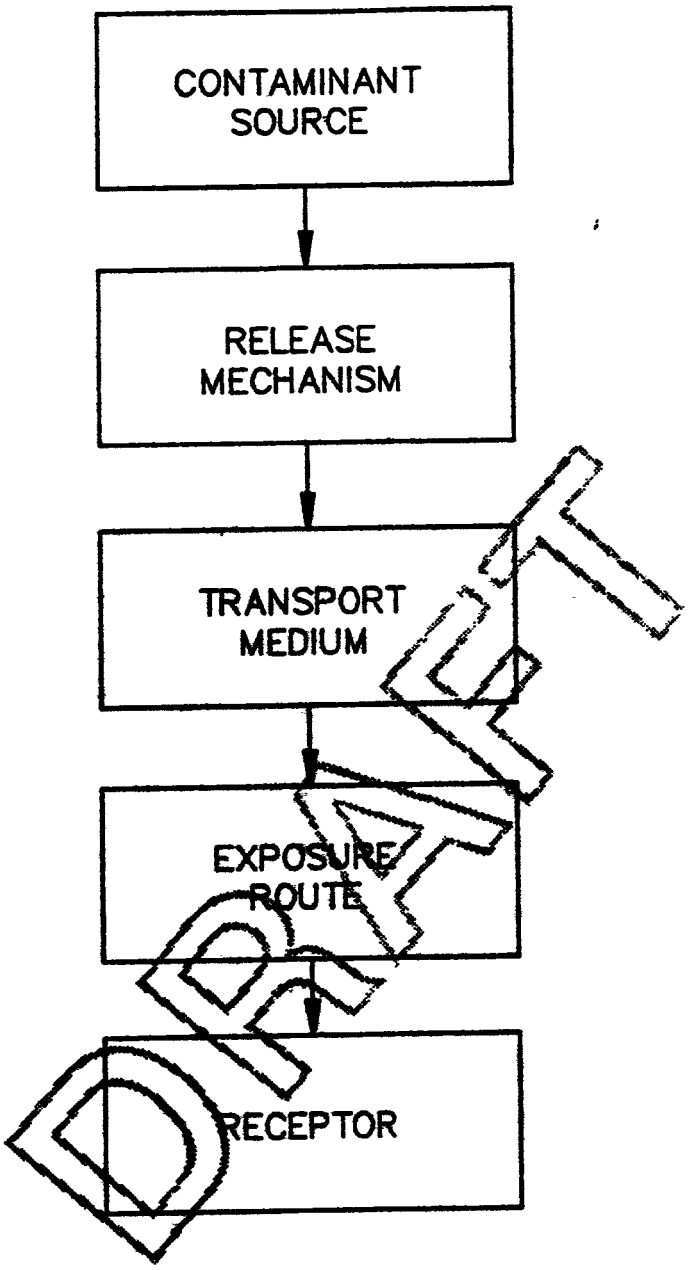

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Figure 2-7
COMPONENTS OF A COMPLETED EXPOSURE PATHWAY

mechanisms) Numerous potential release mechanisms and secondary release mechanisms for OU 3 are discussed in the conceptual models

- Transport Medium Transport media are the environmental media into which contaminants are released from the source and from which the contaminants are in turn released to a receptor (or to another transport medium by a secondary release mechanism) Potential transport media for OU 3 include air, surface water, groundwater, and biota (both flora and fauna)

- Exposure Route Exposure routes are avenues through which contaminants are physiologically incorporated by a receptor Exposure routes for receptors at OU 3 are inhalation, ingestion and dermal contact.

- Receptor Receptors are human or environmental populations which are affected by the contamination released from a site. Human receptors for OU 3 include nearby residents and visitors to the area. Environmental receptors include biota (both flora and fauna) indigenous to the OU 3 environs.

The conceptual models provide a contaminant source characterization and an overview of all the potential exposure pathways that may result from releases from and/or into each transport medium Some of these pathways have a higher potential for occurrence than others Significant exposure pathways are identified by evaluating the fate and mobility of the contaminant in each potential source and transport medium that is included in the conceptual models.

2.5 1 Conceptual Model for Off-Site Surface Soils (IHSS 199)

The general conceptual model for off-site surface soils is shown in Figure 2.8 The various elements of the conceptual model are explained in the following subsections

2.5 1 1 Historical Contamination Source

As shown in Figure 2-8, the RFP is considered the historical contamination source to the off-site surface soils Based on information presented in Sections 1 0 and 2.0 on RFP geographical setting and environmental monitoring, the airborne pathway is considered the only reasonable migration pathway that could transport contamination from the RFP to off-site surface soils Known and

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potential RFP impacts on IHSS 199 are discussed in Subsection 2.1 4 1 An understanding of the fate and mobility of the potential contaminants involved is critical in determining whether they could reasonably have impacted off-site surface soils and, if so, whether they still exist in the soils today

Radionuclides

Most of the studies performed to date at IHSS 199 have focused on plutonium contamination It has been conclusively demonstrated that plutonium has been transported from the RFP via the airborne pathway and affected off-site surface soils immediately east of the RFP Americium has also been detected in these soils, indicating either direct airborne transport from the RFP or in situ ingrowth with the plutonium in the soils It is likewise conceivable that airborne transport of uranium to off-site soils could occur

Nonradioactive Contaminants

Nonradioactive contaminants discussed in Subsection 2.1.4 1 include metals, VOCs, semi-volatile organics, and inorganic ions Nonradioactive metals, particularly beryllium, could feasibly have been transported by air to off-site surface soils. Few potential airborne pathway sources appear to exist on the RFP for metals other than beryllium. It is not likely that VOCs or semi-volatile organics have affected off-site surface soils, because these compounds tend to volatilize in air rather than settle out in a discrete surface deposit. It is remotely possible that fugitive dust from the RFP could contain organic compounds which might remain bound to the particles through airborne transport and settle out on surface soils. It is also very unlikely that inorganic ions could be transported via fugitive dust to off-site soils because of their high solubility and tendency to quickly leach into deeper soils

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2.5 1 2 Current Contaminant Source

Contaminated off-site surface soils are considered the current contaminant source at IHSS 199 (Figure 2-8) The following subsections focus on contaminant and soil characteristics which may affect contaminant transport from the surface soils.

2.5 1.2.1 Contaminant Characteristics Surface soils immediately east of the RFP have been shown to contain plutonium and its decay product americium, in excess of expected background concentrations (as measured at Colorado Front Range sites remote from the RFP) Beryllium and

selected radionuclides other than plutonium and americium have also been characterized in these soils, although to a much lesser extent than plutonium. Other potential RFP-derived contaminants, including VOCs and semi-volatiles, metals other than beryllium, and inorganic ions, have not been characterized in off-site surface soils.

Radionuclides

Plutonium and americium are the only RFP-derived radioactive contaminants known to exist in off-site surface soils. Plutonium concentrations in selected off-site surface soils have been well-characterized through numerous sampling programs. Americium is expected through ingrowth with plutonium and apparently has been measured above background concentrations in off-site surface soils (Rockwell, 1985a) The following discussions focus on characteristics of plutonium which may affect its fate and mobility in the environment. Numerous studies of plutonium fate and mobility are incorporated by reference into the discussions. Much less information is available on the nature of amencium in the environment. Americium is slightly more mobile in the environment than plutonium, but is still considered insoluble under typical environmental conditions.

There are 15 known isotopes of plutonium that decay into other elements at half-lives ranging from hours to 387,000 years (Ames and Rai, 1978). At the RFP, plutonium exists primarily as plutonium-239 and -240 (Table 2.5)

Plutonium speciation in the environment is heavily influenced by hydrogen ion concentration (pH) and oxidation-reduction capacity (Eh). Typical environmental conditions are pH in the range of 5 to 8 and a positive Eh (greater than 0.05 volts) (Brownlow, 1979) Under these conditions, plutonium species will most likely be found in the following order of occurrence. $Pu^{+4} > PuO_2^{+2} > Pu^{+3} > PuO^{+1}$ (Ames and Rai, 1978)

As shown above, the most probable species in the environment is the plus 4 valence (oxidation state) species, which will exist either as plutonium dioxide (PuO_2) or as a solid hydroxide, $Pu(OH)_4$ (Brookins, 1984, Dragun, 1988) The assertion is based on the assumption that the pH of the environmental system is not low and that the system is in an oxidative state (Eh > 0.0)
Plutonium shows a very strong tendency to adsorb to clays, metal dioxides, and organic matter in soils and thus has a very low migration potential in the environment (CSU, 1974, Brookins, 1984) The distribution coefficient (K_d), which is the ratio of the concentration of adsorbed material to concentration of material in water at equilibrium, for plutonium is 10^3-10^5 (Allard and Rydberg, 1983),

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TABLE 2-5

GENERAL CONCEPTUAL MODEL FOR IHSS 199

Contaminant Source	Release Mechanism	Transport Medium	Secondary Release Mechanism	Exposure Route	Receptor
Offsite Surface Soils	None	None	None	Ingestion Dermal Contact	Humans Biota
	Fugitive Dust (wind erosion)	Air	None	Inhalation	Humans Biota
	Fugitive Dust (wind erosion)	Air	Settled Dust Plants Settled Dust-Soil Settled Dust Water	Ingestion Dermal Contact	Humans Biota
	Surface Runoff (sediment load)	Surface Water	None	Ingestion Dermal Contact	Humans Biota
	Surface Runoff (sediment load)	Surface Water	Deposition/ Precipitation	Ingestion Dermal Contact	Humans Biota
	Infiltration/ Leaching	Groundwater	Pumpage	Ingestion Dermal Contact	Humans Biota
	Bioconcentration/ Bioaccumulation	Biota	None	Ingestion Dermal Contact	Humans Biota
	Tracking	Biota	None	Ingestion Dermal Contact	Humans Biota

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meaning that the ratio of plutonium bound to soil to plutonium dissolved in water would be expected to vary from 1,000 1 to 100,000;1 The EPA (1990b) gives a K_d of $2x10^3$ for plutonium

Nonradioactive Contaminants

Based on the discussion presented in Section 2.5 1 1, the only nonradioactive contaminants which could reasonably be expected to exist in off-site surface soils are metals. Beryllium is the only nonradioactive metal for which a potential RFP source to the airborne pathway is recognized. It should be noted here that beryllium concentrations were measured in off-site soils in 1971 by CDH. Higher concentrations were found west of the RFP, where deposition resulting from releases to air are very unlikely (CDH, 1991) More probably, the higher concentrations result from increased natural background in the soil due to closer proximity to granitic rocks, which contain naturally-occurring beryllium oxide. CDH measured beryllium in off-site surface soils around the RFP again in 1989; results were reported as <2.7 ppm for all samples analyzed, consistent with background samples collected at locations remote from the RFP (CDH, 1991)

2.5.1.2.2 **Soil Characteristics.** A detailed discussion of surface soils in the RFP vicinity is presented in Subsection 2.1.3.1 The organic matter content of the surface soils varies between 2 to 4 percent and the pH values range from 6.8 to 8.4 (neutral to slightly alkaline) The vertical permeability of these soils is 0 06 to 0.6 in/hr (0.15 to 1 5 cm/hr) Runoff is generally rapid and water erosion potential is high where not protected by vegetation. The predominant minerals of the fine soil fraction are montmorillonitic clays with calcareous materials (SCS, 1980) As discussed in Subsection 2.1 3.1, surface soil conditions may have changed on the IHSS 199 remedy acreage as a result of court-ordered tilling.

2.5.1.3 **Release Mechanisms and Transport Media**

Factors which ultimately determine the processes that may be responsible for releasing contaminants between transport media or to receptors include the contaminant and soil characteristics discussed in the preceding subsection, the climatological characteristics of the site, and the behavior of the contaminant in the various potential transport media.

Preceding discussions have indicated that plutonium and americium are the only contaminants likely to exist in off-site surface soils as a result of RFP releases. Plutonium release mechanisms and behavior in transport media have been well-studied at the RFP and elsewhere, while specific

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information on the environmental fate and transport of americium are all but unavailable As mentioned in Subsection 2.5 1 2 1 americium is known to be slightly more mobile than plutonium however for practical purposes the two radionuclides behave similarly in the environment. For these reasons the following subsections focus on plutonium

2.5 1 3 1 Climatological Characteristics Of particular importance to the fate and mobility of contaminants in off-site surface soils are wind and precipitation The climate in the RFP area is typified by strong, often gusty winds The stronger winds blow from the west and northwest, and occur more often during the winter months The average annual precipitation (total moisture) for the area is 15 in (38 cm), of which 40 percent falls during the spring Rainfall intensity varies from long, low-intensity frontal storms in the fall and early spring to short, intense cloudbursts in the late spring and summer months Snowmelt can also generate high runoff in the area. Snowfall at the RFP averages 85 in/yr (216 cm/yr) (DOE, 1980) Climatology in the RFP vicinity is discussed in more detail in Subsection 2.1 4 4

2.5 1 3.2 Contaminant Fate and Mobility in Air Atmospheric resuspension of contaminated soil particles is the principal release mechanism affecting the plutonium and americium contamination in off-site surface soils The same mechanism will exist for any nonradioactive metals present in the soils. Resuspension occurs as a result of wind action, and is often amplified by soil disturbance The resuspension factor is defined as the ratio of the air concentration to soil concentration and is expressed as per meter (m^{-1})

Resuspension factors for each known contaminated section of T2S, R69W are presented in Rockwell International s disclosure to the City of Broomfield regarding the remedy acreage (Appendix D, Document D-8) These resuspension factors are

- Section 6–1 5x10^{-9} m^{-1}
- Section 7–1 0x10^{-9} m^{-1}
- Section 18–1 8x10^{-9} m^{-1}

The methodology behind the development of these values is given in SCS remedy recommendations (SCS 1985) CDH developed similar values in the 1970s for quiescent, vegetated lands in the vicinity of the RFP A further finding was that vehicular disturbance would change the average values to approximately 1x10^{-8} m^{-1} (CDH 1976)

Once resuspended in air, soil particles can move long distances depending on wind velocity and turbulence. Smaller diameter particles will be carried longer distances; therefore, the size of the resuspended soil particles is critical in assessing their mobility Previous studies have shown that the distribution of plutonium by soil particle sizes at the RFP was variable, indicating the association of plutonium with soil mineral phases of various sizes (McDowell and Whicker, 1978) The respirable percentage of suspended plutonium-contaminated soil particles in air (those with diameters less than 10 micrometers [μm]) has been estimated to be approximately 20 to 40 percent (Whicker et al., 1974) Because of the low settling velocities associated with such small particles, the particles can be transported relatively long distances by winds before settling.

2.5.1.3.3 <u>Contaminant Fate and Mobility in Groundwater</u> As discussed in Subsection 2.5.1.2.1, the predominant form of plutonium expected in the RFP environs, PuO_2, is considered insoluble in water Plutonium will tend to remain adsorbed to solid particles at pH values between 3 and 9 (Roxburgh, 1987) Plutonium can, however, undergo extremely limited dissolution in the pH range of environmental systems. The solid phase of PuO_2 is a colloidal polymer of neutral or positive charge. Such colloids can contain from 10^6 to 10^{16} atoms of plutonium (Andelman and Rozzell, 1970) Increasing pH tends to reduce the charge density of the polymer, and at pH > 9, it is expected that the colloids become negatively charged, decreasing the affinity of PuO_2 for soils and thus increasing its mobility in surface water The solubility of plutonium can also be increased through complexation with humic acid (DOE, 1991). Numerous measurements have shown that RFP ground waters tend to be neutral to slightly basic (typical pH is 7 5)

The migration of plutonium ions in groundwater is retarded due to continuous distribution of plutonium between soil and water phases. The K_d values discussed in Subsection 2.5.1.2.1 indicate that plutonium will not leach readily to groundwater or migrate within groundwater However, it has been shown that plutonium bound to colloidal particles in groundwater may be unaffected by the forces that act to retard plutonium ion movement through groundwater systems, allowing migration farther than predicted based on K_d values alone (Penrose et al. 1990) The Penrose et al. study describes dissolved plutonium (and americium) from a treated aqueous effluent migrating through a shallow alluvial aquifer derived from volcanic tuff The mineralogy of this aquifer is not described, but fine-grained material described as silty clay may, in fact, be zeolites. The plutonium source, mode of transport, depositional mechanism, and aquifer environment are potentially very different than the surface soil environment in the RFP vicinity The Penrose et al. study cautions against extrapolating the results to dissimilar environments and conditions without careful site-specific study

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2 5 1 3 4 **Contaminant Fate and Mobility in Surface Water** The fate and transport of plutonium in drainage and reservoir sediments in the vicinity of the RFP have been evaluated and discussed (DOE 1990) This document provides an evaluation of the potential transport and exposure pathways associated with the potential surface water runoff and soil erosion release mechanisms discussed below

Surface runoff may erode contaminated surface soil and transport them as sediment load to surface waters (e g , streams and reservoirs) In stagnant surface waters (e g reservoirs and holding ponds), the suspended sediments settle out as bottom sediments Plutonium transported in this manner will tend to remain bound to the sediments during transport and after redeposition as bottom sediment, as illustrated by the high K_d values associated with plutonium As a result, bottom sediments will immobilize plutonium considerably This strong adsorption has been demonstrated in laboratory studies of plutonium uptake by the clay-rich sediments typical of surface water impoundments near the RFP (CSU, 1974) High dissolved organic carbon, carbonate fluoride chloride, or nitrate concentrations along with high percolation rates could conceivably leach some of the plutonium in bottom sediments downward toward the water table There is no evidence, however, that such a process is occurring in impoundments near the RFP Plutonium concentrations in off-site reservoir sediments decrease to background levels at a depth of 8 to 12 inches (20 to 30 cm) in the reservoir sediment columns (Rockwell, 1984, Rockwell, 1985a) Furthermore, groundwater monitoring directly downgradient of on-site RFP holding ponds has not yielded a single detection of plutonium

It has been demonstrated that density stratification of lake waters in summer months results in a reducing environment in deeper water. The distribution coefficient of plutonium in reducing waters is threefold to tenfold lower than in oxidizing conditions, indicating that plutonium mobility will increase somewhat. However, the K_d values for these waters are still very high (ANL, 1986)

Resuspension of plutonium from bottom sediments is also possible by organisms that disturb the sediments. The resuspended plutonium will eventually settle and again become part of the sediment.

2.5 1 3 5 **Contaminant Fate and Mobility in Biota.** Contaminants can be released from surface soils by biota either through mechanical spreading (tracking) or through physical incorporation of the contaminant into the biomass (bioconcentration and bioaccumulation) Tracking is considered

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an insignificant release mechanism when compared to the potential for wind or water erosion from surface soils.

Plutonium eroded from surface soils by wind or water can settle onto foliar surfaces. The magnitude of foliar retention will depend on the physical structure of the surface Foliar contamination can be removed by weather or by dropping of plant parts (field loss)

Plutonium which settles onto foliar surfaces or physically adsorbs to the surfaces of plants or zooplankton can be taken up into the food chain. Plutonium on foliar surfaces may be absorbed metabolically by plants, or may pass from soil into the root systems of plants. A study using a water-soluble form of plutonium (unlike PuO_2) mixed into soil, however, demonstrated that significant uptake of plutonium does not occur in plants grown in the soil (specifically, the first crop of plants) The relative concentration factor expressed as concentration in dry plant material/concentration in dry soil was measured at less than 0.0001 in the study (Menzel, 1965) Similar values were obtained in a study involving a marsh estuary near Sellfield, England (Ham, 1989)

Plutonium taken up in the food chain by animals will not tend to bioconcentrate or bioaccumulate. The gastrointestinal absorption factor for PuO_2 listed by the International Commission on Radiation Protection (ICRP) is $1x10^{-5}$, indicating that plutonium will not easily be absorbed through the intestine, but rather will pass through the intestine and be discharged as waste (ICRP, 1979) In adult animals less than 0.01 percent of ingested plutonium is absorbed from the intestine (ICRP, 1988) Past RFP studies which have included bioassays of aquatic and terrestrial indicator plant and animal species have found normal background concentrations of plutonium (EPA, 1971, CSU, 1974, CDH, 1990c)

2.5.1.4 Exposure Routes and Receptors

As illustrated in Figure 2-8, contaminants released from off-site surface soils can affect potential receptors through inhalation of airborne particles and through ingestion of or dermal contact with contaminated source or transport media. The most plausible exposure routes appear to be inhalation of plutonium-contaminated particles eroded from surface soil by wind and ingestion of plants with surficial contamination as a result of settled dust eroded from surface soil by wind. Potential human receptors include both residents of and visitors to the RFP area. The demographics of the RFP vicinity are discussed in Subsection 1.3.6. At the present time, both the Jefferson County and City of Broomfield remedy acreage at IHSS 199 are fenced and posted to

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prevent public access Environmental receptors include biota (both flora and fauna) indigenous to the RFP environs as addressed in Subsection 1 3 5

2 5 1 5 Soils Conceptual Model Summary

Plutonium and americium are the only contaminants likely to exist in off-site surface soils as a result of RFP releases Plutonium in off-site surface soils most likely exists as the thermodynamically stable solid PuO_2. Plutonium fate and mobility in the environment are controlled by its strong tendency to adsorb to clays, metal oxides and organic matter in soils Plutonium potentially can be released from surface soils into the transport media of air (by wind erosion) and surface water (by water erosion) Plutonium released into these media will tend to remain bound to the particles which transport it Plutonium can also be taken up in the food chain by ingestion of plants with surficial PuO_2 contamination, but will not concentrate or accumulate in biota.

Groundwater does not appear to be a viable transport medium for plutonium from off-site surface soils in the RFP area. Research and investigations into plutonium mobility at other locations have demonstrated that lack of plutonium transport through unsaturated porous media is the rule rather than the exception (Andelman and Rozzell, 1970, Brookins, 1984, Kim et al , 1984, Shade et al , 1984 Silva et al., 1979, Staley et al , 1979) The reasons appear to be the insolubility of plutonium and the strength with which it is adsorbed to fine-grained particles in unsaturated porous media.

The most plausible exposure routes are inhalation of fugitive dust generated from surface soils and ingestion of plants onto which fugitive dust has settled

2.5.2 Conceptual Model for Off-Site Reservoirs and Drainages (IHSSs 200, 201, and 202)

The general conceptual model for off-site reservoirs and drainages is shown in Figure 2-9 The various elements of the conceptual model are explained in the following subsections.

2.5 2.1 Historical Contamination Source

As shown in Figure 2-9 the RFP is considered the historical contamination source to the off-site reservoirs in the reservoir conceptual model Based on information presented in Sections 1 0 and 2.0 on RFP geographical setting and environmental monitoring the airborne and surface water pathways are considered the only reasonable migration pathways that could transport

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contamination from the RFP to off-site reservoirs and drainages. Known and potential RFP sources of airborne and surface waterborne contamination to IHSSs 200, 201, and 202 are discussed in Subsections 2.2.3, 2.3 3 and 2.4 3, respectively An understanding of the fate and mobility of the potential contaminants involved is critical in determining whether they could reasonably have impacted off-site reservoirs and drainages and, if so whether they still exist in the reservoirs and drainages today

Radionuclides

Most of the studies performed to date at IHSSs 200, 201, and 202 have focused on plutonium contamination of reservoir sediments. It has been conclusively demonstrated that plutonium has been transported from the RFP via the surface water and air pathways and affected off-site reservoir and drainage sediments. Americium has also been detected in these sediments, indicating either direct surface waterborne or airborne transport from the RFP or in situ ingrowth with the plutonium in the sediments Tritium is known to have been released to Great Western Reservoir through surface water It is conceivable that surface waterborne or airborne transport of uranium to off-site drainages and reservoirs could occur

Nonradioactive Contaminants

Nonradioactive contaminants discussed in Subsections 2.2.3, 2.3 3 and 2.4 3 include metals, VOCs, semi-volatile organics, inorganic ions, and herbicides. Potential sources of airborne contaminants discussed in Subsection 2 5 1 1 for off-site surface soils also apply to the off-site reservoirs Nonradioactive metals, VOCs, semi-volatile organics inorganic ions, and herbicides all could feasibly have been transported in surface water to the off-site drainages and reservoirs

2.5 2.2 Current Contaminant Source

Contaminated off-site drainage and reservoir water and sediments are considered the current contaminant source in the conceptual model (Figure 2-9) The following subsections focus on contaminant and source media characteristics which may affect contaminant transport from the source media.

2.5 2.2.1 Contaminant Characteristics As discussed in Sections 2.1 3 2.2.2, and 2.3 2, reservoir sediments at IHSSs 200, 201, and 202 have been shown to contain plutonium and its decay

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product, americium, in excess of expected background concentrations (as measured in Colorado Front Range reservoirs remote from the RFP) Concentrations of beryllium and of selected radionuclides other than plutonium and americium have also been characterized in these sediments, although to a much lesser extent than plutonium. Other potential RFP derived contaminants, including VOCs, semi-volatiles, metals other than beryllium, inorganic ions, and herbicides have been characterized in drainage and reservoir water through routine monitoring, but have not been measured in drainage and reservoir sediments.

Radionuclides

Plutonium, americium and tritium are the only RFP-derived radioactive contaminants known to exist in the off-site reservoirs and drainages. Plutonium concentrations in off-site drainage and reservoir sediments have been well-characterized through numerous sampling programs. Americium can be expected through ingrowth with plutonium and also has been measured above background concentrations in off-site reservoir sediments (Battelle, 1981) Plutonium characteristics which may affect its fate and mobility in the environment are discussed in detail in Subsection 2.5.1.2.1 Much less information is available on the nature of americium in the environment. Americium is slightly more mobile in the environment than plutonium, but is still considered insoluble under typical environmental conditions. Routine water quality monitoring in Great Western Reservoir and Standley Lake has indicated that the water in these reservoirs is not measurably impacted by the radionuclide contamination known to exist in the bottom sediments or by other potential radioactive contaminants, including uranium.

A significant release of tritium to IHSS 280 occurred in 1973. Environmental monitoring of water quality in the off-site drainages and reservoirs indicated that the tritium returned to expected background levels by 1976 and has remained at these levels. The potential impact of tritium on drainage and reservoir sediments has not been studied, but it is expected that tritium's extreme mobility in the environment would preclude concentration in sediments. Furthermore, natural radioactive decay (half life· 12.3 years) will have reduced any concentration of tritium substantially since the 1973 release.

Vertical profiles of the plutonium-bearing horizons developed from off-site reservoir sediment cores have also shown that the horizons in Great Western Reservoir and Standley Lake have been buried to varying depths by subsequent sedimentation. The four cores collected during the most recent Great Western Reservoir study (by Rockwell International in 1983) showed between 3-9 in (7 5-

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23 cm) of sediment overlying the plutonium-bearing layer The depth of burial in two cores collected in 1984 by Rockwell International from Standley Lake ranged from 6 3-8 7 in (16-22 cm) These cores were collected from deeper areas of the reservoirs, where greater sedimentation rates occur and the highest plutonium concentrations have been found to exist. Based on calculated sedimentation rates for the reservoirs, which range from 0 1 in/yr (0 25 cm/yr) in shallow, near-shore areas to 1 4 in/yr (3 6 cm/yr) in deeper areas, it can be inferred that the plutonium-bearing horizons in each reservoir potentially have been covered by an additional 0 7 inches (1 8 cm) of sediment in shallow areas and an additional 9 8 in (25 cm) of sediment in deeper areas in the approximately seven years since the Rockwell International studies were conducted

Nonradioactive Contaminants

As discussed in Subsection 2.5.2.1, nonradioactive contaminants which could reasonably be expected to exist in the off-site drainages and reservoirs include VOCs, semi-volatiles, metals, inorganic ions, and herbicides Routine monitoring of surface water drainages at the RFP boundary by various agencies and municipalities has occasionally detected trace concentrations of VOCs metals, inorganic ions, and herbicides. Because of the erosional nature of most drainages in the RFP area (Section 2.5.2.2.2), it is reasonable to expect that any contaminants in the drainages will eventually reach the reservoirs, unless surface water infiltration transports soluble contaminants to groundwater

Due to the soluble nature of most VOCs, inorganic ions, and herbicides, it is reasonable to expect that these potential contaminants would not tend to concentrate in bottom sediments, but rather would remain dissolved in surface water. Routine monitoring of Great Western Reservoir and Standley Lake have indicated that VOCs, inorganic ions and herbicides have not measurably impacted reservoir water quality in these reservoirs It is probable that nonradioactive metals would tend to adsorb to suspended sediments in the water and settle out in bottom sediments in the reservoirs in a manner similar to the radioactive metals plutonium and americium.

2.5.2.2.2 Sediment and Water Characteristics Drainages in the vicinity of the RFP are expected to be erosional, meaning that they will tend over time to transport their full sediment load downstream rather than permanently depositing it within the drainage If the sediment load eventually reaches a stagnant impoundment such as a holding pond or reservoir, the sediment will gradually settle out to form bottom sediments Section 2.5 1 3 4 discusses the fate and mobility of plutonium in sediments and surface water

A distinction is made in Figure 2-9 between dry and saturated sediments because potential exposure pathways differ significantly for dry and saturated sediments. Because the water level in reservoirs fluctuates widely with varying supply and demand, particularly on a seasonal basis, bottom sediments in near-shore and other shallow water areas may be exposed for long enough periods to dry Dry sediments are potentially subject to a similar set of release mechanisms as that described in Subsection 2.5.1.3 for surface soils

As discussed in Subsection 2.5.1 1, plutonium fate and mobility is heavily influenced by pH and Eh. Surface water typically is characterized by oxidizing conditions and neutral or near-neutral pH. Under these conditions, plutonium will exist in the plus 4 oxidation state as solid plutonium hydroxide, $Pu(OH)_4$. Density stratification of lake waters in summer, however, can result in a reducing environment in deeper water Under reducing conditions, the K_d of plutonium may be three- to ten-fold lower than under typical reservoir conditions, meaning that plutonium mobility may increase slightly The magnitude of this increase is not significant, however, in terms of overall plutonium mobility (ANL, 1986)

The pH and Eh of environmental systems will influence the fate and mobility of mobility of most nonradioactive metals in a similar manner as plutonium.

2.5.2.3 Release Mechanisms and Transport Media

As shown in Figure 2-9, potential release mechanisms and transport media can combine in a variety of ways to transport contamination from the reservoirs to human and other biotic receptors. The identification of potential release mechanisms and transport media is not meant to imply that they will occur or be significant in the reservoirs. Preceding discussions have indicated that plutonium, americium and possibly nonradioactive metals are the only contaminants likely to exist in off-site drainages and reservoirs, and that these contaminants will exist in measurable concentrations only in the drainage and reservoir sediments. The source medium in which the known and potential contaminants exist is a semi-consolidated mass buried in the bottom sediment of each reservoir, and is in fact not expected to be readily available for release into the environment by any of the mechanisms described below

Plutonium release mechanisms and behavior in transport media have been well-studied at the RFP and elsewhere, while specific information on the environmental fate and transport of americium are all but unavailable. As mentioned in Subsection 2.5.1.2.1, americium is known to be slightly more

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mobile than plutonium, however, for practical purposes the two radionuclides behave similarly in the environment For these reasons, the following subsections focus on plutonium

2 5.2 3 1 **Contaminant Fate and Mobility in Surface Water** Plutonium fate and mobility in surface water are addressed in Subsection 2.5 1 3 4 This discussion will also apply to the general fate and mobility of potential nonradioactive metals in the off-site drainages and reservoirs

As indicated previously, nonradioactive contaminants which have been detected in trace amounts in drainage water at the RFP boundary include VOCs, metals, inorganic ions and herbicides Because most of the ephemeral streams in the RFP area are losing streams (i e, streams which recharge groundwater) it is conceivable that soluble contaminants in surface water could be transported to groundwater by infiltration of surface water into the drainage bed

2.5 2.3 2 **Contaminant Fate and Mobility in Air** Plutonium fate and mobility in air are addressed in Subsection 2.5 1 3 2. This discussion will also apply to the general fate and mobility of potential nonradioactive metals in the off-site drainages and reservoirs.

2.5.2.3 3 **Contaminant Fate and Mobility in Groundwater** No evidence has been observed in past studies of Great Western Reservoir or Standley Lake of solubilization and leaching of plutonium downward in the sediment column towards the groundwater table (subsection 2.5 1 3 4) This lack of mobility results primarily from the strong tendency of plutonium to adsorb to clay in the sediments. The discussion in Subsection 2.5 1.3 4 will also apply to the general fate and mobility of potential nonradioactive metals in the off-site drainages and reservoirs.

2.5.2.3 4 **Contaminant Fate and Mobility in Biota.** Plutonium fate and mobility in biota are addressed in Subsection 2 5 1 3 5.

2.5 2.4 Exposure Routes and Receptors

As illustrated in Figure 2-9, contaminants released from off-site drainages and reservoirs can affect potential receptors through inhalation of airborne particles and through ingestion of or dermal contact with contaminated source or transport media. The most plausible exposure routes appear to be inhalation of plutonium-contaminated particles eroded from exposed (dry) sediments by wind and ingestion of plants with surficial contamination as a result of settled dust eroded from exposed sediments by wind

Potential human receptors include both residents of and visitors to the RFP area. The demographics of the RFP vicinity are discussed in Subsection 1.3.6. At the present time, Standley Lake (IHSS 201) and the surrounding area are used extensively for recreational purposes, including boating, fishing and hiking. Great Western Reservoir (IHSS 200) is fenced and posted by the City of Broomfield to prevent public access. Both of these reservoirs are utilized as public water supplies. Standley Lake water is also used for irrigation of croplands, primarily in areas northeast of the reservoir Mower Reservoir (IHSS 202) is used solely for cattle watering and irrigation and is located on private land

Environmental receptors include biota (both flora and fauna) indigenous to the RFP environs, as addressed in Subsections 1.3.5 and 2.2.2.3.

2.5.2.5 Reservoir Conceptual Model Summary

Plutonium, americium and possibly nonradioactive metals are the only contaminants likely to exist in off-site drainage and reservoir sediments as a result of RFP releases. Other potential contaminants, including VOCs, inorganic ions, and herbicides, may exist incidentally in drainage surface water, based on the results of environmental monitoring at the RFP boundary

Plutonium in off-site drainages and reservoirs most likely exists as the thermodynamically stable solid $Pu(OH)_4$. Plutonium fate and mobility in the environment are controlled by its strong tendency to adsorb to clays, metal oxides, and organic matter in soils. Plutonium potentially can be released from exposed (dry) reservoir sediments by wind erosion into the transport medium of air Plutonium released into air will tend to remain bound to the particles which transport it. Plutonium can also be taken up in the food chain by ingestion of plants with surficial PuO_2 contamination, but will not concentrate or accumulate in biota.

Groundwater does not appear to be a viable transport medium for plutonium from off-site drainages and reservoirs in the RFP area. Results of past studies of Great Western Reservoir and Standley Lake have shown that the plutonium is effectively immobilized in the bottom sediments and is not being leached toward the water table. Incidental soluble contaminants in off-site drainage water may be transported to groundwater if the surface water infiltrates the drainage bed.

The most plausible exposure routes are inhalation of fugitive dust generated from exposed reservoir sediments and ingestion of plants onto which fugitive dust has settled.

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This section provides a preliminary identification of potential chemical-specific applicable or relevant and appropriate requirements (ARARs) for surface water and groundwater at OU 3 Chemical-specific ARARs do not currently exist for soils Under the terms of the 1985 Settlement Agreement for IHSS 199, the remedy action level was based upon the CDH special construction requirements standard for plutonium in soil of 0 9 pCi/g The court-ordered agreement in IHSS 199 established a remediation goal of less than the CDH special construction requirements standard of 0 9 pCi/g However, it is stated in the Settlement Agreement that adoption of the CDH standard is not meant to imply concurrence between the lawsuit parties on the reasonableness, appropriateness, or applicability of the standard as an action level for the remedy As the remedial investigation proceeds, information will become available from the risk assessment, which will allow a determination of acceptable contaminant concentrations in soils to protect human health and the environment.

The summary of possible ARARs presented in this section is based on current federal and state health and environmental statutes and regulations and the chemicals suspected to be present at OU 3 The rationale for the chemicals suspected to be present at OU 3 is presented in Subsection 6.2. The preliminary identification and examination of potential ARARs provide for the use of appropriate analytical detection limits during the RFI/RI As data become available during the RFI/RI specific ARARs will be proposed for OU 3 If conducted the Corrective Measures Study (CMS)/Feasibility Study (FS) report will further address chemical-specific ARARs as well as action- and location-specific ARARs in the development and evaluation of remedial alternatives

3 1 THE ARARs BASIS

The basis for ARARs is cited in Section 121(d) for 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 applicable or relevant and appropriate federal laws or promulgated state laws whichever is more stringent 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 (NCP 40 CFR 300 400[g][4]) Colorado

Department of Health (CDH) Water Quality Control Commission (WQCC) groundwater standards are to-be-considered (TBC) since they are not yet enforceable.

3.2 THE ARAR PROCESS

A screening and analysis process will be used to determine the potential ARARs to be applied to OU 3. The analysis will address compliance with chemical-, location-, and action-specific ARARs in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) The screening process will consider relevant and appropriate requirements in the same manner as applicable requirements. When more than one ARAR is identified, the most stringent ARAR will be used.

The first step in identifying potential ARARs will occur after the initial scoping and site characterization and will involve the analysis of the chemicals suspected to be present at the site and any location-specific characteristics at the site. Once the chemicals have been identified, the presence or absence of chemical-specific ARARs will be determined.

Chemical-specific ARARs are derived primarily from federal and state health and environmental statutes and regulations, including the following:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) applied to both surface and groundwater
- Clean Water Act (CWA) Water Quality Criteria (WQC) applied to surface water
- RCRA Subpart F Groundwater Concentration Limits (40 CFR 264.94)—applied to groundwater
- Colorado Department of Health (CDH) surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, Section 3.8.29, Final Rule Effective March 30, 1990)—applied to surface water
- CDH WQCC proposed statewide and classified groundwater area standards (5 CCR 1002-8, Section 3.11)—applied to groundwater as TBC

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A summary of chemical specific standard or potential ARARs based on the above regulations and contaminants that may be found at OU 3 is presented in Table 3-1, Groundwater Quality Standards Table 3-2, Federal Surface Water Quality Standards and Table 3-3 State Surface Water Quality Standards These potential chemical-specific ARARs and accompanying regulations will be screened to determine their jurisdictional requirements and applicability to OU 3 If the requirements are not applicable they will be further screened to determine whether they are relevant and appropriate to the particular site-specific conditions at OU 3 Where ARARs do not exist for a particular chemical or where existing ARARs are not protective of human health or the environment, TBC criteria, such as guidances proposed standards and advisories will be evaluated for use Where ARARs and TBCs are not available or are less than laboratory practical quantitation limits (PQLs) PQLs will be utilized Standards identified as potential ARARs as well as TBC criteria, will be analyzed according to the procedures outlined in the NCP, CERCLA Compliance with Other Laws Manual (EPA 1989b) Risk Assessment Guidance for Superfund Human Health Evaluation Manual Volume 1 (EPA 1989c) and Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites (EPA 1988b)

3 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 stringent laws that, while not "applicable" to a hazardous substance pollutant contaminant, remedial action, location, or other circumstance 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)

TABLE 3-1

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs FOR OU 3, OFFSITE AREAS
GROUNDWATER QUALITY STANDARDS

		Federal Standards					State Standards (TBCs)				
							CDH WQCC Groundwater Quality Standards[4]				
Parameter	Type	SDWA Maximum Contaminant Level[1]	SDWA Secondary Contaminant Level TBCs[2]	SDWA Maximum Contaminant Level Goal[1]	SDWA Maximum Contaminant Level Goal TBCs[2]	RCRA Subpart F Concentration Limit (40 CFR 264.94)[3]	Tables A and B Statewide	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agricultural	Table 4 TDS Standard
pH	Field Parameter	6.5-8.5[5]							6.5-8.5	6.5-8.5	
Specific Conductance	Field Parameter										
Temperature	Field Parameter										
Total Dissolved Solids	Indicator	500 mg/l[5]									400 mg/l[6]
Bicarbonate	Anion										
Carbonate	Anion										
Chloride	Anion	250 mg/l[5]							250 mg/l		
Fluoride	Anion	4 mg/l, 2 mg/l[5]		4 mg/l				4 mg/l		2 mg/l	
N as Nitrate	Anion	10 mg/l						10.0 mg/l			
N as Nitrate+Nitrite	Anion		10 mg/l		10 mg/l					100 mg/l	
N as Nitrite	Anion		1 mg/l		1 mg/l			1.0 mg/l		10 mg/l	
Potassium	Anion										
Sulfate	Anion	250 mg/l[5]							250 mg/l		
Americium 241	Radionuclide										
Gross Alpha	Radionuclide	15 pCi/l						15 pCi/l			
Gross Beta	Radionuclide	4 mrem/yr						4 mrem/yr			
Plutonium 239+240	Radionuclide						15 pCi/l[6]	15 pCi/l			
Uranium 233+234	Radionuclide										
Uranium 235	Radionuclide										
Uranium 238	Radionuclide										

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TABLE 3 1

POTENTIAL CHEMICAL SPECIFIC ARARs/TBCs FOR OU 3, OFFSITE AREAS
GROUNDWATER QUALITY STANDARDS
(Concluded)

EXPLANATION OF TABLE

Notes
[1] EPA National Primary and Secondary Drinking Water Regulations 40 CFR 141 and 40 CFR 143 (as of 5/1990)
[2] EPA National Primary and Secondary Drinking Water Regulations 40 CFR Parts 141 142 143 Final Rule Effective July 30 1992 (56 Federal Register 3526)
[3] NCP 40 CFR 300 NCP Preamble 55 FR 8764 CERCLA Compliance with Other Laws Manual EPA/540/G 89/006 August 1988 However, concentration limits are not established for any of the OU 3 groundwater contaminants of concern
[4] CDH/Water Quality Control Commission The Basic Standards for Ground Water 3 11 0 (5 CCR 1002 8) 1/5/1987 amended 9/11/1990
[5] Secondary maximum contaminant level
[6] Radionuclide standards–see sec 3 11 5(c)2 in (d)

CDH = Colorado Department of Health
RCRA = Resource Conservation and Recovery Act
SDWA = Safe Drinking Water Act
WQCC = Water Quality Control Commission

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TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs FOR OU 3, OFFSITE AREAS
FEDERAL SURFACE WATER QUALITY STANDARDS

Parameter	Type	SDWA Maximum Contaminant Level[1]	SDWA Maximum Contaminant Level TBCs[2]	SDWA Maximum Contaminant Level Goal[1]	SDWA Maximum Contaminant Level Goal TBCs[2]	CWA AWQC for Protection of Aquatic Life[3]		CWA Water Quality Criteria for Protection of Human Health[3]	
						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Dissolved Oxygen	Field Parameter					5.0 mg/l			
pH	Field Parameter	6.5-9.5[4]					6.5 9		
Specific Conductance	Field Parameter								
Temperature	Field Parameter								
Bicarbonate	Anion					SS	SS		
Carbonate	Anion								
Chloride	Anion	250 mg/l[4]							
Fluoride	Anion	4 mg/l, 2 mg/l[4]		4 mg/l					
N as Nitrate	Anion	10 mg/l			10 mg/l			10 mg/l	
N as Nitrate+Nitrite	Anion		10 mg/l		10 mg/l				
N as Nitrite	Anion		1 mg/l		1 mg/l				
Potassium	Anion								
Sulfate	Anion	250 mg/l[4]							
Aluminum	Metal		0.05-0.2 mg/l[4]						
Antimony	Metal								
Arsenic	Metal	50 µg/l				9 mg/l	1.8 mg/l	146 µg/l	45 mg/l
Arsenic III	Metal							2.2 ng/l	17 5 ng/l
Arsenic V	Metal					360 µg/l	190 µg/l		
Barium	Metal	1 mg/l				850 µg/l	48 µg/l		
Beryllium	Metal							1 mg/l	
Cadmium	Metal	10 µg/l	5 µg/l		5 µg/l	130 µg/l	5.3 µg/l	6.8 ng/l[6]	117 ng/l[6]
Calcium	Metal					3.9 µg/l5	1 1 µg/l[5]	10 µg/l	
Chromium	Metal	50 µg/l	100 µg/l		100 µg/l				
Chromium III	Metal								
Chromium VI	Metal					1 7 mg/l	210 µg/l	170 mg/l	3 433 mg/l
Cobalt	Metal					18 µg/l	11 µg/l	50 µg/l	
Copper	Metal	1 mg/l[4]				18 µg/l[5]	12 µg/l[5]		
Iron	Metal	300 µg/l[4]					1 0 mg/l	300 µg/l	
Lead	Metal	50 µg/l				82 µg/l[5]	3.2 µg/l[5]	50 µg/l	
Magnesium	Metal								
Manganese	Metal	50 µg/l[4]						50 µg/l	100 µg/l

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TABLE 3 2

POTENTIAL CHEMICAL SPECIFIC ARARs FOR OU 3, OFFSITE AREAS
FEDERAL SURFACE WATER QUALITY STANDARDS
(Continued)

Parameter	Type	SDWA Maximum Contaminant Level[1]	SDWA Maximum Contaminant Level TBCs[2]	SDWA Maximum Contaminant Level Goal[1]	SDWA Maximum Contaminant Level Goal TBCs[2]	CWA AWQC for Protection of Aquatic Life[3]		CWA Water Quality Criteria for Protection of Human Health[3]	
						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Mercury	Metal	2 µg/l			2 µg/l	2 4 µg/l	12 ng/l	144 ng/l	146 ng/l
Nickel	Metal					1 4 mg/l[5]	160 µg/l[5]	13 4 µg/l	100 µg/l
Selenium	Metal	10 µg/l	50 µg/l		50 µg/l	260 µg/l	36 µg/l	10 µg/l	
Silver	Metal	50 µg/l	100 µg/l			4 1 µg/l[5]	120 ng/l	50 µg/l	
Sodium	Metal								
Thallium	Metal					1 4 mg/l [7]	40 µg/l[7]	13 µg/l	48 µg/l
Vanadium	Metal								
Zinc	Metal	5 mg/l[4]				120 µg/l[5]	110 µg/l[5]		
Americium 241	Radionuclide								
Gross Alpha	Radionuclide	15 pCi/l							
Gross Beta	Radionuclide	4 mrem/yr							
Plutonium 239+240	Radionuclide								
Tritium	Radionuclide								
Uranium 233+234	Radionuclide								
Uranium 235	Radionuclide								
Uranium 238	Radionuclide								
Uranium (total)	Radionuclide								
1 1 Dichloroethane	Volatile								
1 1 Dichloroethene	Volatile	7 µg/l		7 µg/l					
1 1,1 Trichloroethane	Volatile	200 µg/l		200 µg/l				18 4 mg/l	1 03 g/l
1 1 2 2 Tetrachloroethane	Volatile						2 4 mg/l[7]	170 ng/l[6]	10 7 µg/l[6]
1 1 2-Trichloroethane	Volatile						9 4 mg/l7	600 ng/l[6]	41 8 µg/l[6]
1 2 Dichloroethane	Volatile	5 µg/l		0 µg/l		118 mg/l[7]	20 mg/l[7]	940 ng/l[6]	243 µg/l[6]
1,2 Dichloroethene	Volatile								
1,2 Dichloropropane	Volatile		5 µg/l		0 µg/l	23 mg/l[7]	5 7 mg/l[7]		
2 Butanone	Volatile								
2 Hexanone	Volatile								
4 Methyl 2 pentanone	Volatile								

TABLE 3-2

POTENTIAL CHEMICAL-SPECIFIC ARARs FOR OU 3, OFFSITE AREAS
FEDERAL SURFACE WATER QUALITY STANDARDS
(Continued)

Parameter	Type	SDWA Maximum Contaminant Level[1]	SDWA Maximum Contaminant Level TBCs[2]	SDWA Maximum Contaminant Level Goal[1]	SDWA Maximum Contaminant Level Goal TBCs[2]	CWA AWQC for Protection of Aquatic Life[3]		CWA Water Quality Criteria for Protection of Human Health[3]	
						Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Acetone	Volatile								
Benzene	Volatile	5 µg/l		0 mg/l		5.3 mg/l[7]		660 ng/l[6]	40 µg/l[6]
Bromodichloromethane	Volatile								
Bromoform	Volatile								
Bromomethane	Volatile								
Carbon Disulfide	Volatile								
Carbon Tetrachloride	Volatile	5 µg/l		0 mg/l		35.2 mg/l[7]		400 ng/l[6]	6.94 µg/l[6]
Chlorobenzene	Volatile								
Chloroethane	Volatile								
Chloroform	Volatile	Tot THM <100 µg/l[6]				28.9 mg/l[7]	1 24 mg/l[6]	0.19 µg/l[6]	15 7 µg/l[6]
Chloromethane	Volatile								
cis-1,3-Dichloropropene	Volatile					6.06 mg/l[7]	244 µg/l[7]	87 µg/l	14 1 mg/l
Dibromochloromethane	Volatile								
Ethyl Benzene	Volatile		0.7 mg/l		0.7 mg/l	[illegible] mg/l[7]		1 4 mg/l	3.28 mg/l
Methylene Chloride	Volatile								
Styrene	Volatile		0.1 mg/l		0.1 mg/l				
Tetrachloroethene	Volatile		5 µg/l		0 µg/l	5.28 mg/l[7]	840 µg/l[7]	800 ng/l[6]	6.85 µg/l[6]
Toluene	Volatile	1 mg/l		1 mg/l		17.5 mg/l[7]		14 3 mg/l	424 mg/l
Total Xylenes	Volatile		10 mg/l		10 mg/l				
trans-1,3-Dichloropropene	Volatile					6.06 mg/l[7]	244 µg/l[7]	87 µg/l	14 1 mg/l
Trichloroethene	Volatile	5 µg/l		0 µg/l		45 mg/l[7]	21 9 mg/l[7]	2 7 µg/l[6]	80 7 µg/l[6]
Vinyl Acetate	Volatile								
Vinyl Chloride	Volatile								

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TABLE 3 2

POTENTIAL CHEMICAL SPECIFIC ARARs FOR OU 3, OFFSITE AREAS
FEDERAL SURFACE WATER QUALITY STANDARDS
(Concluded)

EXPLANATION OF TABLE

Notes
[1] EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990)
[2] EPA National Primary and Secondary Drinking Water Regulations 40 CFR Parts 141 142 and 143 Final Rule effective July 30 1992
[3] EPA Quality Criteria for Protection of Aquatic Life 1986
[4] Secondary maximum contaminant level
[5] Hardness dependent criteria
[6] Human health criteria for carcinogens reported for three risk levels Value presented is the 10^{-5} risk level
[7] Criteria not developed value presented is lowest observed effects level (LOEL)
[8] Total trihalomethanes chloroform bromoform bromodichloromethane dibromochloromethane
[9] pH dependent criteria (7 8 pH used)

AWQC = Ambient Water Quality Criteria
CWA = Clean Water Act
SDWA = Safe Drinking Water Act
SS = species specific

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TABLE 3-3

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs FOR OU 3, OFFSITE AREAS
STATE SURFACE WATER QUALITY STANDARDS

		Statewide Standards[1] CDH/WQCC						Segment 4 and 5 Stream Classification Water Quality Standards[2,3] CDH/WQCC						
			Table C Aquatic Life		Tables I, II, III[4]						Stream Segment Table[5]		Table 2 Radionuclides	
Parameter	Type	Tables A,B Carcinogenic/ Noncarcinogenic[6]	Acute Value	Chronic Value	Acute Value[6]	Chronic Value[6]	Agricultural Standard[7]	Tables A,B[6]	Table C Fish and Water Ingestion	Table D Radionuclide Standards	Acute Value	Chronic Value	Woman Creek	Walnut Creek
Dissolved Oxygen	Field Parameter				5.0 mg/l	5.0 mg/l	3.0 mg/l				5.0 mg/l	5.0 mg/l		
pH	Field Parameter				6.5-9.0	6.5-9.0					6.5-9	6.5-9		
Specific Conductance	Field Parameter													
Temperature	Field Parameter				30 degrees	30 degrees								
Bicarbonate	Anion													
Carbonate	Anion													
Chloride	Anion										3 µg/l	3 µg/l		
Fluoride	Anion													
N as Nitrate	Anion						100 mg/l				10 mg/l	10 mg/l		
N as Nitrate+Nitrite	Anion													
N as Nitrite	Anion				SS	SS	10 mg/l				1 mg/l	1 mg/l		
Potassium	Anion													
Sulfate	Anion										250 mg/l	250 mg/l		
Aluminum	Metal				950 µg/l	150 µg/l								
Antimony	Metal													
Arsenic	Metal				360 µg/l	150 µg/l	100 µg/l				50 µg/l			
Arsenic III	Metal													
Arsenic V	Metal													
Barium	Metal													
Beryllium	Metal						100 µg/l							
Cadmium	Metal				TVS	TVS	10 µg/l				TVS	TVS		
Calcium	Metal													
Chromium	Metal													
Chromium III	Metal				TVS	TVS	100 µg/l				50 µg/l			
Chromium VI	Metal				16 µg/l	11 µg/l	100 µg/l				TVS	TVS		
Cobalt	Metal													
Copper	Metal				TVS	TVS	200 µg/l				TVS	TVS		

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TABLE 3-3

POTENTIAL CHEMICAL SPECIFIC ARARs/TBCs FOR OU 3, OFFSITE AREAS
STATE SURFACE WATER QUALITY STANDARDS
(Continued)

		Statewide Standards[1] CDH/WQCC						Segment 4 and 5 Stream Classification Water Quality Standards[2 3] CDH/WQCC						
			Table C Aquatic Life		Tables I, II, III[4]						Stream Segment Table[5]		Table 2 Radionuclides	
Parameter	Type	Tables A B Carcinogenic/ Noncarcinogenic[6]	Acute Value	Chronic Value	Acute Value[6]	Chronic Value[6]	Agricultural Standard[7]	Tables A B[6]	Table C Fish and Water Ingestion	Table D Radionuclide Standards	Acute Value	Chronic Value	Woman Creek	Walnut Creek
Iron	Metal					1 mg/l						300 µg/l[8]		
Lead	Metal				TVS	TVS	100 µg/l				TVS	TVS		
Magnesium	Metal													
Manganese	Metal					1 mg/l	200 µg/l					50 µg/l[8]		
Mercury	Metal				2 4 µg/l	0 1 µg/l						10 ng/l		
Nickel	Metal				TVS	TVS	200 µg/l				TVS	TVS		
Selenium	Metal				135 µg/l	17 µg/l	20 µg/l				10 µg/l			
Silver	Metal				TVS	TVS					TVS	TVS		
Sodium	Metal													
Thallium	Metal					15 µg/l								
Vanadium	Metal													
Zinc	Metal				TVS	TVS	2 0 mg/l				TVS	TVS		
Americium 241	Radionuclide									30 pCi/l				
Gross Alpha	Radionuclide												7 pCi/l	11 pCi/l
Gross Beta	Radionuclide												5 pCi/l	19 pCi/l
Plutonium 239+240	Radionuclide									15 pCi/l				
Tritium	Radionuclide									20 000 pCi/l			500 pCi/l	500 pCi/l
Uranium 233+234	Radionuclide													
Uranium 235	Radionuclide													
Uranium 238	Radionuclide													
Uranium (total)	Radionuclide									40 pCi/l			5 pCi/l	10 pCi/l
1 1 Dichloroethane	Volatile													
1 1 Dichloroethene	Volatile	7 µg/l						7 µg/l						
1,1,1 Trichloroethane	Volatile	200 µg/l						200 µg/l						
1 1,2 2 Tetrachloroethane	Volatile			2 4 mg/l					170 ng/l			170 ng/l		

TABLE 3-3

POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs FOR OU 3, OFFSITE AREAS
STATE SURFACE WATER QUALITY STANDARDS
(Continued)

		Statewide Standards[1] CDH/WQCC						Segment 4 and 5 Stream Classification Water Quality Standards[2,3] CDH/WQCC						
			Table C Aquatic Life		Tables I, II, III[4]						Stream Segment Table[5]		Table 2 Radionuclides	
Parameter	Type	Tables A,B Carcinogenic/ Noncarcinogenic[6]	Acute Value	Chronic Value	Acute Value[8]	Chronic Value[9]	Agricultural Standard[7]	Tables A,B[6]	Table C Fish and Water Ingestion	Table D Radionuclide Standards	Acute Value	Chronic Value	Woman Creek	Walnut Creek
1,1,2-Trichloroethane	Volatile	28 µg/l[6]		9.4 mg/l				28 µg/l[6]	600 ng/l			600 ng/l		
1,2-Dichloroethane	Volatile	5 µg/l	118 mg/l	20 mg/l				5 µg/l						
1,2-Dichloroethene	Volatile	70 µg/l						70 µg/l						
1,2-Dichloropropane	Volatile	560 ng/l	23 mg/l	5.7 mg/l				560 ng/l						
2-Butanone	Volatile													
2-Hexanone	Volatile													
4-Methyl-2-pentanone	Volatile													
Acetone	Volatile													
Benzene	Volatile	5 µg/l						5 µg/l						
Bromodichloromethane	Volatile													
Bromoform	Volatile													
Bromomethane	Volatile													
Carbon Disulfide	Volatile													
Carbon Tetrachloride	Volatile	5 µg/l	35.2 mg/l					5 µg/l						
Chlorobenzene	Volatile	300 µg/l						300 µg/l						
Chloroethane	Volatile													
Chloroform	Volatile	Tot THM <100 µg/l[10]	28.9 mg/l	1.24 mg/l				Tot THM <100 µg/l[10]	0.19 µg/l			0.19 µg/l		
Chloromethane	Volatile													
cis-1,3-Dichloropropene	Volatile													
Dibromochloromethane	Volatile													
Ethyl Benzene	Volatile	680 µg/l	32 mg/l					680 µg/l						
Methylene Chloride	Volatile													
Styrene	Volatile													
Tetrachloroethene	Volatile	10 µg/l	5.28 mg/l	840 µg/l				10 µg/l	800 ng/l					
Toluene	Volatile	2.42 mg/l	17.5 mg/l					2.42 mg/l						
Total Xylenes	Volatile													

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TABLE 3 3

POTENTIAL CHEMICAL SPECIFIC ARARs/TBCs FOR OU 3, OFFSITE AREAS
STATE SURFACE WATER QUALITY STANDARDS
(Concluded)

		Statewide Standards[1] CDH/WQCC						Segment 4 and 5 Stream Classification Water Quality Standards[2 3] CDH/WQCC						
			Table C Aquatic Life		Tables I II III[4]						Stream Segment Table[5]		Table 2 Radionuclides	
Parameter	Type	Tables A,B[5] Carcinogenic/ Noncarcinogenic[6]	Acute Value	Chronic Value	Acute Value[6]	Chronic Value[6]	Agricultural Standard[7]	Tables A,B[5]	Table C Fish and Water Ingestion	Table D Radionuclide Standards	Acute Value	Chronic Value	Woman Creek	Walnut Creek
trans-1 3 Dichloropropene	Volatile													
Trichloroethene	Volatile	5 µg/l	45 mg/l	21 9 mg/l				5 µg/l						
Vinyl Acetate	Volatile													
Vinyl Chloride	Volatile	2 µg/l						2 µg/l						

EXPLANATION OF TABLE

Notes
[1] CDH/WQCC Colorado Water Quality Standards 3 1 0 (5 CCR 1002 8) 1/15/1974 amended 9/30/1989 (Environmental Reporter 726 1001-1020 6/1990)
[2] CDH/WQCC Classifications and Numeric Standards for S Platte River Basin Laramie River Basin Republican River Basin Smoky Hill River Basin 3 8 0 (5 CCR 1002 8) 4/6/1981 amended 2/15/1990
[3] Segment 4 standards are ARARs and Segment 5 standards are goals (TBCs)
[4] Table I–physical and biological parameters
Table II Inorganic parameters
Table III metal parameters
Values in Tables I, II and III for recreational uses cold water biota and domestic water supply are not included
[5] Includes Table 1 Additional Organic Chemical Standards (chronic only)
[6] In the absence of specific numeric standards for nonnaturally occurring organics the narrative standard is interpreted as zero with enforcement based on practical quantification levels (PQLs) as defined by CDH/WQCC or EPA
[7] All are 30-day standards except for nitrate+nitrite
[8] Lowest value given dissolved or total recoverable
[9] Based on 10E-6 cancer risk from EPA Integrated Risk Information System
[10] Total trihalomethanes chloroform bromoform bromodichloromethane dibromochloromethane

CDH = Colorado Department of Health
SS = species specific
TVS = Table Value Standard (hardness dependent) see Table III in (a)
WQCC = Water Quality Control Commission

3.2.2 TBCs

In addition to applicable or relevant and appropriate requirements, advisories, criteria, or guidance may be identified as 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 is the case with ARARs.

3.2.3 ARAR Categories

In general, there are three categories of ARARs:

1. Ambient or chemical-specific requirements
2. Location-specific requirements
3. Performance, design, or other action-specific requirements

ARAs 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 ensure appropriate detection limits have been established so that data collected in the RI will be amendable for comparison to ARAR standards. Chemical-specific ARARs may be deleted if they are found to be inappropriate any time in the RFI/RI process. Deletion of chemical-specific ARARs will be based on analytical information obtained from sampling at OU 3. It is also appropriate to identify location-specific ARARs early in the RI process so that information may be gathered to determine if restrictions may be placed on the concentration of hazardous substances or on the conduct of an activity solely because it occurs in a special location

As discussed in the introductory paragraph to this section (3 0), detailed location-specific ARARs will be proposed in the RFI/RI Report. Identification of action-specific ARARs and remediation goals is part of the Feasibility Study process and will be addressed in the CMS/FS Report, if a CMS/FS Report is necessary

For the proper management of investigation-derived wastes, as required in the IAG, Attachment 2, Statement of Work, Section IV, DOE has developed SOPs for field investigation activities. All waste

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generated by the various investigations conducted at RFP will follow the SOPs The SOPs satisfy the IAG requirement to comply with ARARs as they relate to investigation activities This approach is consistent with EPA policy as provided in the "Draft Guide to Managment of Investigation–Derived Waste" (U S EPA 1991b)

3 2.4 Remedial Action

CERCLA §121 specifically requires attainment of ARARs Moreover, as explained in the preamble to the NCP (55 FR 8741), in order to attain 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 attain ARARs and be protective of human health and the environment. Consequently, remedial action objectives based on ARARs require modification as new information and data are collected in the RFI/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.

3 2.5 Remediation Goals

Development of remediation goals is actually a portion of the overall development of remedial action objectives, which ultimately 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 (such as 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

- ARARs (chemical-specific) including
  - Acceptable exposure levels for systemic toxicants
  - Acceptable exposure levels for known or suspected carcinogens
  - Technical limitations (such as detection limits)

- Uncertainty factors
- Other pertinent information

- 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

- Acceptable exposure levels where multiple contaminants or multiple exposure pathways will cause exposure at ARAR levels will result in cumulative risk in excess of 10^{-4}

- Clean Water Act (CWA) Water Quality Criteria, where relevant and appropriate.

- A CERCLA Alternative Concentration Limit (ACL) established pursuant to CERCLA § 121(d)(2)(B)(ii)

- Environmental evaluation, performed to assess specific threats to the environment.

Once a remedial action alternative is formally selected, all chemical-, location-, and action-specific ARARs are 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 becomes the final remedy as it is incorporated into the Record of Decision (ROD). Once the final ROD has been signed, measurements 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])

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This section describes the tasks to be implemented during the course of the RFI/RI The specific tasks are designed to provide information to meet the data quality objectives (DQOs) that are identified in Section 5 0 of this document, Data Needs and Data Quality Objectives The following tasks are described in this section

- Task 1—Project Planning/Management
- Task 2—Community Relations
- Task 3—Field Investigation
- Task 4—Sample Analysis and Data Validation
- Task 5—Data Evaluation
- Task 6—Baseline Risk Assessment and Environmental Evaluation
- Task 7—Treatability Studies
- Task 8—Remedial Investigation Report
- Task 9—Remedial Alternatives Development/Screening
- Task 10—Detailed Analysis of Remedial Alternatives

The tasks presented above are 10 of the 14 standard tasks that have been identified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (EPA, 1988a) The four standard tasks not included are Task 11—Feasibility Study Reports Task 12—Post-RI/FS Support, Task 13—Enforcement Support, and Task 14—Miscellaneous Support. Task 11 is included as part of Task 10 in this document. The remaining tasks are not relevant to the scope of this work plan

4 1 TASK 1—PROJECT PLANNING/MANAGEMENT

The objective of project planning/management during the performance of the OU 3 RFI/RI is to direct and document project activities so that data collected and evaluations conducted meet the goals and objectives of the Work Plan Specific project management activities that will occur throughout the RFI/RI include the following

- Meetings

- Cost and Schedule Control
- Data Management
- Progress Reports

These activities will be conducted to identify potential problems with sufficient time to make necessary corrections and keep the project focused on its objectives, on schedule, and within budget.

The project planning activities to be conducted early in the project include

- Review of existing information
- Site surveys
- Access agreements

The first two planning activities are discussed briefly within this subsection and in more detail in Section 6.0.

4.1 1 Review of Existing Information

Existing site information will be reviewed to facilitate project planning. Aerial photographs will be reviewed to identify undisturbed areas. These areas will aid in refining soil and sediment sampling locations. Data collected for reservoirs will also be reviewed to obtain information about them such as hydrologic characteristics and historic low levels. This information will be used to refine sediment and air sampling locations.

In addition, data collected since the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3 Sites 200, 201, 202 (DOE, April 1991b) and the Final Past Remedy Report Operable Unit No 3--IHSS 199 (DOE, April 1991a) were developed will be evaluated. The data useability will be evaluated following the requirements set forth in the Guidance for Data Useability in Risk Assessment (EPA, 1990b). The data are anticipated to include analytical results from soil and water samples collected by municipalities, collected from other RFP OU field investigations, and collected by RFP monitoring programs.

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4 1.2 Site Surveys

Site surveys will be performed as part of project planning The site surveys will including touring OU 3 and taking detailed notes on and photographs of vegetation and biota present and of areas where contamination could accumulate Such areas include snow accumulation areas and wetlands This information will also be used to refine the field investigations described in Subsection 4 3 and Section 6 0 of this document

4 1 3 Access Agreements

Access agreements will be obtained to perform the RFI/RI Tax assessment records will be reviewed to determine the property owners names and addresses. This information will be provided to EG&G, who will secure the access agreements, if needed

4 2 TASK 2–COMMUNITY RELATIONS

The information contained in this section is summarized from (DOE, 1990b) In accordance with the IAG, the Communications Department at Rocky Flats has developed a Plant-wide Community Relations Plan (CRP) to develop an interactive relationship with the public relating to ER activities A Draft Community Relations Survey Plan has been completed and forwarded to EPA, CDH, and the public for review This plan specified activities to be conducted to complete the ER Program CRP, including plans for community interviews. The draft CRP was completed in September and the final CRP in November 1990, in accordance with the IAG schedules Accordingly, a site-specific CRP is not required for OU 3 The ER Program community relations activities include participation by Plant representatives in informational workshops, meetings of the Rocky Flats Environmental Monitoring Council, briefings for the public on proposed remedial action plans and meetings to solicit public comment on various ER Program plans and actions

The RFP Communications Department is continuing other public information efforts to keep the public informed of ER activities and other issues related to Plant operations. A Speakers Bureau program sends speakers to civic groups and educational organizations, while a public tour program allows the public to visit Rocky Flats An Outreach Program is also in place in which Plant officials visit elected officials, the news media, and business and civic organizations to further discuss issues related to Rocky Flats and ER activities The Communications Department receives numerous

public inquiries, which are answered through telephone conversations or by sending written informational materials to the requestor

OU 3 activities to be performed as part of the ongoing community relations efforts include such activities or materials as preparation of briefings, fact sheets, and presentations, and participation in site tours or public meetings.

4.3 TASK 3—FIELD INVESTIGATION

A field investigation will be conducted at all of the OU 3 IHSSs to collect samples and data concerning the nature and extent of contamination at each unit. The data and sample results also will be used to support the Human Health Risk Assessment (Section 7.0 of this document), as well as meet the objectives and data needs described in Section 5.0 of this document. It is important to recognize that additional phases of investigation and risk assessment may be required at some IHSSs, if contamination besides plutonium, and americium is detected, or if higher than anticipated concentrations of plutonium and americium are detected. A phased approach, if necessary, is consistent with the approach presented in EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (EPA, 1988a)

The following activities will be performed during the field investigation:

- Procurement of subcontractor (well driller and laboratories)
- Mobilization
- Well installation
- Media sampling
- Ecological surveys
- RI waste disposal

The field investigation associated with IHSS 199 will deal primarily with soil and terrestrial biota sampling, while the field investigations associated with the reservoirs and drainages (IHSSs 200, 201, and 202) will focus on sediment, surface water, aquatic biota, and groundwater sampling. Details regarding the field investigation are provided in Section 6.0 of this document.

Detailed sampling plans will be developed for each sampling activity

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4 4 TASK 4–SAMPLE ANALYSIS AND DATA VALIDATION

A critical task in the RFI/RI is the sample analysis and data validation procedures Data useability is critical in performing a quantitative risk assessment. The sample analysis and data validation procedures are essential elements of data useability Activities included in this task are sample management, analyses use of mobile laboratories data validation, and testing of physical parameters

The analytical methods will be completed in accordance with the ER Program Quality Assurance Project Plan (QAPjP) Project-specific QA requirements are included in the QAA, Section 10 0 of this work plan Section 6 0 of this document specifies the analytical requirements, and field QC requirements, as well as sample containers, preservation and holding times The samples collected will be analyzed by an RFP contract laboratory

Data will be reviewed and validated according to the data validation guidelines in the QAPP and the Date Validation Functional Guidelines (EG&G, 1990d) These documents state how the results of data review and validation activities will be conducted and documented in data validation reports

4 5 TASK 5–DATA EVALUATION

The data evaluation task includes the analysis of data once it has been verified that the data are of acceptable accuracy and precision as described in Subsection 4 4 of this document. Activities associated with the data evaluation task include data evaluation data reduction and tabulation, statistical analyses, and environmental fate and transport evaluation The conceptual models will be refined based on new information as it is acquired

Data collected during the field investigation will be incorporated into the existing data base, Rocky Flats Environmental Database System (RFEDS), and used to better define the nature and extent of contamination and to support the Baseline Risk Assessment. If the data collected supports historical data, the historical data will also be used to support the Baseline Risk Assessment.

4 6 TASK 6–BASELINE RISK ASSESSMENT

The purpose of this task is to conduct the Baseline Risk Assessment for OU 3 The purposes of the Baseline Risk Assessment is to assess the potential human health and environmental risks associated with the site and to provide a basis for determining whether remedial actions are

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necessary The Baseline Risk Assessment includes a Human Health Risk Assessment and an Environmental Evaluation. The approaches to conducting these two assessments are presented in Sections 7 0 and 8.0 of this document. Conclusions from the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3 Sites 200, 201, and 202 (DOE, 1991b) and the Final Past Remedy Report Operable Unit No 3--IHSS 199 (DOE, 1991a), state that the specificity and quality of existing information are insufficient to perform a rigorous quantitative human health risk assessment. Additional data will be collected during the field investigations in order to perform a quantitative Baseline Risk Assessment. As previously stated, if the new data supports historical data, the historical data will also be used to support the Baseline Risk Assessment.

The sampling program is designed to generate data that meet the requirements of the Guidance for Data Useability in Risk Assessment (EPA, 1990b) Efforts included in this task are identification of contaminants of concern, characterization of animal and plant communities, exposure assessment, toxicity assessment, qualitative and quantitative uncertainty analysis, and risk characterization.

The Baseline Risk Assessment will address the potential public health risks and the environmental impacts. The current and potential (future) risks associated with the site under the no-action alternative (no remedial action taken) will be assessed based on the data collected. If the Baseline Risk Assessment determines that risks posed by contamination at OU 3 must be remediated, Tasks 7, 9, and 10 will be conducted. The Human Health Risk Assessment and Environmental Evaluation Work Plans are presented in Sections 7.0 and 8.0 of this document, respectively

4.7 TASK 7--TREATABILITY STUDIES

The primary purpose of a treatability study is to provide sufficient technology performance information and to reduce cost and performance uncertainties to acceptable levels, so that treatment alternatives can be fully developed and evaluated during detailed analysis. The task includes efforts to evaluate whether treatability studies are necessary and, if so, to prepare for and conduct treatability studies. If remedial alternatives are developed, the data collected as part of the field investigation will be reviewed in terms of whether the alternatives can be evaluated. Based on the data collected and evaluated to date, it is unlikely treatability studies will be necessary However, if additional data are required, treatability studies or field investigations will occur

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If it is determined that a treatability study is necessary, a treatability work plan will also be prepared The plan will identify treatability tests that need to be conducted along with test materials and equipment needed

The treatability work plan will discuss the following

- The scale of the treatability test
- Key parameters to be varied and evaluated and criteria to be used to evaluate the tests
- Specifications for test samples and the means for obtaining these samples
- The test equipment, materials, and procedures to be used in the treatability test
- Identification of potential vendors who may conduct the tests and analytical services that will be conducted, as well as any special procedures and permits required to transport samples and residues and conduct tests
- The methods required for residue management and disposal
- Any special QA/QC needed for tests

4 8 TASK 8—REMEDIAL INVESTIGATION REPORT

This task includes development of a draft and a final RFI/RI Report. The RFI/RI Report will summarize efforts related to the findings of the data evaluation and the Baseline Risk Assessment. Table 4-1 presents a typical outline for an RFI/RI Report. The RFI/RI Report will

- Describe the field activities that serve as the basis for the RFI/RI Report in detail This will include any deviations from the work plan that occurred during implementation of the field investigation

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TABLE 4-1

SUGGESTED RI REPORT FORMAT

Executive Summary

1 Introduction
- 1.1 Purpose of Report
- 1.2 Site Background
  - 1.2.1 Site Description
  - 1.2.2 Site History
  - 1.2.3 Previous Investigations
- 1.3 Report Organization

2. Study Area Investigation
- 2.1 Includes field activities associated with site characterization. These may include physical and chemical monitoring of some but not necessarily all, of the following:
  - 2.1.1 Surface Features (such as topographic mapping, natural and manmade features)
  - 2.1.2 Contaminant Source Investigations
  - 2.1.3 Surface Water and Sediment Investigations
  - 2.1.4 Soil Investigations
  - 2.1.5 Groundwater Investigations
  - 2.1.6 Human Population Surveys
  - 2.1.7 Ecological Investigations
- 2.2. If technical memoranda documenting field activities were prepared, they may be included in an appendix and summarized in this report chapter.

3. Physical Characteristics of the Study Area
- 3.1 Includes results of field activities to determine physical characteristics. These may include some, but not necessarily all, of the following:
  - 3.1.1 Surface Features
  - 3.1.2 Surface Water Hydrology
  - 3.1.3 Soils
  - 3.1.4 Hydrogeology
  - 3.1.5 Ecology

4 Nature and Extent of Contamination
- 4.1 Presents the result of site characterization, both natural chemical components and contaminants in some, but not necessarily all, of the following media.
  - 4.1.1 Soils
  - 4.1.2 Groundwater
  - 4.1.3 Surface Water and Sediments
  - 4.1.4 Air

5. Contaminant Fate and Transport
- 5.1 Potential Routes of Migration (such as air and groundwater)
- 5.2 Contaminant Persistence
- 5.3 Contaminant Migration

6 Baseline Risk Assessment
- 6.1 Human Health Evaluation
  - 6.1.1 Exposure Assessment
  - 6.1.2 Toxicity Assessment
  - 6.1.3 Risk Characterization
- 6.2 Environmental Evaluation

7 Summary and Conclusions
- 7.1 Summary
  - 7.1.1 Nature and Extent of Contamination
  - 7.1.2 Fate and Transport
  - 7.1.3 Risk Assessment

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TABLE 4-1

SUGGESTED RI REPORT FORMAT
Continued

7 2 Conclusions
- 7.2.1 Data Limitations and Recommendations for Future Work
- 7.2.2 Recommended Remedial Action Objectives

Appendices
- A. Technical Memoranda on Field Activities (if available)
- B Analytical Data and QA/QC Evaluation Results
- C Risk Assessment Methods

Source EPA, 1988b

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- Discuss site physical conditions. This discussion will include surface features, meteorology, surface water hydrology, surficial and subsurface geology, groundwater hydrology, demography and land use, and ecology

- Present site characterization results from RFI/RI activities at OU 3 to characterize the nature and extent of contamination, including contaminant sources, soils, sediments, groundwater, surface water, air, and biota.

- Discuss contaminant fate and transport. This discussion will include potential contaminant migration routes, contaminant persistence, and potential receptors.

- Present the Baseline Risk Assessment.

- Present a summary of the findings and conclusions.

- Identify data needs, if any

4.9 TASK 9—REMEDIAL ALTERNATIVES DEVELOPMENT/SCREENING

This task includes efforts to develop and screen the remedial alternatives that will be subject to full evaluation. This task will be performed only if the Baseline Risk Assessment determines that the risks posed by contamination at OU 3 must be remediated. Activities to be included in the task, if performed, are the following:

- Establishing remedial action objectives

- Identifying and screening potential technologies

- Assembling potential alternatives

- Identifying location- and action-specific ARARs and refining chemical-specific ARARs

- Evaluating each alternative on the basis of screening criteria (effectiveness, implementability, and cost)

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- Reviewing and providing QA/QC

- Refining the list of alternatives to be evaluated

4 10 TASK 10—DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of alternatives consists of the analysis and presentation of the relevant information needed to allow decisionmakers to select a site remedy Each alternative retained after conducting Task 9 is assessed against the evaluation criteria and the results of the assessment are arrayed to compare the alternatives and identify the key trade offs. The following will be performed, if this task is needed

- Refinement of alternatives
- Individual analysis of alternatives against the criteria
- Comparative analysis of alternatives against the criteria
- Review of QA/QC efforts
- Development of an FS

Nine evaluation criteria have been established to address the statutory considerations and include the following

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

These criteria are described in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (EPA, 1988a) The initial two criteria are considered threshold criteria because these alternatives must be satisfied before further consideration of the remaining criteria. The next five criteria are considered the primary criteria on which the analysis is based The final

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two criteria, state and community acceptance, will be addressed during the final decisionmaking process after completion of the CMS/FS

As stated previously, the Baseline Risk Assessment will determine if any other risks posed by contamination at OU 3 require remediation.

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The primary objective of the RFI/RI is to collect the data necessary to determine the nature, distribution, and migration pathways of contaminants and to quantify any risks to human health and the environment Human health and environmental assessments determine the need for remediation and are used along with the RFI/RI site characterization data to evaluate remedial alternatives, if necessary The five general goals of an RFI/RI (EPA, 1988a) are to

- Characterize the physical and biological nature of the site
- Define contaminant sources
- Determine the nature and extent of contamination
- Describe contaminant fate and transport
- Produce a baseline risk assessment (human health and environmental risks)

Data quality objectives (DQOs) are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI (EPA, 1987c) DQOs are developed using the following three-stage process

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

Through application of the DQO process, site-specific RFI/RI goals were established and data needs were identified for achieving those goals This section of the RFI/RI Work Plan presents the data needs and the DQOs for OU 3.

Data collected during previous investigations have been useful in defining and focusing the DQOs Previous data collection activities focused on site characterization and not on performing a quantitative human health risk assessment or an environmental evaluation This historical data, along with the OU 3 conceptual model, were summarized in Section 2.0 of this work plan This section presents the rationale used in identifying OU 3 data needs.

5 1 STAGE 1--IDENTIFY DECISION TYPES

Stage 1 of the DQO process was to identify decisionmakers, data users, and define the types of decisions which will be made as part of the RFI/RI The general decision types were identified early in Stage 1 to determine data types sufficient to support decisions.

5.1 1 Identify and Involve Data Users

Data users are the decision makers, the primary, and secondary data users. The decisionmakers for OU 3, are the management and regulatory personnel of EG&G, the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Colorado Department of Health (CDH), and the Rocky Flats Technical Review Group. EG&G's contractors will provide day-to-day management of the RFI/RI in accordance with this work plan. The decisionmakers have been and are involved in the OU 3 DQO process through the IAG, which specifies the minimum level of effort for the RFI/RI. The decisionmakers remain involved through the review and approval process specified in the IAG.

Primary data users are those individuals involved in ongoing RFI/RI activities. The primary data users are EG&G and EG&G's contractor They will be involved in the data collection and analysis and in the preparation of the RFI/RI Report, including the Human Health Risk Assessment and the Environmental Evaluation.

Secondary data users are those users that rely on RI outputs to support their activities. Secondary users include EG&G and EG&G contractor personnel working on other operable units or sitewide projects, DOE, EPA, and CDH.

5.1.2 Evaluate Available Data

Historical data for the IHSSs included in OU 3 have been reviewed and summarized in the Final Past Remedy Report Operable Unit No. 3--IHSS 199 (DOE, 1991a) and in the Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3 IHSS 200-202 (DOE, 1991b) Section 2.0 of this work plan summarizes previous work performed. The data useability of the previous data collected have been reviewed in accordance with the Guidance for Data Useability in Risk Assessment (EPA, 1990b) procedures. The conclusions of the review indicate that much of the data does not meet the necessary DQOs to perform a rigorous quantitative Baseline Risk Assessment (human health and environmental)

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5 1 3 Develop Conceptual Model

The OU 3 conceptual model is presented in Subsection 2 5 The model includes a description of potential sources, pathways, and receptors The potential pathways identified include surface water, groundwater, aquatic and terrestrial biota, and air/wind The potential release mechanisms include fugitive dust and wind erosion, surface runoff, infiltration and percolation, biotic uptake, and tracking by organisms The primary pathway is through the air/wind dispersion of surface soils This pathway and the other potential pathways will be characterized and evaluated during the RFI/RI for this operable unit.

5 1 4 Specify RFI/RI Objectives and Data Needs

Based on existing data and the conceptual model presented in Section 2.0 the site-specific RFI/RI objectives and data needs associated with determining the nature and extent of contamination and performing the Human Health Risk Assessment and Environmental Evaluation were developed.

The objectives of the RFI/RI are to

- Characterize site physical features and ecological characteristics
- Characterize the nature and extent of plutonium and americium contamination at each IHSS in each media that is a potential pathway
- Assess the presence or absence of other chemicals identified that may be in OU 3 in sediments and surface water
- Collect data to support the quantitative Human Health Risk Assessment
- Collect data to support the Environmental Evaluation

Previous work has focused on site characterization and not the objectives described above

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5.2 STAGE 2--IDENTIFYING DATA USES/NEEDS

Stage 2 of the DQO process defines data uses and specifies the data types needed to meet the project objectives The conceptual model presented in Section 2.0 of this work plan was the basis for identifying data needs. For an exposure pathway to be complete, there must be a contaminant source, release mechanism, transport mechanism, route of exposure, and a receptor To evaluate each potential exposure pathway identified in the conceptual model, the historical data and some of the ongoing Rocky Flats Plant site environmental monitoring data was reviewed to determine if information of sufficient quality and quantity was available to characterize the OU and to perform the quantitative Human Health Risk Assessment and the Environmental Evaluation.

The data review indicated that the existing data were not of sufficient quality to meet the DQOs for performing a quantitative Baseline Risk Assessment. The data needs identified for this RFI/RI focus on confirming past sampling results. If past sampling results are confirmed, historical data will be used to substantiate the quantitative Baseline Risk Assessment.

Characterizing each potential exposure pathway is considered a data need for this OU Most of the data needs have multiple data uses. For instance, the characterization data will be used for site characterization and performing the Human Health Risk Assessment and the Environmental Evaluation.

Table 5-1 describes the data needed to fulfill specific objectives, the type of activity to collect the data, the analytical level, and the intended data use. Each data need and field activity is described in more detail in Section 6.0 of this document. The designated data in Table 5-1 are referenced in Section 6.0. The data references correspond to their respective collection activities.

The following subsections describe the Stage 2 DQO steps that were followed to develop Table 5-1

5.2.1 Identifying Data Uses

Data uses for OU 3 include the following.

- Site characterization
- Human Health Risk Assessment
- Environmental Evaluation

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TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO 3

Data Item	Data Need	Activity	Analytical Level	Data Use
CHARACTERIZE NATURE AND EXTENT OF SURFACE WATER AND SEDIMENT CONTAMINATION				
SW 1, SW 2	Characterize potential plutonium americium, metals, and volatile contamination in surface water reservoirs and drainages	Collect stratified water samples from each reservoir and drainages with surface flow at time of sampling Samples will be analyzed for plutonium americium uranium Target Analyte List (TAL) metals and Target Compound List (TCL) volatiles and cation/anions	II–Dissolved oxygen, pH and temperature Electrical conductivity III–Cation/anions IV–TAL metals and TCL volatiles V–Radionuclides	• Site characterization • Risk assessment–assess pathway and potential exposure through ingestion of surface water • Environmental evaluation
SED 1, SED 2	Characterize potential contamination in drainage and reservoir sediments	Collect sediment samples from reservoirs and drainages and analyze for plutonium, americium TAL metals, and TCL volatiles	IV -TCL VOAs TAL metals, V -radionuclides	• Site characterization • Risk assessment–assess transport media • Environmental evaluation
SED 3	Characterize potential plutonium and americium entrapment to sediments exposed along reservoir shoreline	Collect sediment samples along reservoir shoreline and analyze for radionuclides, TAL metals and TCL volatiles,	IV–TCL VOAs TAL metals V–radionuclides	• Site characterization • Risk assessment • Environmental evaluation
CHARACTERIZE NATURE AND EXTENT OF SOIL CONTAMINATION				
S 1	Characterize vertical extent of soil contamination	Collect undisturbed soil samples from vertical profile to a depth of approximately 100 cm and analyze for plutonium and americium	V–radionuclides	• Site characterization • Risk assessment–assess pathway and transport potential • Environmental evaluation
S 2	Characterize lateral extent of soil contamination	Collect surface soil samples using CDH method and analyze samples for plutonium and americium A sampling grid based on geostatistics will be used	V–radionuclides	• Site characterization (current source) • Risk assessment–assess pathway and potential exposure through ingestion of soils • Environmental evaluation
S 3	Delineate lateral extent of soil types and correlate with vegetation types	Identify soil types	I–Field observation	• Environmental evaluation

TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO 3
(Continued)

Data Item	Data Need	Activity	Analytical Level	Data Use
S-4	Characterize fate and transport of plutonium and americium	Soil and sediment samples will be collected and analyzed for particle size, bulk density, and total organic carbon content. Results of the physicochemical processes of plutonium that is being performed for OU 2 will be reviewed	III–particle size, bulk density, total organic carbon (TOC)	• Risk assessment–assess transport potential
CHARACTERIZE HYDROGEOLOGY				
GW-1	Characterize hydrogeology near IHSSs and groundwater/surface water contamination and interactions	Install monitoring wells in alluvium and bedrock and collect groundwater samples and analyze for radionuclides. Water level measurements will also be collected.	III–Cation/anions V–radionuclides	• Site characterization • Risk assessment–assess pathway and potential exposure through ingestion of ground water • Environmental evaluation
CHARACTERIZE AIR PATHWAY				
A-1	Characterize particulates in air	Collect discrete air samples from near exposed reservoir sediments and analyze air samples for plutonium and americium.	V–radionuclides	• Site characterization • Risk assessment–assess pathway, transport media, and potential exposure through inhalation
CHARACTERIZE ECOLOGICAL SETTING				
Characterize Terrestrial Biota				
B-1	Characterize terrestrial ecosystem for vegetation	Conduct qualitative surveys and quantitative field sampling for species composition and cover	I–Field surveys	• Site characterization • Comparative ecology
B-2	Characterize animal species and populations	Conduct field surveys for major species of mammals, birds, and reptiles	I–Field surveys	• Site characterization • Comparative ecology
B-3	Characterize wetlands	Conduct qualitative survey for types, size, location, and major species	I–Field surveys	• Site characterization • Comparative ecology

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TABLE 5-1

DATA QUALITY OBJECTIVES AND DATA NEEDS
OPERABLE UNIT NO 3
(Continued)

Data Item	Data Need	Activity	Analytical Level	Data Use
B-4	Assess bioaccumulation in vegetation	Analyze tissue samples from above-ground plant biomass for radionuclides and metals	V radionuclides TAL methods	• Toxicity assessment • Exposure pathways
B 5	Assess bioaccumulation and concentration in wetland vegetation	Analyze tissue samples for radionuclides and metals	V–TAL methods radionuclides	• Toxicity assessment • Exposure pathways
B 6	Assess bioaccumulation in small mammals	Analyze tissue samples for radionuclides and metals	V -TAL metals radionuclides	• Toxicity assessment • Exposure pathways
Characterize Aquatic Biota				
AQ-1	Characterize benthic macroinvertebrate communities in creeks and reservoirs	Collect triplicate samples with Ekman or Surber sampler Identify and enumate to lowest practical toxin Identify trophic types	V–Biological analyses	• Site characterization • Exposure pathways • Ecological endpoints • Comparative ecology
AQ 2	Characterize periphyton in creeks and shallow reservoir areas	Scrape periphyton off natural substrates Identify major taxonomic groups	I -Field Data V–Biological analyses	• Site Characterization • Comparative ecology
AQ 3	Characterize fish communities in creeks and reservoirs	Collect fish with electroshocker and gill nets Identify count, measure and weigh Determine trophic types	I–Field Data V–Biological analyses	• Site characterization • Exposure pathways • Ecological endpoints • Comparative ecology
AQ 5	Assess bioaccumulation in benthic invertebrates	Collect macroinvertebrates with dip nets kick nets, and samplers Analyze select species for metals and radionuclides to assess bioaccumulation	V -Radionuclides and TAL metals	Exposure pathways • Toxicity assessment
AQ 6	Access bioaccumulation in fish	Collect fish with electroshocker and gill nets Analyze select species for metals and radionuclides to assess bioaccumulation	V–radionuclides and TAL metals	• Exposure pathways • Toxicity assessment
AQ 7	Determine if water in creeks and reservoirs is toxic to fish or aquatic invertebrates	Conduct standard acute and chronic toxicity tests with fathead minnow and *ceriodophnia*	V -Biological analyses	• Exposure pathway • Toxicity assessment

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- Community Relations

5.2.2 Identify Data Types

Data types can be initially specified in broad groups and then divided into more specific components. For example, soil, sediment, groundwater, surface water, air, terrestrial, and biota samples will be collected during the field investigation. The selection of analytical parameters and physical testing was based on the OU 3 RFI/RI objectives and on past activities. These data types provide information to evaluate potential pathways identified in the conceptual model and meet the other objectives of the RFI/RI presented in Subsection 5 1 4

5.2.3 Identify Data Quality Needs

EPA defines five levels of analytical data (EPA, 1987c) associated with data quality The analytical levels correspond with those noted in Table 5-1

- Level I—Field screening or analysis using portable instruments. Results are often not compound specific or quantitative but results are available in real-time. Level I is the least costly analytical option. Level I is typically used for initial site characterization.

- Level II—Field analyses using more sophisticated portable analytical instruments. In some cases, the instruments may be set up in a mobile laboratory onsite. There is a wide range in the quality of data that can be generated. Quality depends on the use of suitable calibration standards, reference materials, and sample preparation procedures, and the training of the operator Results are available in real time or several hours later. Level II is typically used for site characterization and evaluation of alternatives.

- Level III—These analyses are performed in an offsite analytical laboratory Level III analyses may or may not use contract laboratory program (CLP) procedures, but do not usually utilize the validation or documentation procedures required of CLP Level IV analysis. The laboratory may or may not be a CLP laboratory Level III is typically used for site characterization, evaluation of alternatives, and risk assessment.

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- **Level IV**—CLP routine analytical services (RAS) All analyses are performed in an offsite CLP analytical laboratory following CLP protocols Level IV is characterized by rigorous QA/QC protocols and documentation Level IV is typically used for risk assessment and evaluation of alternatives

- **Level V**—Analysis by nonstandard methods All analyses are performed in an offsite analytical laboratory which may or may not be a CLP laboratory Method development or method modification may be required for specific constituents or detection limits CLP special analytical services (SAS) are Level V Level V is typically used for risk assessments

The levels appropriate to the data need and data use have been specified on Table 5-1 The levels as they apply to this work plan and specific activities are presented in Table 5-2. The analytical levels specified have been identified by comparing the detection limits for an analytical method to the preliminary OU 3 chemical-specific ARARs.

5 2.4 Identify Data Quantity Needs

Data quantity needs were based on a review of the historical data presented in the Final Past Remedy Report (DOE, May 1991a) and the Historical Information Summary and Preliminary Health Risk Assessment (DOE, May 1991b). Some data have been collected previously at the site that helped focus the additional data quantity needs. In addition, the EPA s Guidance for Data Useability in Risk Assessments (EPA, 1990b) has been followed to help determine the data quantity needs

The rationale for sampling quantities is described Section 6 0—Field Sampling Plan in this document. In areas where some data exist (such as soil samples), a statistical approach to defining sample quantity and location was followed. The rationale for sample quantities also assumed that the data to be collected will confirm past results and some of the historical data will be used qualitatively to support the Human Health Risk Assessment and the Environmental Evaluation

5 2 5 Evaluate Sampling/Analysis Options

Data collection activities must be designed to obtain maximum use of the data. The sampling/ analysis approach for this work plan is based on previous site investigations If sampling does not confirm previous investigation, additional data collection activities may be necessary However, an

TABLE 5-2

LEVEL OF ANALYSIS
OPERABLE UNIT NO. 3

Required Analytical Level	Task
Level I (Field Screens)	• Water level measurement • pH measurement (field) • Temperature (field) • Specific conductance (field)
Level II (Field Analyses)	• Analysis of engineering properties
Level III (Laboratory Analyses using EPA Standard Methods)	• Major ion analysis • Organics analysis • Inorganics analysis
Level IV (Laboratory Analyses using EPA CLP Methods)	• Analysis of Target Compound List (TCL) and Target Analyte list (TAL)
Level V (Nonstandard Analyses)	• Radiological analyses • Contaminant analyses requiring modification of standard methods • Special Analytical Services (SAS) • Bioaccumulation in biota (TAL metals) • Biological analyses

Source U S EPA (1987c)

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effort has been made to anticipate most of the field work necessary to meet the DQOs. In addition, results from other OUs and from the OU 3 sampling program will be evaluated as data become available If results indicate that additional analyses or sampling is necessary, modifications will be made to the sampling program This will be done to avoid performing a successive RFI/RI

5 2 6 Review of PARCC Parameter Information

PARCC (precision, accuracy, representativeness, completeness and comparability) parameters are indicators of data quality Precision, accuracy, and completeness goals were established for this work plan based on the analyses to be performed and the analytical levels. In the quantitative Human Health Risk Assessment and the Environmental Evaluation, only data that have been reviewed and met a specific criteria can be used A summary of the minimum requirements for data quality indicators is presented in Table 5-3, as is a description of the potential impact to the human health risk assessment, and the suggested corrective action The criteria presented in Table 5-3 will be used to evaluate the data useability of the data collected from the OU 3 field sampling program

The analytical program requirements for OU 3 are discussed in Subsection 6 3 of this work plan The analytical program specifies the use of analytical methods referenced in the EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (DOE, 1990c) for all analytes These analytical methods are appropriate for meeting the data quality requirements for analytical levels II through V The precision, accuracy, and completeness parameters for analytical levels II through V are discussed below along with the comparability and representativeness for all analytical levels The DQOs specified for the precision, accuracy, and completeness will be used in evaluating the quality and useability of the laboratory and field data.

Precision and accuracy objectives for the analytical data collected for OU 3 will be evaluated based on the control limits specified in the referenced analytical method and/or in data validation guidelines For the radionuclide analyses, the accuracy objectives specified in the GRRASP will be followed The specified criteria for precision and accuracy are described in Section 10 0–Quality Assurance Addendum for OU 3

The target completeness objective for the OU 3 field and analytical data is 90 percent.

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared with another In order to achieve comparability, work performed at OU 3 will follow

TABLE 5-3

MINIMUM REQUIREMENTS, IMPACT, AND CORRECTIVE ACTIONS FOR DATA USEABILITY CRITERIA OPERABLE UNIT NO. 3

Data Useability Criterion	Minimum Data Quality Requirement	Potential Impact on Risk Assessment	Suggested Corrective Action
Reports to Risk Assessor	• Site description • Sample design with sample locations • Analytical method and detection limit • Results on per-sample basis, qualified for analytical limitations • Sample-specific quantitation limits (SQLs) and detection limit for nondetects • Field conditions for media and environment • Preliminary reports	• Unable to perform quantitative risk assessment	• Request missing information • Perform qualitative risk assessment
Documentation	• Sample results related to geographic location (chain-of-custody records, SOPs, field and analytical records)	• Unable to assess exposure pathways • Unable to identify appropriate concentration for exposure areas	• Request locations identified • Resampling
Data Sources	• Analytical data results for one sample per medium per exposure pathway • Broad spectrum analysis for one sample per medium per exposure pathway • Field measurements data for media and environment	• Potential for false negatives and positives • Increased variability in exposure modeling	• Resampling or reanalysis for critical samples

TABLE 5-3

MINIMUM REQUIREMENTS, IMPACT, AND CORRECTIVE ACTIONS FOR DATA USEABILITY CRITERIA OPERABLE UNIT NO 3 (Concluded)

Data Useability Criterion	Minimum Data Quality Requirement	Potential Impact on Risk Assessment	Suggested Corrective Action
Analytical Method and Detection Limit	• Routine methods used for critical samples and chemicals of potential concern • Detection limit less than 20 percent of concentration of concern	• Unquantified precision and accuracy • False negatives	• Reanalysis • Resampling and analysis for critical samples • Documented statements of limitation for noncritical samples
Data Review	• Correctness of analytical results reviewed	• Potential for false negatives or false positives • Increased variability and bias because of analytical process, calculation, or transcription errors	• Perform data review
Data Quality Indicators	• Sampling variability quantified for each analyte • QC samples required to identify and quantify precision and accuracy • Sampling and analytical precision and accuracy quantified	• Unable to quantify confidence levels for uncertainty • Potential for false negatives or false positives	• Resampling for critical samples • Perform qualitative risk assessment • Perform quantitative risk assessment for noncritical samples with documented discussion of potential limitations

Source Guidance for Data Useability In Risk Assessment (EPA, 1990b)

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approved sampling and analysis plans, use standardized analytical protocols, collect data following SOPs, and report data in consistent units of measurement.

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. It is a qualitative parameter that is most concerned with the proper design of the sampling program. The field sampling plan described in Section 6.0 of this work plan and the referenced SOPs describe the rationale for the sample program to provide for representative samples. In designing the field sampling program, statistical considerations were given in selection of sample locations and sample numbers.

5.3 STAGE 3--DESIGN DATA COLLECTION PROGRAM

The purpose of Stage 3 of the DQO process is to design the specific data program for the OU 3 RFI/RI To accomplish this, the elements identified in Stages 1 and 2 were assembled and the Field Sampling Plan was prepared. The Field Sampling Plan and the Quality Assurance Addendum are presented in Sections 6.0 and 10.0 of this work plan, respectively A detailed discussion of all samples to be obtained is presented Subsection 6 4 for each media and includes sample type, number of samples, sample location, analytical methods, and QA/QC samples.

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6 1 INTRODUCTION

The purpose of this section of the work plan is to present the field sampling plan (FSP) that has been developed to meet the RFI/RI objectives As stated in Section 5 0, the primary objective of the RFI/RI is to collect the data necessary to determine the nature, distribution, and migration pathways of contaminants, and to quantify any risks to human health and the environment. More specific objectives were listed in Subsection 5 1 4 Based on these objectives, the site-specific DQOs and data needs have been identified in Section 5 0 and are the basis for developing the field sampling plan in this section Field sampling activities, by media, are presented in Subsections 6 3 1 through 6 3 6

It is important to recognize that additional phases of investigation may be required at some of the IHSSs prior to feasibility studies if contaminants other than plutonium and americium are detected However, an effort has been made to anticipate all the data needs necessary to complete the RFI/RI

The FSP presents a summary of previous OU 3 activities, a discussion of relevant studies by other OUs, rationale for chemical analyses, and field sampling activities by media—soil, sediments, surface water, groundwater, air, and biota. Following the description of sampling activities, the sample analysis program (sample designations, analytical requirements, sample containers and preservations, sample labeling and documentation, and data reporting requirements) and the field quality control procedures are discussed As discussed in Subsection 4 3, detailed sampling plans will be developed prior to performing the specific sampling activities

6 1 1 Background

Previous investigations in the vicinity of OU 3 have been performed and are described in the Past Remedy Report (DOE 1991a), the Historical Information Summary and Preliminary Health Risk Assessment (DOE, 1991b), and briefly in Section 2.0 of this work plan These data have helped focus the field activities necessary to complete the RFI/RI and perform the quantitative Human Health Risk Assessment and Environmental Evaluation Additional field investigations are being

performed for other operable units as mentioned previously in Subsection 1.3.8. These studies are discussed in Subsection 6.1.2.

In addition, an extensive environmental monitoring program performed by EG&G, CDH, and the Cities of Broomfield and Westminster, including the following items, is performed and summarized in annual Rocky Flats Plant Site Environmental Reports

- Effluent air monitoring
- Ambient air monitoring for nonradioactive and radioactive contaminants
- Drinking water monitoring
- Groundwater monitoring
- Soil sampling
- External gamma radiation dose
- Assessing of potential plant contribution to public radiation dose

In order to not duplicate ongoing work at Rocky Flats, these investigations have been reviewed to identify which data will be used in evaluating OU 3 data. The data identified and its use as part of the OU 3 RFI/RI are described in Subsection 6.1.2.

An evaluation of data useability for existing data at IHSS 199 through 202 was performed and summarized in the Final Past Remedy Report (DOE, May 1991a) and the Historical Information Summary and Preliminary Health Assessment (DOE, May 1991b). The evaluation concluded that few of the criteria found in the EPA Guidance Document for Data Useability in Risk Assessment (EPA, 1990b) were met. The field sampling program developed in this work plan is designed with the intent of the data collected to meet the criteria described in the EPA guidance. The field sampling program is also designed to evaluate results of previous investigations. If the historical results are confirmed, previously collected data will be used to substantiate the quantitative Human Health Risk Assessment and the Environmental Evaluation. If the previous sampling results are not confirmed and contaminants other than plutonium and americium are detected, another phase of field sampling may be required.

The Guidance for Data Useability in Risk Assessment (EPA, 1990b) provides guidance for evaluating the necessity of alternative sampling strategies and designing a statistical sampling plan. The objective is to determine a strategy that collects data representative of conditions at the site and is within resource limitations. The rationale for each sampling program is provided in Subsection 6.3

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6 1 2 Relevant Studies of Other OUs

As previously mentioned investigations are occurring at OU 2–903 Pad Mound, 881 Hillside and East Trenches Areas OU 5–Woman Creek and OU 6–Walnut Creek Priority Drainage that are relevant to OU 3 Similar field sampling techniques and analytical methods will be used, where appropriate so data collected from the OUs are comparable Work performed in other OUs will also be used when evaluating OU 3 results In addition some of the sampling results from OUs 5 and 6 should be available before OU 3 sampling begins. The OUs 5 and 6 results that are available will be reviewed and modifications to the OU 3 sampling program will be made if necessary

At OU 2, studies to evaluate the static and mobile soil phase of the physiochemical association of plutonium and americium will be performed This work will provide information on the mobility and environmental fate of radionuclides in the soils. Hydrological analyses of the frequency, duration, and intensity of summer precipitation events and spring snowmelt events coupled with direct measurements of solute transport in soils, will provide information to assess the movements of water and radionuclides (dissolved and particulate) down through the soil column A description of the work to be performed is provided in Attachment 1 of the Final Phase II RCRA Facility Investigation Remedial Investigation Work Plan for OU 2 (EG&G, 1991a) The information provided from these studies at OU 2 will be applied to predict the fate and transport of plutonium and americium found in soils and sediments at OU 3

At OUs 5 and 6, the Woman Creek and Walnut Creek drainages are being investigated The results from these activities will be used in evaluating the drainage investigations for OU 3 In addition, background sampling for OU 6 will consist of sediment and surface water sampling that will be collected west of OU 6 to provide background information on Walnut Creek This information will be used in evaluating sediment and surface water results from the OU 3 investigation Background groundwater quality will be based on the 50 wells that were installed in 1989 as part of the network to characterize upgradient groundwater unaffected by RFP (Rocky Flats Plant Site Environmental Report, January through December 1989) (EG&G 1990b) The wells are sampled quarterly as part of the Rocky Flats Plant site environmental monitoring program In addition, the Background Geochemical Characterization Report for 1989 (EG&G 1990f) describes and summarizes background geochemical data for surface

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6 1 3 Summary of Field Investigation Activities

In Section 5 0, general data needs were identified with their associated data quality objectives From these data needs and data quality objectives, a detailed sampling program for OU 3 was developed. A summary of field sampling activities by media for OU 3 is presented in Table 6-1 The table summarizes the purpose of the field activity, location, estimated number of sample locations, and the rationale for the activity The first column includes a data need designations. The designations can be used to cross-reference the proposed sampling activity to Table 5-1, which identifies the OU 3 data needs. The following subsections provide additional detail by media. soil, sediment, surface water, groundwater, air, terrestrial and aquatic, and biota, and describe the rational for chemical analyses and the field sampling procedures to perform field activities.

6.2 OU 3 CHEMICAL ANALYSES RATIONALE

This subsection presents the rationale for selecting OU 3 specific chemical analyses. The identification and rationale for OU 3 chemical analyses selection has followed EPA guidance documents including Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988), Data Quality Objectives for Remedial Response Activities (EPA, 1989), and Guidance Document for Data Usability in Risk Assessment (EPA, 1990b) It is also consistent with the proposed approach presented for amending the analytical strategy for OU 1 and 2.

Comprehensive site characterization has been ongoing at OU 1 and 2 since 1986. In addition, annual monitoring by EG&G, CDH, and the Cities of Broomfield and Westminster has been performed on and around the RFP as part of the Rocky Flats Plant site environmental monitoring For the identification of OU 3 specific data analyses, the data review has focused on data from groundwater, surface water, and sediments along Indiana Street, just west of OU 3. These locations represent the downgradient property boundary of the RFP If contaminants are not detected in these locations, they are not likely to be present in OU 3

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TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA
FOR OPERABLE UNIT NO 3

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
SOIL					
S 1, S 4 Profile soil sampling	Characterize vertical plutonium and americium concentrations in undis turbed areas	• Plutonium and americium • Ten percent of the sam ples will also be ana lyzed for total organic carbon (TOC) bulk den sity and grain size	Undisturbed areas identi fied from historical aerial photographs Samples will be collected using the modified trench method Samples will be collected to a depth of approximately 100 cm	Undisturbed areas identified from aerial photographs (10 samples estimated -two trenches per area) Possi ble locations include draina ges wetlands and snow accumulation areas	Undisturbed areas have the highest potential for accumulation of contami nants The locations will be refined after the aerial photograph review and field reconnaissance
S 2, S 4 Soil grid survey	Delineate lateral extent of plutonium and americium contamination and verify/ confirm previous soil sam pling	• Plutonium americium, and uranium • Ten percent of samples will be analyzed for bulk density grain size and TOC	1,000 meter grid east of Indiana Street	Approximately thirty five 10 acre plots will be sampled	Sampling grid based on geostatistical kriging of previous soil data
S 3 Soil types	Delineate lateral extent of soil types and correlate with vegetation types	Standard soil survey analyses	Undisturbed or minimally disturbed areas	As needed to correspond to vegetation sampling	Field reconnaissance and survey will be sufficient to determine if soil types are supporting unexpected vegetation or vegetation typical for the habitat

Notes [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations initial data review and field decisions Quality control samples are not included

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
SEDIMENT					
SED-1, S-4 Sediment sampling in drainages	Characterize contamination in drainage ditches	• Plutonium, americium, uranium, and gross alpha and beta • TCL volatiles • TCL metals • Ten percent of the samples will be analyzed for TOC, bulk density, and grain size.	Sediment samples will be collected in Walnut Creek, Broomfield Diversion Ditch, Woman Creek, and ditch above Mower Reservoir	• 7–Above Great Western Reservoir along Walnut Creek drainages • 3–Below Great Western Reservoir • 2–Broomfield Diversion Ditch • 3–Above Mower Reservoir • 3–Below Mower Reservoir • 6–Above Standley Lake along Woman Creek drainages • 3–Below Standley Lake • 1–Near the inlet of Clear Creek Irrigation Ditch	Drainages are a potential pathway for offsite migration.

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Notes. [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations, initial data review, and field decisions. Quality control samples are not included

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
SED-2, S-4 Sediment sampling in reservoirs	Characterize sediments in reservoirs Vertical profile samples of sediments from reservoirs will provide information on plutonium and americium concentrations as it varies with depth Grab samples will be collected to characterize potential metals and volatile contamination	• Plutonium and americium for vertical profile samples • TAL metals TCL volatiles plutonium americium, uranium gross alpha and beta on grab samples • Ten percent of the samples will be analyzed for TOC bulk density and grain size	Sediment locations will be in the deepest area of each reservoir and in reservoir bays Vertical profile samples (for radionuclides) and a grab sample (for VOAs and metals) will be collected	• 5 grab 3 vertical profile–Great Western Reservoir • 5 grab 3 vertical profile–Mower Reservoir • 6 grab 4 vertical profile–Standley Lake	The vertical profiling of radionuclides will help identify depths of plutonium and americium contamination Grab samples will be analyzed for the TCL VOAs and TCL metals to identify presence of other potential contaminants
SED 3, S 4 Near shore sediment sampling of reservoirs	Characterize sediments that may be potentially exposed during low reservoir capacity In addition one sample per reservoir will be a vertical profile sample to characterize how plutonium and americium vary with depth	• Plutonium, americium, uranium, and gross alpha and beta • TCL volatiles • TCL metals • Ten percent of the samples will be analyzed for TOC bulk density, and grain size	Random samples will be collected in zones identified during a field reconnaissance based on access recreational use and near the inlet and outlet of reservoirs when the reservoirs are at a low capacity	Numbers to be determined based on zones identified during field reconnaissance and on statistical considerations	Exposed sediments are a potential pathway of dispersion of contaminants by wind

Notes [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations initial data review and field decisions Quality control samples are not included

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
SURFACE WATER					
SW 1 Sample surface water drainages	Characterize radionuclides, VOAs, and metals in surface water	• Plutonium, americium, uranium, and gross alpha and beta • TCL volatiles • TCL metals • Atrazine and simazine • Cations/anions • DO, pH, EC	Drainages above and below reservoirs	• 3–Walnut Creek (2 upgradient, 1 downgradient) • 3–Woman Creek (2 upgradient, 1 downgradient) • 2–Broomfield Diversion • 3–Mower Reservoir (2 upgradient, 1 downgradient)	Provides information on plutonium, americium, VOAs, and metals entering and exiting the reservoir. Cation/anions, DO, pH, and EC parameters will be used in the Environmental Evaluation. Two surface water sampling events are scheduled, one during high flow and one during low flow
SW 2 Sample Reservoirs	Characterize radionuclides, VOAs, and metals in surface water and variations in plutonium and americium in vertical profile	• Plutonium, americium, uranium, and gross alpha and beta • TCL metals • TCL volatiles in Mower Reservoir only • Atrazine and simazine • Cations/anions	Deepest area of each reservoir and in bays of reservoir	• 3–Great Western • 3–Mower • 4–Standley	Supplements and verifies existing data and allows for identification of stratification, if it exists. Two surface water sampling events are scheduled, one during high flow and one during low flow

Notes: [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations, initial data review, and field decisions. Quality control samples are not included

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TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
GROUNDWATER					
GW 1 Install and sample groundwater monitoring wells	To obtain site specific hydrogeology and assess plutonium and americium in alluvial and confined groundwater systems	• Plutonium americium uranium and gross alpha and beta • Major cations/anions	Downgradient of Great Western Reservoir and Standley Lake	2–Great Western Reservoir 2–Standley Lake	Provides data to evaluate if contaminants in soils or surface water have migrated to groundwater Provides site specific information on hydrogeology Wells will be sampled quarterly
AIR					
A 1 Discrete air sampling	Characterize the potential for dispersion of plutonium and americium contaminated sediments	Plutonium and americium	Discrete sampling during variable wind conditions in low lying areas where reservoir sediments are exposed	• 1–Location at Great Western • 1–Location at Standley Lake	Higher concentrations of plutonium at Great Western Reservoir have been observed and the potential exists for greater entrainment of sediments at Great Western because of diversion creating lower reservoir levels There is greater exposure potential at Standley Lake because of recreational use

Notes [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations, initial data review and field decisions Quality control samples are not included

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
TERRESTRIAL BIOTA					
Qualitative Field Surveys					
B-1 Vegetation	Characterize vegetation types	Field reconnaissance for species and cover using quadrant sampling	As needed to characterize	As needed using quadrants and linear transects	Field reconnaissance and survey will be sufficient to record species composition and present conditions, and to estimate cover, identify potential hot spots, and snow accumulation areas.
B-2 Wildlife/habitat types	Characterize species and habitat type	Field reconnaissance by driving and walking transects	As needed to characterize	As needed	Records of species present and habitat types, utilization, and estimates of population densities for site characterization
B-3 Wetlands/riparian zones	Characterizes for distribution	Field reconnaissance	As needed to characterize	As needed	Field surveys will be sufficient to characterize number, size, distribution, and condition of all wetlands and riparian zones

Notes [1] The data need designation refers to the data needs presented in Table 5-1.
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations, initial data review, and field decisions. Quality control samples are not included.

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TABLE 6 1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
Quantitative Field Sampling					
B 4 Vegetation–above ground biomass	Characterize contaminant concentrations and bio accumulation	Radionuclides on all sam ples plus 10 percent will also be analyzed for metals	In conjunction with 1,000 meter grid for soils nearest vegetation type to soils location	~100 in grid using 0 25 m^2 plots 2 inch hot spots 4 inch snow accumulation areas	Vegetation above ground biomass sampling will determine uptake and foliar deposition of con taminants for dose response and as a trans fer into food chains
B 5 Wetlands vegetation	Characterize contaminant concentrations and bioaccumulation	Radionuclides and metals	Dependent on field surveys	Estimates at 10 general 2 inch hot spots	Wetland vegetation has the potential for accumu lation of contaminants through filtration and uptake
B 6 Small mammals	Characterize bioaccumulation	Radionuclides on all sam ples plus 10 percent will be analyzed for metals	Dependant on field surveys	100	Small mammals have the potential for contaminant accumulation through ingestion of plants and soil

Notes [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations initial data review and field decisions Quality control samples are not included

TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
AQUATIC BIOTA					
Qualitative Field Surveys					
AQ-1 Benthic Macroinvertebrates	Determine predominant invertebrates, characterize habitats, select reference stations, observe obvious impacts, assess proposed sampling methods	Field identification of benthos, relative abundance, spatial distribution of major types, record habitat characteristics	Woman Creek Walnut Creek Reservoirs Wetlands and seeps	As needed to sample major habitat types	RFP contaminants have been found in creeks and reservoirs. Benthic macroinvertebrates are good indicators of water and sediment quality
AQ-2 Periphyton	Evaluate abundance and composition, assess proposed sampling methods, record available substrates	Record relative abundance, periphyton types, and available substrates	Woman Creek Walnut Creek Wetlands Reservoir shoreline	As needed to sample major habitat types	Abundance of these primary producers may indicate water quality and influence abundance of aquatic animals
AQ-3 Fish	Determine predominant species, characterize habitats, observe spatial distribution, select reference stations, assess proposed sampling methods	Identify and measure common species, count fish present, record abnormalities and external parasites.	Woman Creek Walnut Creek Reservoirs	As needed to sample major habitat types	Abundance, spatial distribution and condition may indicate impacts. Determine which species to use for bioaccumulation

Notes: [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations, initial data review, and field decisions. Quality control samples are not included

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TABLE 6 1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Continued)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
Quantitative Sampling					
AQ 4 Benthic Macroinvertebrates	• Compare benthic communities in OU 3 Creeks/Lakes with onsite RFP locations and reference areas • Determine if benthic organisms are accumulating contaminants	Metals Radionuclides Pesticides/PCBs Numbers of organisms per taxa trophic types	• Walnut Creek above and below Great Western Reservoir • Woman Creek above and below Standley Lake • Ditch above and below Mower Reservoir • Reservoirs and Lake	3–Walnut Creek 3–Great Western Reservoir 3–Woman Creek 4–Standley Lake 2–Mower Ditch 3 -Mower Reservoir 2–To be Determined	• Assess potential impact of contaminants on creeks and reservoirs • Characterize benthic populations in creeks and reservoirs Compare populations in impacted and unimpacted areas • Determine if bioaccumulation of contaminants has occurred • Analytical parameters target the contaminants most likely to bioaccumulate
AQ 5 Periphyton	• Characterize periphyton communities in OU 3 creeks and compare with onsite RFP and reference locations	Number of organisms per class	• Walnut Creek above and below Great Western Reservoir • Woman Creek above and below Standley Lake • Ditch above and below Mower Reservoir	2–Walnut Creek 2–Great Western Reservoir 2–Woman Creek 3–Standley Lake 3–Mower Ditch 2–Mower Reservoir 2–To be Determined	• Characterize periphyton communities in creeks and reservoirs • Compare populations in impacted and unimpacted areas

Notes [1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations initial data review and field decisions Quality control samples are not included

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TABLE 6-1

SUMMARY OF FIELD SAMPLING ACTIVITIES BY MEDIA FOR OU 3
(Concluded)

Data Need Addressed[1]/ Field Activity	Purpose	Analyses	Location	Estimated Number of Sample Locations[2]	Rationale
AQ-7 Fish	• Characterize fish communities in Walnut and Woman Creeks and Great Western and Mower Reservoirs. Compare with onsite RFP locations and reference areas. • Determine if fish are accumulating contaminants. • Determine if water at selected location is toxic to fish	• Number of fish by species, lengths and weights • Identify, measure, count, and weigh Metals Radionuclides Pesticides/PCBs Semivolatiles • Standard acute and chronic toxicity tests	• Walnut Creek above and below Great Western Reservoir • Woman Creek above and below Standley Lake • Great Western and Mower Reservoirs • Mower Ditch above and below Mower Reservoir	3–Walnut Creek 3–Great Western Reservoir 3–Woman Creek 3–Mower Reservoir 2–Mower Ditch 4–Standley Lake	• Characterize fish communities in creeks and reservoirs Compare fish communities in OU 3 creeks with onsite RFP and reference locations • Determine if bioaccumulation of contaminants has occurred • Determine toxicity of water • Determine if contaminants and/or environmental stress have caused increase in parasites or deformities

Notes
[1] The data need designation refers to the data needs presented in Table 5-1
[2] Estimated number of sample locations is approximate and will be refined based on statistical considerations, initial data review, and field decisions. Quality control samples are not included

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6 2.1 Approach

The approach to identifying and selecting the chemical analyses for OU 3 consists of the following two steps

- **Step 1**–Summarize compounds that have been detected along Indiana Street for groundwater, surface water, and sediments by analytical group

- **Step 2**–Evaluate results to identify prevalent compounds and chemicals of concern

In Step 1 pertinent data are tabulated showing the number of detections of each chemical that are detected one or more times, the maximum value detected and the average of the detected values Compounds that were not detected are not included in the summaries. This is performed for each media sampled The analytical groups are as follows

- Target compound list (TCL) volatile organic analyses (VOAs)

- TCL Semivolatiles
  - Acid Extractables
  - Base/Neutral Extractables

- Pesticides/PCBs

- Radionuclides

- Inorganics (metals)

Three possible outcomes are identified through the tabulation of data.

- **Case 1**–The tabulation demonstrates that chemicals within one or more analytical groups in a specified media have not been detected at the given detection limit Therefore, additional sampling for that analytical group is not necessary to achieve the RFI/RI objectives

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- **Case 2**–The tabulation demonstrates that one or more chemicals from an analytical group have been detected in a specified media either inconsistently or at low concentrations and further evaluation should be made as to whether additional investigative sampling and analysis is necessary Evaluations include toxicity and mobility of compounds, and historical releases of compounds known to have occurred onsite

- **Case 3**–The tabulation demonstrates consistent detections of one or more chemicals from an analytical group in a specified media and suggests that further investigative sampling and analysis is required to achieve the RFI/RI objectives.

After tabulating the results and assigning either Case 1, 2, or 3 to the chemical groups, the implications of eliminating the analytical group from the sampling program were evaluated. In Case 1, the analytical group can be eliminated provided the historical data are of adequate quality or useability, and are representative of the site. Data quality is assessed in accordance with the ER Program Quality Assurance Project Plan (QAPjP), the General Radiochemistry and Analytical Services Protocol (GRAASP), and EPA's Guidance Document for Data Usability in Risk Assessment (EPA, 1990b) Elimination of the groups where historical data fits Case 2, requires an assessment of data quality, chemical fate and transport, and human and environmental risks posed by the chemicals In addition, any historical release information and chemicals of concern at other OUs are evaluated. Assessment of chemical fate and transport and human/environmental risks allows a determination to be made as to whether the chemical is at a concentration in a specific media that poses an unacceptable risk to human health or the environment through a likely exposure pathway and whether the chemical is likely to migrate to another medium at concentrations that also pose an unacceptable risk. For Case 3, continued monitoring for the analytical group in order to better characterize the media is justified particularly for chemicals that are mobile and toxic

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6.2.1 1 Fate and Transport

Several chemical and physical parameters affect the environmental fate and transport of a chemical. Table 6-2 presents some of the relevant chemical/physical parameters that relate to the environmental fate and transport of representative chemicals from each of the analytical groups previously described The table summarizes the molecular weight, specific gravity, vapor pressure, Henry's Constant, water solubility, log of the particular coefficient, log of the octanol/water partition

TABLE 6 2

CHEMICAL/PHYSICAL PARAMETERS AFFECTING
ENVIRONMENTAL FATE AND TRANSPORT

Chemical	Molecular Weight (g/mole)	Specific Gravity (g/cc)	Vapor Pressure (mmHg)	Henry s Constant (Dimensionless)	Water Solubility (mg/l)	Log Kow (c/c)	Log Koc (ml/g)	Saturated Zone Rd	Mobility Index MI	Env Mobility
TCL VOLATILE ORGANICS										
Ketones & Aldehydes										
Acetone	55 1	0 1	270 00	0 013	60000 0	0 24	0 43	1 0	8	Extremely Mobile
Monocyclic Aromatics										
Benzene	78 1	0 9	76 00	0 182	1780 0	2 13	1 81	6 8	3	Very Mobile
Toluene	92 1	0 9	22 00	0 214	515 0	2 79	2 48	28 0	2	Very Mobile
Ethyl Benzene	106 2	0 9	7	0 266	152 0	3 34	3 04	100 0	0	Slightly Mobile
Xylene	106 2	0 9	10	0 380	152 0	3 13	2 11	12 6	1	Very Mobile
Chlorinated Aliphatics										
Carbon Tetrachloride	153 8	1 6	90 00	0 960	785 0	2 96	2 64	40 5	2	Very Mobile
Trichloroethene	131 4	1 5	60 00	0 390	1100 0	2 42	2 10	12 3	3	Very Mobile
Chloroform	119 4	1 5	160 00	0 130	8000 0	1 97	1 64	4 9	4	Very Mobile
1,1 2 2 Trichloroethane	167 9	1 6	5 00	0 016	2900 0	2 39	2 07	11 6	2	Very Mobile
SEMIVOLATILE ORGANICS										
Acid Extractables (Phenolics)										
Phenol	94 1	1 1	0 20	1 2E-04	8200 0	1 46	1 15	2 3	2	Very Mobile
Pentachlorophenol	266 4	2 0	1 1E-04	1 1E-04	14 0	5 18	4 72	4771 3	8	Immobile
2 4 Dinitrophenol	184 1	1 7	1 5E-05	2 7E-08	5600 0	1 54	1 22	2 5	2	Slightly Immobile
2 4 6 Trichlorophenol	197 5	1 5	0 012	1 6E-04	800 0	3 61	3 30	181 0	2	Slightly Immobile

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TABLE 6-2

CHEMICAL/PHYSICAL PARAMETERS AFFECTING
ENVIRONMENTAL FATE AND TRANSPORT
(Continued)

Chemical	Molecular Weight (g/mole)	Specific Gravity (g/cc)	Vapor Pressure (mmHg)	Henry's Constant (Dimensionless)	Water Solubility (mg/l)	Log Kow (c/c)	Log Koc (ml/g)	Saturated Zone Rd	Mobility Index MI	Env Mobility
Base-Neutral Extractables										
Bis(2 ethylhexyl)phthalate	391 1	1.0	2.7E-07	4 4E-06	1 3	9 61	9 30	1 8E+08	16	Very Immobile
Chrysene	22[illegible].2	1.3	1.0E-11	6 9E-08	0.0	5.81	5 30	1 8E+04	19	Very Immobile
1,2,4--Trichlorobenzene	181.5	1.5	0.29	9.8E-02	30	4 28	3 96	8 3E+02	-3	Slightly Immobile
1,3-Dichlorobenzene	147 0	1.3	2.28	1.5E-01	123	4.28	3.96	8 3E+02	-2	Slightly Immobile
Naphthalene	128.2	1.0	0.087	1.9E-02	31 7	3.29	2.97	8.6E+01	-3	Slightly Immobile
Benzo(a)pyrene	252.0	1 4	5.6E-09	2.0E-05	3.8E-03	6 06	6 74	5 0E+05	17	Very Immobile
PCBs AND PESTICIDES										
PCBs										
PCB-1248	299.5	1.4	4.8E-04	1.5E-01	0 054	5.78	5 44	24931 0	10	Immobile
PCB-1254	328.4	1.5	7 7E-05	4 6E-02	0.0	6.03	5 72	47233 7	11	Very Immobile
PCB-1260	375.7	1.6	4.1E-05	2.8E-01	0.0	7 15	6 82	594625 1	14	Very Immobile
Chlorinated Pesticides										
Dieldrin	381.0	1 8	1.8E-07	1.9E-05	0.2	3 54	3.23	153 8	11	Very Immobile
DDT	375.7	1.6	1 9E-07	7 1E-04	5.5E-03	6 91	6 59	350141 6	16	Very Immobile
Heptachlor	375.0	1.6	3.0E-04	3.4E-02	0 18	4 4	4 1	1061 0	-8	Immobile
Lindane	291.0	1.6	2.5E-05	2.5E-04	1.6	3.9	3 6	343.0	-8	Immobile

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TABLE 6-2

CHEMICAL/PHYSICAL PARAMETERS AFFECTING
ENVIRONMENTAL FATE AND TRANSPORT
(Concluded)

Chemical	Molecular Weight (g/mole)	Specific Gravity (g/cc)	Vapor Pressure (mmHg)	Henry's Constant (Dimensionless)	Water Solubility (mg/l)	Log Kow (c/c)	Log Koc (ml/g)	Saturated Zone Rd	Mobility Index MI	Env Mobility
Chlordane	409 8	1 6	1 0E 05	4 0E 03	0 056	5 5	5 1	12601 0	11	Very Immobile
Toxaphene	414 0	1 6	0 3	1 4E+01	0 5	3 3	3 0	87 8	4	

Source EG&G, 1990e

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coefficient, saturated zone retardation, mobility index, and environmental mobility These properties affect how mobile a chemical is in the environment.

Generally, TCL volatiles have mobility indices that suggest higher mobility in the environment than other chemicals. The detected volatiles are generally characterized by relatively high water solubility (greater than 100 mg/l) and volatility (vapor pressures greater than 1 0 mm Hg and Henry's Law Constants greater than 0 1) Volatiles can be expected to migrate through soils in both liquid and vapor phase, and to be transported by groundwater and surface water as neutral solutes This is denoted by retardation factors (Rd) between 1 and 50 (Chemical migration velocity = water migration velocity/Rd) The Henry's Constants of volatiles suggest a tendency to volatilize from aqueous systems (including soil water) to the atmosphere.

Semivolatile compounds and pesticides/PCBs are considered to be much less mobile than volatile compounds. The retardation factors for semivolatiles and pesticides/PCBs range from approximately 100 to over 180,000,000 with the exception of phenolic compounds. Phenols are relatively mobile because of their high water solubility Semivolatiles and pesticides/PCBs exhibit low to negligible volatiles as indicated by the low vapor pressures and Henry's Constants, This suggests a low propensity for volatilization of these compounds to the atmosphere from soil and soil water

6.2.1.2 Toxicity

Another factor in considering whether or not to analyze certain chemical groups is the toxicity of various chemicals in the media they are found. In this analysis, the concentrations of the chemical detected were compared to the Applicable or Relevant and Appropriate Requirements (ARARs) Tables 6-3, 6-4, and 6-5 summarize the ARARs for the chemicals detected in the groundwater, surface water, and sediments along Indiana Street. The action levels for sediments are based on EPA's proposed RCRA Corrective Action Regulations (FR v.55, No 145, July 27, 1990, 40 CFR 264 521) They are based on likely chemical exposure scenarios of a 10^{-6} incremental cancer risk (for carcinogens) or a no adverse health effect from a lifetime exposure to a systemic contaminant (noncarcinogen) The proposed action levels are for soils, not sediments, and are included for comparison purposes. They are not considered ARARs.

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TABLE 6-3

SUMMARY OF COMPOUNDS DETECTED IN GROUNDWATER

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	MCL[2]	Units
VOA–CASE 2						
Methylene Chloride	56	11	24	9 4		µg/l
Acetone	52	5	24	12		µg/l
1 1 1-trichlorethane	50	1	9	9	200	µg/l
Carbon disulfide	44	3	3	2		µg/l
Trans-1,3-dichloropropene	33	1	5	5		µg/l
SEMIVOLATILES–CASE 1						
Pesticides/PCBs–No analyses						
RADIONUCLIDES–CASE 2						
Gross alpha	–	35	170	27.2	80	pCi/L
Gross beta	–	36	220	31 3	4 mrem/yr	pCi/L
Plutonium $^{238+239+240}$	–	14	1 1	0 3	15	pCi/L
Radium $^{226+228}$	–	4	0 4	0.28	5	pCi/L
Strontium^{90}	–	18	2.5	1 0	8	pCi/L
Tritium	–	13	320	213	20 000	pCi/L
INORGANICS–CASE 2						
Aluminum	–	19	0.27	0 07	0.05	mg/l
Barium	–	24	0 219 3	0 135	1	mg/l
Cadmium	–	1	0 000 3	0 0003	0 005	mg/l
Chromium	–	3	0 017 8	0 0148	0 05	mg/l
Copper	–	9	0 016 9	0 0092	0.2	mg/l
Iron		21	1 69	0 159	0 30	mg/l
Lead	–	3	0 046	0 017	0 05	mg/l
Manganese	–	29	0.974 5	0.278	0 05	mg/l
Mercury	–	2	0 000 24	0 0002 2	0 002	mg/l
Nickel	–	18	0 62	0 157	0.2	mg/l
Selenium	–	18	0 039	0 016	0 010	mg/l
Silver	–	3	0 025 6	0 0202	0 05	mg/l
Zinc	–	16	0 138	0 0493	2	mg/l

[1] Average value of detections (nondetects not included in average)
[2] Lowest ARAR identified

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TABLE 6-4

SUMMARY OF COMPOUNDS DETECTED IN SURFACE WATER

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	MCL[2]	Units
VOA–CASE 2						
Acetone	60	3	19	77.3		µg/l
Benzene	52	1	1	1	0	µg/l
Carbon disulfide	55	1	5	5		µg/l
Chlorobenzene	32	1	1	1		µg/l
Ethylbenzene	11	1	1	1	700	µg/l
Methylene chloride	65	10	3.1	2.1		µg/l
Tetrachloroethene	57	1	4	4	0	µg/l
Toluene	68	9	6	4.3	2420	µg/l
Trichlorethene	47	3	2	1.7	0	µg/l
Total Xylenes	60	7	6	5	10,000	µg/l
Vinyl acetate	63	1	3	3		µg/l
2-butanone	58	2	27	14		µg/l
1,2-dichloroethane	43	2	3	3	0	µg/l
1 1 1-trichloroethane	61	1	4	4	200	µg/l
SEMIVOLATILE–CASE 2						
Bis(2-ethylhexyl)phthalate	17	5	19	5.8	15,000	µg/l
Di-n-butyl-phthalate	18	1	1.6	1.6		µg/l
Di-n-octyl-phthalate	11	1	2	2		µg/l
N-nitrosodiphenylamine	13	1	1	1	4.9	µg/l
PESTICIDES/PCBs–CASE 2						
Atrazine	5	3	0.62	.39	3	µg/l
Simazine	4	2	6	3.2		µg/l
RADIONUCLIDES–CASE 2						
Gross alpha		34	5.3	2.6	15	pCi/l
Gross beta		32	9.2	5.1 mrem/yr		pCi/l
Plutonium 238+239+240		18	0.00969	0.0075	15	pCi/l
Radium 226+228		2	0.3	0.2	5	pCi/l
Strontium[90]		19	0.7962	0.27	8	pCi/l
Tritium		10	230	13.6	20,000	pCi/l
INORGANICS–CASE 2						
Aluminum		12	2.14	0.47	0.05	mg/l
Arsenic		1	0.0021	0.002	0.000002	mg/l
Barium		4	0.0991	0.091	1	mg/l
Beryllium		1	0.09	0.09	0.0000068	mg/l
Copper		4	0.0383	0.083	0.012	mg/l
Iron		21	1.41	0.36	0.3	mg/l
Lead		5	0.0046	0.004	0.0032	mg/l
Manganese		14	0.191	0.065	0.05	mg/l
Mercury		2	0.0003	0.0003	0.000012	mg/l

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TABLE 6-4

SUMMARY OF COMPOUNDS DETECTED IN SURFACE WATER
(Concluded)

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	MCL[2]	Units
Selenium		2	0 0118	0 009	0 01	mg/l
Silver		1	0 02	0 02	0 12	mg/l
Zinc		27	0 3414	0 023	0 1	mg/l

[1]Average value of detection s (nondetects not included in average)
[2]Lowest ARAR identified

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TABLE 6-5

SUMMARY OF COMPOUNDS DETECTED IN SEDIMENTS

Parameter	Number of Analyses	Number of Detections	Maximum Value	Average Value[1]	MCL[2]	Units
VOA–CASE 2						
Acetone	9	4	240	92	8,000,000	µg/kg
1 1 1-trichloroethane	7	1	3	3	7,000,000	µg/kg
Toluene	9	1	2	2	20 000,000	µg/kg
Methylene chloride	9	1	90	90	90,000	µg/kg
SEMIVOLATILES–CASE 2						
Bis(2-ethyhexyl)phthalate	10	2	1,000	580	50,000	µg/kg
Fluoranthene	6	1	41	41	–	µg/g
Pyrene	8	1	41	41	–	µg/g
Di-n-butylphthalate	7	1	60	60	–	µg/g
Benzoic acid	7	1	390	390	–	µg/g
4-methylphenol	7	1	2,200	2,200	–	µg/kg
PESTICIDE/PCBs–CASE 2						
Beta-BHC	3	1	1.5	1.5	–	µg/kg
RADIONUCLIDES–CASE 2						
Gross alpha	–	6	39	22.3	–	pCi/g
Gross beta	–	6	35	29.0	–	pCi/g
Plutonium 238+239+240	–	8	1.9	0 63	–	pCi/g
Radium 226+228	–	6	3.248	1.9	–	pCi/g
Strontium 90	–	2	0.1423	0.13	–	pCi/g
Tritium	–	6	300	136	–	pCi/g
INORGANICS–CASE 2						
Aluminum	–	5	17,800	8,984	–	mg/kg
Arsenic	–	6	4.6	2.3	–	mg/kg
Barium	–	7	157	113.4	–	mg/kg
Beryllium	–	1	2.3	2.3	–	mg/kg
Cadmium	–	1	1.8	1.8	–	mg/kg
Chromium	–	7	16	10 7	–	mg/kg
Cobalt	–	2	8	6.8	–	mg/kg
Copper	–	6	19.6	13.3	–	mg/kg
Iron	–	5	20,100	15,840	–	mg/kg
Lead	–	7	27 6	17.9	–	mg/kg
Manganese	–	6	293	225.2	–	mg/kg
Mercury	–	3	0.39	0.27	–	mg/kg
Nickel	–	6	17 7	89.2	–	mg/kg
Selenium	–	3	1.3	0.55	–	mg/kg
Silver	–	2	21.2	11 7	–	mg/kg
Vanadium	–	8	40	29.2	–	mg/kg
Zinc	–	4	77 1	63 6	–	mg/kg

[1] Average value of detections (nondetects not included in average)
[2] Lowest ARAR identified (proposed RCRA corrective action)

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6 2 2 Data Review Summary

The data reviewed for this evaluation were from four alluvial wells along Indiana Street, three surface water samples at Walnut Creek and Woman Creek located along Indiana Street and sediment samples collocated with the surface water samples (Figure 6-1) The data were collected from 1987 to 1990 Results are tabulated by media and are summarized on Table 6-3 through Table 6-5 A chemical was considered detected if the value was above the method detection limit or if it was qualified with a "J indicating the presence of the chemical but below the method detection limit Those values qualified with a "B" were not considered a detection A "B" qualifier indicates the chemical was found in the laboratory quality control (QC) blank and is probably associated with laboratory contamination rather than site-related

The data quality and useability was also considered in the data review Most of the water quality data were validated or acceptable with qualifications relative to guidance provided in the QAPjP and GRAASP However, high concentrations of acetone, butanone, and methylene chloride in the laboratory blanks in the 1987 investigations render it difficult to ascertain their presence in samples as an indication of site contamination More recent validated data indicate they are not likely site contaminants in groundwater or surface water (EG&G, 1990e).

A summary of OU 3 analyses for groundwater, surface water soils, and sediments is presented in Table 6-6 For groundwater wells, the samples will be analyzed for plutonium 239+240, americium 241 uranium 233+234, 235 238, and tritium The surface water samples will be analyzed for TCL volatile compounds in samples collected in the drainages and Mower Reservoir only All surface water samples will be analyzed for plutonium 239+240, americium 241, uranium 233+234 235, 238 and metals The sediment samples will be analyzed for TCL volatiles, plutonium 239+240, americium 241 uranium 233+234, 235 238, and metals The surface water and sediment samples along Walnut Creek will also be analyzed for tritium The soil samples will be analyzed for the plutonium 239+240, americium 241 and uranium 233+234 235 238 isotopes The rationale for each analysis is described in the following paragraphs and arranged by media.

Miscellaneous analyses such as total organic content bulk density and cation/anions will be addressed in Subsection 6 3 Field Sampling Program

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TABLE 6-6
SUMMARY OF CHEMICAL ANALYSES FOR OU 3

Analyses	Ground Water	Surface Water*	Sediments	Soils
TCL VOA	NO - 2	YES - 3	YES - 3	NO
TCL Acid Extractable	NO - 1	NO - 1	NO - 1	NO
TCL Base/Neutral	NO - 1	NO - 2	NO - 2	NO
TCL Pest/PCB	NO - 5	NO* - 2	NO - 1	NO
Radionuclides	YES - 2	YES - 2	YES - 3	YES
TCL Metals	NO - 2	YES - 2	YES 3	NO

Notes
1 CASE 1
2. CASE 2, Further data not required.
3 CASE 2, Supplemental data required
4 CASE 3, Data required
5 No analyses performed for data set reviewed, but OUs 1 and 2 data indicate not present.

* Surface water samples will be analyzed for atrazine and simazine

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6.2.2.1 Groundwater

The four alluvial groundwater wells along Indiana Street were analyzed for volatiles, semivolatiles, radionuclides, and inorganic parameters from 1987 to 1990 A summary of the data evaluation and rationale for selecting analyses is provided in the following paragraphs.

Two groundwater flow systems have been identified within the Rocky Flats Plant; (1) as a surficial flow system within the Rocky Flats Alluvium, colluvium, valley fill and weather bedrock, and (2) as a bedrock flow system within unweathered bedrock sandstones. A schematic of the groundwater and surface water interaction is presented in Figure 6-2. The figure depicts conceptually how groundwater flows in the alluvium and colluvium discharges to the streams. The flow pathway for potential contaminants in the shallow groundwater system is to the stream drainages. In OU 3, site contaminants in groundwater can be assessed by sampling surface water and sediments in drainages exiting the Rocky Flats property

6.2.2.1.1 Volatiles–Case 2. The volatile analyses fall into Case 2 with some low level and infrequent detections. Five volatile compounds were detected in the alluvial wells (Table 6-3). The most frequently detected compound was methylene chloride followed by acetone. Both of these compounds are common laboratory artifacts. In addition, 1,1,1-trichloroethane was detected one time out of 50 analyses at a level of 9 µg/l. The MCL for 1,1,1-trichloroethane is 200 µg/l. Trans-1,3-dichloropropene was detected at 5 µg/l and carbon disulfide was detected below the method detection limit 3 times. There are no MCLs for trans-1,3 dichloropropene and carbon disulfide.

Because the volatile compounds are not frequently detected and occur in such low levels, VOAs will not be analyzed in the proposed groundwater monitoring wells. If VOAs are identified as a problem in the surface water and sediments, VOAs for groundwater will be incorporated into the sampling program.

6.2.2.1.2 Semivolatiles–Case 1 The semivolatile analyses fall into Case 1 No semivolatile compounds were detected in the four alluvial wells located along Indiana Street. Very few semivolatiles were detected in OU 1 (1/141) and OU 2 (3/517) and no additional analyses are proposed for these OUs. Therefore, semivolatile compounds will not be analyzed in OU 3

6.2.2.1.3 Pesticides/PCBs–No Analyses. There were no pesticide or PCB analyses performed in the wells along Indiana Street. However in OU 1 there were no detections of pesticides or PCBs

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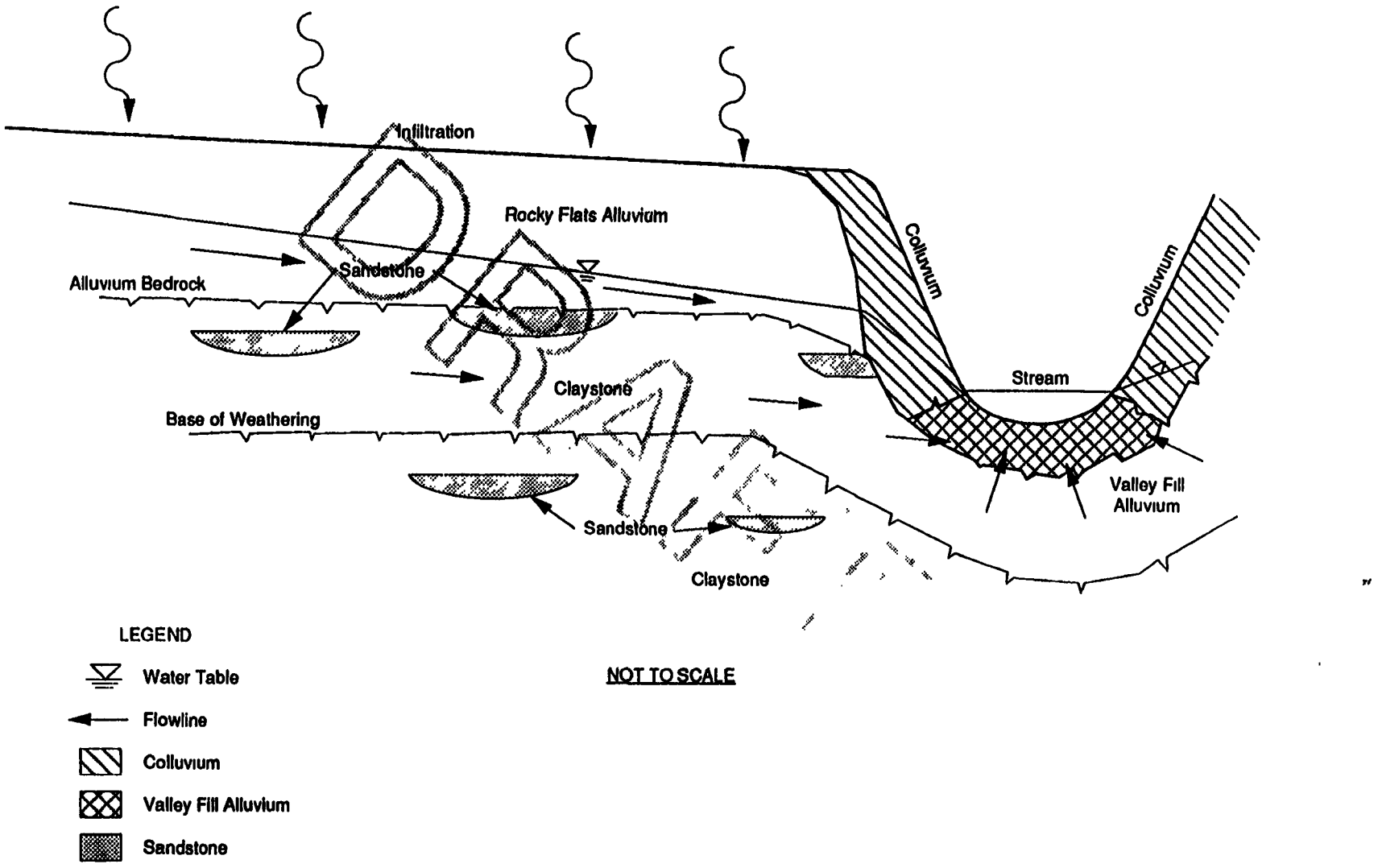

Source Background Geochemical Characterization Report for 1989 (EG & G December 21 1990)

Figure 6-2
SCHEMATIC OF GROUND WATER/SURFACE WATER INTERACTION

out of 121 analyses and for OU 2 there was 1 detection out of 401 analyses. Pesticides and PCBs have been eliminated from the OUs 1 and 2 sampling program There is no record of disposal of pesticides and PCBs at OUs 1 and 2. Because of the low and infrequent occurrences of pesticides and PCBs in the groundwater at OUs 1 and 2, they will not be analyzed in the proposed groundwater wells for OU 3.

6.2.2.1.4 **Radionuclides–Case 2.** The radionuclides fall into Case 2. Radionuclide activity in groundwater was detected for plutonium 238+239+240, radium 226+228, strontium 90, and tritium in low levels (Table 6-3) All activities for these isotopes were below MCLs. Gross alpha and beta were detected in levels above the MCL for several of the analyses. Because plutonium 239+240, americium 241, and uranium 233+234, 235, 238, have been identified as site-wide contaminants of concern, these radionuclides will be analyzed in the groundwater at OU 3. In addition, gross alpha and beta analyses will be performed.

6.2.2.1 5 **Inorganics/Metals–Case 2.** Metal analyses fall into Case 2. Metals were detected in groundwater with some exceedances of MCLs. Aluminum, iron, manganese, nickel, and selenium were detected in over 15 of the analyses with some of the analyses exceeding MCLs (Table 6-3) Other metals were detected but were below MCLs for groundwater. In evaluating groundwater quality, establishing background is important. Background conditions are being evaluated in the Background Geochemical Characterization Report for 1989 (EG&G, 1990f) The primary pathway for metals migrating to groundwater at OU 3 is through the surface water and sediments as described in Subsection 6.2.2.1 If metals are determined to be a problem in surface water and sediments at OU 3, metals will be added to the analyte list. The data from the surface water and sediment samples will be evaluated using the statistical approach described in Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance (EPA, 1989f)

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6.2.2.2 Surface Water

The three surface water samples along Indiana Street were sampled and analyzed for volatiles, semivolatiles, pesticides/PCBs, of radionuclides, and inorganic parameters from 1987 to 1990.

6.2.2.2.1 **VOA–Case 2.** The volatile analyses for surface water fall into Case 2. Fourteen volatile compounds were detected in low levels and were infrequent (Table 6-4) Seven of the compounds

were detected only once out of approximately 60 analyses Methylene chloride was detected the most frequently with 10 occurrences however methylene chloride is a common laboratory contaminant Toluene was detected 9 (maximum value of 6 µg/l) times but in levels significantly lower than the MCL of 2,420 µg/l None of the spurious detections occur above the MCLs As described in the fate and transport section, volatile compounds readily undergo volatilization so it is unlikely volatiles would be detected at significant levels VOAs are being analyzed in OUs 1 and 2. The Standley Lake and Great Western Reservoir are sampled monthly and analyzed for volatile compounds Since Mower Reservoir has not been sampled and since spurious volatiles have been detected in the streams along Indiana Street, VOAs will be collected in Mower Reservoir and the stream ditches No VOA analyses will be performed at Standley and Great Western Reservoir

6 2.2.2.2 **Semivolatiles–Case 1 and 2.** No acid extractable compounds were detected in the surface water samples located along Indiana Street. There has also been no historical release of acid extractables at the site and OUs 1 and 2 have dropped acid extractable analyses from their sampling program

Four low detections of base/neutral compounds were detected in the surface water samples (Table 6-4) Bis(2-ethylhexyl) phthalate was the only compound detected more than once The maximum level detected was 19 µg/l, well below the MCL of 15,000 µg/l In addition, at OU 2, there were only 3 detections of base/neutral extractables out of 3,240 analyses OUs 1 and 2 are no longer sampling for base/neutral extractables. Therefore, semivolatiles will not be analyzed in the proposed surface water samples collected for OU 3

6.2.2.2.3 **Pesticides/PCBs–Case 2.** No TCL pesticides or PCBs were detected in the surface water samples. However, two herbicides were detected Atrazine and simazine were detected in low levels (Table 6-4). The maximum value detected of atrazine was 0 62 µg/l, well below the MCL of 3 µg/l There is no surface water MCL established for simazine At OU 2, there were 3 detections of pesticides/PCBs/herbicides out of 2,368 analyses. The three detections from samples at OU 2 were also for atrazine TCL pesticides and PCBs are being dropped from the analysis program for OUs 1 and 2 The TCL pesticide and PCB analyses will not be performed at OU 3 However, the herbicides atrazine and simazine will be analyzed for in the OU 3 surface water samples

6 2.2.2.4 **Radionuclides–Case 2.** Radionuclides were detected with low levels of activity and therefore are assigned Case 2. Plutonium radium strontium and tritium were detected in low levels

(Table 6-4) The activities detected are below MCLs for surface water. Gross alpha and beta were also detected. The surface water samples collected for OU 3 will be analyzed for plutonium 239+240, americium 241, uranium 233+234, 235, 238, gross alpha and beta since these are site-wide radionuclides of concern. Tritium will also be analyzed in surface water samples collected along Walnut Creek to characterize tritium in surface water from an accidental release of tritium in 1973 from the RFP into Walnut Creek

6.2.2.2.5 Inorganics--Case 2. Metals were detected in the surface water samples along Indiana Street and therefore are assigned to Case 2. Zinc, iron, manganese, and aluminum were detected more than 10 times (Table 6-4) Arsenic, barium, beryllium, copper, lead, mercury, selenium, and silver were detected 5 times or less in the surface water Several of the metals exceed MCLs for surface water However, background water quality conditions are important in evaluating metals in surface water. Metal analyses will be performed on OU 3 samples and data will be compared to levels presented in the Background Geochemical Characterization Report for 1989 (EG&G, 1990f) Comparison will be following the statistical approach described in Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance (EPA, 1989f).

6.2.2.3 Sediments

Sediment samples were located at similar locations as the surface water samples along Indiana Street at Walnut and Woman Creeks. The sediment samples were analyzed for VOAs, semivolatiles, pesticide/PCBs, radionuclides, and inorganic compounds.

6.2.2.3.1 VOAs--Case 2. Four volatile compounds were detected in the sediments in low levels and infrequently, and, therefore assigned Case 2 (Table 6-5). Acetone and methylene chloride were detected 4 times and 1 time, respectively These compounds are common laboratory artifacts. Toluene and 1,1,1-trichloroethane were detected one time at levels significantly below the proposed RCRA action levels. Volatiles have been identified as a chemical of concern for OUs 1 and 2. Therefore VOAs will be analyzed in the sediments along the drainages and in the reservoirs for OU 3.

6.2.2.3.2 Semivolatiles--Case 2. Six semivolatile compounds have been detected in the sediments at low levels and infrequently, and, therefore are assigned Case 2 (Table 6-5) Five of the semivolatiles were detected once. Bis(2-ethylhexyl)phthalate was detected 2 times but in levels

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significantly than the proposed RCRA action limit Semivolatiles are no longer being analyzed at OUs 1 and 2 in sediment samples They will not be analyzed in sediments for OU 3

6 2.2.3 3 **Pesticides/PCBs–Case 2** One pesticide was detected in the sediment samples Beta-BHC was detected at 1 5 µg/kg At OU 2 there were no detections out of 486 analyses. Pesticide and PCB analyses have been eliminated at OUs 1 and 2. No pesticide/PCB analyses will be performed in sediments at OU 3

6 2 2.3 4 **Radionuclides–Case 2.** Low levels of radionuclide activity have been detected in the sediment samples (Table 6-5) Gross alpha and beta have been detected at 39 and 36 pCi/g, respectively In addition, plutonium 238+239+240 radium 226+228, strontium 90, and tritium have been detected in the sediment samples The sediment samples at OU 3 will be analyzed plutonium 239+240, americium 241, and uranium 233+234, 235, 238 and gross alpha and beta. Tritium will also be analyzed in sediment samples collected along Walnut Creek to characterize tritium in surface water from an accidental release of tritium in 1973

6.2.2.3.5 **Inorganics–Case 2.** Metals have been detected in sediment samples and therefore are assigned Case 2 (Table 6-5) Vanadium barium, lead nickel manganese, iron, copper, chromium, and arsenic have been detected five or more times in the sediment samples. To evaluate metals in sediments, establishing background levels is important The metals in sediments will be evaluated based on a statistical comparison to background levels established in the Background Geochemical Characterization Report for 1989 (EG&G December 21 1990) Metals will be analyzed in sediments for OU 3

6 2.2.4 **Soils**

Soil samples have been collected in the area and analyzed for plutonium americium, and beryllium by CDH Beryllium has been analyzed in the 13 sectors sampled by CDH in 1989 The results for beryllium in all sectors are below the method detection limit of 2.7 µg/kg Soil samples have not been analyzed for volatiles, semivolatiles, pesticides/PCBs, or other inorganics in this area. Because of the high potential for volatilization of VOAs, it is unlikely VOAs have migrated far in soils, therefore, no VOA analyses will be performed for the soil samples Semivolatiles have not been detected in significant levels in the groundwater surface water and sediments at OU 1 and 2 and along Indiana Street, therefore semivolatile analyses will not be performed at OU 3 Pesticides and PCBS have also not been identified as a chemical concern at OU 1 and 2 and have not been detected at

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significant levels in the groundwater, surface water, and sediments along Indiana Street, therefore pesticides and PCBs will not be analyzed in the soils. At OU 1 and 2, the surface soil samples are only being analyzed for plutonium, americium, and uranium. The same radionuclide isotopes will be analyzed in the soils at OU 3 because they have been identified as site wide chemicals of concern.

6.3 FIELD SAMPLING PROGRAM

This subsection divides and describes the OU 3 RFI/RI field investigation program by media. As part of the field sampling program, the data from the sitewide monitoring program and other OU investigations will be used as appropriate to add to data collected during the OU 3 investigation as previously discussed. A number of SOPs will be used during the investigation. The SOPs are cited in this section and discussed further in Section 11 0 of this work plan.

6.3.1 Soil

The purpose of the soil sampling program is to characterize the vertical and lateral extent of plutonium and americium contamination in OU 3. Because of the prevailing wind conditions and results from previous investigations, the OU 3 areas with the highest plutonium concentrations are believed to be east of the Rocky Flats buffer zone boundary, east of Indiana Street.

6.3.1 1. Soil Profile Sampling

Two soil sampling activities will be performed. The first activity is soil profile sampling. The purpose of the profile sampling is to characterize vertical plutonium and americium concentrations in the soils. Sampling locations will be selected by reviewing historical aerial photographs and conducting a site reconnaissance to identify areas that have not been disturbed in the past 20 years. The undisturbed areas have the highest potential for accumulation of contaminants. The exact number of samples cannot be identified until the historical review of aerial photographs is performed but it is estimated that 10 profile samples will be collected from undisturbed areas (two profiles per undisturbed area) identified from the photos. Examples of potential locations include drainages, wetlands, and areas of snow accumulation. Snow accumulation areas will be identified from vegetation cover and visual observation of lingering snow patches, if possible.

A description of the type of land use and vegetation cover at each sample location will be included in the field notebooks to help determine if different land use and vegetation impact plutonium and

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americium concentrations with depth Vertical profile samples will be collected following the method used at OUs 1 and 2 This method consists of collecting 11 samples at various depths according to the following sample scheme

- The upper 12 on will be sampled in 3 cm intervals at 0, 3 6, 9 and 12 cm
- The next 12 cm will be sampled in 6 cm intervals at 18 and 24 cm
- The next 24 cm will be sampled in 12 cm intervals at 36 and 48 cm
- The deepest 48 cm will be sampled in 24 cm intervals at 72 and 96 cm

The samples will be collected by digging a trench with a backhoe or shovel 1 5-meter long, 1 0-meter wide and 1 0-meter deep One wall of the trench will be dug as a block/staircase with each stair step being 15 cm in height. The stair-step wall helps minimize cross contamination of soils with depth The vegetation at the surface of the selected wall will be cropped closely to the surface and discarded An SOP for soil sampling is currently being developed. The soil will be sampled at the appropriate interval starting at the deepest block/stair in a given pit. The soil morphology will be described according to the SOP currently being developed for logging soil samples Soil samples will be collected using a stainless steel scoop and template (3 cm x 20 cm), which will be pressed into the wall of the block/staircase. Three samples from each depth will be composited to provide a better representation of the site. After a sample has been collected, soil layers below it will be cleared of sloughed material to prevent possible contamination from the upper soil layers. A flag will be placed on the ground surface of a given pit, and the depth below surface for each sample will be measured from the base of the flag Each pit will be backfilled with the original soil mixture removed during the excavation

The samples will be analyzed for plutonium and americium Ten percent of the samples will also be analyzed for TOC, bulk density, and grain size Information regarding sample analysis and field quality control samples is summarized in Subsections 6 4 and 6 5 of this document, respectively

6 3 1.2. Surface Soil Survey

The second soil sampling activity is to perform a surface soil survey using a grid The purpose of this sampling activity is to delineate the lateral extent of plutonium and americium contamination in OU 3 and to confirm pervious soil investigations Numerous soil samples were collected and analyzed for plutonium in surficial soils east of Indiana Street during past investigations. Most of these analyses were performed during 1971 and from 1975 to 1978 These past sampling events

can be used to predict the spatial dependency of plutonium in the soils located in OU 3 The existing data have been used to construct a semi-variogram to aid in designing an optimal sampling strategy for plutonium and americium in soils east of Indiana Street.

Kriging can be used to make spatial distribution (contour) maps. Unlike conventional contouring subroutines, kriging uses certain statistical optimal properties and provides measures of the error of the contoured surface Kriging uses the information from the semivariogram to find an optimal set of weights that are used in the estimation of the surface at unsampled locations. The semivariogram describes the rate of change in a regionalized variable and measures the degree of spatial dependence between samples within geographical boundaries. The variogram splits the total variance in a data set into two parts. The first represents the spatial differences between the values of the samples taken at points separated by increasingly large distances, whereas the second represent local or short-range variances. The latter is called the nugget variance, which represents random variance. Because the semivariogram is a function of distance, the weights change according to the geographical arrangements of the samples (Isaaks and Srivastava, 1989)

Based on this geostatistical approach that uses the regionalized variable theory and the semi-variogram, a means of describing spatial variation in soils has been developed. This approach provides the maximum sample separation distance for optimal soil sampling in OU 3. The geostatistical analysis was performed by EG&G and is summarized in Appendix A of this document. The soil plutonium concentrations east of Indiana Street were kriged using an exponential model. Plutonium concentrations higher than the recommended CDH special construction requirements standard CDH standard of 0 9 pCi/g were observed only near the eastern boundary of the RFP The concentrations of plutonium decreased rapidly with distance. By using a maximum acceptable error of 0.41 pCi/g, which seems reasonable based on the CDH standard, an equivalent kriging variance of 0.168 was used in predicting optimal sample spacing. Based on this variance an optimal sampling interval of 1,950 meters was calculated

These calculations were based on the RFP soil-sampling technique where five subsamples were collected from the corners and the center of two 1-meter squares, which were 1 meter apart. Surfacial soil-sampling for plutonium in soils at OU 3 will follow the procedure recommended by CDH This method allows for the top 1/4-inch of soil to be sampled. The top 1/4-inch of soil can most easily be dispersed by wind and potentially leads to direct contact by ingestion to people. This soil-sampling technique recommends the collection of 25 subsamples from a 10-acre plot within a specified parcel of land to yield a single composite sample. The sampling locations should be

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more or less evenly spaced within the area The difference in area between the RFP soil sampling and the CDH sampling techniques introduces some uncertainty in the optimal spacing calculations Therefore the optimal spacing will be reduced from 1 750 to 1 000 meters between 10-acre plots to implement a more conservative grid spacing The semi variogram was isotropic so the 1 000 meters will be used in all directions

As stated in Subsection 2 1 4 2 attempts were made by Krey and Hardy (1970) and Dow Chemical (DOW 1971) to establish plutonium contours surrounding the RFP A grid approximately 3 by 5 miles located east of the RFP boundary has been overlaid on the Krey and Hardy map showing plutonium contours in the vicinity of the RFP The grid encompasses the three IHSS reservoirs (Great Western Mower, and Standley Lake) and most areas within the 10 mCi/km^2 (approximately 1 pCi/gm) contour developed by Krey and Hardy Approximately thirty five 10-acre plots will be sampled within the grid (Figure 6-3)

The grid does not encompass areas located to the west of the 903 pad (source of plutonium and americium contamination for OU 3) because previous studies indicate that prevailing wind conditions and dispersion are to the northeast, east, and southeast of the RFP In addition sampling has been performed for Western Aggregates on approximately 478 acres of land located on the Rocky Flats West Buffer Zone The samples were collected using the CDH soil sampling method and were analyzed for plutonium isotopes 238 and 239/240. Plutonium 238 values ranged from not detected to 0 550 pCi/g Plutonium 239/240 results ranged from not detected to 0 695 pCi/g (Western Aggregates, 1991) These results are all below the 0 9 pCi/g CDH standard for plutonium Sampling results and locations are included in Appendix B

The samples will be collected using the CDH soil-sampling method that is described in the SOP No 3.8, Subsection 5.2.1. A sample will be composited from 25 samples evenly spaced within a 10-acre plot and each plot will be spaced 1,000 meters apart. In areas where sampling the plot is not feasible—such as in parking lots and reservoirs—the location will be shifted to a more appropriate location, if possible Otherwise no sample will be collected for that location Plutonium 239/240, americium 241, uranium 233/234, 235 238 will be analyzed for all samples In 10 percent of the grids a grab sample will also be collected and analyzed for TOC bulk density, and grain size to assess fate and transport properties of the surficial soils

In addition to the soil samples collected within the grid samples will be randomly collected in locations between the 10 mCi/km^2 (approximately 1 pCi/g) and 3 mCi/km^2 (approximately 0 3 pCi/g)

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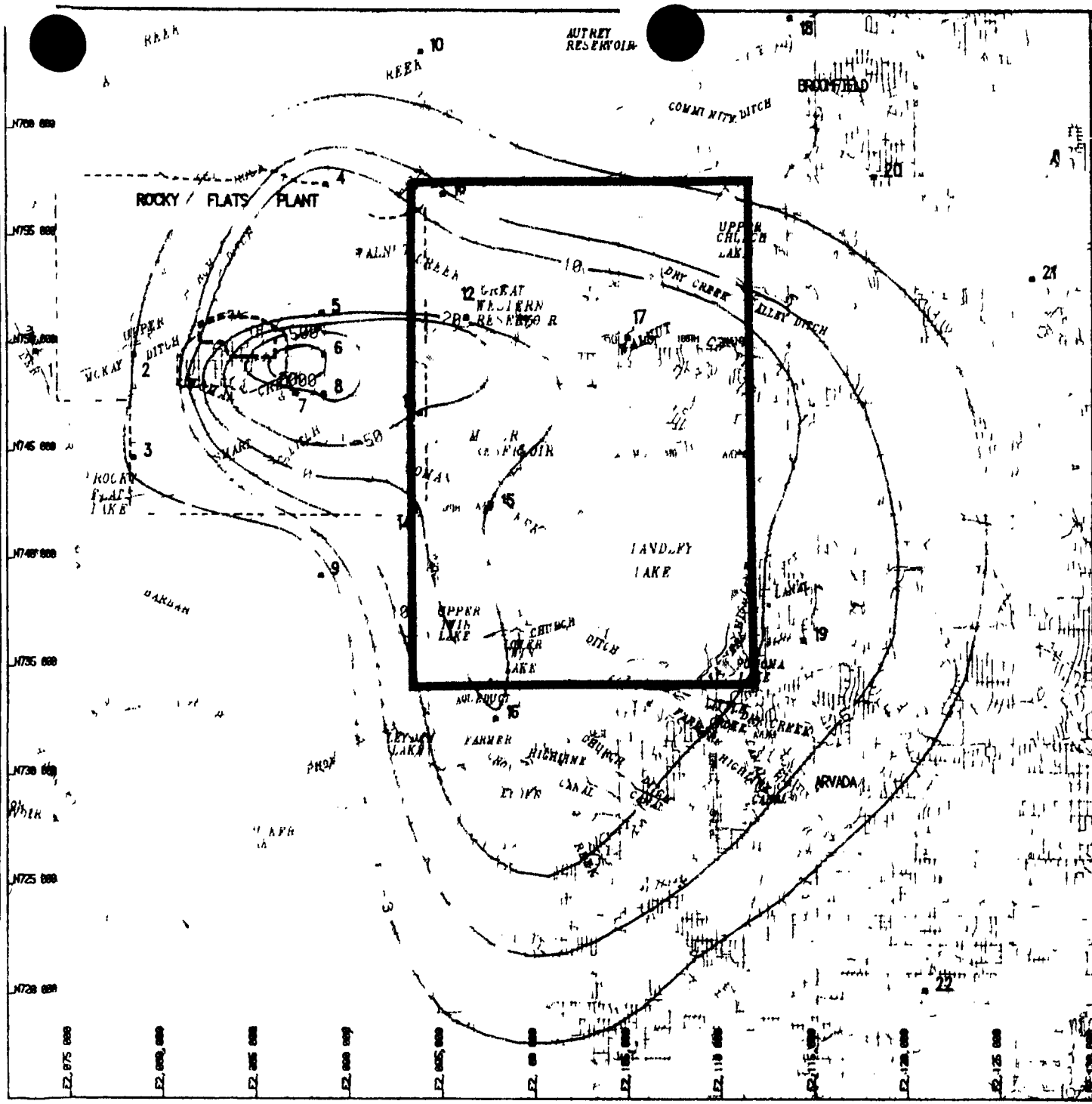

MAP LEGEND

- - - -RFP Boundary and PSZ

—— Contour Values in mCi per Km²

■ Numbered Sampling Sites

Proposed Sample Location (plutonium and americium analyses)
Each Sample Location is a 10 Acre Plot where 25 Subsamples will be Collected to Form 1 Composite Sample (CDH Method)

N

0 3400 6800
SCALE IN FEET

Figure 6 3
Approximate Soil Sampling Locations for Soil Survey and Plutonium-239 Contours in the Vicinity of the Rocky Flats Plant (Krey and Hardy, 1970)

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contours of the Krey and Hardy map (Figure 6-3) This area is more developed than the area within the grid These samples will be collected to characterize plutonium americium, and uranium concentrations for different land use types and to delineate these concentrations at more distal points from the RFP Varying land uses include residential open spaces, and agricultural If 10-acre plots of similar land use cannot be located, plot sizes will be reduced (The 25 subsamples will still be collected from the reduce plots) These samples will be analyzed for plutonium and americium and uranium

6 3 2 Sediment

The sediment sampling activities proposed for OU 3 consist of sampling drainages, reservoirs and near-shore sediments Drainages are a potential pathway for offsite migration Exposed sediments in turn, are a potential pathway of dispersion of contaminants by wind

6 3 2.1 Sediment Samples in Ditches

To characterize the extent of contamination in drainage ditches, the following sediment samples will be collected (see Figure 6-4)

- Seven sediment samples above Great Western Reservoir along Walnut Creek Drainage
- Three samples below Great Western Reservoir
- Two samples along Broomfield Diversion Ditch
- Three samples above Mower Reservoir
- Three samples below Mower Reservoir
- Six samples above Standley Lake along Woman Creek Drainages
- Three samples below Standley Lake
- One sample near the inlet of Clear Creek Irrigation Ditch

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A total of 28 sediment samples are proposed for the sediment drainage investigation Two sediment sampling locations (SED 002 and SED 003) are part of the annual monitoring program at the RFP and will be used to represent upgradient sediment locations along Walnut and Woman Creeks (Figure 6-4) Previous investigations have focused on sediment samples in the reservoirs rather than in the drainages. Samples associated with the drainages of each reservoir were estimated based on a statistical approach Collecting seven samples in the drainages above the reservoirs provides an approximately 99 percent confidence level that the median concentration for a population will not exceed the largest concentration detected in the sample population (Conover, 1980) Three samples provide for an approximately 85 percent confidence level These general statistical guidelines were used to estimate number of sediment samples along the drainages and will fulfill the data needs for the quantitative Human Health Risk Assessment and the Environmental Evaluation

The drainage sediment samples will be collected similar to the methods proposed in OUs 5 and 6 in areas where sediments have accumulated. The sample at each location will consist of a 2-foot composite sample taken to the depth of the first gravel layer below the sediment. If the sediment is thicker than 2 feet, a second composite sample will be collected from 2 to 4 feet. All sediment samples will be collected according to SOP No. 4.6 Sediment samples will also be geologically logged according to SOP No 3 1 These samples will be analyzed for plutonium, americium, uranium TCL volatiles, and TCL metals The sediment samples along Walnut Creek will also be analyzed for tritium to characterize the potential release of tritium to sediments from the 1973 accidental tritium release to Walnut Creek. Twenty percent of the sediment samples will also be analyzed for TOC, bulk density, and grain size to assess fate and transport.

6 3 2.2 Sediment Samples in Reservoirs

Reservoir sediment samples will consist of two types sediment samples located near the shoreline that may potentially be exposed during low reservoir capacity and samples collected from within the deeper areas of the reservoir

6 3 2.2.1 Near-shore Reservoir Samples The near-shore reservoir sediment samples will be collected to characterize sediments that potentially may be exposed during low reservoir capacity The exposed sediments may be dispersed by wind which potentially leads to ingestion by people

Previous sampling activities for sediments have focused on the reservoirs and not along the shoreline of the reservoirs.

Samples will be collected randomly at different zones identified during a field reconnaissance. The zones will be based on access, recreational use, and locations near the inlet and outlet of the reservoirs. Sample collection will occur when the reservoir is anticipated to be at its lowest capacity and will be determined from historical reservoir records for Great Western Reservoir and Standley Lake

The near-shore sediment samples will be grab samples collected from a dredge sampler Procedures described in SOP No. 4 6 will be followed. The samples will be analyzed for plutonium, americium, uranium, gross alpha and beta, TCL volatiles, and TAL metals. Ten percent of the samples will be analyzed for TOC, bulk density, and grain size.

Sedimentation rates from the near-shore areas have been estimated to be less than 0.1 inches/year (Historical Information Summary, Battelle, 1991a). Therefore, to obtain a vertical profile of concentrations of plutonium and americium with depth from sediments that may have accumulated from 1950 to present, a 4-inch sediment core is necessary. One near-shore vertical profile sediment sample from each reservoir will be collected in addition to the grab samples previously discussed, using a stainless steel core sample so that vertical profile sediments may be obtained. The core sampler will be manually pushed into the sediment using a rod and handle. The cores will be pushed in a minimum of 6 inches if possible. One-inch sample intervals will then be collected and sent to the laboratory for plutonium and americium analyses. This will provide information on how plutonium and americium concentrations change with depth.

6.3.2.2.2 Reservoir Sediment Samples. Sediment samples will also be collected from the reservoirs. Sediment reservoir samples have been collected from previous investigations in both Standley Lake and Great Western reservoirs and analyzed for plutonium. Two types of sediment samples in the reservoir will be collected; one type will be vertical profile samples and the other will be grab sediment samples. Three vertical profile sediment samples will be collected for Great Western and Mower Reservoirs, and four will be collected in Standley Lake (10 total profiles) One sample from each reservoir will be located in the deepest portion of the reservoir, where historical information on accumulation of plutonium and americium will be obtained. The other vertical profile reservoir sediment samples will be collected in reservoir bays (see Figure 6-4) Surface water and aquatic samples will be collected in conjunction with the sediment samples.

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Sedimentation rates for the eastern end of Great Western Reservoir range from 0 82 to 1 45 inches per year and in the center of the reservoir from about 0 1 to 0 46 inches per year, (Battelle 1981) Using an average sedimentation rate of 1 inch per year, a core of approximately 30 inches would be required to represent sedimentation from 1960 A gravity core sampler will be used to collect the reservoir vertical profile sediment samples Depending on the density of the substrate and weight of the cores, penetration rates of 30 inches can be attained Vertical profile samples will be collected from the core and analyzed for plutonium and americium The top 6 inches, which is likely to get compacted, will be the first interval sample From 6 inches to the bottom of the core, 1-inch interval samples will be collected and analyzed for plutonium and americium If core recoveries are low, field personnel will select appropriate sample intervals.

In addition to the vertical profile samples, grab sediment samples will be collected A total of 16 samples will be collected to characterize the potential metal and volatile contamination in the reservoir sediments. Approximate grab sample locations are shown in Figure 6-4 The gravity core sampler will be used for sample collection but the core recovered will be composited into one sample and analyzed for plutonium, americium, uranium, gross alpha and beta, TAL metals and TCL volatiles. Ten percent of the grab samples will also be analyzed for TOC, bulk density, and grain size The procedures for sampling will generally follow SOP No 4 6 Variations to the SOPs are described in Section 11 0 of this work plan.

6 3 3 Surface Water

The surface water program for the OU 3 RFI/RI is designed to characterize plutonium, americium, uranium, TCL volatiles, and TCL metals in surface water To accomplish this goal, surface water samples will be collected at locations in Great Western Reservoir and associated drainages, Mower Reservoir and associated drainages, and Standley Lake and associated drainages The program is also designed to evaluate past investigations at the reservoirs. Great Western Reservoir and Standley Lake are routinely monitored by CDH, the Cities of Broomfield, and City of Westminster Thornton, and Northglenn Therefore, an extensive surface water monitoring program is not required Results from these monitoring activities will be incorporated into the quantitative baseline risk assessment.

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6 3.3.1 Surface Water Drainages

Three surface water samples will be collected from the Walnut Creek drainage Two samples will be located upgradient along the drainages leaving the RFP property (see Figure 6-5), and one will be located downgradient of Great Western Reservoir Surface water sampling station SW-003 which is part of the routine monitoring at the RFP will represent the upgradient location along Walnut Creek (Figure 6-5) Efforts will be made to coordinate the sampling activities so they occur at the same time. Two surface water samples will also be collected in the Broomfield Diversion ditch. At Mower Reservoir, a surface water sample will be collected near the eastern RFP boundary, the inlet to the reservoir, and downgradient of the reservoir Two surface water samples will also be collected near the inlet to Standley Lake along Woman Creek and along Smart Ditch south of Woman Creek (see Figure 6-5) Surface water sampling station SW-002 which is part of the routine monitoring at the RFP will represent the upgradient location along Woman Creek (Figure 6-5) One surface water sample will also be collected in Big Dry Creek downgradient of Standley Lake. The sampling will be performed concurrently with the monthly sampling at Walnut Creek and Woman Creek that is sampled as part of the RFP environmental monitoring. Results from this monitoring will provide information on water quality entering and exiting the reservoirs. Samples will be collected from each drainage and analyzed for plutonium, americium, uranium, gross alpha and beta, TCL volatiles, TCL metals, cations and anions, dissolved oxygen, pH, and specific conductance. As discussed in Subsection 6.2, surface water samples will also be analyzed for atrazine and simazine. In addition, surface water samples along Walnut Creek will be analyzed for tritium to assess the 1973 accidental tritium release to Walnut Creek. Surface water samples will be collected twice, once during high flow and once during low flow periods. Approximate surface water locations are presented in Figure 6-5

6.3.3.2 Reservoirs

Three locations at each reservoir will be sampled to supplement and verify the existing data. Samples from both reservoirs and drainages will be collected in reservoir bays and from the deepest part of the reservoir, near the same location as the sediment samples (see Figure 6-5). Discrete samples at each location will be collected at the near surface, the middle of the water column, and at the water/sediment interface. Stratification of the water, if present, will be identified through temperature dissolved oxygen, and pH measurements taken according to SOP No. 4.8. If stratification is identified in the reservoir, a discrete grab sample will be taken from each vertically stratified zone instead of at the top, middle, and bottom of the water column. General surface water

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sampling procedures described in SOP No 4 3 will be followed Modifications to the SOP are described in Section 11 0 of this work plan

All surface water samples will be analyzed for plutonium americium, uranium gross alpha and beta TCL metals atrazine simazine cations/anions DO pH and specific conductance Samples from Mower Reservoir will also be analyzed for TCL volatiles since Mower Reservoir has not previously been sampled for volatiles, unlike Great Mower Reservoir and Standley Lake Samples will be collected twice, once during high capacity, and once during low capacity to identify changes in concentration because of reservoir conditions High and low capacities will be identified based on historical capacity of reservoirs

6 3 4 Groundwater

A limited groundwater field investigation will be performed at OU 3 Currently, 14 wells in the eastern buffer zone are sampled on a quarterly basis as part of the RFP site environmental monitoring program. Seven of these wells are located along Indiana Street (Figure 6-6) The groundwater monitoring wells are analyzed for total dissolved solids, anions, CLP target compounds (volatiles and semivolatiles), oil and grease, metals, and radionuclides These wells are located upgradient of OU 3, but downgradient of the RFP source areas. The results to date from the RFP boundary wells have not detected contaminants Historical Information Summary and Preliminary Health Risk Assessment (DOE, 1991b) Therefore, no contaminants are believed to be leaving the RFP through the groundwater pathway Data from the buffer zone wells will continue to be reviewed quarterly during the implementation of the OU 3 work to identify if contaminants are detected in these wells If contaminants are detected, an expanded groundwater field investigation will be developed

The purpose of the groundwater investigation is to obtain site-specific hydrogeology in the vicinity of Great Western Reservoir and Standley Lake and to assess impacts on groundwater from potential contamination that has been dispersed offsite to OU 3 Groundwater sampling will also identify potential contamination in the groundwater from soil/groundwater interactions and surface water/ groundwater interactions, if present.

Two groundwater monitoring wells will be located downgradient of both Great Western Reservoir and Standley Lake One well will be installed and completed in the unconfined alluvial system and one well will be completed in the confined Arapahoe formation at both locations The shallow

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alluvium wells will be drilled according to SOP No 3.2, logged according to SOP No. 3 1, installed according to SOP No 3 6, and developed according to SOP No. 2.2. The alluvial wells are estimated to be approximately 20 to 30 feet deep

Two bedrock wells will be drilled to the Arapahoe Formation, which will monitor the first water-producing sand encountered at Great Western Reservoir and Standley Lake. If subcropping sandstone is encountered, drilling will continue until confined sandstone is found to a maximum depth of 200 feet. The bedrock wells will be drilled according to SOP No. 3.6, logged according to SOP No 3 1, and installed according to SOP No 2.2. In addition, the procedures described in SOP No 3.3 for isolating the bedrock from the alluvium will be followed. The purpose of the Arapahoe wells are to obtain information on the interaction between the alluvial system and the deeper confined system. In addition, the wells will help assess the presence or absence of plutonium, americium, uranium, and gross alpha and beta in the deeper groundwater system. If contamination is found in the groundwater monitoring wells, an additional investigation will be necessary

After well installation, all wells will be developed and sampled and water level measurements will be collected according to SOP Nos. 2.1, 2.2, 2.5, and 2.6. The wells will be sampled quarterly for 1 year and analyzed for plutonium, americium, uranium, and cation/anions. Field parameters (pH, specific conductance, temperature, and hydrostatic pressure) will be collected prior to sampling. The second, third, and fourth quarter samples will be analyzed for plutonium and americium and other compounds detected from the first quarter sampling event. Water level measurements will be collected on a monthly basis for 1 year to identify seasonal fluctuations in groundwater, if present. Figure 6-6 shows approximate location of the groundwater wells for the hydrogeologic investigation.

6.3.5 Air

The purpose of the air sampling program is to characterize the potential for dispersion of plutonium contaminated sediments. Because of the difficulty in measuring the wind erosion of the banks, air sampling is the selected method of characterization.

Discrete sampling will be performed in low-lying areas downwind of exposed reservoir sediments during variable wind conditions. Two locations will be sampled: one at Great Western Reservoir and one at Standley Lake. The Great Western Reservoir location was selected because it has higher concentrations of plutonium in sediments than the other reservoirs, and because the water diversions create lower water levels than seen in the other reservoirs and subsequently expose

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more sediments for potential dispersion The Standley Lake location was selected because of its recreational use and proximity to residents If dispersion does occur Standley Lake has a greater potential for exposure because of these factors

In addition to the site-specific air sampling program an extensive air monitoring program is currently being implemented as part of the RFP site environmental monitoring One portion of the air monitoring program is the radioactive ambient air monitoring Radioactive ambient air samplers monitor airborne dispersion of radioactive materials from RFP into the surrounding environment. There are 14 perimeter samplers along the border of the RFP and 14 community samplers located in metropolitan areas adjacent to the RFP Samplers operate continuously at a volumetric flow rate of approximately 12 liters per second and collect air particles on 20 by 25-cm fiberglass filters

The data collected from the discrete sampling and existing air monitoring program will be used for human risk assessment. Individual exposure pathways will not be considered in the environmental assessment. For this reason, sampling will target inhalable particles.

Sampling will be performed at two locations as described above. Separate sampling episodes will be performed during forecasted low, medium, and high wind conditions. Wind at the site is usually gusty, so expected average wind velocity will be used

Analyses of collected samples will be analyzed for isotopic plutonium and isotopic americium. If soil and water sampling indicate significant levels of other radionuclides or contaminants on the reservoir banks, the analyses will be expanded as required to characterize the other contaminants

SOPs do not currently exist for anticipated requirements Sampling will probably follow the Radioactive Ambient Air Program (RMAAP) Procedure No AP 13 for PMIO sampling This method consists of "Hivol" sampling, a special inlet such as the Anderson Sampler GMW-321-A will be used to limit collected samples to inhalable thoracic particles

Two samples each from the two locations will be collected during each of the three wind conditions, for a total of 12 samples In addition, one duplicate sample will be collected for field QA/QC each day, for an expected total of six additional samples These six will be split equally between the two locations These duplicates will be checked only for weight of particles collected on the filter However one of these duplicates will be used for lab matrix spike and a second for a lab duplicate

Because of the difficulty in collecting two identical air samples, separate duplicates for laboratory QA/QC will not be collected. Instead, one of the field duplicates will be split into quarters, two of the quarters will be analyzed for americium and two for plutonium. These extra analyses will be performed instead of splitting 1 of the 12 primary samples because it will reduce the detection limit by one half

Expected radionuclide concentrations downwind of the exposed sediments are not known at this time, so required sampling duration to collect detectable quantities is not known. Because of daytime/nighttime variations in wind speed on the front range, targeted sample duration will be selected as 8 hours.

On days where the wind speed is expected to match sampling requirements, sampling will be initiated. The required samples will be collected over the 8-hour period. At the end of the 8 hours, average wind speed will be checked from the onsite meteorological station to confirm wind speeds during sampling. If this average matches one of the sample conditions still required in the matrix of 12 samples, the sample will be prepared for analysis at the lab. If it does not match one of the samples still required, the sample will be archived and stored for future reference.

6.3.6 Terrestrial and Aquatic Biota

The field sampling plan for biota describes the program for sampling biota and ecological parameters in aquatic and terrestrial ecosystems within and near the operable unit in order to assess the ecological consequences of releases of contaminants. The plan is designed primarily to provide comprehensive data and information on biological and ecological field characteristics of the operable unit. The ecological field sampling program has two overall objectives:

1 Characterize biological resources in order to conduct the ecological impact assessment.

2. Acquire the data necessary to measure ecological effects of contaminants that cannot be assessed by the dose-response and comparison-to-criteria approaches.

The field sampling procedures have been developed following protocols recommended by the U S Environmental Protection Agency (EPA) (1987a, 1988a, 1989d, 1989f), the U S Fish and Wildlife Service (1981a, 1981b), and those currently being developed at the Rocky Flats Plant (DOE, 1991f and 1991g) The Ecology Standard Operating Procedures (SOP) developed by the Environmental

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Monitoring and Assessment Division (EMAD) for RFP monitoring programs will be followed when applicable This SOP includes procedures for sampling organisms, and protocol for sample documentation and management The ecological field sampling plan presented here will be reviewed periodically and updated as needed

The ecological field sampling has been carefully integrated with the RFI/RI sampling for OU 3 in order to coordinate the water, sediment, and soil sampling efforts with the ecological sampling Where possible vegetation sampling will be located in the same areas and scheduled to coincide with soil sampling, and surface water and sediment sampling will coincide with aquatic sampling In addition to planning sampling events during the same timeframe, the ecological evaluation staff will review RFI/RI sampling procedures and analytical protocols for water, sediment, soil, and air samples so that the data necessary to develop and model exposure pathways during the EE will be available from the RFI/RI program The ecological field sampling at OU 3 will also be integrated with the ecological field sampling at Walnut Creek (OU 6) and Woman Creek (OU 5) so that the data produced at these two adjacent operable units are compatible with OU 3 data. If appropriate, the OU 3 comparative ecology studies may use the same or common reference areas established on a RFP site-wide basis Prior to finalize this work plan, an initial site visit will be conducted to select terrestrial sampling locations.

The field sampling program will consist of an initial qualitative field survey conducted in the spring, followed by two quantitative field sampling events in late spring-early summer and in late summer-early autumn During the two quantitative sampling efforts the sampling teams will continue to record qualitative observations to assist in interpretation of the field data collected during the program and provide seasonal biological data. The initial qualitative survey will be scheduled to coincide with the start of the growing season of prairie vegetation

In general the ecological field sampling program will provide data necessary to compare aquatic and terrestrial populations or communities at impacted and reference areas, measure toxicity directly and measure the accumulation of contaminants in plant and animal tissue As stated above, the field sampling program is divided into two components qualitative surveys and quantitative field sampling The objectives of the qualitative surveys are as follows

- Acquire additional site-specific data on plants animals and habitat types to assist in identifying potential exposure pathways

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- Acquire data needed to characterize the major ecosystem components within the area of OU 3

- Determine the presence, absence, and distribution of plant and animal receptors within OU 3

- Confirm that no threatened or endangered species, critical habitats, or sensitive species of concern are within OU 3

- Acquire information needed to "fine-tune" the quantitative sampling plans presented in this FSP

- Observe and document obvious indications of contamination and, if possible, impacts on biota or habitats

- Fill gaps identified during review of existing data.

The objectives of the quantitative ecological field sampling program are as follows:

- Document the presence and distribution of biological species and acquire additional information needed to assess seasonal changes in biota and habitat types and document the presence and distribution of biological species

- Measure populations for composition, productivity, standing crop or biomass

- Collect quantitative data to estimate intake rates, exposures, and food chain relationships

- Measure indicators of toxicity (ecological endpoints) and assess the differences between endpoints in populations and communities in impacted and reference areas

- Measure toxicity directly by standard EPA biomonitoring methods

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- Measure accumulation of selected inorganics and radionuclides in plant and animal tissue

- Fill data gaps identified during the literature review and the qualitative field surveys

6 3 6 1 Aquatic Ecosystems and Biota

The aquatic ecology sampling program will have two major objectives (1) characterize aquatic communities and couple this information with soil, surface water, sediment, and air data to conduct an ecological risk assessment, and (2) acquire the data necessary to measure ecological effects of contaminants that cannot be assessed by the dose-response and comparison-to-criteria approaches In general, the aquatic sampling program will provide data necessary to compare aquatic communities at impacted and reference areas, to measure toxicity directly, and to measure bioaccumulation of selected contaminants in benthic macroinvertebrates and fish

Sampling of aquatic biota will be scheduled along with surface water and sediment sampling so both the abiotic and biotic components of the sampling locations can be described Also, sample methods and protocols used at the offsite OU 3 will be similar to those used at onsite OU 5 (Woman Creek) and OU 6 (Walnut Creek) This will maintain continuity between the studies on these two watersheds within the RFP boundary and OU 3, immediately east of the RFP

As described in Subsections 6 3 6, the aquatic sampling program will be divided into a qualitative field survey in the early spring, followed by two quantitative sampling events in the late spring/early summer and late summer/early fall.

6 3 6 1 1 Qualitative Survey The qualitative field survey will be conducted in the spring to identify aquatic biota and habitats, to characterize aquatic communities, to select reference sites, and to acquire data to further define the conceptual model of contaminant transport to aquatic receptors The initial spring survey will also be used to confirm the sampling locations and protocol for the later quantitative sampling efforts The qualitative surveys will be conducted along Woman Creek, Walnut Creek, and Mower Ditch above and below the respective reservoirs Wetlands adjacent to the creeks will also be included Sections of Rock Creek and/or the upper end of Woman Creek that are physically and ecologically similar to the OU 3 sampling areas will be surveyed to identify the most appropriate reference stations for the quantitative sampling The qualitative survey will also search for seepage areas where groundwater may be entering the surface water system

The qualitative survey of the reservoirs will be limited to sampling shoreline areas, especially where creeks flow into the reservoirs. Shoreline profiles and near-shore substrates will be described and areas of aquatic vegetation, if any, will be located

The physical characteristics of stream sections (including the Great Western Diversion Canal) and ponds will be documented in the field logbook and on field survey maps. Descriptive parameters such as stream width and depth, pool/riffle ratios, water velocity, bottom substrate, bank vegetation, proportion of undercut banks, fish cover, and channel morphology will be recorded. In situ measurements of water temperature, specific conductivity, and pH will be taken with field instruments along the creeks and at seeps to document potential contaminant and/or groundwater inflow Measurements will be taken above and below locations where surface water enters the creek, and above and below locations where there are indications of possible groundwater inflow (such as a change in turbidity) or environmental stress (such as an increase in filamentous algae)

The biological characteristics of stream sections, ponds, and seeps will be described using three techniques:

1 Qualitative observations of filamentous algae, slimes, aquatic macrophytes, and vertebrate and invertebrate animals.

2. Qualitative sampling of fish with short seines and dip nets.

3 Sampling of benthic macroinvertebrates utilizing the Rapid Bioassessment Protocols (RBP I) developed by U.S. EPA (1989d) for cost-effective assessments of lotic systems.

Fish collected by seines and dip nets will be identified, measured (total length), and released. Abnormalities such as fin rot, lesions, and external parasites will be recorded.

The RBP I reconnaissance assessment technique for benthic macroinvertebrate communities will be used to describe those sections of Woman and Walnut Creek with permanent flows. The RBP I method focuses on qualitative sampling of benthos, supplemented by a preliminary examination of other aquatic biota such as periphyton, macrophytes, fish, and slimes. Standard field data sheets will be used to record the relative abundance of macroinvertebrate orders (families for *Megaloptera* and *Diptera*); occurrence of periphyton, algae, aquatic macrophytes (plants), abundance of fish by species, and water quality measurements.

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The occurrence of potential contamination along Woman and Walnut Creeks within OU 3 will be defined based on results of field water quality measurements observations of obvious contaminant impacts such as stressed vegetation or absence of aquatic organisms and biological indicators Some examples of biological indicators include changes in species diversity, changes in nutrients, absence of pollution-sensitive taxa or dominance of pollution-tolerant taxa, abundance of filamentous algae or large differences in reference and impacted areas

6 3 6 1 2 **Quantitative Aquatic Sampling** Quantitative sampling of aquatic communities at OU 3 will be conducted primarily to characterize periphyton, benthos, and fish populations at impacted and reference (nonimpacted) locations, to measure contaminant bioaccumulation in benthic macroinvertebrates, and to determine if creek and reservoir water at selected locations is toxic to fathead minnows and *Ceriodaphnia* Plankton communities will not be sampled for quantitative data because these primary producers are short-lived, relatively resistant to radioactive contamination, and exhibit large natural temporal variations in density and diversity It would be difficult to establish a relationship between plankton community changes and contaminants in the reservoirs because responses to non-contaminant parameters such as water temperature, turbidity, and nutrients would likely overshadow responses to the low level of contaminants present in the water column (DOE, 1991b) Wetlands vegetation will be sampled as part of the terrestrial program because the field survey techniques used for terrestrial and wetland vegetation are similar The quantitative field sampling program will be carefully integrated with similar ecological assessment field programs at OU 5 and OU 6, with the ongoing National Pollutant Discharge Elimination System (NPDES) monitoring program that assesses water quality of plant discharges, and with routine monitoring events conducted by the EMAD The sampling procedures will follow where appropriate, the Volume V EMAD SOP for sampling periphyton, benthic macroinvertebrates and fish

Field sampling procedures for aquatic ecology sampling are described in the following subsections The sampling locations are summarized in Table 6-7 and shown in Figure 6-7 These locations may be modified based on the qualitative survey results scheduled for spring 1992 As indicated in Table 6-7 the most upgradient aquatic ecology sampling stations on Woman Creek and Walnut Creek for OU 3 are the same stations used for the most downgradient stations in OU 5 and OU 6 If possible, these two stations will be sampled so that the data are available for all three operable units without duplicating field effort

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TABLE 6-7

SAMPLING STATIONS FOR AQUATIC ECOLOGY—OPERABLE UNIT NO 3

Drainage/Reservoir	Station No.	Aquatic Sampling: Periphyton	Aquatic Sampling: Benthos	Aquatic Sampling: Fish	Description (See Figure 6-5)
Walnut Creek	WN-1[1]	X	X[2,3]	X[2,3]	Near Indiana Street, Above Broomfield Diversion
	WN-2	X	X[2,3]	X[2,3]	Creek habitat above Great Western Reservoir
	WN-3		X[3]	X[3]	Below Reservoir and Broomfield Diversion
Great Western Reservoir	WN-11	X	X[2,3]	X[2,3]	Walnut Creek inlet area
	WN-12	X	X	X	Southwest Bay area
	WN-13		X	X	Deepest portion of Reservoir
Broomfield Diversion	WN-21		X		Downgradient of C-2 Pond Pipeline Discharge
Woman Creek and Mower Ditch	WO-1[1]	X	X[2,3]	X[2,3]	Woman Creek just west of Indiana Street
	WO-2	X	X[2,3]	X[2,3]	Creek habitat above Standley Lake
	WO-3		X[3]	X[3]	Below Standley Lake
	WO-4	X	X[3]	X[2]	Mower Ditch near Indiana Street
	WO-5	X	X	X	Mower Ditch below dam
Mower Reservoir	WO-11	X	X	X	Near Mower Ditch inlet
	WO-12	X	X	X	South Shore area
	WO-13	X	X	X	East Shore area
Standley Lake	WO-14	X	X[2,3]	X[2,3]	Woman Creek inlet area
	WO-15	X	X	X	South Shore area
	WO-16		X	X	Deepest portion of the Lake
	WO-17	X	X	X	Southeast Shore area
To be Determined		X	X		Springs, seeps, Creek sections with water in all seasons
Reference	R-1 and R-2	X X	X[3] X[3]	X[3] X[3]	Upper end of Woman Creek, Rock Creek, or offsite reference drainage

[1]Stations WN-1 and WO-2 are the same as the most downstream stations for Operable Unit Nos. 5 and 6, respectively If possible, these stations will be sampled to provide data for all Operable Unit Nos. 3, 5, and 6.
[2]Stations used to collect water for toxicity tests.
[3]Stations used to assess bioaccumulation in benthic macroinvertebrates and fish.

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The main objectives of the quantitative aquatic sampling program are

- Document the distribution and seasonal abundance of periphyton, benthos, and fish

- Collect data to define contaminant pathways to aquatic receptors

- Measure indicators of impact (ecological endpoints) in aquatic populations at impacted and reference locations

- Measure toxicity of surface waters to fathead minnows and *Ceriodaphnia*

- Measure bioaccumulation of selected contaminants in benthic macroinvertebrates and fish

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Periphyton. The periphyton communities at seven or eight creek stations and eight reservoir stations (Table 6-7) will be monitored to characterize these communities at impacted and reference areas. The primary purpose of this monitoring is to determine if periphyton communities at potentially impacted locations within OU 3 differ significantly from one another or from periphyton communities in upgradient reference locations. Periphyton will be sampled by scraping these aquatic organisms off hard natural substrates (SOP No. 5.1), using equivalent surface areas and similar substrates at the different locations as much as possible. Water quality data such as temperature, specific conductivity, and pH will be collected as per SOP No. 4.2. Samples may also be collected at seep areas if there is enough water to support periphyton growth.

Periphyton samples will be scraped from approximately 2 square inches of substrate, transferred to a pre-labeled sample vial with distilled water, and preserved according to SOP No 5.1 The surface area scraped will be measured and recorded. Flow conditions and other physical and biological characteristics of the sampling location will be documented in the field log. Qualitative observations regarding the occurrence of periphyton, filamentous algae, slimes, and benthos will be recorded.

Periphyton samples will be analyzed for relative abundance of major taxa (generally Divisions) and proportions of pollution-sensitive and pollution-tolerant taxa. Qualitative estimates of total periphyton abundance will be noted in the field log.

Since total mass of periphyton samples at each station is expected to be low these samples will not be analyzed for contaminants Potential for bioaccumulation of contaminants will be investigated using benthic macroinvertebrates and fish

Benthic Macroinvertebrates Benthic macroinvertebrates are the most common fauna used in ecological assessments of contaminant releases or pollution discharges They are defined as the aquatic invertebrates that are large enough to be seen without magnification and capable of being retained by a U S Standard No 30 sieve (0 595 mm openings) Benthic macroinvertebrates will be collected from all aquatic sampling stations (Table 6-7) In cases where the habitat does not allow quantitative sampling, qualitative samples will be collected with dip nets and by grab samples of substrate and coarse particulate organic matter (CPOM for example, leaves, twigs, and plant debris)

Benthic macroinvertebrate samples will be analyzed to characterize the benthic community at each station and, subsequently used to compare ecological aspects at impacted and reference locations. The potential for contaminants to accumulate in living organisms and be transferred through the food chain will also be investigated using benthic organisms Also, the macroinvertebrate *Cenodaphnia* will be used to test the potential toxicity of creek and reservoir water using standard toxicity tests.

Benthic macroinvertebrates will be collected at all nine creek stations, two reference stations, ten reservoir stations and, potentially, two seep stations (Table 6-7 and Figure 6-7) The benthic communities will be sampled under high and base flow conditions (spring and late-summer/fall) In shallow flowing creek stations benthic samples will be collected using 0 1 m^2 Surber Sampler with 0 595 mm mesh net. Six replicate samples will be collected within a 25-meter creek segment, as per SOP No 5 2, moving upstream as replicates are taken Each replicate sample will be transferred directly into a separate sample container, preserved in 10 percent formalin or 70 percent isopropanol and labeled as per SOP No 1 13 At reservoir stations, and in creeks where water is pooled, six replicate samples will be taken with an Ekman Grab This rope-suspended sampler is triggered with a messenger and is suited for sampling the soft mud substrates expected at these stations Each replicate sample will be transferred from the sampler directly to a field wash bucket with a No 30 sieve mesh (or smaller) washed thoroughly, transferred to a sample container, and preserved as per SOP No 5 2. Large rocks and twigs can be discarded after organisms are hand-picked or washed into the bucket with a water spray

At stations where additional biomass is needed to collect samples for contaminant analysis (see Table 6-7), additional macroinvertebrates will be collected with dip nets, kick nets, or the Surber and Ekman samplers Sampling will continue until sufficient biomass of some of the dominant species are obtained These samples will be washed in the field, placed in sample containers and kept on ice.

The flow conditions and other physical and biological characteristics of the sampling station will be documented in the field log. Field instruments will be used to collect basic water quality data. Qualitative statements regarding the occurrence of periphyton, algae, amphibians, and fish will be recorded. All samples will be numbered and labeled as they are collected as per SOP No. 1 13.

Decontamination will be performed before and after all sampling and data collection activities, as described in SOP No. 1.3, General Equipment Decontamination; SOP No. 1.6, Handling of Personal Protective Equipment; SOP No. 1 7, Handling of Decontamination Water and Wash Water; and SOP No. 1.9, Handling of Residual Core and Laboratory Samples.

Benthic macroinvertebrate samples will be processed in the laboratory by rinsing the sample in fresh water (U.S. Standard No. 60-mesh screen) and transferring the sample to a shallow white tray Benthic organisms will be separated from the debris with forceps, using a table-mounted magnifier, and placed into sample vials of 70 percent ethanol. The samples will be analyzed by identifying the organisms to genus (with some exceptions such as chironomids) and counting the number of individuals in each taxon. Identification and enumeration will be made using dissecting microscopes.

Benthic macroinvertebrate samples at each station will be analyzed for genera present, species diversity, total number of organisms by taxa, and the proportion of pollution-tolerant or pollution-sensitive taxa. The relative abundance of scaper, filter collector, and shredder Functional Groups will also be determined (EPA, 1989d) The data from quantitative samples will be used to determine macroinvertebrate density (standing crop), taxa richness; species diversity; ratio of scraper, filter collector, and shredder functional feeding groups; ratio of pollution-tolerant and pollution-sensitive taxa, and community similarity indices.

<u>Fish.</u> Fish communities will be sampled at eight creek stations, ten reservoir stations, and two reference stations (Table 6-7) The Broomfield Diversion will not be sampled because this water body is frequently dry and is not a natural creek. Fish will be collected by electrofishing

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similar-sized creek segments (SOP No 5 4) or reservoir shoreline areas and by setting gill nets at reservoir stations All fish will be identified and counted, and the physical characteristics of each sampling location will be documented to assess the influence of physical features on fishing success and habitat. Water quality data will be taken according to SOP No 4 2. Fish sampling, where appropriate will follow SOP No 5 4

The purpose of the fish investigations is to evaluate fish communities at impacted and reference locations and to determine if contaminants are bioaccumulating in fish tissues to the extent that they pose a hazard to the fish itself, to predators, or to human consumers. Creek and reservoir waters will also be collected from fish sampling locations to determine if these waters are toxic to fathead minnows (Table 6-7)

The sample stations for fisheries work will be the same 10- to 25-meter creek segments or shoreline and deep areas in reservoirs used for benthic sampling. Fish will be collected from all stations during the late spring-early summer period and again in late summer-early fall All fish will be released back to the creek or reservoir, except for a limited number of reference specimens, small fish that cannot be identified in the field, and individuals collected for tissue analysis. Precautions will be taken so that the sampling effort itself does not produce an impact on fish populations. Fish kept for identification or reference will be preserved in 70 percent ethanol or 10 percent formalin, and fish kept for tissue analysis will be put on ice.

Collecting fish with backpack and boat-mounted electrofishing equipment will follow SOP No 5 4 and field data will be recorded on the standard SOP forms (such as Form 5 4B) A standard sampling time will be used, and blocknets will be used at creek stations, to maintain comparability between stations

The shallow shoreline stations at the three reservoirs will be sampled by electrofishing, and the deep and shallow reservoir stations will be sampled by gill nets. The field sampling procedures are described in the SOP Addendum in Subsection 11 3 of this report. The gill nets will be set on the bottom using procedures similar to the Colorado Department of Health s fisheries studies on Standley Lake (CDH, 1990) Fish will be removed at 4- to 12-hour intervals, depending on catch rates.

Fish samples will be processed immediately All fish will be identified, counted and measured (total length to the nearest mm) Dominant species will also be weighed Most fish will be released back

to the creek or reservoir Data will be recorded on standard field data sheets Small individuals may be kept for identification in the laboratory

The physical characteristics of each sampling station will be described in the field log and on standard data forms (SOP No. 5.4), and conditions which may influence catch success will be recorded. Basic water quality measurements will be taken with field instruments at each sampling station.

Fish specimens retained for reference or identification will be preserved and labeled. Fish kept for tissue analysis will be placed on ice in labeled plastic bags or aluminum foil and processed within 4 hours of collection. If possible, minnows and/or sunfish will be collected for tissue analysis at all stations. In creeks, large fish of other species, such as bullheads, will be kept if more biomass is needed for analysis. In the reservoirs, sport fish such as walleye, smallmouth bass, and channel catfish will be collected, in addition to minnows and sunfish, to determine if bioaccumulation is occurring, and to provide data for the human risk assessment. Standley Lake, Mower Reservoir, and Great Western Reservoir will be sampled to provide valid and comparative data to supplement an earlier study on Standley Lake by CDH The larger fish will be filleted and the right and left fillets will be wrapped separately in aluminum foil, labeled, and frozen at -20°F Large fish of other species, such as bullheads, will be kept if more biomass is needed for analysis. Catfish and bullheads, if collected, will be skinned, then each fish will be divided along the backbone so that the right and left sides can be wrapped and frozen separately. Right and left fillets can be used as duplicate samples and/or submitted to different laboratories for inorganic and radionuclide analyses. Smaller fish selected for tissue analysis will be cleaned and frozen whole.

All fish will be identified, counted, and measured, and dominant species will also be weighted. The fisheries data will be analyzed for relative abundance, catch-per-unit-effort statistics, and the relative proportions of herbivorous, carnivorous, or omnivorous species. Scale samples may be collected from the most common species to determine growth rates, age classes, and mortality

6.3.6.2 Terrestrial Ecosystems and Biota

The purpose of the terrestrial field sampling program is to develop a thorough familiarization with terrestrial habitats, sample for biotic components, and measure for bioaccumulation. The initial qualitative field survey conducted in the spring will be followed by quantitative surveys in early and late summer Quantitative sampling of terrestrial ecosystems and biota will be conducted primarily

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to characterize the ecosystems and measure the ecological consequences of contaminants released from the source areas

6 3 6 2 1 **Qualitative Survey** The purpose of the reconnaissance and qualitative field survey is to develop a thorough familiarization with site characteristics (both biotic and abiotic) in order to guide the quantitative field surveys All features of OU 3 will be covered in the reconnaissance field surveys, including topography drainages soils, vegetation animals, wetlands, and the relationship of these features to land use This FSP was based in part on information produced in the two reports on OU 3 by DOE (DOE 1991a, 1991b) The site was visited on a familiarization field trip, but no detailed observations were made Qualitative surveys will follow protocol in Section 5 10 in the Ecology SOP

The initial qualitative field survey will be conducted in the spring, coinciding with the start of the growing season of grassland vegetation The surveys were designed to describe the terrestrial ecosystems within OU 3, identify the biota and habitats present, and further define the conceptual model of contaminant transport or uptake by biotic and abiotic mechanisms This survey will also be used to confirm the sampling locations, frequencies, and protocol for the quantitative sampling effort to be conducted later in the spring or early summer

The initial qualitative survey will include locating and evaluating all sampling sites selected for quantitative sampling, including several potential reference areas The survey will include documenting visual observations, collecting some vegetation samples, testing terrestrial habitats with field instruments to detect indications of contamination and recording all observations in field logbooks

The qualitative field surveys will be planned in advance to provide the following information

- Physical description of all sampling sites
- Documentation of similarities and differences between the reference areas and on-site sampling locations
- Identification collection, and initial inventory of plant and animal species

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- Vegetation/habitat map and descriptions of principal habitats, and initial sampling of vegetation for characterization

- Description and location of critical or sensitive habitats, list of threatened or endangered species observed

- Description of the principal exposure pathways and conceptual model of principal food chain relationships

- Qualitative descriptions and some quantitative sampling of wetland and prairie grassland communities, including identification of dominant and subdominant species

- Descriptions and locations of obvious signs of impact on terrestrial vegetation or terrestrial communities

- Relative abundance of key terrestrial receptors.

The qualitative field surveys for the terrestrial ecosystems will follow a similar protocol and timing as for the aquatic ecosystems. The entire area of OU 3 along Indiana Street and down-slope to the east will be driven and walked to identify terrestrial communities and general ecosystem components. Information developed during the field survey will be verified using information from other past and current sampling programs on the biota in the area of OU 3. Observations will be made on species present and voucher specimens will be collected. Information will be collected on general land use patterns, distribution of plant and animal species, conditions of the land surface, soils and substrates, boundaries of plant community types and habitats, relationships to soil types, and the physical and biological condition of the vegetation and habitats. Wetlands around seeps and along drainages and possible snow accumulation areas will be located and delineated for later quantitative sampling. All observations will be recorded in field logbooks and voucher specimens will be given a unique identification.

The physical limits of the proposed quantitative sampling locations will be determined. A reconnaissance will be conducted of the vegetation, small and large mammals, predators, birds, and signs of animals (such as tracks, scat, skeletons, and burrows) At sampling locations close to the RFP boundaries, obvious signs of impacts or effects of contaminants will be recorded. Observations

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on recent biological activities that may impede or increase the movement of soil- or water-borne contaminants will be noted In particular, a visual survey will be made for prairie dogs ants and fossorial animals such as gopher which bring large amounts of subsurface soil to the surface where it is distributed by wind Observations will also be made for badgers and foxes which excavate dens or dig in search of prey All areas of OU 3 will then be systematically surveyed for amounts and kinds of soil and subsoil disturbances by animal activity An intensive study of these activities will be performed in selected areas during the quantitative sampling program, if warranted

The selection of species or ecosystem components to be collected for quantitative sampling or tissue collection will be verified Based on information from other operable units and DOE reports, wetland plant communities that have developed around springs and seeps downgradient of the source areas may be sensitive indicators of contaminant migration via the groundwater pathway, or may accumulate contaminants by physical processes Wetland plant communities are known to filter and accumulate contaminants such as heavy metals The wetland areas present at OU 3 will be examined for evidence of contaminant accumulations. A second component that may accumulate contaminants are snow accumulation areas that concentrate airborne particles.

Qualitative surveys for mammals, birds, and reptiles will be conducted by systematically driving and walking the area on preselected routes at appropriate times. Bird surveys will be conducted at dawn and dusk Records will be kept of species and other features observed such as numbers, condition, habitat, and activities Other evidence of animals or birds including burrows, scat, and nests will be recorded Checklists will be prepared prior to the qualitative surveys of animal and plant species to record survey information

The results of the qualitative field surveys for terrestrial ecosystems will be included in the Environmental Evaluation report. The specific conditions of the grassland and wetland ecosystems will be discussed as they relate to exposure pathways Obvious indicators of stress related to contamination including pathological conditions such as necrosis, chlorosis, and stunting of vegetation will be described Other indicators are the diversity and abundance of species in impacted areas Revisions in the quantitative sampling plan may result from the qualitative survey

6 3 6.2.2 **Reference Areas** The use of reference areas is a potential method of comparing impacted and nonimpacted areas as discussed in Subsection 8 2 7 Reference areas for appropriate terrestrial ecosystems will be selected during the qualitative survey These areas will generally be upwind of and upgradient from the RFP to avoid contamination. The number of

reference areas chosen and their size will reflect the major vegetation types determined in OU 3 during the qualitative surveys. As a practical matter, generally one reference area for each major ecosystem type will be chosen. Reference areas will be chosen to separate the effects of contaminants from those of physical disturbance. This will be accomplished by keeping the physical characteristics of the reference areas as similar as possible to those of the operable unit, and controlling access and sampling disturbance. The reference and onsite areas will be similar in topography, soils, slope and aspect and ecosystems present. If references areas have already been chosen for other operable units, they will be assessed for comparability to the ecosystems at OU 3.

6.3.6.2.3 **Quantitative Terrestrial Studies.** Quantitative sampling of terrestrial ecosystems at OU 3 will be conducted primarily to complete an inventory of the ecosystems for site characterization and to measure the ecological consequences of contaminants released or resuspended from the source areas. The quantitative sampling program will include measuring biota at selected sampling stations, measuring contaminant bioaccumulation, and conducting comparative ecological studies if appropriate. The quantitative sampling will supplement qualitative survey information used for characterizing the ecosystems, identifying major plant and animal receptors, and developing exposure pathways. Qualitative observations will continue to be recorded when field biologists are conducting quantitative sampling.

The parameters chosen for quantitative sampling are determined by the needs of the ecological risk assessment. In the information to date, the principal contaminants in terrestrial environments at OU 3 are plutonium and americium which are generally immobile in the environment and are not bioaccumulated. At the expected levels of soil contamination at OU 3, the uptake into terrestrial plants and animals would be below detection levels. The rationale for the choice of terrestrial organisms to sample and contaminants to measure is to demonstrate whether the uptake and accumulation of known contaminants from RFP are below detection limits. For this reason a primary producer, above ground plant biomass, and a primary consumer, a small mammal (microtine) were chosen as the most likely to shown contaminant uptake. If these two principal components of the food chain do not show measurable accumulations, hence ecological effects, then other higher components in the food chain will not be affected The lack of effects can also be demonstrated by comparative ecology, that is, by measuring reference areas against comparable ecosystem components in OU 3.

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Field sampling operations for measuring bioaccumulation and conducting comparative ecological studies in selected species are described in the following subsections The field procedures will be carefully integrated with similar ecological assessment field studies at OU 6 (Walnut Creek) OU 5 (Woman Creek) OU 2 (903 Pad Mound and East Trenches) and with routine monitoring conducted by the EMAD Selection of sampling locations will be coordinated with other RFI/RI sampling, specifically for surface water sediment, and surficial soil sampling locations The planning and preparation for field sampling at OU 3 will include development of sample and waste management protocols that are integrated with, and in conformance with, sample and waste management procedures and quality assurance/quality control (QA/QC) requirements for the Environment Restoration (ER) Program (EG&G, 1991b)

The field sampling program for terrestrial communities is directed at sampling grassland vegetation and soil types, wetlands, and small mammal populations, at selected locations on OU 3 The area within OU 3 has a diverse pattern of residential development, agriculture and semi-natural terrestrial ecosystems The vegetation, soil types and associated animals reflect these land uses and recent and repeated surface disturbances. The stations selected for terrestrial sampling have not been located although the sampling program is summarized in Table 6-8 The station locations and the selection of the vegetation types to be sampled will be consistent with the results of the Spring qualitative survey and will correspond to soil and surficial sampling locations for associated tasks (see Subsections 6 2.1 and 6.2.5) as much as possible For this reason a map of the locations is not possible until soil sampling sites are located, as described in Subsection 6.2.1 2.) A reference area or areas selected for comparative studies will be sampled for similar components and parameters

Grassland Vegetation The grassland communities at the reference and sample areas will be measured for plant species composition cover, and productivity using standardized procedures. These parameters give the best indication of the structure and function of dryland vegetation Soil types will be identified and mapped in the vegetation sampling areas using procedures in SOP No 5 12. Soil mapping will contribute to assessing vegetational patterns, erosion potential, and contaminant transport. Plant species growing on the OU 3 will be noted and collected for tissue analysis Shrub and woodland types of a sufficient size will be sampled using linear transects or a counting method for numbers and sizes of plants The sampling protocol will follow Section 5 10 in the Ecology SOP (EG&G 1991b)

TABLE 6-8

TERRESTRIAL FIELD SAMPLING PROGRAM FOR VEGETATION, SMALL MAMMALS, AND WETLANDS OPERABLE UNIT NO 3

Component	Parameter	Sampling Period	Station
Grassland	Cover by species Productivity Tissue analysis	Early Summer Late Summer	To be determined
Small Mammals	Species Density Tissue analysis	Early Summer Late Summer	To be determined
Wetlands	Species Dominance Tissue analysis	Late Summer	To be determined

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The specific locations for sampling grassland vegetation will be determined during the qualitative surveys and will correspond where appropriate, with the soil sampling and soil mapping locations (see Table 6-8 and Figure 6-3) The specific sites will be located to represent the grassland type in the vicinity of the location selected and will be marked by stakes for later quantitative sampling Within the sampling area, transects for vegetative cover and clipping plots for productivity will be located close to the soil sampling points. Quadrant locations may be rejected for being disturbed or not representative of the vegetation in the area. A secondary method for sampling sufficient quantities of plant material to measure plutonium uptake or foliar deposition is to mow an area of sufficient size to collect up to 5 kilograms of material If located during the qualitative surveys, vegetation will be sampled from sites that are known to accumulate snow, and that may have higher levels of contaminants from physical concentration This vegetation will be sampled using the same procedures as the grassland areas

Grassland will be sampled during two periods an early season sample during late spring-early summer and a late season sample during the late summer-early autumn Cool-weather grasses and early-season forbs will be primarily sampled during the first sampling period Warm-season grasses and late-season forbs will be sampled during the latter period Soil mapping will be conducted during the first field investigation effort

Field Methods. Two types of quantitative surveys will be used for cover estimates, point intercept transects for grasslands and linear transects for shrubby and woody vegetation In the intercept transects, plant species will be recorded based the number of hits and notes made on height, condition and phenology One-half square-meter plots will be clipped according to the current season s growth by species or type of species and bagged for dry weight and tissue analysis The number of transects or quadrants for both cover and productivity will be determined by a sample adequacy formula. The sample adequacy will be determined using a formula for adequacy and the level of accuracy desired Sample procedures will follow Section 5 10 in the Ecology SOP (EG&G, 1991b)

The transects will be analyzed for species composition and cover, and the frequency and dominance (importance) values will be derived The sample clipped for productivity will be collected in bags, oven-dried to a constant weight (104°C for 24 hours) and weighed to the nearest 0 1 gram Additional samples will be collected and analyzed for tissue concentrations of a standard list of inorganic chemicals and radionuclides The analytical parameters are listed in Subsection 6 3 The grassland quadrant sample will provide species composition, cover, productivity diversity, and

structure of the terrestrial ecosystem. Tissue sample analysis will provide information on concentrations of contaminants in vegetation as an indication of bioaccumulation.

Small Mammals. Small mammals will be trapped live at some of the same locations as the grassland plots for tissue analysis. Systematic sampling for population densities and conditions will not be conducted because of the large area involved, lack of control on offsite properties, and the diversity of the habitats. The number and locations of sampling sites will be chosen to represent the habitat types determined during the qualitative survey Small mammals, particularly microtines, will be trapped because they are primary consumers of vegetation and form the basis for the link to the higher levels in the food chain leading to top carnivores. Other mammals that may be collected for tissue analysis are prairie dogs or pocket gophers because they live on and in the soil; they would be directly exposed to contaminants in the area. Small mammals will be trapped at sampling locations determined in the field during the qualitative field surveys conducted in the late spring. There will be two trapping periods, the first in mid-June for early season populations, and one in late August to determine changes in concentrations during the seasons.

Traps will be laid out in a systematic pattern to adequately sample a habitat as per SOP No. 5.6. The traps will be run for four consecutive days during the early evening or until an adequate number of animals are trapped to meet work plan objectives. Animals trapped will be identified to genus (or species if possible) and the weight, sex, and breeding condition. Obvious signs of environmental stress will be recorded. The individual animals will be collected and preserved for tissue analysis. Animals selected for tissue analysis will be placed in plastic bags, and stored on dry ice for transport to the laboratory for analysis. Sampling procedures will follow Section 5.6 in the Ecology SOP (EG&G, 1991b) The animals will be prepared according to laboratory procedures established for the type of analysis to be conducted. Animals selected for analysis will be dissected and specific tissue types or organs will be submitted as discrete samples.

The contaminants to be sampled in small mammals is listed in Table 6-8. The radionuclides are known contaminants in OU 3, but the metals are possible contaminants from the RFP although these have not been measured in soils at OU 3. These contaminants will be indicative of the condition of this important trophic level.

6.3.7.2.3 **Wetlands.** Wetlands, although small in size and extent, will be sampled because they are an important and productive vegetation type. The wetlands at OU 3 grow around seeps in the drainages and ditches east and downslope of the RFP east the reservoirs. Wetlands will be

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characterized for location size and condition and sampled in late summer for dominant species present Samples will be taken of major plant species for tissue analysis. The growing shoots will be clipped and handled in the same manner as the grassland samples The ecological endpoint of the wetland sampling is a determination of whether wetland plant tissues bioaccumulate contaminants in surface water from underground springs and seeps

6 4 SAMPLE ANALYSIS

This section describes the sample handling procedures and analytical program for samples collected during the OU 3 RFI/RI This section discusses sample designations, analytical requirements, sample containers and preservation and sample handling and documentation.

6 4 1 Sample Designations

All sample designations generated for this RFI/RI will conform to the input requirements of the RFEDS Each sample designation will contain a nine-character sample number consisting of a two-letter prefix identifying the media samples (such as, "SB" for soil borings, "SS" for stream sediments), a unique five-digit number, and a two-letter suffix identifying the contractor (such as, "CH" for CH2M HILL) One sample number will be required for each sample generated including QA/QC samples. In this manner, 99,999 unique sample numbers are available for each contractor that contributes sample data to the data base. A block of numbers will be reserved for the OU 3 RFI/RI sampling Boring numbers will be developed independently of the sample number for a given boring Specific sample location numbers are not assigned at this time, pending the results of the aerial photograph analysis and review of existing information

6 4 2 Analytical Requirements

Generally, all samples from the RFI/RI will be analyzed for plutonium 239/240 americium 241, and uranium 233/234 235 238 The surface water and sediment samples will also be analyzed for TCL volatiles and metals

The specific analytes in the groups listed above and their detection/quantitation limits for water and for soil/sediment are contained in Table 6-9 The specific OU 3 analytical programs are contained in Table 6-10 Both filtered and unfiltered samples for the surface water and groundwater samples will be collected and analyzed for radionuclides and for surface water TAL metals

TABLE 6-9

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS
AND THEIR DETECTION LIMITS
OPERABLE UNIT NO 3

TARGET ANALYTE LIST—METALS	DETECTION LIMITS[1] Water (µg/l)	Soil/Sediment (mg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	10	2
Barium	200	40
Beryllium	5	1 0
Cadmium	5	1 0
Calcium	5,000	2,000
Cesium	1,000	200
Chromium	10	2.0
Cobalt	50	10
Copper	25	5.0
Cyanide	10	10
Iron	100	20
Lead	5	1 0
Lithium	100	20
Magnesium	5,000	2,000
Manganese	15	3.0
Mercury	0.2	0.2
Molybdenum	200	40
Nickel	40	8.0
Potassium	5,000	2,000
Selenium	5	1 0
Silver	10	2.0
Sodium	5,000	2,000
Strontium	200	40
Thallium	10	2.0
Tin	200	40
Vanadium	50	10.0
Zinc	20	4.0

Note [1] Detection and quantitation limits are highly matrix-dependent. The limits listed here are the minimum achievable under ideal conditions. Actual limits may be higher, however levels in OU 3 should be achievable

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TABLE 6-9

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS
AND THEIR DETECTION LIMITS
OPERABLE UNIT NO 3
(Continued)

TARGET COMPOUNDS LIST-VOLATILES	QUANTITATION LIMITS[1] Water (µg/l)	Soil/Sediment (µg/kg)
Chloromethane	10	10
Bromomethane	10	10
Vinyl Chloride	10	10
Chloroethane	10	10
Methylene Chloride	5	5
Acetone	10	10
Carbon Disulfide	5	5
1,1-Dichloroethene	5	5
1,1-Dichloroethane	5	5
total 1,2,-Dichloroethene	5	5
Chloroform	5	5
1 2 Dichloroethane	5	5
2-Butanone	10	10
1,1,1-Tricholoroethane	5	5
Carbon Tetrachloride	5	5
Vinyl Acetate	10	10
Bromodichloromethane	5	5
1 1,2,2-Tetrachloroethane	5	5
1,2-Dichloropropane	5	5
trans-1 3-Dichloropropene	5	5
Trichloroethene	5	5
Dibromochloromethane	5	5
1,1,2 Trichloroethane	5	5
Benzene	5	5
cis-1,3-Dichloropropene	5	5
Bromoform	5	5
2-Hexanone	10	10
4-Methyl-2-pentanone	10	10
Tetrachloroethene	5	5

Note [1] Detection and quantitation limits are highly matrix-dependent. The limits listed here are the minimum achievable under ideal conditions Actual limits may be higher, however levels in OU 3 should be achievable

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TABLE 6-9

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS
AND THEIR DETECTION LIMITS
OPERABLE UNIT NO 3
(Continued)

TARGET COMPOUNDS LIST-VOLATILES (Continued)	QUANTITATION LIMITS[1] Water (µg/l)	Soil/Sediment (µg/kg)
Toluene	5	5
Chlorobenzene	5	5
Ethyl Benzene	5	5
Styrene	5	5
Total Xylenes		

RADIONUCLIDES	REQUIRED DETECTION LIMITS[1] Water (pCi/l)	Soil/Sediment (pCi/g)
Gross Alpha	2	4 dry
Gross Beta	4	10 dry
Uranium 233+234, 235, and 238 (each species)	0.6	0.3 dry
Americium 241	0.01	0.02 dry
Plutonium 239+240	0.01	0.03 dry
Tritium	400	400 (pCi/ml)

Parameters Exclusively for Groundwater Samples	DETECTION LIMITS[1] Water (mg/l)
ANIONS	
Carbonate	10
Biocarbonate	10
Chloride	5
Sulfate	5
Nitrate as N	5

Note. [1] Detection and quantitation limits are highly matrix-dependent. The limits listed here are the minimum achievable under ideal conditions. Actual limits may be higher, however levels in OU 3 should be achievable.

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TABLE 6-9

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS AND THEIR DETECTION LIMITS OPERABLE UNIT NO 3 (Concluded)

	DETECTION LIMITS[1] Water (mg/ℓ)
FIELD PARAMETERS	
pH	0 1 pH unit
Specific Conductance	1
Temperature	
Dissolved Oxygen	0 5
Barometric Pressure	

Source (DOE, 1991c)

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Note [1] Detection and quantitation limits are highly matrix-dependent. The limits listed here are the minimum achievable under ideal conditions Actual limits may be higher however levels in OU 3 should be achievable

TABLE 6-10

ANALYTICAL PROGRAM FOR OPERABLE UNIT NO. 3

Sample Activity	Media	Pu 239/240	Am 241	U 233/234	U 235	U 238	H3[1]	Gross α
Profile soil sampling	Soil	X	X					
Soil grid survey	Soil	X	X	X	X	X		
Sediment sample in drainages	Sediment	X	X	X	X	X		X
Sediment sample near reservoir shoreline	Sediment	X	X	X	X	X		X
Reservoir vertical profile sediment samples	Sediment	X	X					
Reservoir grab sediment samples	Sediment	X	X	X	X	X		X
Surface water samples in drainages	Water	X	X	X	X	X	X	X
Surface water samples in reservoirs	Water	X	X	X	X	X		X
Groundwater monitoring wells	Water	X	X	X	X	X		X
Air sampling	Air	X	X					

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[1]Samples collected along Walnut Creek only
[2]Twenty percent of the samples
[3]Mower Reservoir only

TABLE 6 10

ANALYTICAL PROGRAM
FOR OPERABLE UNIT NO 3
(Concluded)

Sample Activity	Gross B	TAL Metals	TCL VOAs	TOC[2]	Bulk[2] Density	Grain[2] Size	Major Cations/Anions	Field pH, EC, DO
Profile soil sampling				X	X	X		
Soil grid survey				X	X	X		
Sediment sample in drainages	X	X	X					
Sediment sample near reservoir shoreline	X	X	X	X	X	X		
Reservoir vertical profile sediment samples								
Reservoir grab sediment samples	X	X	X	X	X	X		
Surface water samples in drainages	X	X	X				X	X
Surface water samples in reservoirs	X	X	X[3]				X	X
Groundwater monitoring wells	X						X	X
Air sampling								

[1]Samples collected along Walnut Creek only
[2]Twenty percent of the samples
[3]Mower Reservoir only

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The analytical program for each media is summarized in Table 6-10. The specific analytes and detection/quantitation limit are the same as those used for investigations of OU 6 that were specified in the IAG by reference to CLP (Contract Laboratory Program) analyses. The General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (DOE, 1990c) provides a listing of CLP analytes and limits that will be used for this RFI/RI. These analytes and limits are presented in Table 6-10 The program shown in Table 6-11 is based on the chemical analyses rationale presented in Subsection 6-2.

Alpha spectroscopy will be used to analyze the air samples for plutonium (238, 239, and 240) and for americium (241) While gamma spectroscopy can be used to measure multiple components per air sample, alpha spectroscopy usually measures only one compound per sample because of different sample preparations for the various radionuclides. Alpha is the appropriate method for measurement of plutonium and americium, so each filter will be split for the two measurements.

First, the samples brought into the lab will be weighed and compared versus tare weights previously recorded to determine total particulate loading. Then the samples will be digested and split into two equal quantities. One half will be used for plutonium measurement and the other for americium measurement.

Laboratory results will be made on a "per filter" basis. This data will then be used with field durations and flow rates recorded to determine particulate loading and radionuclide concentrations per cubic meter of air

Biotic samples will be analyzed principally for the radionuclides and metals.

Uranium is likely to have been a constituent of the wastes at OU 6, therefore, it will be analyzed for in the soil, sediment, surface water, and groundwater samples for OU 3. The isotopes U-233, U-234, U-235 and U-238 have been selected for analysis. Plutonium is the only transuranic element that is used on the site. However, americium is a daughter product of plutonium and is found at RFP Therefore, plutonium 239/240 and americium 241 will be analyzed on all samples. Gross alpha and gross beta are included as screening parameters because they are useful indicators of radionuclides. Tritium will be analyzed in the surface water and sediment samples collected along Walnut Creek to assess the 1973 accidental tritium release to Walnut Creek.

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TABLE 6-11

SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES FOR WATER SAMPLES OPERABLE UNIT NO 3

Parameter	Container	Preservative	Holding Time
LIQUID—LOW TO MEDIUM CONCENTRATION SAMPLES			
Organic Compounds			
Purgeable Organics (VOCs)	2 x 40-mL VOA vials with teflon-lined septum lids	Cool 4°C[a] with HCl to pH<2	7 days 14 days
Extractable Organics (BNAs), Pesticides and PCBs	1 x 4-L amber[b] glass bottle	Cool, 4°C[a]	7 days until extraction, 40 days after extraction
Inorganic Compounds			
Metals (TAL)	1 x 1-L polyethylene bottle	Nitric acid pH<2, Cool, 4°C	180 days[c]
Cyanide	1 x 1-L polyethylene bottle	Sodium hydroxide[d] pH>12, Cool, 4°C	14 days
Anions	1 x 1-L polyethylene bottle	Cool, 4°C	14 days
Sulfide	1 x 1-L polyethylene bottle	1 mL-zinc acetate sodium hydroxide to pH>9, Cool, 4°C	7 days
Nitrate	1 x 1-L polyethylene bottle	Cool, 4°C	48 hours
Total Dissolved Solids (TDS)	1 x 1-L polyethylene bottle	Cool, 4°C	48 hours
Radionuclides (Full Suite)	1 x 1-L polyethylene bottle	Nitric acid pH<2	180 days

[a]Add 0 008 percent sodium thiosulfate ($Na_2S_2O_3$) in the presence of residual chlorine
[b]Container requirement is for any or all of the parameters given
[c]Holding time for mercury is 28 days
[d]Use ascorbic acid only if the sample contains residual chlorine Test a drop of sample with potassium iodine-starch test paper; a blue color indicates need for treatment. Add ascorbic acid, a few crystals at a time, until a drop sample produces no color on the indicator paper Then add an additional 0 6g of ascorbic acid for each L of sample volume

Source (DOE 1991c) and (EPA 1987)

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Volatile organics may have been handled at OU 6 in small quantities, therefore, surface water and sediment samples collected for OU 3 will be analyzed for volatile organic compounds. Twenty percent of the soil and sediment samples will be analyzed for TOC, bulk density, and grain size for evaluating fate and transport of plutonium.

6 4 3 Sample Containers and Preservation

Sample volume requirements, holding times, and container material requirements are dictated by the media being sampled and the analyses to be performed.

The soil matrices to be analyzed will include soils and sediments. The water matrices for analysis will include surface water and groundwater Tables 6-11 and 6-12 list analytical parameters of interest in OU 3 for water and soil matrices, along with the associated container size, preservatives (chemical and/or temperature), and holding times. Additional specific guidance on the appropriate use of containers and preservatives is provided in SOP No. 1 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples.

6.4.4 Sample Handling and Documentation

Sample control and documentation is necessary to ensure the defensibility of data and to verify the quality and quantity of work performed in the field. Accountable documents include logbooks, data collection forms, sample labels or tags, chain-of-custody forms, photographs, and analytical records and reports. Specific guidance defining the necessary sample control, identification, and chain-of-custody documentation is discussed in SOP No 1 14

6.4.5 Data Reporting Requirements

Field data will be input in to the RFEDS using a remote data entry module supplies by EG&G. The data will be put through a prescribed QC process based on SOP No. 1 14 to be generated by EG&G. A sample tracking spreadsheet will be maintained by the contractor for use in tracking sample collection and shipment. Computer and data security will also follow acceptable procedures outlined by EG&G.

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TABLE 6-12

SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES FOR SOIL SAMPLES OPERABLE UNIT NO 3

Parameter	Container	Preservative	Holding Time
SOIL OR SEDIMENT SAMPLES—LOW TO MEDIUM CONCENTRATION			
Organic Compounds			
Purgeable Organics (VOCs)	1 x 4-oz wide-mouth teflon lined glass vials	Cool, 4°C	14 days
Inorganic Compounds			
Metals (TAL)	1 x 1-oz wide-mouth glass jar	Cool, 4°C	180 days[a]
Cyanide	1 x 8-oz wide-mouth glass jar	Cool, 4°C	14 days
Sulfide	1 x 8-oz wide-mouth glass jar	Cool, 4°C	28 days
Nitrate	1 x 8-oz wide-mouth glass jar	Cool, 4°C	48 hours
Radionuclides	1 x 1-L wide-mouth glass jar	None	45 days

[a]Holding time for mercury is 28 days.

Source (DOE, 1991c)

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6 5 FIELD QC PROCEDURES

Sample duplicates, bottle blanks, equipment rinseate blanks and performance evaluation samples will be prepared Trip blanks will be obtained from the laboratory The analytical results obtained for these samples will be used by the data users to assess the quality of the field sampling effort. The types of field QC samples to be collected and their applications are discussed below The frequency for QC samples to be collected and analyzed is provided in Table 6-13

Duplicate samples will be collected and will be used as a relative measure of the precision of the sample collection process. These samples will be collected at the same time, using the same procedures, the same equipment, and in the same types of containers as required for the samples. They will also be preserved in the same manner and submitted for the same analyses as required for the samples.

Bottle blanks of distilled water, preserved according to the preservation requirements (Subsection 6.3.3), will be used to provide an indication of any contamination introduced from the sample bottles. As indicated by Table 6-11, these QC samples are applicable only to samples requirement chemical preservation.

Equipment (rinseate) blanks will be collected from final decontamination rinseate to evaluate the success of decontamination efforts on nondedicated sampling equipment. Equipment blanks are obtained by rinsing cleaned equipment with distilled water prior to sample collection. The rinseate is collected and placed in the appropriate sample containers. Equipment rinseate blanks are applicable to all analyses for water and soil samples as indicated in Table 6-11

Trip blanks consisting of deionized water will be prepared by the laboratory technician and will accompany each shipment of water samples for volatile organic analysis. Trip blanks will be stored with the group of samples with which they are associated. Analysis of the trip blank will indicate migration of volatile organics or any problems associated with the shipment, handling, or storage of the samples.

Performance evaluation samples will be prepared that contain known compounds and will be sent to the laboratory for analysis to monitor laboratory and method performance. Performance evaluation samples are used to evaluate accuracy

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TABLE 6-13
FIELD QC SAMPLE FREQUENCY
OPERABLE UNIT NO 3

Sample Type	Type of Analysis	Media	
		Solids	Liquids
Duplicates	Organics	1/10	1/10
	Inorganics	1/10	1/10
	Radionuclides	1/10	1/10
Bottle Blanks (Rinseates)	Organics	NA	NA
	Inorganics	NA	1/20
	Radionuclides	NA	1/20
Equipment Blanks (Rinseates)	Organics	1/20	1/20
	Inorganics	1/20	1/20
	Radionuclides	1/20	1/20
Trip Blanks	Organics (Volatiles)	NR	1/20
	Inorganics	NR	NR
	Radionuclides	NR	NR
Performance Evaluation	Organics	1/20	1/20
	Inorganics	1/20	1/20
	Radionuclides	1/20	1/20

NA = Not Applicable
NR = Not Required

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Procedures for monitoring field QC are given in the sitewide Quality Assurance Project Plan (QAPjP) In addition, information regarding the collection of matrix spike and matrix spike duplicates for laboratory quality control are included in the QAPjP

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7 1 OVERVIEW

7 1 1 Regulatory Basis

Section 300 430(d) of the National Contingency Plan (Federal Register March 8 1990 p 8709) states that as part of the remedial investigation, a Human Health Risk Assessment is to be conducted to determine whether contaminants of concern identified at the site pose a current or potential risk to human health and the environment in the absence of remedial action This section describes the Human Health Risk Assessment components, including the following

- Contaminant description
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

Figure 7-1 illustrates the basic Human Health Risk Assessment process and components The Human Health Risk Assessment objective is to identify and assess potential human health risks resulting from exposure to site contaminants present in various environmental media. The Human Health Risk Assessment considers risks from both radiological and nonradiological contaminants EPA and DOE require a two-phase evaluation for the radiological portion of the assessment. The Human Health Risk Assessment will incorporate the two-phase analysis which includes

- Procedures established by the ICRP and adopted by EPA used to estimate the radiation dose equivalent to humans from potential exposure to radionuclides through all pertinent exposure pathways

- Estimates of health risk, based on the age-averaged lifetime excess cancer incidence per unit intake (and per unit external exposure) for radionuclides of concern

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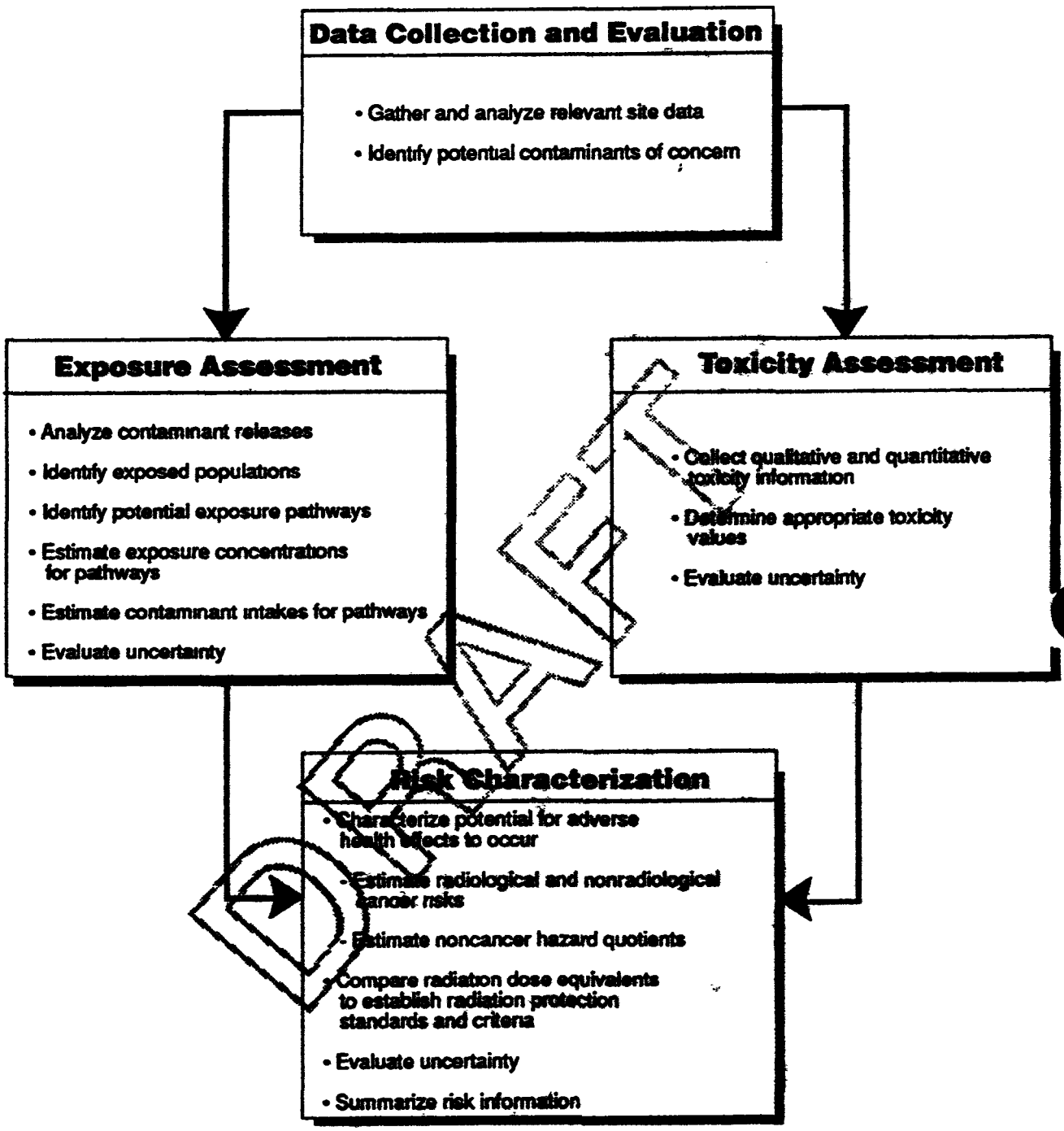

Source Risk Assessment Guidance for Superfund, Vol. 1
Human Health Evaluation Manual (Part A).
Interim Final 1989 EPA/540/1-89/002

Figure 7-1
HUMAN HEALTH RISK ASSESSMENT

Human Health Risk Assessment results will be used to determine if remedial actions are warranted at OU 3 and if so, the associated cleanup levels necessary to protect human health

A number of guidance and information documents will be used to provide direction for developing the Human Health Risk Assessment These include

- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Volume 1 (Part A) Interim Final 1989 EPA/540/1-89/002 (EPA, 1989c) including OSWER Directive 9285 6-03 Human Health Evaluation Supplemental Guidance "Standard Default Exposure Factors"

- Guidance for Data Usability in Risk Assessment. Interim Final 1990 EPA/540/G-90/008 (EPA, 1990b)

- Superfund Exposure Assessment Manual. 1988 EPA/540/1-88/001 (EPA, 1988b)

- Procedures established by the International Commission on Radiological Protection (ICRP) and adopted by EPA in Federal Guidance Report No 11 (EPA, 1988)

- Radiation Protection of the Public and the Environment, DOE Order 5400 4

- Risk Assessment in the Federal Government Managing the Process, 1983 National Academy Press, Washington, D C

- Publications of the National Council of Radiation Protection, International Council on Radiological Protection, United National Scientific Committee on the Effects of Atomic Radiation, as appropriate

In addition to available national EPA guidance, supplemental Region VIII risk assessment guidance will be used if applicable

7 1 2 Background—Preliminary Human Health Risk Assessment

Human health risk assessments prepared to date include preliminary assessments for IHSS 199 and 200 through 202. These assessments relied on existing data to qualitatively describe the potential

exposure pathways and risks. They were based on conclusions in the Final Past Remedy Report for OU 3, (DOE, 1991a) and the Historical Information Summary and Preliminary Health Risk Assessment for Operable Unit No 3 (DOE, 1991b), which identified data limitations prohibiting use of the existing data in a quantitative assessment. The quantitative assessment has been deferred until completion of the RFI/RI, which will collect data to verify historical data and adequate data for quantitatively evaluating risk. Data used to develop the preliminary risk assessments will be used in the Human Health Risk Assessment to the extent practicable. Some data may be used quantitatively, and some will be used qualitatively These decisions will be based on the RFI/RI results and the kinds, quantities, and quality of historic data and information.

The objectives of the preliminary risk assessments were the following:

- Identify all potential exposure pathways to be evaluated in the RFI/RI
- Discuss the relative significance of each pathway using existing information to qualitative judgements
- Identify additional information needed to perform a quantitative assessment

The preliminary qualitative assessment used existing information to make judgements concerning the potential exposure pathways and to identify the plausible exposure pathways and qualitative risks that are applicable to the following scenarios:

- No further action for current land use scenario
- Implementation of the remedy (workers and public) for the current land-use scenario
- Past remedy for current and future land-use scenarios

These judgements are not used to eliminate potential exposure pathways from evaluation in the RFI/RI

The preliminary risk assessment for the no further action alternative and the remedy implementation alternative were based on current recreational land use condition for IHSS 199 A hypothetical risk assessment used generic exposure pathways assumptions based on a future residential land use.

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Only plutonium risk was assessed based on soil concentrations of 1, 10 and 100 pCi/g These concentration values provide a range of risks from 7×10^{7} to 7×10^{-8} (DOE 1991a)

As indicated in Table 7-1 risk incurred from exposure to plutonium-239 in a recreational exposure scenario at IHSS 199 before during, and after remedial activities would be below EPA's target range of acceptable risk (i e, below 1×10^{6}) Residential use exposure cannot occur at IHSS 199 before or during the remedy activities

Table 7-1 summarizes the hypothetical qualitative risk characterization derived from the generic risk assessment. The generic risk assessment is based on a hypothetical multipathway exposure scenario All exposure pathways utilize plutonium-239 in soil as the source media. The following two scenarios and component pathways are considered

Residential	Recreational
Incidental Soil Ingestion	Incidental Soil Ingestion
Inhalation of Dust	Inhalation of Dust
Ingestion of Leafy Vegetables	
Ingestion of Tuber Vegetables	
Ingestion of Beef Tissue	
Ingestion of Beef Liver	
Ingestion of Cow's Milk	

All of the data reviewed indicate that radionuclides in sediments are the only contaminants of concern at IHSS 202-202 which can be attributed to RFP historical releases Some media specific analyses of plutonium and other radionuclides present at the RFP, such as americium-241, have been performed at Great Western Reservoir and Standley Lake However only plutonium was addressed specifically in the qualitative risk assessment and in the general risk assessment, since the potential exposure pathways for the radionuclides of concern are similar (although significance may vary) and significantly more data would be needed to quantitatively address the risks of these other radionuclides A more comprehensive assessment of all contaminants of concern and of the potential exposure pathways will be performed during the scheduled RFI/RI activities.

The preliminary risk assessment for IHSS 200-202 was based on hypothetical plutonium concentrations in reservoir sediments and water under various exposure scenarios The added lifetime excess cancer risk for all potentially exposed member of the public would range from 7×10^{-9} to 7×10^{-6} based on soil concentrations of 0 01 0 1 1 and 10 pCi/g (DOE, 1991a)

TABLE 7-1

HYPOTHETICAL QUALITATIVE RISK CHARACTERIZATION DERIVED FROM THE GENERAL RISK ASSESSMENT[1]

Exposure Scenario	Before Remedy	During Remedy	After Remedy
Recreational Use	Below EPA's Range of Acceptable Risk	Below EPA's Range of Acceptable Risk	Below EPA's Range of Acceptable Risk
Residential Use	NA	NA	Below EPA's Range of Acceptable Risk

Notes [1] The risk estimates presented in this table are hypothetical.

NA - Based on conditions at the site, these exposure conditions did not exist during the remedy phase specified.

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Data needs and DQOs were presented in Section 5 0 of this work plan Section 6 0 of this work plan described how the data needs identified will be collected The data needs and FSP address the objectives described in Subsection 5 1 4 and include characterizing the nature and extent of contamination and the data collection necessary to assess the complete potential exposure pathways The data to be collected and its use in the Human Health Risk Assessment include the following

- **S-1** Data characterizing vertical plutonium and americium concentrations in undisturbed areas can be used to support discussions of contaminant fate and transport.

- **S-2** Surface soil data will be used to estimate exposure and risk through ingestion and, if necessary, estimate windborne particulate concentrations for subsequent inhalation exposures

- **S-4** The soil and sediment data on particle size, bulk density, and TOC can be used to address contaminant fate and transport.

- **SED-1** Data characterizing contamination in drainage ditches can be used to support discussions of contaminant fate and transport and offsite migration pathways

- **SED-2** Data characterizing sediments in the reservoirs can be used to support discussions of contaminant fate and transport and offsite migration pathways

- **SED-3** Data characterizing sediments that may be potentially exposed during low reservoir capacity can be used to support discussions of contaminant fate and transport and offsite migration pathways, in addition to estimating exposure and risk through incidental ingestion during recreational uses of the reservoirs or to estimate windborne particulate concentrations for subsequent inhalation exposures

- **SW-1** Data characterizing radionuclides in surface water can be used to support discussions of contaminant fate and transport and offsite migration pathways in addition to estimating exposure and risk from ingestion or dermal contact with surface water

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- SW-2: Same as SW-1

- GW-1 Data characterizing site-specific hydrogeology and potential contaminants in alluvial and confined groundwater systems can be used to support discussions of contaminant fate and transport in addition to estimating exposure and risk from ingestion, inhalation, or dermal contact with groundwater

- A-1 Data characterizing the potential for dispersion of contaminated sediments can be used to support discussions of contaminant fate and transport in addition to estimating exposure and risk from inhalation

- AQ-6 Data to determine if fish are accumulating contaminants can be used to estimate exposures and risk from fish ingestion.

Because of the inherent uncertainty of the preliminary assessment, the relative risks of the no-action, remedy implementation, and past remedy scenarios could not be accurately compared. A comprehensive quantitative assessment of all contaminants of concern and potential exposure pathways will be performed as part of the RFI/RI. The remainder of this section generally describes the individual Human Health Risk Assessment components as they relate to the overall risk assessment.

7.2 CONTAMINANT DESCRIPTION

The objective of this section is to identify source-related chemicals present at OU 3 at concentrations that could be of concern to human health. The contaminant description component of the Human Health Risk Assessment summarizes historical and RFI/RI data collected at OU 3, evaluates historical and RFI/RI data relative to performing the Human Health Risk Assessment, and uses this information to perform the hazard identification. The contaminant description section includes the following information.

- Data collection
- Data evaluation
- Hazard identification

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7 2 1 Data Collection

The objective of this task is to summarize all data available for use in the Human Health Risk Assessment in preparation of further data evaluation activities This step, then identifies the historical data relevant to performing the Human Health Risk Assessment assembles the RI data, and establishes data formats to facilitate data evaluation Data attributes important to this step include the following information

- A site description
- A sample design with sample locations
- An analytical method and detection limit
- The results for each sample, including qualifiers
- Sample quantitation limits and/or detection limits for nondetects
- Field conditions
- Sample documentation (for example chain-of-custody and SOPs)

Data lacking any of the above information will be considered for qualitative use in the Human Health Risk Assessment. Data associated with all of these attributes will be carried forward for further detailed evaluation and summary

7.2.2 Data Evaluation

Historical and RFI/RI data will be further evaluated based on EPA s guidelines issued in Guidance for Data Useability in Risk Assessment (EPA, 1990b) EPA identified the following data usability criteria.

- Assessment of data documentation for completeness
- Assessment of data sources for appropriateness and completeness
- Assessment of analytical methods and detection limits for appropriateness
- Assessment of data validation review

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- Assessment of sampling data quality indicators (completeness, comparability, representativeness, precision, and accuracy)

- Assessment of analytical data quality indicators (such as spike recoveries, duplicates, and blanks) for completeness, comparability, representativeness, precision, and accuracy

The Final Past Remedy Report for Operable Unit No. 3–IHSS 199 and the Historical Information Summary (DOE, 1991a), and the Historical Information Summary and Preliminary Health Risk Assessment for Operable Unit No 3–IHSS 200 to 202 (DOE, 1991b) contained evaluations of data useability for historical data. The evaluation was based on the above data useability criteria. In both cases, it was determined that available data would not, by themselves, support a quantitative risk assessment.

Following completion of the RFI/RI data collection, analysis, and validation, the new data will be evaluated to determine if they support historical trends. Where new data and historical data appear compatible, the historical data will undergo re-evaluation to identify those that could be used quantitatively in conjunction with new data.

Based on the outcome of this evaluation, the data set containing historical and RFI/RI data that can be used to support a quantitative Human Health Risk Assessment will be identified. Part of this evaluation will include the most appropriate summary process and format. This will involve identifying statistical summary techniques that consider spatial and temporal data distributions, determining if arithmetic or geometric means are appropriate, and determining the appropriate method for dealing with nondetected values and qualified data. The data summary will include

- The frequency of detection (number of positive detects/number of analyses) for each compound and sample location

- The minimum- and maximum-reported concentrations for each compound at each sample location

Tentatively identified compounds (TICs) reported in the RFI/RI data will be evaluated relative to their usefulness in the Human Health Risk Assessment. If only a few TICs are reported relative to other contaminants, or if they are unrelated to the RFP, they will be excluded from the Human Health Risk

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Assessment. If numerous TICs are reported and they appear related to the RFP, they will be carried through the Human Health Risk Assessment only to the extent that they aid characterizing human health risk as needed for site decisions It is anticipated that risks resulting from exposure to TICs will not be characterized because of the absence of specific contaminant identity and available toxicological information

7 2 3 Hazard Identification

The objective of the hazard identification is to identify RFP-related contaminants present at OU 3 in concentrations high enough that may be of concern relative to human health considerations. Previous OU 3 investigations identified Pu-239, Pu-240 and Am-241 within OU 3 In addition to these contaminants, others may be identified based on RFI/RI analytical results. Criteria for performing the hazard identification include but may not be limited to

- Frequency of detection
- Environmental media concentrations exceed background concentrations
- Toxicity, mobility, and persistence
- Contaminant can be attributed to RFP activities

Depending on the number of site-related contaminants identified, one of two things will happen

1 If only a few site-related contaminants are identified, all of them will be carried through the risk assessment. The contaminants responsible for dominant risks at the site, as well as those contributing lower risk, will be identified

2. If a large number of site-related contaminants are identified, contaminants of concern may be selected and carried through the risk assessment to characterize only those expected to contribute the highest risk. Contaminants of concern will be selected based on the following tasks

   - Evaluating site historical information consideration as site-specific, waste-activity related compounds

   - Evaluating contaminant toxicities

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- Examining contaminant mobility, persistence, and bioaccumulation, decay and degradation products

- Identifying special exposure routes

- Contaminant concentrations versus chemical-specific ARARs

- Grouping chemicals by class according to structure-activity relationships or other similarities

- Evaluating frequency of detection

- Evaluating "hot spot" occurrences

- Identifying essential nutrients

- Comparison with background

- Using a concentration-toxicity screen to identify those contaminants that are expected to contribute the most to overall risks

If contaminants of concern have to be selected, adequate documentation will be prepared to justify including or excluding specific contaminants.

7.3 EXPOSURE ASSESSMENT

The exposure assessment objective is to determine how exposures to site contaminants could occur, and to estimate the extent of exposure if it occurs. The exposure assessment includes several tasks

- Characterize the exposure setting relative to contaminant fate and transport and potentially exposed populations

- Identify exposure pathways based on chemical source and release, exposure point and exposure route

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- Identify potentially exposed populations and the dynamics of their exposure

- Identify uncertainties associated with the exposure assessment that impact the risk characterization

Exposure is defined as the contact of an organism with a contaminant or physical agent The magnitude of exposure is determined by measuring or estimating the amount of a contaminant available at the exchange boundaries (that is the lungs, intestines, and skin) When contaminants migrate from the site to an exposure point (a location where receptors can come into contact with contaminants) or when a receptor directly contacts contaminated media, exposure can occur

7 3 1 Conceptual Site Model

The conceptual site models developed for OU 3 (Figures 2-8 and 2-9) will be used to evaluate primary and secondary contaminant sources and releases, and potential receptors and associated exposures. The model helps to characterize the exposure setting relative to contaminant fate and transport mechanisms through exposed receptors. It may be revised based on RFI/RI data collected for the OU to incorporate new information

7 3.2 Contaminant Fate and Transport

The conceptual site model helps identify potential contaminant fate and transport mechanisms These could include soil contaminants leaching to groundwater and subsequent transport, soil entrainment and downwind deposition, or surface runoff that transports surface soil downslope Contaminant-specific characteristics affect fate and transport. Factors affecting the probability a contaminant will migrate include but are not limited to

- Solubility
- Partition coefficients
- Vapor pressure
- Henry s Law constant
- Bioconcentration factors
- Half-life or degradation

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The evaluation of these factors will help determine if contaminants can migrate from their sources to potential receptors, not only those identified under current use scenarios but those identified under potential future exposure scenarios as well.

7 3.3 Exposure Pathways

By using the conceptual site model and information on contaminant fate and transport, exposure pathways can be identified. The Human Health Risk Assessment will consider only complete exposure pathways (or pathways that could reasonably be expected to be complete), those for which data support the presence of a source, release mechanism, transport mechanism, exposure route and affected receptor Complete exposure pathways include the receptors and exposure route (ingestion, inhalation, and dermal)

7.3.4 Exposure Point Concentrations

By using the data set identified as part of Subsection 7.2.2, exposure point concentrations will be estimated. Some data will be collected at the point of exposure. Other data collected at the source may be used in conjunction with a transport model to estimate expected concentration at some exposure point. Because modeling may add uncertainty, the Work Plan emphasizes collecting data at exposure points where possible (even though these data provide only a snapshot of conditions in time and space)

Exposure point concentrations will be expressed for a variety of anticipated exposure conditions including the reasonable minimum exposure (RMinE), the expected exposure concentration, and the reasonable maximum exposure (RMaxE) RMinE and RMaxE concentrations are represented by the 95th percent confidence limit on the average or the maximum-reported concentration, whichever is lower Depending on the quantity of data and their appropriateness for grouping, data distribution will be used to determine the appropriateness of using geometric or arithmetic means to estimate the RMinE and RMaxE and average concentrations.

7.3.5 Contaminant Intake Estimation

Contaminant exposure (or intake) is normalized for time and body weight and is expressed as milligrams of chemical per kilogram of body weight per day (mg/kg/day) Radionuclide intake is expressed as picoCuries of radionuclide per kilogram of body weight per day (pCi/kg/day) Six

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basic factors are used to estimate intake exposure frequency, exposure duration, contact rate, chemical concentrations body weight and averaging time These factors are based on the types of exposure for example residential or occupational ingestion or inhalation

The RMinE and RMaxE and average exposure point concentrations are used in conjunction with receptor activity patterns to estimate contaminant intake for each exposure route as appropriate EPA guidance such as Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Supplemental Guidance, "Standard Default Exposure Factors" Interim Final, March 25, 1991 (EPA, 1989c) will be consulted in developing bounding case exposure parameters to support an unbiased exposure assessment Also the averaging time for carcinogens and noncarcinogens differ

Other standard contaminant intake rates established by EPA that will be used, if appropriate, include the following

- Soil ingestion rates for children ages 1 through 6 years
- Soil ingestion rates for all others (workers and residents greater than 6 years of age)
- Inhalation rates based on activity levels

Contaminant intake rates can also be estimated for dermal exposures Of the three routes of exposure (ingestion, inhalation and dermal), the greatest uncertainty is associated with dermal exposures.

Depending on the data collected and the refinement of the conceptual site model, nontraditional exposure routes that may be included in the Human Health Risk Assessment, include fish ingestion and exposures resulting from recreational uses of the reservoirs (contact with sediments, ingestion and dermal contact with surface water) and the nearly open spaces (hiking bicycling)

Other nontraditional exposure routes may be identified by using land use data for the OU 3 area. These include exposure scenarios related to agricultural land uses and nearby open space land uses within the OU 3 area.

Two future use exposure scenarios to be considered include

- A light industrial setting (warehouse-type operations)

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- A research biologist setting (assuming the area is turned into a wildlife reserve)

7 3 6 Uncertainty in the Exposure Assessment

The ability to construct exposure scenarios for a site depends on the amounts and kinds of environmental data collected for that purpose. Some uncertainty is inherent in environmental data collection. The numbers and kinds of uncertainties included in the exposure assessment directly impact the risk characterization; many professional judgements impact the identification and description of physical site attributes that affect exposure and activity patterns. One of the major areas of uncertainty in the exposure assessment is the prediction of human activities that lead to contact with environmental media and exposures to site-related contaminants. This section of the Human Health Risk Assessment will identify and evaluate how site attributes related to environmental sampling and analysis, fate and transport modeling, and exposure parameter estimation and assumptions about them affect uncertainty relative to assessing risk. The exposure assessment uncertainty analysis will evaluate the potential magnitude of over or under estimation, or both, provides an indication of the impact, by orders of magnitude, the uncertainty imparts on the estimation of risk.

7 4 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to describe the contaminants considered in the Human Health Risk Assessment relative to their potential to cause harm. The toxicity assessment has two general steps. The first determines what adverse health impacts, if any, could result from exposure to a particular contaminant. These are typically classified as carcinogenic and noncarcinogenic health effects. The second step, dose-response evaluation, quantitatively examines the relationship between the level of exposure and the incidence of adverse health effects.

Toxicity depends on the dose or concentration of the substance (dose-response relationship). Toxicity values are a quantitative expression of the dose-response relationship for a contaminant and take the form of reference doses (RfD) and cancer slope factors, both of which are specific to exposure via different routes.

Two sources of toxicity values are currently available for chemicals and radionuclides. The primary source is the EPA's Integrated Risk Information System (IRIS) data base IRIS contains up-to-date health risk and regulatory information. IRIS contains only those RfDs and slope factors that have

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been verified by the U S EPA work groups and is considered by U S EPA to be the preferred source of toxicity information for chemicals Other sources such as ICRP and NCRP will also be consulted

Following IRIS, the most recently available Health Effects Assessment Summary Tables (HEAST), issued by the U S EPA's Office of Research and Development, will be consulted to identify interim RfDs and slope factors for radionuclides

In addition to identifying appropriate toxicity values, this section of the Human Health Risk Assessment will provide brief toxicity profiles based on recent, published literature for each contaminant evaluated in the Human Health Risk Assessment. These profiles will describe the acute, chronic and carcinogenic health effects associated with site-related contaminants identified in OU 3 Acute and chronic exposure to site-related radionuclides will be discussed, but most of the information presented will deal with the carcinogenic hazard posed by the site-specific radionuclides

The toxicity assessment section will include a discussion of uncertainties The numbers and kinds of uncertainties identified for the toxicity assessment directly impact the risk assessment Uncertainties for the toxicity assessment are associated with the toxicity values and their derivation or the lack of toxicity values for site-related contaminants. These could include but may not be limited to the following

- Not all constituents at the site have critical toxicity values (such as cancer slope factors or reference doses), potential risk cannot be quantified for these constituents and this may underestimate risk from the site

- Using cancer slope factors derived from the upper 95th percent confidence limit is likely to lead to overestimation of risk Carcinogen slope factors assume no threshold for effects, if thresholds do exist, the true risks could be zero at sufficiently low doses

- Critical toxicity values derivation include but may not be limited to the following

  - Extrapolating toxicity values from high experimental does to low doses for environmental exposures

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- Extrapolating data from tests with experimental animals to humans; extrapolating test data collected over short durations to long-term exposure durations

- Extrapolating data collected using homogeneous experimental animal populations to humans who individually can vary substantially in their individual dose-response reactions

- Extrapolating from continuous experimental doses given to animals to intermittent human exposures

- Extrapolating absorption rates

The methods used to derive slope factors and reference doses are intended to be conservative in recognizing these types of uncertainties. In addition to the numerical approaches to incorporating uncertainty in deriving toxicity values, the overall quality of the toxicology data base for a compound is evaluated. This can include consideration of a number of studies, their consistency, the availability of information on multiple species and multiple routes of administration, the demonstration of a clear dose-response relationship, plausible biological mechanisms of action, and especially direct evidence of effects in humans. Such reviews are performed by EPA in developing toxicity parameter values and result in an overall evaluation of the confidence level in the toxicity values. Not all toxicity values represent the same degree of uncertainty; all are subject to change as new evidence becomes available.

7.5 RISK CHARACTERIZATION

This section of the Human Health Risk Assessment presents the evaluation of potential risks to public health associated with exposure to contaminants at the OU 3 site. Potential carcinogenic and noncarcinogenic risks associated with complete exposure pathways will be estimated.

Noncancer risk will be assessed by comparing the estimated daily intake of a contaminant to its RfD. This comparison measures the potential for noncarcinogenic health effects given the chemical intake factors used to estimate exposure. To assess the potential for noncancer effects posed by multiple chemicals, the EPA's hazard index approach will be used. The method assumes dose additivity. Hazard quotients (individual chemical intake divided by the chemical RfD) are summed

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based on identification of target-tissues and like impacts to provide a hazard index, and if the index exceeds one a potential for health risk is suggested

The potential for carcinogenic effects for nonradiological contaminants will be estimated by calculating excess lifetime cancer risks from the lifetime average exposure and cancer slope factor IRIS slope factors for radionuclides of concern will be used to estimate radiological risks from exposure for up to four pathways inhalation, ingestion, air immersion, and ground-surface irradiation. Calculations will be performed according to guidance provided by EPA (1989c) The sum of the risks from all radionuclides and pathways yields the lifetime risk from the overall exposure Risks will be combined as appropriate, taking into consideration the plausibility of multiple exposures

The Human Health Risk Assessment will present the chemical and radiological risk estimates separately with discussion on the additivity potential for these risks.

Both noncancer and cancer risks will be estimated by using RMinE and RMaxE combined with exposure assumptions. This allows risk ranges to be considered rather than a single value and more closely considers the uncertainty associated with the estimates. In addition, risks may be added across exposure routes if conditions for doing so (i e , biologically plausible and consistent with reasonably expected exposure scenarios) indicate that it is appropriate

Not all contaminants identified at OU 3 will have toxicity values thereby limiting the ability to develop quantitative estimates of risk Where adequate toxicity values cannot be identified, potential risks associated with exposure to those constituents will be dealt with qualitatively

7 6 UNCERTAINTIES, LIMITATIONS, AND ASSUMPTIONS

The numbers and kinds of uncertainties identified in the Human Health Risk Assessment directly impact the interpretation of estimated risks developed in this section Quantitative risk estimates derived in risk assessments are conditional estimates that include numerous assumptions about exposures and toxicity Uncertainty is introduced from a variety of sources including but not limited to, the following sources

- Sampling and analysis
- Exposure estimation

- Exposure population dynamics
- Toxicological data

The objective of this task will be to evaluate the reliability of the Human Health Baseline Risk Assessment as a scientifically credible instrument upon which to base risk management decisions. An uncertainty analysis will be performed to characterize and quantify, to the extent practicable, the sources and magnitudes of uncertainty in the Baseline Risk Assessment. Quantitative techniques may include sensitivity analysis, first-order analysis to evaluate the propagation of errors, or numerical methods such as stratified Monte Carlo sampling.

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8 1 INTRODUCTION

This Environmental Evaluation Work Plan (EEWP) for OU 3 provides a detailed approach to determining ecological risks specifically to offsite areas The plan develops the major steps in an environmental evaluation methodology and details the sequence of tasks for performing the ecological risk assessment or environmental evaluation (EE) The EEWP prescribes how potential impacts or risks to the environment from existing OU 3 conditions will be evaluated using both biotic and abiotic data collected during the RFI/RI process and data collected during the field sampling effort (Section 6) The EE is conducted as part of the RFI/RI process to determine if the contaminants of concern pose a current or potential risk to the environment specifically to the biota present in OU 3, in the absence of remedial action

The EE will identify and characterize the levels of hazardous substances present, their toxicities, the fate and transport of contaminants and the actual or potential environmental exposure and consequences to plants and animals It will address the potential environmental impacts associated with OU 3 under the "no-action" alternative (no remedial action taken) The impacts will be determined in a quantitative manner where possible, and a qualitative perspective where a quantification of the impacts is not possible The EE will also provide environmental information needed to evaluate remedial alternatives and the mitigation of environmental risks. This EEWP used information developed in two reports on OU 3 the Final Past Remedy Report on IHSS 199 (DOE 1991a) and the Historical Information Summary and Preliminary Health Risk Assessment for IHSS 200-202 (DOE 1991b)

The information in these two documents (DOE 1991a, 1991b) and the RFP monitoring data indicate that the main contaminant of concern is plutonium that originated as windborne particulates from the 903 pad, and from activities at RFP during the period of the 1950 s and 1960 s (Subsection 6 2) The concentrations of plutonium have been measured in previous studies (Subsection 2.1 4) for soils, but the results vary widely Contamination has also been measured in the IHSS 199 lawsuit acreage, and in the reservoir and drainage sediments Most of these studies have focused on plutonium and other radionuclides, and very few data exist for other contaminants Although these results are inconclusive for definite contaminant concentrations, the concentrations of plutonium

measured are generally in the range below which biota may be impacted The methods proposed in this EE are designed to provide a variety of impact and risk assessments so that a weight of evidence determination can be made if there are actual impacts to biota.

This plan has been prepared in accordance with Section 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA" or "Superfund") CERCLA Section 106(a) mandates EPA to take appropriate action whenever "there may be an imminent and substantial endangerment to the public health or welfare or the environment because of an actual or threatened release of a hazardous substance from a facility" This same language is employed in CERCLA Subsection 104, although the concept of a hazardous substance is broadened to include "any pollutant or contaminant." The EPA's mandate to protect human health and the environment is reiterated throughout CERCLA (in Sections 121[b][1], 121[c], and 121[d]), and its major implementing regulations which are contained in the National Oil and Hazardous Substances Contingency Plan (NCP) (40 CFR Part 300, Subpart F). The NCP was extensively revised on March 8, 1990 (55 FR 8666) to incorporate requirements of the Superfund Amendments and Reauthorization Act of 1986 (SARA) It provides the overall framework for identifying and obtaining information on hazardous substance sites, assessing the nature and extent of the contamination, determining the risk to human health and the environment, evaluating and selecting remedial action technologies, and implementing decisions on remedial actions. Although a formal Natural Resource Drainage Assessment (NRDA) process has not been initiated at RFP as of this date, the EE will be conducted to be consistent with the NRDA to the maximum extent possible.

Detailed guidance on conducting environmental evaluations is contained in EPA's Risk Assessment Guidance for Superfund, Volume II—Environmental Evaluation Manual (EPA, 1989d) Although an "environmental evaluation" is specifically required by the NCP, the EPA uses the term "ecological assessment" as being a more precise description of the activities that actually take place in the environmental evaluation process. The EPA Manual defines an ecological assessment as "a qualitative and/or quantitative appraisal of the actual or potential effects of a hazardous waste site on plants and animals other than people and domesticated species" (EPA, 1989d) The manual recognizes that ecological assessments may identify new or unexpected exposure pathways which may affect human populations.

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8 1 1 Purpose and Objectives

The overall purpose of the OU 3 EE is to perform a qualitative and where possible, a quantitative evaluation of actual or potential threats of damage to the environment, including protected wildlife and vegetation species, habitats, and exposed ecosystems offsite of the RFP This purpose is consistent with the mandates of CERCLA/SARA and the IAG The IAG states in Part 3 that one of its purposes is to ensure that an appropriate response action is taken and completed as necessary to protect the public health, welfare, and the environment." The purpose of the EEWP is to establish a scientifically credible procedure to be followed and implemented during the performance of the EE

The EE will provide decisionmakers with the information required to determine risks to the environment at OU 3 as it presently exists, and an estimate of risks in the absence of remedial action on offsite areas It will also be used along with the Human Health Risk Assessment, to determine whether or not offsite contamination requires additional remedial action. The EE will examine existing data and supplement this information with additional studies and sampling as necessary (Subsection 6 3 6) It will also provide information for assessing the potential effects of the remedial alternatives on the environment, and in the case of IHSS 199, the effects of the court-mandated remediation (Subsection 2.1 2) In addition, the EE can suggest future strategies for monitoring the effectiveness of any remediation or revegetation accomplished in offsite areas.

The EE for OU 3 has multiple objectives They are to determine the following

- Biological and ecological characteristics of the areas within OU 3
- Types forms, and quantities of contaminants of concern for the environment
- Current distribution and concentrations of these contaminants in the environment
- Migration pathways to and exposure of ecological populations to contaminants
- Habitats potentially affected and populations potentially exposed to contaminants
- Actual or potential ecological effects and the overall nature of the risk

8 1 2 General Approach

The Environmental Evaluation provides a general framework for ecological assessment as a process for analyzing the likelihood that an adverse effect will occur or has occurred the magnitude and intensity of the adverse effect, and its spatial and temporal distribution The basic steps in a

CERCLA risk assessment for determining risk to either human populations or the environment are contaminant identification, exposure assessment, toxicity assessment, and risk characterization (shown in Figure 8-1) In an ecological assessment, this is accomplished through evaluating site characteristics, determining the nature and extent of contamination, developing and implementing a sampling and analysis plan, identifying the potential for exposure of plants and animals to contaminants, and selecting ecological measurement "endpoints" The above activities are combined with an evaluation of the toxicity of contaminants of concern to characterize the ecological risks

This EEWP undertakes a comprehensive approach to performing an ecological assessment including establishing objectives, developing an overall investigation methodology, implementing the work plan, and producing and documenting the results. As stated earlier, the EEWP is based on guidance provided in the EPA EE Manual (EPA, 1989d) and other guidance documents (see list of example guidance documents in Table 8-1 and the References at the end of this document in Section 12.0) A comprehensive methodology for performing and implementing an EE is detailed in Subsection 8.2. The procedures recommended provide a means of determining and measuring ecological risks in a systematic, controlled, and step-by-step manner The same procedures can be used in subsequent efforts to reduce or manage the risk. While the EEWP structures the methodology for conducting the environmental evaluation for OU 3, the plan does not attempt to define the offsite areas either in terms of nature and extent of contamination or ecological characteristics since the offsite areas will be defined during the actual implementation of the EE.

The rationale for selection of chemical analyses for OU 3 is discussed in Subsection 6.2. There is no source of contaminants on OU 3 other than plutonium-contaminated soils of IHSS 199, and the contaminants that have a historical source on the RFP is presented in Subsection 2.5. The approach to this EEWP concerning contaminants and sampling was partly developed after review of the two reports on OU 3 (DOE, 1991a and 1991b) However, there was no complete review of all the reports or review of the data base for OU 3, nor the general offsite information outside the identified IHSSs. The data that exist pertaining to OU 3 will be collected and evaluated as part of the task of actually performing the environmental assessment (see Subsection 8.2.1) The annual monitoring and sampling programs and information developed onsite at the RFP will also provide information to guide sampling. EEWPs have been developed for OU 2 (903 pad), OU 5 (Woman Creek) and OU 6 (Walnut Creek). OUs 2, 5, and 6 are adjacent to OU 3 and upgradient from OU 3 with respect to

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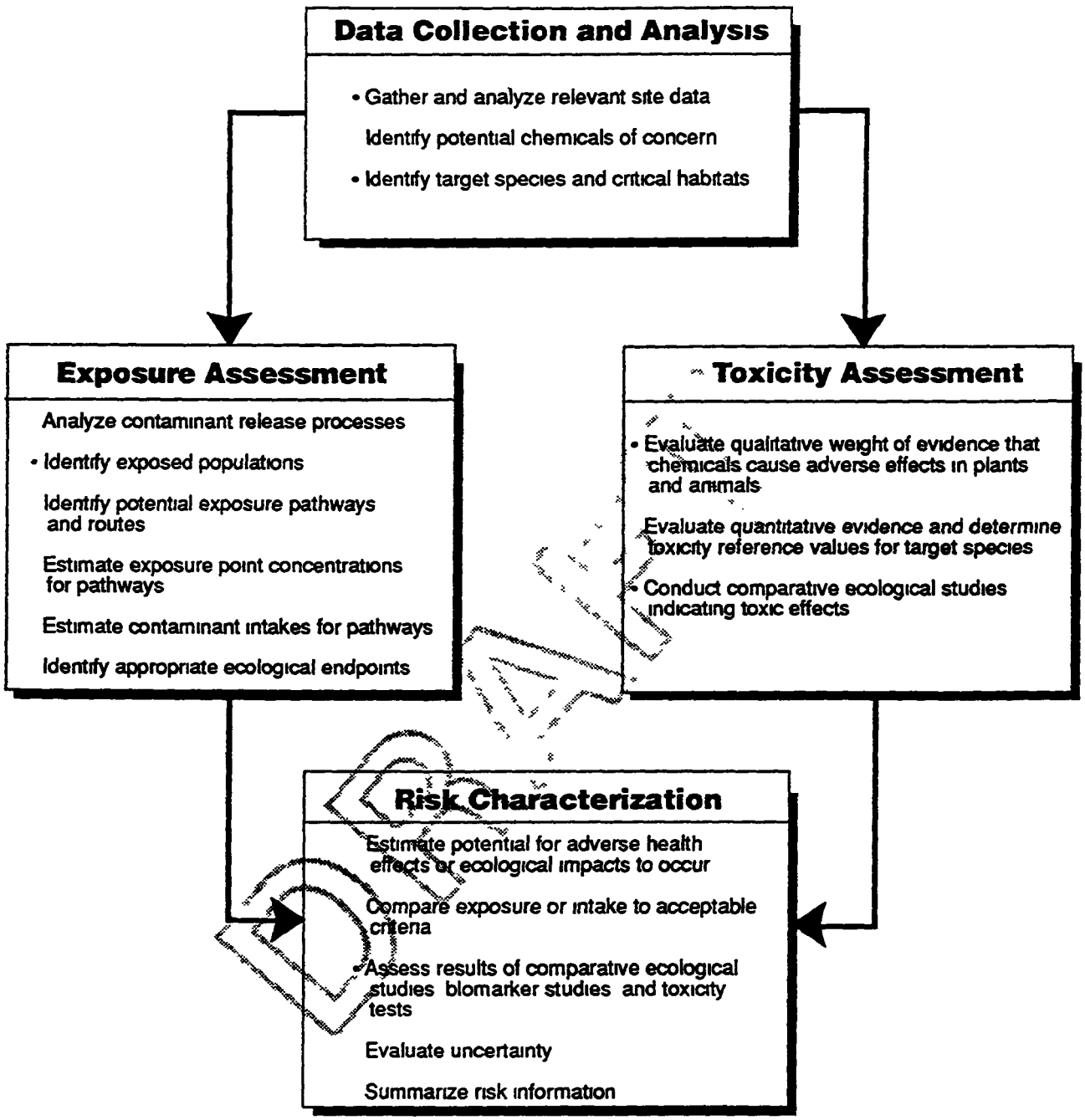

Figure 8-1
MAJOR STEPS IN DEVELOPING AN ECOLOGICAL RISK ASSESSMENT

DRAWN BY Douvill 6/24/91
CHECKED BY P Smith x 2516 6/24/91
APPROVED BY KAW 6/25/91
DRAWING NUMBER 901-A

TABLE 8-1
EXAMPLE U S. ENVIRONMENTAL PROTECTION AGENCY AND U S DEPARTMENT OF ENERGY GUIDANCE DOCUMENTS AND REFERENCES FOR FIELD INVESTIGATIONS AND ENVIRONMENTAL EVALUATIONS

Barnthouse, L. W, Suter, G. W, Bartell, S M., Beauchamp, J J, Gardener, R. H Linder, E., O'Neill, R V, and Rosen, A. E., 1986, "User's Manual for Ecological Risk Assessment," Environmental Sciences Division, Publication No 2679, ORNL-6251

DOE, 1988, "Comprehensive Environmental Response, Compensation, and Liability Act Requirements," DOE Order 5400 YY, Draft September 1988

DOE, 1988, "Radiological Effluent Monitoring and Environmental Surveillance," DOE Order 5400.XY, Draft September 1988.

DOE, 1990, "Radiation Protection of the Public and the Environment," DOE Order 5400.5

EPA, 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final," Office of Emergency and Remedial Response, Washington, D C, EPA/540/G-89/004

EPA, 1988, "Superfund Exposure Assessment Manual," Office of Emergency and Remedial Response, Washington, D C, EPA/540/1-88/001

EPA, 1988, "Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-88/003.

EPA, 1988, "Technological Approaches to the Cleanup of Radiologically Contaminated Superfund Sites," Office of Research and Development, Washington, D C, EPA/540/2-88/002.

EPA, 1989, "Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual, Interim Final," Office of Emergency and Remedial Response, Washington, D C, EPA/540/1-89/001

EPA, 1989, "Ecological Assessment of Hazardous Waste Sites, A Field and Laboratory Reference Document," Environmental Research Laboratory, Corvallis, Oregon, EPA/600/3-89/013.

EPA, 1989, "Exposure Factors Handbook," Office of Health and Environmental Assessment, Washington, D C EPA/600/8-89/043.

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prevailing winds, and surface and groundwater flows (see Figure 2-1) The information developed for the EEs at OUs 2 5, and 6 will be coordinated with data collected at OU 3

8 1 3 Scope of the Environmental Evaluation Work Plan

The principal focus of this EEWP is on the basic methodology and implementation for performing an ecological assessment as described in Subsection 8 2 The methodology has been developed based on the present evaluation of the data and information available and assembled in the synthesis of historical information (DOE 1991a, 1991b) The ecological assessment process prescribed has been used at other sites and in other situations and is generally accepted by the scientific community

The basic components in the EE methodology described in this EEWP are the following

- Data evaluation and field investigations to develop a data base adequate for characterizing the site and contaminants at OU 3 and assessing the potential effects on the plant and animal populations in the area

- Site characterization, including descriptions of plant and animal communities within OU 3, and assessment of physical and chemical characteristics governing the uptake or transport of contaminants

- Exposure assessment, including selection of contaminants of concern, identification of the populations at risk, evaluation of fate and transport of contaminants, and identification of the main exposure pathways and contaminant intake processes

- Toxicity assessment, including estimating exposure and intake of contaminants to compare to acceptable doses or toxicity reference values, and measuring ecological endpoints" to determine biotic responses to contaminants

- Determine ecological consequences using comparative ecological studies and bioaccumulation studies

- Risk characterization, to estimate the potential occurrence of adverse ecological effects, and evaluate the uncertainties associated with the estimates

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The environmental evaluation, as described in the EEWP, will also draw conclusions about whether or not EE objectives were achieved The expected results of the EEWP will determine in both a quantitative and qualitative sense the actual or potential risk to biota of exposure to the known contaminants identified in OU 3--principally plutonium. The EEWP will demonstrate a reasonable determination of risks based on validated concentrations, actual and expected exposures and intake, and site specific data. It will also identify the limitations and uncertainty of the analysis.

Of particular concern is the lack of studies on uptake and effects of plutonium on plants and animals in natural or managed ecosystems at the concentrations measured to date on OU 3. Previous studies of the lack of mobility and fixation of plutonium in environment, and the low uptake by organisms pose a special problem in determining effects on biota (Whicker et al, 1974, Amer and Rai, 1978,) The demonstration of a lack of effects at the concentrations measured and expected on the offsite areas will require basing estimates of risk on reasonable assumptions. Radiological risks to biological receptors in natural ecosystems or outside laboratory experimentation are not well understood, and the methodology presented here has been developed taking into account these difficulties.

EEWP implementation of the basic methodology is presented in the following Subsection 8.2 as separate tasks.

8.2 ENVIRONMENTAL EVALUATION METHODOLOGY AND IMPLEMENTATION

This section identifies and discusses the principal components of the Environmental Evaluation for OU 3. They are presented as tasks in the sequence that would normally be followed in performing an EE, although interaction among the components is necessary and some procedures may be conducted simultaneously. Some tasks must necessarily be completed before others can start. The principal components and tasks of this EE will be the following

- Task 1--Data Evaluation (Subsection 8.2.1)
- Task 2--Qualitative Field Surveys (Subsection 8.2.2)
- Task 3--Site Characterization (Subsection 8.2.3)
- Task 4--Site-Specific Field Investigations (Subsection 8 2.4)
- Task 5--Exposure Assessment (Subsection 8.2.5)
- Task 6--Toxicity Assessment (Subsection 8.2.6)

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- Task 7–Ecological Consequences (Subsection 8 2 7)
- Task 8–Risk Characterization (Subsection 8 2 8)
- Task 9–Environmental Evaluation Report (Subsection 8 2 9)

The first three tasks can be conducted simultaneously and based on this information tasks 4 to 6 can be revised or additional work scoped Tasks 2 and 4 must, by necessity be conducted at the appropriate season, and must have the methodology and protocol already established Tasks 7 and 8 are a synthesis of the preceding tasks that require them to be completed prior to determining consequences and characterizing risks Task 4 the site-specific field investigations, will be conducted at the same time and coordinated with the water soils and sediments studies of the general RFI/RI work as presented in the field sampling plan given in Section 6

8 2.1 Task 1–Data Evaluation

The existing physical and chemical data and information for site characterization pertaining to OU 3, as well as the extent and distribution of contaminants in the immediate vicinity, are evaluated and summarized in two recent DOE reports the Final Past Remedy Report (DOE 1991a) and the Historical Information Summary and Preliminary Health Risks Assessment (DOE 1991b) These two reports summarize several previous studies of the offsite area east of RFP and include a qualitative human health risk assessment for the four IHSS's identified These prior investigations specifically targeted offsite contamination as a result of past releases from RFP, primarily plutonium and its degradation product, americium As documented in these reports data on other types of contaminants are limited, and the data from the earlier reports generally do not meet current quality control standards to support a rigorous quantitative health risk assessment These documents do not discuss environmental risks, and have not presented or summarized the information available on biotic studies or terrestrial and aquatic ecosystems

A number of other reports and data resources will be reviewed for general and data-specific information for the ecological risk assessment These include reports by federal, state and county agencies studies by local universities that are currently being or have been conducted for DOE, and ongoing programs at Standley Lake such as the limnological study by USGS and studies/ sampling for the Standley Lake Diversion Canal The collection and review of the existing data base on terrestrial and aquatic ecosystems wetlands and flood plains threatened and endangered species soils and other topics will in itself be a significant task It will guide how each of the subsequent tasks are to be conducted The information and data reviewed will be systematically

evaluated and entered into a data base system to be set up as a portion of Task 1 The information collected will be evaluated for usability, and will be systematically entered into categories based on abiotic ecosystem components, type of ecosystem, and biotic species or population

Site-specific information and the scientific literature will be reviewed and analyzed to provide a comprehensive data source for the EE The data evaluation and analysis task will review the existing data base to determine, among other things, the following information

- The identification and concentration of possible additional contaminants of concern and understanding the fate and transport of these contaminants (radionuclides and possibly heavy metals)

- Site-specific characteristics (climatology, surface water, groundwater, soils, geology, hydrology, geochemistry, and terrestrial and aquatic ecosystems) related to the release, transport, and uptake of contaminants.

- The adequacy of data and additional data needs.

- The identity of the plants and animals that make up the living component of the ecosystems and determining the mechanisms that result in the exposure to contaminants and uptake by biota.

- The assessment of the toxicity or other effects of the contaminants on the living organisms at OU 3.

- The estimated potential or actual adverse effects on the plants and animals that result from exposure to site contaminants.

Site-specific (offsite of the RFP) and operable unit-specific (OU 3) data collected during the previous reports or prior studies by DOE and the RFP operating contractors also will be reviewed and evaluated These data and reports will be collected and analyzed as source documents and will help to define additional data requirements for the field sampling plans. Likewise, scientific literature on the general area and scientific information on ecological processes related to this assessment (such as the mobility of plutonium in terrestrial and aquatic ecosystems) will be reviewed. This RFI/RI investigation will provide the majority of the site-specific data needed on surface water,

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groundwater, soils, and air quality (see Section 6 0 of this document) Previous environmental studies should provide the general ecological information However site-specific ecological data and estimates of contaminant transfer within the OU 3 area are additional investigations to be conducted during the field investigations

The following sources will be used to acquire general information and site specific data this information will be incorporated into the data base established for the site

- Project and data files maintained by Rockwell International and EG&G, including but not limited to the background (geochemical) characterization studies and the annual environmental surveillance program reports including offsite areas

- Studies on radionuclide uptake retention, and effects on plant and animal populations conducted by the University of Colorado and Colorado State University on the RFP and on OU 3

- The Rocky Flats Environmental Impact Statement data base

- Sampling results from ongoing RFI/RI programs at Operable Units 1, 2, 5 and 6 including ecological investigations similar to those proposed here for OU 3

- The scientific literature, including ecological and risk assessment reports at the following DOE facilities Oak Ridge National Laboratory Los Alamos National Laboratory, Brookhaven National Laboratory, and the Nevada Test Site

This data review/evaluation task will culminate in a working document that will summarize the cumulative inventories of flora and fauna in the OU 3 area, present preliminary exposure pathways to the biological receptors, and identify sensitive populations The existing files on threatened and endangered species will be summarized and contacts will be made with the U S Fish and Wildlife Service, Colorado Division of Wildlife and the Natural Areas Inventory Program to update files if needed The working document will be used to communicate to DOE the principal data gaps that exist relative to the ecological risk assessment. The contaminants of concern and target species for the EE are proposed in this EEWP, but these groups will be re-evaluated using the additional information acquired in Tasks 1 and 2

8.2.2 Task 2--Qualitative Field Surveys

Qualitative field surveys will be conducted early in the process since the main objective is to obtain site-specific information on the biological resources, land uses, and boundaries The actual occurrence of ecosystems and habitat types will be reviewed in order to refine the quantitative sampling program and complete a "reality check" on exposure pathways. An initial qualitative field survey will be conducted before this work plan is finalized. The results will be used to refine the EE field investigations. Additional qualitative surveys in the spring, summer, and autumn will be conducted as part of the quantitative program Winter surveys are optional, depending on the results of the earlier surveys. Field surveys will also be used to select the best locations for reference areas and for non-routine or special areas, such as "hot spots." In particular, areas of wind-blown debris, snow accumulation on lee slopes, and wetlands that may concentrate contaminants will be located and evaluated for sampling. These areas may fall outside of the systematic sampling areas, and require locating and sampling as non-routine areas.

The qualitative field surveys will be conducted by qualified terrestrial and aquatic ecologists. Some field instruments (specified in Subsection 6.3 of this document) will be used to assist in locating potential contaminant impacted areas, although most information will be acquired through visual observations. Relative densities (cover) and types of vegetation in different areas at and near OU 3 will be noted. Field biologists will perform the following tasks.

- Record all observations of animal sightings and animal signs such as nests, burrows, and scat

- Record locations of any sensitive habitats and wetlands

- Note any visual evidence of stressed vegetation or unusual conditions

- Assess the suitability of different habitat types to support aquatic and terrestrial communities

- Use field instruments to measure conditions such as differences in pH and conductivity in surface water

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Details of field observations will be recorded in field logbooks Subsection 6 3 specifies details on the quantitative investigations

The qualitative field surveys will also be used to identify and map critical habitats search for threatened and endangered species map major prairie dog colonies confirm the presence and distribution of key species assist in exposure pathways development, select reference (control) sampling locations and fine-tune the quantitative sampling program.

8 2 3 Task 3—Site Characterization

The areas within OU 3 outside the RFP boundary will be described in terms of site characteristics that influence contaminant transport, exposure and uptake Surrounding land features that control pathways to the local ecosystems will also be characterized The site physical features that are important for the EE are general topography and surface configuration, gradients of drainage wind and weather patterns, geology, sediment, soils and substrate conditions, and groundwater Current land use and future development are also important with respect to the source materials deposited on soils and in sediments and their potential for release and transport. Conceptual site models for the site ecological factors and ecosystems necessary as a framework for conducting and evaluating information will be developed during this task These site models will define the components and processes important for the ecological risk assessment

The biotic and abiotic components of the existing ecosystems will be described and analyzed to assist in determining the impacts associated with the presence of contaminants. This process includes characterizing the principal site factors or abiotic components in the area (see Subsection 8 2.3 1) and describing the biological populations that are at risk (see Subsection 8 2.3 2)

8 2.3 1 Site Factors

Offsite areas will be characterized in detail for topography and other site parameters based on information from the previous studies and information developed during this RFI/RI Information on the physical properties of the soil and sediments and the soil types within OU 3 will be collected to determine the potential for contaminant release and migration (refer to Data Needs S-2, S-3 and SED-1 in Table 5-1 and Table 6-1) The airborne pathway has been determined as a significant potential for re-entrainment of plutonium in soils and exposed sediments (Data Need SED-3 in

Table 5-1) and exposure in the local ecosystems (DOE, 1991b) The geology, surface drainage, and groundwater hydrology of the OU 3 area will also determine possible contaminant fate and transport mechanisms

The remediation measures already instituted, and other proposed activities, may change the potential for wind and water erosion as well as surface characteristics, percolation, infiltration, and surface and groundwater flow The anticipated changes in the land use and future development will be examined for effects on site characteristics.

8.2.3.2 Ecosystem Characterization

In general, there are three levels of ecological organization to be characterized populations, communities, and ecosystems. Each level has its own dimensions of extent, structure, and change. This EEWP places emphasis on assessing impacts at the population and community levels in terrestrial and aquatic ecosystems because the ecological endpoints generally can be more precisely measured at these levels. For example, population dynamic parameters (such as mortality and recruitment), and community endpoints (such as species diversity and productivity), may be used to assess the impacts of contaminants. However, ecosystem level endpoints will be measured where appropriate For example, variations in soil nutrients may provide a sensitive endpoint. At the concentrations of contaminants expected in OU 3, ecological effects will most likely be detected at the individual organism or population level, and as bioaccumulation factors. Effects to be expected will be determined from literature and or from other studies conducted at the concentrations measured at OU 3. In determining the effects of the contaminants on biota, an understanding of the chemical, energy, and nutrient cycles in the ecosystems will help describe and analyze contaminant uptake, and determine if uptake and transport in the food chains is possible

The area within OU 3 has had a variety of uses and disturbances: the cultivation of irrigated crops and dryland grains, rangeland grazing, and the development of canals, and reservoirs, roads, and housing Much of the area is disturbed to the point where no natural ecosystems are present, or those that are present have been modified.

Terrestrial ecosystems at OU 3 that have not been disturbed or developed for use include prairie grasslands on alluvial flats and uplands; and alluvial fans interspersed with wetlands, creek drainages, and riparian zones. Animal populations are the indigenous species in the area, and some domestic livestock. Aquatic ecosystems include intermittent streams, reservoirs, and some

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ponds and canals that have been constructed within the drainages for runoff control and water retention purposes The ecosystems present within OU 3 will be inventoried and described (refer to Data Needs B 1 through B-6 and AQ-1 through AQ-6 in Table 5-1)

The terrestrial portion of OU 3 is in IHSS 199 designated as Contamination of Land Surfaces There are no natural preserves, although some areas are now being maintained as open space by Jefferson County and the City of Broomfield Prairie dog populations are expanding affecting large areas of vegetation and are making revegetation of remediated areas difficult. Standley Lake Great Western Reservoir, Mower Reservoir (IHSS 200 to 202), and Woman and Walnut Creeks that flow off the RFP are the principal aquatic ecosystems Canals and diversion ditches within OU 3 are also part of the aquatic ecosystems

The OU 3 area will be characterized using current surface and substrate conditions, citing drainages and bodies of water, and noting plant and animal species that have persisted or reinvaded the area. In the diverse areas around RFP, the ecosystem characterization process will include inventorying and characterizing the terrestrial and aquatic biota, describing the habitats that support the growth and existence of these biota, and defining the general flow of nutrients and energy through the food webs Types and amounts of disturbance will be categorized, and their effects on local vegetation, animals, and aquatic ecosystems determined In contrast to other operable units at RFP, the offsite areas have three reservoirs that are used as sources of municipal drinking water or irrigation water Standley Lake is also a heavily used recreational area. These reservoirs support populations of fish

8 2.3 3 Aquatic and Terrestrial Population

Field investigations and existing reports will be used to determine which species of plants and animals make up the major biological components of the OU 3 ecosystems (refer to Data Needs B-1 through B-5 and AQ-1 through AQ-6 in Table 5-1) The primary objective will be to measure the characteristics of major aquatic components, vegetation communities and animal populations in the area. The amount, type reliability, and currency of the data may vary according to species, time, and place The inventory of biotic species will be comprehensive and based on existing reports plus field sampling and investigations Certain species (target species) and populations will be selected for detailed study based on criteria including but not limited to the following

- Their value as habitat quality indicators

- Their role in the food chain

- Their local ecological significance and public interest in the species/population

- The potential for the species/population to accumulate or be exposed to contaminants

- The potential for the species/population to be impacted, and the ease of measuring the impact or stress

- The potential future conflict with land use, development, or remediation activities

- The critical nature of the habitat or sensitivity of the species/population (such as wetlands or species likely to be used as food such as fish or local crops)

Each species or population selected for detailed study (the target species) will be inventoried to produce information with the degree of reliability needed to effectively evaluate ecological impacts. Potential target species that may be used in an ecological assessment at OU 3 are listed in Table 8-2. Not all of these species will necessarily be considered during this planned assessment.

8.2.3.4 Habitats

An "available habitat" is defined as the surface area capable of providing direct life support for an evaluation species (U S. Fish and Wildlife Service, 1981a), or "habitat" is the combination of biotic and abiotic features that determine the distribution of a species within its geographic range (Ecology SOP No 5 11) Habitat types on OU 3 will be identified and delineated according to the protocol established in Section 5.11 of the Ecology SOP The areal extent and potential for impacts resulting from contaminants at OU 3 on available habitats and their ability to support biotic populations will be assessed (refer to Data Needs S-3, B-1 through B-6, and AQ-1 through AQ-6 in Table 5-1) Care will be taken to separate normal and human-related impacts from RFP contamination. Factors that may potentially affect habitats present at OU 3 will be addressed and include

- Physical disruption of the habitat, if any, attributed to contamination

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Table 8-2

POTENTIAL TARGET SPECIES AND HABITATS FOR ASSESSMENT OF ECOLOGICAL IMPACTS AT RFP OPERABLE UNIT NO 3

Community/Population	Species/Organism
Periphyton	• Diatoms • Green algae • Blue-green algae
Benthic Macroinvertebrates	• Mayflies • Caddis flies • Chironomids
Fish	• Sun fish • Minnows • Bullhead • Walleye • Smallmouth bass • Channel catfish
Herbivores	• Deer mice • Northern pocket gopher • Microtines • Prairie dog
Carnivores	• Long-tailed weasel • Red fox • Coyote
Grasses	• Western wheatgrass • Blue grama
Shrubs/Forbs	• Yucca • Snowberry • Sumac
Trees	• Cottonwood
Wetlands	• Willows • Cattails • Sedges • Rushes

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- **Physical or chemical disturbances** or destruction attributed to cleanup or remediation activities

- **Direct or indirect exposure** to site-related contaminants because of transport from the source

- **Physical disruption** of ecosystem processes because of contaminant interference with natural biochemical, physiological, and behavioral processes

- **Other stresses** not directed related to the RFP contamination, such as extreme weather conditions or excessive grazing

The areal extent of these habitats will be measured to determine major and minor habitats. Other measurements, if needed to assess habitats effects, will be determined during the qualitative field surveys.

8.2.3.5 Food Webs

Energy and nutrients flow through ecosystems by means of complex interactions between organisms known as food chains and food webs. Food chains describe the transfer of energy and nutrients from one organism to another as one consumes or decomposes the other Food chains selected for the EE generally represent the five major trophic levels:

- Primary producers
- Primary consumers (herbivores)
- Secondary consumers (carnivores or omnivores)
- Tertiary consumers (carnivores)
- Decomposers

The biotic species selected as target organisms for the OU 3 EE will include those which may accumulate or absorb the contaminants of concern The major contaminant of concern known from previous studies is plutonium, which is deposited by wind as particles. Plutonium is relatively immobile in the environment and is not accumulated by living organisms (DOE, 1991a and 1991b) Contamination of biota by plutonium in soils and sediments will be the result of resuspension by wind or water and deposition on surfaces or passive uptake The biotic components most likely to

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be contaminated by this route are foliar surfaces of land vegetation and phytoplankton in the reservoirs both primary producers Primary consumers will be studied if a link exists to contamination of primary producers Secondary and tertiary consumers and decomposers will not be investigated during this study Large herbivores such as deer, will use the OU 3 site only on an occasional basis They are not specific to any one area and will be studied on a regional basis on and in the vicinity of RFP

Food webs are interconnecting food chains Food webs more realistically describe the complex system of pathways by which the flow of energy and nutrients, and also contaminants, take place in nature A general discussion will be included to explain how the selected food chain components interrelate with the aquatic and terrestrial and below ground ecosystems found at or in the vicinity of OU 3

8 2.4 Task 4—Site-Specific Field Investigations

An evaluation of the existing data for the offsite areas of OU 3 contained in available reports (DOE, 1991a and 1991b), indicates that completion of the EE requires that additional data be collected during the RFI/RI activities For the EE these requirements include the following

- **Source characterization**, including presence, absence and concentration gradients of potential site contaminants (refer to Data Needs S-2 and 3 SED-3, SW-1 and 2 in Table 5-1)

- **Exposure pathway characterization**, including contaminant release or resuspension media transport, and receptor exposure mechanisms (refer to Data Needs A-1, S-2 and 3, SED 1-3, SW1 and 2, B-1 to 6, AQ-1 to 6 in Table 5-1)

- **Determination of the presence**, absence, and distribution of receptors (refer to Data Needs B-1 to 6 AQ-1 to 6 in Table 5-1)

- **Assessment of toxicity** or stress on terrestrial and aquatic ecosystems present at the site

Additional data will be collected on the aquatic and terrestrial biota in order to develop an understanding of the population dynamics within these communities Specifically, information will be

developed in the field on species diversity, biomass, sensitive habitats, and food webs All of these data will be needed to characterize populations and assess the potential effects of contaminants (refer to Data Needs B-1 to 6, AQ-1 to 6 in Table 5-1)

The physical and chemical data required for the EE will be available primarily from the soil, sediment, and water portions of the RFI/RI field investigations Specific physical and chemical data required for developing exposure pathways, such as the soil properties or bioavailability of certain metals, are included as components of the RFI/RI plans. The processes by which plants and animals absorb the contaminants from soils or water will be determined in Task 1 and incorporated into the RFI/RI field plans as an EE field investigation. Therefore, all aspects of the field programs will be closely coordinated.

The general biological components of the offsite areas have been described by previous investigations (DOE 1980, 1991a, 1991b) However, more site-specific data (those specific to OU 3) must be acquired to determine biological receptors. In addition to verifying the presence and distribution of receptors, specific information on the uptake or possibly bioaccumulation of contaminants must be acquired to adequately assess their toxicity or effects. This will be accomplished by using the scientific literature to the extent possible and supplementing that resource with site-specific investigations where necessary.

Once Tasks 1 and 2 (Subsections 8.2.1 and 8.2.2) have been completed and the additional data needs specified, the detailed field sampling plan for the EE given in Section 6.0 of this document will be reviewed and modified if necessary The plan describes sampling techniques, field instrumentation, and data management.

In many cases, there is not enough information in the existing literature to estimate intake rates, understand how contaminants are metabolized, or define acceptable intake levels. This is true for the concentration levels of plutonium already measured or expected on OU 3, with averages estimated at 0 085 to 22.1 picocuries per gram (pCi/g) (DOE 1991a, 1991b) In these cases, it may be more appropriate to develop a field program to measure an indicator of contaminant stress (toxicity) rather than undertake the extensive laboratory and field studies needed to assess the toxicity using the quantitative dose-response approach. These indicators of contaminant stress are referred to as "ecological endpoints." Rather than trying to assess toxicity itself, the ecological endpoint approach measures a specific end result of toxicity, such as a decrease in the growth of

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plants or a change in the relative abundance of species that are sensitive or insensitive to certain contaminants

Therefore the site-specific EE field investigations will incorporate a field sampling program to perform the following

- **Acquire site-specific data** needed to assess toxicity (to fill data gaps in the existing literature)

- **Measure toxicity directly** in aquatic organisms using water collected from the site

- **Measure concentrations of contaminants** in aquatic and terrestrial organisms for bioaccumulation, and determine from existing literature if these concentrations are indicative of stress

- **Measure indicators of stress** (ecological endpoints) using comparative ecology studies

The general field programs for measuring toxicity directly, and for the comparative ecology and bioaccumulation investigations, will be conducted in this study If the field investigations indicate that other programs are needed for assessing ecological effects, then programs will be set up for a subsequent study The field sampling program and plan to acquire data needed to complete a EE and assess toxicity is in Section 6 0 of this document. Because the site-specific field methods, sampling procedures, and analytical techniques are so critical to the scientific credibility of the EE, additional details on the aquatic and terrestrial field methods are given Subsection 6 3 6

The EE sampling methods will conform to the guidance provided in the Ecology SOP, and sampling protocol references listed in Table 8-1 the quality assurance health and safety, and sampling protocols used at the RFP (EPA, 1989c 1989d 1989e), and the references cited in Section 12 0 of this document. Evaluation techniques will include a comparison of concentrations measured in environmental media and biotic samples against criteria, toxicity values, and bioaccumulation factors found in literature Field studies will also include measuring bioaccumulation and toxicity directly and conducting comparative ecological studies Each of these techniques contributes a different type of information to the evaluation Information from the different techniques can be used to accumulate weight-of-evidence to support conclusions

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8.2.4 1 Toxicity Evaluation

The actual or potential toxicity of contaminants at sampling stations within and near OU 3 will be assessed using three approaches a comparison of contaminant concentrations at exposure points to criteria or standards, a comparison of existing concentrations to toxicological endpoints presented in the scientific literature, and actual toxicity tests. Subsection 8.2.6 discusses the comparison of onsite contaminant concentrations to criteria and other toxicity endpoints from the literature, and provides additional information on toxicity test methods.

A comparison of onsite concentrations to criteria or toxicity values will not be sufficient to assess the potential impact of those contaminants for which there are no criteria or toxicity values appropriate for the plants or animals being considered. Also, the comparison approach does not account for potential synergistic/antagonistic effects in complex mixtures and may not adequately reflect the real bioavailability of the contaminant or the physical and chemical nature of the environmental medium. For this reason, a limited toxicity testing program will be conducted as an initial phase. If patterns of toxicity are encountered, a second phase of toxicity testing will be designed and implemented.

The initial toxicity testing program will be limited to aquatic organisms and will include standardized acute and chronic tests with fathead minnows and *Ceriodaphnia* (EPA, 1985a, 1985b, 1989e) Comparisons will be made to similar tests at other OUs. Water samples for toxicity tests will be collected from one station in each of the three reservoirs (Great Western Reservoir, Mower Reservoir, and Standley Lake) and from stations above and below the reservoirs on the OU 3 streams. Figure 6-7 presents these proposed stations and reservoirs. Station locations may be modified after the field reconnaissance. The toxicity tests will be run during both wet- and dry-season conditions because the influence of groundwater may vary significantly under different flow conditions.

The potential for a toxicity test involving soil and a terrestrial organism will be evaluated If a standard method is available using a species known to occur at RFP, toxicity tests will be conducted at reference and test areas. Toxicity tests developed for soil microbes, earthworms, crickets, and grasshoppers will be evaluated (EPA, 1989e)

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8 2.4 2 Comparative Ecology Studies

Ecological field surveys involving comparisons of impacted and nonimpacted areas are a definitive and quantitative way of establishing that ecological impacts have occurred (refer to Data Needs B-4 to 6, AQ-4 to 6 in Table 5-1) However, care must be taken to account for differences in the physical and chemical aspects of the reference and test areas as well as natural variations exhibited by biological populations Ecological "endpoints" will be used to assess contaminant impacts To maintain a valid comparison, reference areas will be selected that (1) are on or in close proximity to the OU 3 area, (2) closely resemble OU 3 in terms of topography, soil composition water chemistry, and other parameters listed in Ecology SOP No 5 13 and (3) have no apparent exposure pathways from the RFP or other sources of contamination

Comparative ecological studies will be directed at two terrestrial communities (small mammals and prairie vegetation) and three aquatic communities (periphyton, benthic macroinvertebrates, and fish) These communities are appropriate because

- There is extensive scientific literature available for interpreting results and making conclusions
- The communities exist in impacted and nonimpacted areas
- Standard field techniques have been developed to measure the necessary community parameters such as productivity and diversity
- Field investigations can be completed at reasonable costs

If sampling of contaminants in soil or water indicate whether other pathways are important other terrestrial components such as roots and soil microbes may be added

Parameters such as relative abundance species diversity, community organization biomass or productivity, reproduction, and growth rates are quantitative parameters that can be used to compare the populations or communities at reference (nonimpacted) sites with those in contaminated areas in or near OU 3 Reference areas and contaminated areas will be carefully selected to minimize the influence of chemical and physical differences

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8 2.4 3 Bioaccumulation Studies

Bioaccumulation analyses will be conducted for plutonium and selected metal contaminants using the same two terrestrial communities used for the comparative ecology studies, plus the benthic macroinvertebrates and fish. Because these organisms live in direct contact with the contaminated media (water, sediments, and soil), they are the most likely candidates to exhibit bioaccumulation. Samples will be collected from a limited number of stations that have exhibited prior contamination. If bioaccumulation is measured then the sampling program may be expanded.

Measuring the amount of a particular contaminant that accumulates in plant or animal tissue (bioaccumulation) is one of the most direct techniques for assessing potential impacts. The degree and frequency of bioaccumulation measured in onsite organisms will be compared to similar data in the literature. In addition, the ratio of the tissue concentration to the media concentration (the bioconcentration factor, or BCF) could be calculated and compared to BCFs in the literature.

8.2.5 Task 5–Exposure Assessment

The exposure assessment will describe how the potential contaminants are transported from source areas to the receptors, taking into account the environmental fate and transport of the contaminant through both physical and biological processes. The exposure assessment will also determine the susceptibility of different receptors to the contaminants at OU 3 because of (1) their proximity to areas with the highest contaminant concentrations, (2) the receptor's reliance on contaminated food, or (3) the receptor's presence in contaminated habitats for long durations. The exposure assessment process involves (1) developing exposure pathways for the OU 3 contaminants of concern and target species (receptors) identified during Tasks 1, 2, and 3 earlier in this section, (2) determining logical exposure points for each receptor and measuring or estimating the concentrations of the contaminants at those exposure points, (3) estimating the uptake of the contaminants by the receptor, and (4) identifying appropriate ecological endpoints (see Figure 8-1) The exposure assessment will use site-specific data and available information in the scientific literature to address the following questions

- What receptor(s) are actually exposed to contaminants from OU 3 from site specific data? (Refer to Data Needs B-1 to 6, AQ 1 to 6 in Table 5-1)

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- What are the significant routes of exposure at OU 3? (Refer to Data Needs S-1 to 3, SED 1 to 2 SW-1 to 2 GW-1 A 1)

- To what concentration of each contaminant are the receptor(s) actually or potentially exposed determined from site data? (Refer to Data Needs S 1 to 3, SED-1 to 2 SW 1 to 2, GW-1, A 1)

- How often will the exposure take place and what is the duration of exposure?

- What subpopulations, age groups or life stages are most susceptible (determined from the literature)

- What seasonal and climatic variations are likely to affect exposure? (Refer to Data Need A-1)

- What are the site-specific geophysical, physical, and chemical conditions affecting exposure? (Refer to Data Needs S-1 to 3, SED-1 to 2, SW-1 to 2, A-1)

8 2.5 1 Exposure Pathways

Exposure pathways will be developed to qualitatively describe how the contaminants of concern can be transported from their sources to the target receptors, and to determine if complete exposure pathways exist. The conceptual model developed for the site will identify potential exposure pathways A complete exposure pathway has five components All components must be present or exposure will not occur. These five components are

1. The contaminant source
2. A mechanism for contaminant release
3. An environmental transport medium
4. An exposure point (receptor location)
5. A route of exposure (such as ingestion and/or inhalation)

The most probable exposure pathways to the biological receptors within OU 3 will be assessed and several pathways will be selected for detailed analysis Pathways will be developed for the five transport media air soil groundwater, surface water and sediments These exposure pathways

will be evaluated and modeled where possible in the conceptual model. Since fish and wildlife derive a major portion of their food supply from vegetation or prey species, migration of constituents through the food chains at OU 3 must be incorporated into the exposure assessment analyses.

8.2.5.2 Exposure Points

Aspects of the life history of each target species, such as phenology, food habits, preferred habitat, and seasonal behavior will be evaluated to determine where the aquatic and terrestrial organisms will likely be exposed to contaminants at OU 3 This evaluation will be coupled with fate and transport information on the contaminants of concern to determine which contaminants are likely to be transported to which exposure points. An interactive process, based on the above information, will be used to identify the most logical exposure points. The exact exposure points will vary, depending on both the contaminant and the target receptor species under consideration as detailed in Section 6.0

After the exposure points have been identified, actual field measurements or fate and transport modeling will be used to estimate the concentration of each contaminant at the exposure point. This procedure will rely directly on the RFI/RI field program to provide measured concentrations at exposure points and/or provide input for modeling efforts. Where possible, the average and maximum concentrations for each contaminant will be measured or estimated to evaluate nominal and worst-case scenarios.

8.2.5.3 Contaminant Intake Processes

This subtask will evaluate the methods for contaminant uptake (such as inhalation or ingestion) for each of the target receptors from the environmental media (such as air or vegetation) under consideration. The amounts of chemical and radiological uptake will be estimated using appropriate conservative assumptions, site-specific data, and existing or forthcoming exposure methodology such as those in EPA's Superfund Exposure Assessment Manual, (EPA, 1988b) Published research will be used, where appropriate, to estimate intake rates for terrestrial vertebrates. This subtask, where possible, will estimate the quantity of contaminant taken up on a daily or longer-duration basis by the target receptors from the various environmental media via inhalation, ingestion, dermal contact, and other processes. This actual (estimated) uptake will be compared to an acceptable intake (or exposure) to assess risks.

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In the case of terrestrial vegetation and aquatic organisms the typical approach for comparing actual intake to acceptable intake of ingested or inhaled contaminants is not very appropriate Since vegetation is continuously exposed to contaminants in soil estimates of uptake are based on transport of contaminants from soil (and soil water) via the roots Incorporation of airborne contaminants deposited on leaves and other aboveground plant tissues must also be considered In the case of freshwater organisms the primary uptake mechanism for many contaminants is transfer of dissolved contaminants by absorption across the gill membranes or the integument Aquatic animals can also take in contaminants by ingesting contaminated prey and sediments, although these mechanisms are generally less important than direct uptake across gill membranes

Information derived from the exposure assessment will also be used to select sampling locations for toxicity tests and to determine which locations might be best for comparative ecology studies

8 2 6 Task 6—Toxicity Assessment

The purpose of the toxicity assessment is to weigh the available evidence regarding the potential for the contaminants of concern at OU 3 to cause an adverse effect on the target species. The toxicity assessment will be structured to provide answers to questions such as

1 What are the adverse effects of the contaminant?

2. How toxic is the contaminant to the receptors in question?

3 What environmental conditions influence the toxicity of the contaminant?

4 What relationships exist between the magnitude and frequency of the exposure and the increased likelihood and/or severity of the adverse effects?

5 What are the uncertainties involved in assessing toxicity?

8 2.6 1 Toxicity Profile

The toxicity profile will be developed primarily from existing scientific literature and describes the adverse effects that the contaminant may have on vegetation or terrestrial and aquatic animals This process will also include describing what factors may influence the toxicity of the contaminant (for

example, increasing water hardness decreases the toxicity of several metals) It will also determine possible adverse responses to the contaminant of concern, considering the abiotic and biotic environment at OU 3

8.2.6.2 Toxicity Values

The most fundamental concept in toxicology is that a relationship exists between the dose of an agent and the response produced in a living organism. The process of quantitatively evaluating the toxicity information developed in the toxicity profile (Subsection 8.2.6.1), characterizing the relationship between the dose of the contaminant received, and the incidence of adverse effects on the target species provides toxicity values that express this dose-response relationship These toxicity values can be used to estimate the incidence, or potential for adverse effects, as a function of receptor exposure to a contaminant.

Several different sources and types of toxicity values may be used to assess the toxicity of the contaminants at OU 3. These include reference doses, acute- and chronic-toxicity doses or concentrations, and ambient water quality criteria. For several chemicals, toxicological data have been evaluated by the EPA and other agencies and reference doses (RfDs) have been developed for noncarcinogenic effects, especially for humans (EPA, 1987c) The RfD, based on a survey of current toxicological literature, is an expression of the dose that is acceptable for a given receptor Therefore, a comparison of the estimated dose received by the receptor species at OU 3 and the RfD is a comparison between the actual dose received and the acceptable dose. In most cases, the RfDs have been developed for humans, but are based on laboratory experiments with small mammals. In these cases, the original laboratory results may be useful in determining a no observable adverse effect level (NOEL) that is applicable to small mammals.

Numerous laboratory and in-stream toxicity experiments have been conducted with aquatic organisms to determine what concentrations of a given contaminant cause adverse effects (EPA, 1987d) The results are frequently expressed as the concentration of the contaminant in water that causes a certain percentage of mortality over a given time period For example, the 96-hour LC_{50} is the concentration that kills 50 percent of the test organisms within a 4-day test period. Other experiments are designed to measure chronic effects over longer time periods, such as the concentration of a contaminant that causes a reduction in growth or reproduction in the test population. The results of chronic tests are sometimes expressed as the NOEL and LOEL. the

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highest concentration that causes no observable adverse effects and the lowest concentration that produces a significantly different response in the test and control populations

Similar experiments involving terrestrial animals are usually designed to determine what dose (intake per body weight per time) of a given contaminant will produce an adverse effect The results are frequently expressed as a LD_{50} and the lowest chronic dose to elicit an observable effect. These toxicity values will be compared to the concentrations of contaminants at surface water exposure points (for aquatic organisms) or estimated intakes of contaminated prey or vegetation (for terrestrial organisms) to assess the toxicity of contaminants at OU 3 In assessing toxicity based on experiments presented in the literature care must be taken to consider how the experimental conditions differ from the conditions at the offsite area, and how these differences may affect toxicity

Under the authority of the Clean Water Act EPA has developed federal water quality criteria for the protection of aquatic organisms Numerical criteria for more than 120 organic and inorganic contaminants have been published in EPA s Quality Criteria for Water (EPA, 1986a) Likewise, water quality criteria for protection of humans (and terrestrial animals) have been developed for sources of drinking water State regulatory agencies have utilized these criteria, as well as criteria from the Safe Drinking Water Act, to establish water quality standards for the protection of beneficial uses of state waters The EPA has also developed National Ambient Air Quality Standards (NAAQSs) for a few key air pollutants under authority of the Clean Air Act. Standards for many more toxic air pollutants will be developed under the Clean Air Act amendments of 1990 Other state and federal agencies have developed soil criteria for protection of agricultural lands or as goals for remediation of hazardous waste sites These water, air, and soil criteria/standards will be used if appropriate, as another set of toxicity values to assess the potential toxicity of OU 3 contaminants

In summary the toxicity assessment will describe the adverse effects associated with exposure to the contaminants at OU 3, determine the relationships between the magnitude of the exposures and their adverse effects and evaluate the uncertainties associated with the toxicity assessment process

8 2 6 3 Toxicity Tests

In some cases it will be easier to assess the potential toxicity of contaminants in soil and water at OU 3 by directly measuring toxicity Toxicity tests for a limited number of target species will be

conducted to supplement the toxicity assessments based on dose-response evaluations and comparison to criteria. The dose-response evaluations and comparison-to-criteria approach, addressing one contaminant at a time, do not incorporate potential synergistic or antagonistic effects that may occur when more than one contaminant is present. Likewise, these approaches may not reflect the physical and chemical nature of the receiving water or soil at OU 3 or the actual bioavailability of the contaminants. Therefore, direct measurement of toxicity using toxicity tests will provide important supplemental information to the overall toxicity assessment.

Toxicity tests will be conducted in the laboratory using water or possibly soil collected from OU 3 areas expected or known to be contaminated. For aquatic organisms, standardized acute and chronic tests using established EPA procedures will be conducted (EPA, 1985a, 1985b, 1989b) Toxicity tests developed for soil microbes, earthworms, crickets and grasshoppers will be reviewed and considered for assessing OU 3 toxicity to terrestrial invertebrates (EPA, 1989e)

8.2.7 Task 7—Ecological Consequences

When it becomes difficult, expensive, or impossible to develop quantitative dose-response types of toxicity values for the particular species or contaminant of interest (or too difficult to directly measure toxicity), an ecological consequences approach may be used to assess the adverse effects of a contaminant. Thus, the ecological consequences approach will be used at OU 3 in addition to the more typical toxicity assessment process. In the ecological consequences approach, an ecological endpoint is measured within an impacted population. The ecological endpoint is an indicator of an adverse effect on the exposed population. That measurement is then compared to the same endpoint in a nonimpacted population such as in a reference area.

This approach evaluates the possible relationship between the ecological endpoint (such as increased mortality or slower growth rate) and one or more of the site contaminants. The approach also provides an assessment technique for contaminants that are not directly toxic to plants and animals. For example, some contaminants may decrease the available oxygen in an aquatic ecosystem with catastrophic effects even though they are not directly toxic to the organisms.

The ecological consequences of a contaminant are frequently determined by measuring one or more ecological endpoints in a population exposed to onsite contaminants, and comparing these to the same endpoints in a control population at an unimpacted reference area. However, ecological endpoints for exposed populations can also be compared, in some cases, to information in the

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scientific literature to determine if the exposed population is affected Both of these approaches are referred to as comparative ecology studies

The ecological consequences of contaminants at OU 3 may also be assessed by measuring the bioaccumulation of certain contaminants within the tissues of individual organisms and comparing these levels with levels reported in the scientific literature Finally, the potential impact of some contaminants can be assessed by measuring the frequency of occurrence of certain biomarkers (such as skeletal abnormalities or presence of metal-binding proteins) in the exposed populations All three methods of evaluating ecological consequences--comparative ecology studies bioaccumulation, and biomarker monitoring--are discussed in the following subsections

8.2.7 1 Comparative Ecology Studies

The toxicity of a given contaminant to individual organisms can have consequences on biological populations, communities, and ecosystems For example a contaminant that increases susceptibility to predation or decreases reproductive success in individual organisms will cause a decrease in population size (a population is a group of individuals of the same species) The decrease in population size may, in turn change the relative abundance or distribution of that population with respect to other populations in the community (a community is a group of populations in the same location or habitat) The community change may, in turn, lead to ecosystem effects such as alterations in nutrient cycling

There is a general consensus that adverse effects of contaminants can be assessed by measuring ecological endpoints at the population level (EPA, 1989e) and to a lesser extent, at the community level However, it becomes increasingly difficult and expensive to measure consequences at the ecosystem level since the influence of a multitude of factors, in addition to the effect of the contaminant, come into play Therefore at OU 3 the comparative ecology studies will be designed primarily to measure population and community parameters There are, however a few ecosystem level endpoints such as changes in nutrient concentrations that can be useful endpoints

To effectively characterize the effects of contaminants on a population, one or more ecological endpoints should be selected These endpoints represent responses the population is expected to exhibit as a result of exposure to the contaminant in question Ecological endpoints at the population level would include decreases in growth rate and fecundity increases in frequency of disease or death rate or changes in the relative abundance of different life stages Ecological

endpoints should be selected based on the capability to measure the endpoint, consistent with objectives of the ecological study

Comparative ecology studies are one way of establishing whether an ecological impact has occurred in a quantitative sense. These studies may quantify the impact of site contaminants on populations and provide a means of evaluating the magnitude of the difference between impacted and nonimpacted populations. Comparative ecology studies at OU 3 will be directed at two terrestrial communities prairie vegetation and small mammals, and two aquatic communities. fish and benthic macroinvertebrates (see Subsection 6.3.6)

Vegetation surveys of prairie grass areas will be conducted by establishing transects in reference and contaminated areas and sampling transects and linear plots. Species abundance, cover class, biomass, and signs of stress will be used as assessment endpoints. Small mammal populations in prairie grass areas will be sampled by establishing trapping grids at impacted and reference sites. Live animals will be trapped during the spring and fall. The relative abundance of species, size classes or weight frequency distributions, total biomass, and signs of stress will be used as assessment endpoints. The field sampling methods are described in Subsection 6.3.6.

Fish and benthic macroinvertebrates at stations in Walnut and Woman Creeks upgradient and downgradient of the reservoirs in OU 3 will be sampled and compared to one or more reference sites on Rock Creek or the upper end of Woman Creek. The relative abundance of species and life stages, total density or abundance, presence of contaminant-tolerant species, and size of organisms will be used as assessment endpoints. The field sampling methods are described in Subsection 6.3.6.

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8.2.7.2 Bioaccumulation and Biomarker Studies

Some metals such as cadmium and organic compounds (such as PCBs) will accumulate in living organisms at concentrations much higher than in the media to which the organisms are exposed. One or more processes may be involved. For example, some organisms can convert the contaminant to a less toxic or nontoxic form and store it, or the contaminant may have an affinity for fatty tissue and preferentially accumulate in organs containing a high proportion of fat. Since the stored or accumulated contaminant may be converted to a nontoxic form, bioaccumulation does not necessarily equate to an increase in toxicity

The potential bioaccumulation of selected contaminants (radionuclides and metals) will be measured at OU 3 in fish benthic macroinvertebrates vegetation and small mammals such as praine dogs Bioaccumulation data will be used for the three purposes listed below

1 **Data from OU 3** will be compared to bioaccumulation levels in scientific literature to help evaluate the potential impact of the contaminants on the plants and animals that accumulate the contaminants

2 **Data at different trophic levels** will be evaluated to determine if OU 3 contaminants are being transferred within food chains If this occurs there may be significant impacts on higher predators such as hawks and fish

3 **Data for organisms** that serve as food sources for humans will be used in the human risk assessment process to determine if there are potential health risks from using these resources

Biomarker studies involve measuring responses in individual organisms which indicate that the organism has been exposed to a particular contaminant Generally a biomarker is a biochemical or physiological response that can be detected even at low-exposure levels Examples of biomarkers include a change in the frequency of a genetic abnormality, a histological change in tissue structure, or a physiological response, such as increased production of the metal binding protein metallothionein.

There are many advantages to using biomarkers in ecological assessments, including broad applicability to many taxonomic groups the ability to link field surveys to laboratory tests to interpret the significance of field results and the fact that some biomarkers are diagnostic of specific contaminants However there is currently a lack of accepted standardized, and tested biomarkers for many of the contaminants found at hazardous waste sites Also, the relationship between the measured biomarker response and population-level effects has not been defined in many cases Further, biomarker studies are expensive to conduct Therefore, no biomarker studies will be conducted during this ecological assessment effort. The existing scientific literature on biomarker monitoring will be reviewed to determine if this approach may be useful for the target species and contaminants of concern at OU 3 If biomarker studies could add to or support the assessment of risks in the offsite area, they may be proposed for successive studies

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8.2.8 Task 8—Risk Characterization

Information acquired during the field investigations at OU 3 (Tasks 2, 3 and 4, mentioned earlier in this section) and developed during the exposure assessment, toxicity assessment, and ecological studies (Tasks 5, 6, and 7, earlier in this section) will be used to characterize the risks posed by contaminants released from the RFP into OU 3 The evidence from these tasks that support conclusions that potential impacts on plants and animals within the offsite area are occurring or have occurred, or that no impacts are present will be evaluated. The risk characterization process will include the following.

- Comparing projected contaminant intakes to acceptable intakes
- Comparing exposure point concentrations to toxicity values in the literature, and other criteria and standards, if applicable
- Comparing ecological endpoints of plant and animal populations within OU 3 to reference populations
- Evaluating the results of direct toxicity tests and bioaccumulation studies

The risk characterization will present risk estimates for defined exposure scenarios, in addition to summaries of the relevant biological information, identification of the assumptions used and their limitation, and a discussion of uncertainties. The characterization will address risks associated with the contaminants of concern, plutonium and some metals.

8.2.8.1 Risk Analysis

The risk posed by contaminants released from OU 3 will be assessed using one or more of six different methods of analyzing risks to the environment:

1 Comparing exposure point concentrations to published criteria and toxicity values with known adverse effects

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2 Evaluating toxicity test data on laboratory organisms (such as mice or fathead minnows) to assess risks on actual populations in the reservoirs or terrestrial habitats at OU 3

3 Comparing the ecological endpoints for populations of plants or animals existing in contaminated areas to uncontaminated or "reference areas

4 Comparing estimated intake rates and reference doses for some terrestrial species to assess acceptable and unacceptable risks

5 Evaluating bioaccumulation levels

6 Applying quantitative fault/event tree analysis

8.2.8 1 1 Method 1—Comparing Exposure Point Concentrations. The first method involves comparing the concentrations of a contaminant at known exposure points to published criteria, or regulatory standards, or to concentrations or doses known to cause adverse or toxic effects (for example, an LOEL) As discussed in previous sections, the effects of chemical or radiological contaminants on populations in nature based on toxicity tests or epidemiological data, are not available in many cases Therefore, this comparison-to-criteria approach, employing criteria and toxicity values that have been established from the toxicological literature, is an important component in the process of characterizing risks

8 2.8 1.2 Method 2—Evaluating Toxicity Test Data. A second risk analysis method involves comparing or extrapolating data from laboratory toxicity tests of known contaminant concentrations on standard species, such as laboratory mice, to exposure concentrations on natural onsite populations, such as deer mice in the grassland within OU 3 Appropriate correction factors must be applied to incorporate variability among species and life stages, and account for differences between conditions in the laboratory and in the natural environment. This method will indicate what concentrations of a contaminant can be considered safe below which no adverse effects are expected to occur A logical refinement of this method would be to conduct toxicity tests on native species using water or soil from the OU 3 area, simulating environmental conditions as much as practical This method may not be feasible within the timeframe of this EE

8.2.8.1 3 **Method 3–Comparing Ecological Endpoints.** A third method is based on comparing onsite populations in known or expected contaminated areas to similar populations at reference (upgradient uncontaminated) areas. Population parameters (such as growth, reproduction, and mortality rates) or community parameters (such as species diversity, standing crop, and productivity) will be used to assess the differences between the populations in impacted and nonimpacted areas. At the concentrations of contaminants expected in the RFP ecosystems, this method may demonstrate that consequences are not present.

8.2.8.1.4 **Method 4–Comparing Estimated Intake Rates.** This method is essentially a dose-response approach similar to human health risk techniques, and uses acceptable intake rates from the literature. If the ratio of the estimated onsite intake to an acceptable intake exceeds 1 0 (unity) for the defined exposure scenario, there is an indication that the exposed species may be subject to an adverse impact. If the ratio is below unity, it is generally assumed that no adverse impact will occur This method is similar to the approach used for human health risk assessments.

8.2.8.1.5 **Method 5–Evaluating Bioaccumulation Levels.** In the fifth method, exposed populations will be examined for contaminant-specific bioaccumulation to determine if the contaminant is accumulating in the individual organisms that make up the population. The bioaccumulation factors that are of concern will also be compared to published sources for possible effects or concentrations that may affect the organisms.

8.2.8.1.6 **Method 6–Applying Quantitative Fault/Event Tree Analysis.** A sixth method for analyzing risk that will be considered for OU 3 is the use of fault/event tree analysis. This process examines the release scenarios, pathway analyses, exposures and possible consequences to the ecosystem in a step-by-step sequence. It uses logic diagrams in phased scenarios to which probabilities can be assigned. The risk of separate contaminants or the overall risks can be expressed as an annual probability of a consequence or effect. This is a quantitative probability method in which uncertainties can also be quantified

8.2.8.1 7 **Other Methods.** Other methods that have been used for ecological assessment, such as ecosystem modeling, are not appropriate for use at the offsite areas, at least during this RFI/RI These methods involve the use of computer simulation and require extensive field verification for assumptions in the modeling.

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In summary the potential risks from contaminants at OU 3 will be characterized by using several lines of evidence when possible None of the above six approaches are appropriate for characterizing risks for all the contaminants of concern or all the target species Also the use of just one approach will frequently provide an incomplete evaluation of risks Therefore whenever possible, several lines of evidence will be used to characterize the risks at OU 3 When several line of evidence support the same conclusion the weight of evidence will counterbalance the uncertainties inherently associated with these approaches

8 2.8.2 Uncertainty Analysis

All risk estimates are dependent on numerous assumptions and consideration of the many uncertainties that are inherent in the ecological risk assessment process In any evaluation of the level of risk associated with a site, it is necessary to address the level of confidence or the uncertainty associated with the estimated risk

Uncertainties are associated with both toxicity information (such as toxicity values and site-specific dose-response assessments) and exposure assessment information Consequently, factors that may significantly increase the uncertainty of the ecological risk assessment will be identified and addressed in a qualitative and where possible, quantitative manner

Three qualitatively distinct sources of uncertainty common to any ecological risk assessment are inherent variability, parameter uncertainty, and model error It is essential to distinguish between these uncertainty parameters since they differ with respect to feasibility of quantification and degree of possible reduction through research or environmental monitoring (Barnthouse et al 1986)

8 2 8 2.1 Inherent Variability Constraints on the precision with which variable properties of biological populations can be measured will limit the precision with which it will be possible to predict the ecological effects of stress. The concentration of a constituent in a medium also varies unpredictably in space and time because of unpredictable variation in meteorological parameters such as precipitation and wind direction Finally the space and time distributions and sensitivities to stress of a target species are similarly variable For the OU 3 risk assessment, analytical data will be used to determine containment concentrations in soils sediments and water, and help determine variability The variability of the physical environment that influences the contaminant s environmental fate can also frequently be quantified (Barnthouse et al 1986) The variability of natural ecosystems are both cyclic and in response to abiotic factors Individuals and populations

of plants and animals in complex ecosystems have genetic and behavioral variability in addition to physiological differences.

8.2.8.2.2 **Parameter Uncertainty** Errors in parameter estimates may introduce additional uncertainties. Parameters values from the scientific literature may be estimated from structure activity relationships or from taxonomic correlations that are not corrected for site-specific parameters. In addition, direct laboratory measurements may be subject to error Unlike inherent variability, however, uncertainties resulting from parameter error may be reduced by increasing the precision of measurement, or by replacing extrapolated parameter estimates with direct measurements where possible.

8.2.8.2.3 **Model Errors.** Model errors will constitute the last tractable source of uncertainty in the ecological risk assessment. Major sources of model error are (1) using a small variable to represent a large number of complex phenomena, (2) choosing incorrect functional forms for interactions among variables, and (3) setting inappropriate boundaries or limits on the model universe (Barnthouse et al., 1986) Although these errors cannot be completely eliminated, one of the objectives will be to reduce them as much as possible by model validation and checking against values determined during the investigations.

8.2.9 Task 9–Environmental Evaluation Report

The results of the EE will be presented in a clear, concise manner. The conclusions will be organized around the risks posed by contaminants from OU 3 to specific plant and animal species. Final conclusions will be based on lines of evidence from several assessment techniques. The conclusions section will include a discussion of EE objectives to determine if they were accomplished. Also, uncertainties associated with the EE will be presented, along with an evaluation of how these uncertainties influence the conclusions The EE will determine whether OU 3 presents an unacceptable environmental risk unless remedial actions are undertaken The criteria for determining what constitutes and unacceptable environmental risk will be developed during the EE process.

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The EE Report will have three basic uses It will be used to

- Determine the nature and severity of the environmental risk resulting from existing contamination conditions at OU 3 without further remedial action (the "no action" alternative)

- Provide information for comparison of alternatives and evaluation of potential environmental impacts of the remediation alternatives

- Prepare appropriate environmental documentation needed to comply with the National Environmental Policy Act (NEPA)

- Determine other environmental requirements such as habitat (wetlands) protection and rare and endangered species

The introductory sections of the EE will define the objectives and scope of the EE investigation and generally describe the physical and biological characteristics of the site Information from this EE and prior studies such as the OU 3 reports and previous field investigations will be used to refine the contaminants of concern, assess the sources and fate of transport mechanisms for these contaminants and describe the logical pathways and receptor species or communities

Since the assessment of risk to biological receptors is largely based on the weight of the evidence supporting particular conclusions, a summary section will be included in the EE Report This section will present the various lines of evidence supporting (or failing to support) each basic conclusion and discuss the associated uncertainties The factors that limit or prevent development of definitive conclusions will be described and the degree of confidence in the data used will be presented

The EE Report will be structured and written to facilitate its use by a diverse audience technical specialists scientists, administrators and the general "lay" public Portions involving technical detail such as explanations of methodologies or fate and transport models, will be presented in appendices An Executive Summary will be prepared to briefly present the basic information contained in the ecosystem characterization exposure toxicity and risk assessment portions of the report and describe how this information supports the risk characterization conclusions A complete list of references including the scientific literature cited, will also be included

Other documentation and forms related to conducting the environmental assessment will be kept as backup as required by Volume I of the SOP, (EG&G, 1991b) and other DOE or EG&G requirements.

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A conceptual schedule for conducting the OU 3 RFI/RI is summarized in Figure 9-1 The source of the RFI/RI duration is from the IAG The actual due dates for the RFI/RI Reports have been revised from those presented in the IAG EPA has approved these schedule modifications. According to the schedule, approximately 2 years and 1 month will elapse from the time this work plan is finalized until the RFI/RI Report is issued

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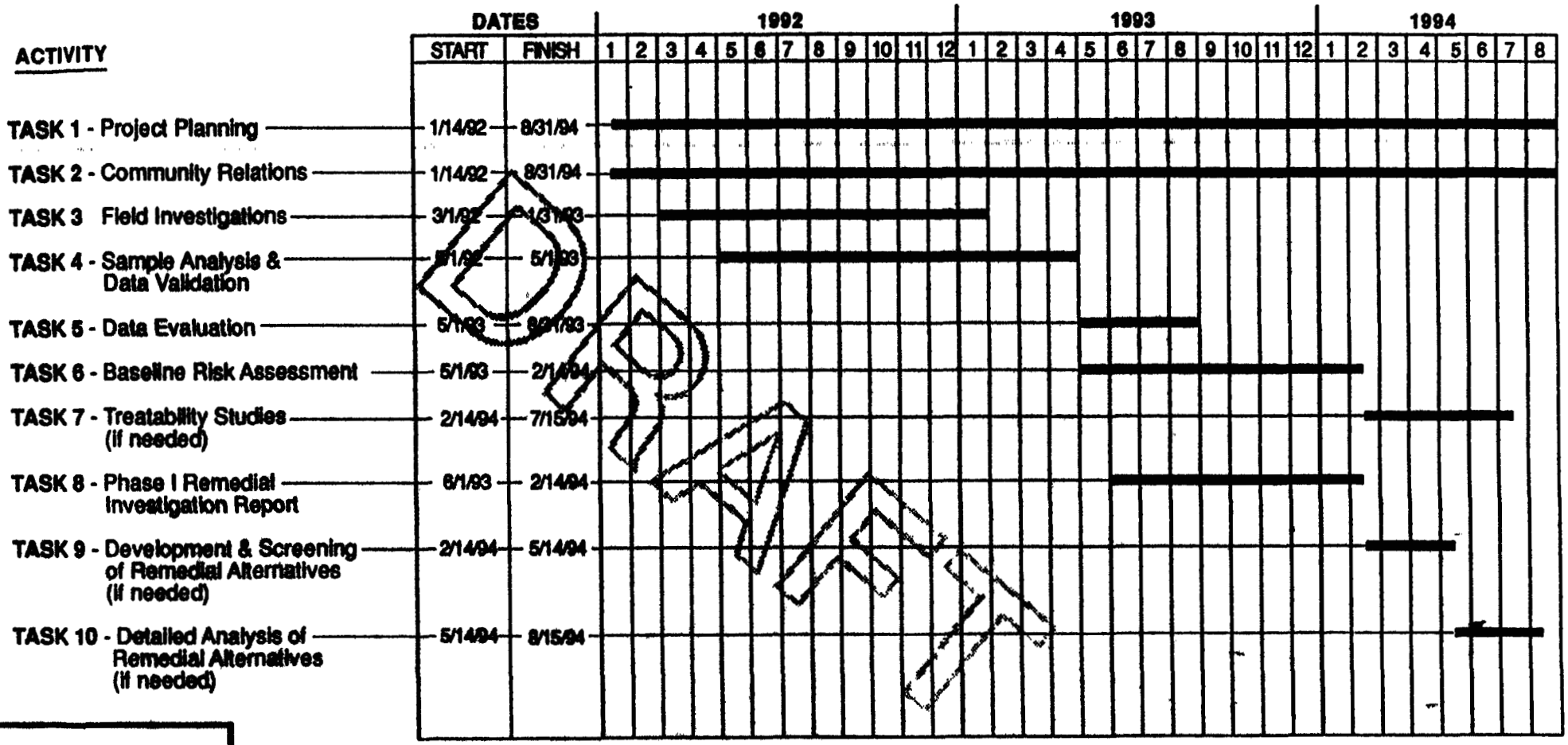

Figure 9-1
OPERABLE UNIT 3
PHASE I RFI/RI
CONCEPTUAL
SCHEDULE

The QAA for OU No 3 and the QAPP will be submitted to EPA and CDH as controlled documents under separate cover These documents will establish specific QA controls applicable to the field investigations for OU No 3

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STANDARD OPERATING PROCEDURES AND PROCEDURE CHANGE NOTICES

The following RFP program-wide SOPs will be utilized where appropriate during the specific field investigations for OU 3 A complete list of the SOPs to be used follows

FIELD OPERATIONS

SOP Number

- 1 1–Wind Blown Contaminant Dispersion Control
- 1 2–Field Document Control
- 1 3–General Equipment Decontamination
- 1 4–Heavy Equipment Decontamination
- 1 5–Handling of Purge and Development Water
- 1 6–Handling of Personal Protective Equipment
- 1 7–Handling of Decontamination Water and Wash Water
- 1 8–Handling of Drilling Fluids and Cuttings
- 1 9–Handling of Residual Samples
- 1 10–Receiving, Labeling, and Handling of Waste Containers
- 1 11–Field Communications
- 1 12–Decontamination Facility Operations
- 1 13–Containerizing Preserving, Handling, and Shipping of Soil and Water Samples
- 1 14–Field Data Management
- 1 15–Use of Photoionizing and Flame Ionizing Detectors
- 1 16–Field Radiological Measurements

GROUNDWATER

SOP Number

- 2.1–Water Level Measurements in Wells and Piezometers
- 2 2–Well Development
- 2.5–Measurement for Groundwater Field Parameters

- 2.6–Groundwater Sampling

GEOTECHNICAL

SOP Number

- 3 1–Logging Alluvial and Bedrock Material
- 3.2–Drilling and Sampling Using Hollow-Stem Auger Techniques
- 3 3–Isolating Bedrock from Alluvium with Grouted Surface Casing
- 3 4–Rotary Drilling and Rock Coring
- 3 5–Plugging and Abandonment of Boreholes
- 3.6–Monitoring Well and Piezometer Installation
- 3 8–Surface Soil Sampling
- 3 10–Borehole Clearing
- 3 11–Plugging and Abandonment of Wells

SURFACE WATER

SOP Number

- 4 1–Surface Water Data Collection Activities
- 4.2–Field Measurements of Surface Water Field Parameters
- 4 3–Surface Water Sampling
- 4 6–Sediment Sampling

ECOLOGY

SOP Number

- 5 1–Sampling of Periphyton
- 5 2–Sampling of Benthic Macroinvertebrates
- 5 4–Sampling of Fishes
- 5.5–Sampling of Large Mammals
- 5 6–Sampling of Small Mammals
- 5.7–Sampling of Birds

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- 5 8–Sampling of Reptiles and Amphibians
- 5 9–Sampling of Terrestrial Arthropods
- 5 10–Sampling of Terrestrial Vegetation
- 5 11–Identification of Habitat Types
- 5 12–Sampling of Soil for Soil Description
- 5 13–Development of Field Sampling Plans

AIR

SOP Number

- 6 1–Effluent Tritium Sample Collection
- 6 2–Tritium Sampler Calibration
- 6 3–Effluent Air Radioparticulate Sample Collection
- 6 4–Effluent Air Radioparticulate
- 6 5–Response to Effluent SAAM ALAR
- 6 6–Effluent Air Pitot Tube Inspection and Replacement
- 6 7–Effluent Air Sample Data Reduction
- 6 12–Preventive Maintenance Procedure for RFP TSP Hivol Sampler

Specific information, including appropriate SOP references concerning sampling activities is provided in Section 6 0 for most of the sampling activities Project-specific details for this work plan not addressed by the SOPs are included in the following procedure change notices These procedure change notices will be attached to the SOP for use during field activities

11 1 PROCEDURE CHANGE NOTICE TO SOP NO 4 6, SEDIMENT SAMPLING

The sediment samples collected from the reservoir will be collected using gravity corer The gravity corer is a method described in A Compendium of Superfund Field Operations (EPA, 1987a)

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top The check valve allows water to pass through the corer on descent but prevents washout during recovery The tapered nosepiece facilitates cutting and reduces core disturbance during penetration Most corers are constructed of brass or steel and many can accept plastic liners and additional weights

Corers are capable of collecting samples of most sludges and sediments. The corers collect essentially undisturbed samples that represent the profile of strata which may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the cores, penetration to depths of 75 cm (30 inches) can be attained Care should be exercised when using gravity corers in vessels or lagoons that have liners, since penetration depths could exceed that of substrate and result in damage to the liner material

The following describes the procedures for using a gravity corer

- Attach a precleaned corer to the required length of sample line Solid braided 5 mm (3/16 inch) nylon line is sufficient; 20 mm (3/4 inch) nylon, however, is easier to grasp during hand hoisting.

- Secure the free end of the line to a fixed support to prevent accidental loss of the corer

- Measure and mark distance to top of sludge on sampler line to determine depth of sludge or sediment coring

- Allow corer to free fall through liquid to bottom.

- Determine depth of sludge penetration.

- Retrieve corer with a smooth, continuous lifting motion. Do not bump corer because this may result in some sample loss.

- Remove nosepiece from corer, and slide sample out of corer into a stainless steel or Teflon pan

- Select sample interval as described in the field sampling plan (Section 6.0)

- Transfer sample into appropriate sample bottle with a stainless steel laboratory spoon, scoop, or spatula.

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11 2 PROCEDURE CHANGE NOTICE TO SOP NO 4 8, POND SAMPLING

The pond sampling SOP is amended to address stratified reservoir sampling Prior to sampling at each sampling point profiles of water temperature and dissolved oxygen in the water column will be collected at the sampling location The Hydrolab Multi-Parameter Measuring Instrument will be used to collect the profiles across the entire water column The sampling will be performed from a boat

Temperature and dissolved oxygen at the sampling point in the deepest part of the reservoir will be measured to determine the location of stratified layers at this point The grab samples will then be collected using a Kemmerer sampler in each stratified zone for all samples The uppermost stratified zone will be sampled first, followed by the next lower zone and so on The zone at the bottom of the pond will be sampled last

11 3 PROCEDURE CHANGE NOTICE TO SOP 5 4, SAMPLING OF FISH

Fish samples from the OU 3 reservoirs will be collected using a boat-mounted boom electroshocker and gill nets. These fishing methods are discussed in detail by Vibert (1967) and Nielsen and Johnson (1983)

The boat-mounted electroshocker is powered by a gasoline generator and the current is controlled by a commercial power unit to provide pulsed DC current The pulse frequency and amperage can be controlled at the power unit, and an automatic trip-switch interrupts the power supply unless the person netting the fish at the bow keeps pressure on the switch Two anodes are suspended from the bow on booms 4 to 6 feet in front of the boat The boat acts as the cathode Consult the manufacturer's manual for specific operating instructions The three-person crew (two netters and the pilot/operator) must wear rubber boots and elbow-length gloves and life preservers

The boat-mounted electroshocker is run parallel to shore in 1 to 6 feet of water at a slow trolling speed Fish that are shocked will surface near the anodes and are netted and placed in a live tank in the boat. Each station will be shocked for 15 to 30 minutes depending upon catch success, and the actual shocking time will be recorded Fish will be processed at the end of the shocking period according to SOP No 5 4 Section 6 2 5 Water quality parameters will be taken as per Section 6 2 6 and data will be collected using the data forms in SOP No 5 4

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Experimental gill nets 200 to 300 feet long with 4 to 6 panels of varying mesh size will be used to sample the deeper portions of reservoirs. Mesh sizes will range from 3/4 inch to 2 1/2 inches. The gill net will be set on the lake bottom, anchored at each end, and marked with buoys. Each net will be fished from 4 to 12 hours depending upon catch success and water temperature. The nets will be fished at those time intervals which minimize mortality Fish will be removed from the net as it is retrieved and placed in a live box. Fishing duration, water depth, and appropriate water quality parameters will be measured and recorded (SOP No 5.4) Sample processing and documentation will be completed according to SOP No. 5.4)

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THE DESIGN OF OPTIMAL STRATEGY FOR SAMPLING PLUTONIUM AND AMERICIUM IN SOILS OF THE OPERATIONAL UNIT NO 3

INTRODUCTION

Over 120 soil samples were collected and analyzed for Pu concentrations in surficial soils east of Indiana street. Most of these analyses were performed during 1971 and 1975 to 1978 Approximately half of the soil samples were taken from the top soil horizons (0 to 5 cm) using the Rocky Flat soil sampling protocol, whereas the other half was sampled using the Colorado Department of Health protocol (0 to 0 64 cm) These soil sampling techniques are described in great details in SOP 3 8 This previous sampling effort provides us with a reasonable knowledge of the spatial dependency of Pu in the soils east of RFP. Hence, the existing information can be used to construct a semi-variogram for designing optimal sampling strategy for Pu and Am in soils east of RFP

GEOSTATISTICAL APPROACH

The use of the regionalized variable theory and the semi-variogram as means of describing spatial variation in soils was demonstrated by numerous authors (e g, Burgess and Webster 1980a, 1980b Webster and McBratney, 1981, McBratney et al 1981 Burgess et al 1981 Gilbert and Simpson, 1985) The semi-variogram describes the rate of change in a regionalized variable and measures the degree of spatial dependence between samples within geographical boundaries (two-dimension analysis) and/or with depth (three-dimension analysis) The spatial structure of the regionalized variable can be described by the semivariogram in the case of stationarity conditions (Bregt et. al 1991) The variogram splits the total variance in a data set into two parts The first represents the spatial variance between samples values relative to the distance between samples, whereas the second represents local, or random variance Because the semi-variogram is a function of distance, the weights change according to the geographical arrangement of the samples (Isaaks and Srivastava, 1989) Hence the semi-variogram can provide the maximum sample separation distance for optimal soil sampling design for OU 3 Optimum sampling for the purpose of this report is defined as the statistically objective determination of a distance between samples that achieves the desired precision

By definition, the value of the theoretical variogram $\tau(h)$ for a given distance h, is the square of the expected difference between the values of the samples separated by distance h

$$\tau(h) = E\{z(x) - z(x + h)\}^2 \qquad (1)$$

where z(x) and z(x + h) are the values of Pu at locations x and x + h separated by the vector h, known as the lag The experimental semi-variogram can be estimated from the data at hand by:

$$\tau(h) = \frac{1}{n(h)} \sum_{i=1}^{n(h)} [z(x_i) - z(x_i + h)]^2 \qquad (2)$$

Thus for a given distance h, the values of all samples which are separated by h are subtracted from each other, and the result squared, accumulated and divided by the number of pairs found. This gives on point on the semi-variogram. The distance h is increased and the process is repeated with a specified direction. A horizontal half window of 90 degrees will effectively cover the entire plane, and is defined as isotropic semi-variogram.

Modeling the experimental semi-variogram provides the necessary parameters (i.e , nugget, sill, and range) for interpolation of soil-Pu concentrations. The calculated variance $\tau(h)$ between samples increases with increasing separation distances up to a distance (a), called the range, where it levels off to a constant value. Samples with separation distance less than the range are spatially correlated, and those with separation distances greater than the range are statistically independent. The point in which the semi-variogram levels off called the sill, and is equal to the overall variance of the sample population. The sill is composed of two components, C and C_0. In most soil studies $\tau(h)$ will remain nonzero as h approaches zero which is called the nugget effect ($\tau(h) = C_0$, $h > 0$) It reflects the inherent random variation of a contaminant dispersion in the environment that cannot be predicted by any method (Clark, 1979), the variability between sampling points at distance less than that actually used or available, analytical error, and samples collected from different populations (depths, soil type and other edaphic factors)

The interpolation procedure known as kriging uses the information from the semi-variogram to find an optimal set of weights that are used in the estimation of the surface at unsampled locations. The kriging procedure is optimal in the sense that it provides estimates with minimum variance or error, and this variance can itself be estimated with certain degree of confidence The main sources of

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the error estimates are (1) number of the nearby samples (2) proximity of the available samples, (3) spatial arrangement, and (4) the nature of the contaminant

Kriging can be applied globally or locally A global application would be to use the data over the entire site and estimate the mean for the site In soil studies it is usually preferable to use a local estimator which means calculating the average value of the regionalized variable over soil blocks (areas) from which a sample was collected For example the kriging estimator of the Pu level at a point x_0 in geographical space is

$$z(x_0) = \sum_{i=1}^{n} \lambda_i z(x_i) \qquad (3)$$

where $z(x_i)$ is the observed datum at the point x_i within the local neighborhood about the point x_0 and λ_i is the weight attached to that datum as obtained using ordinary kriging If the assumptions underlying ordinary kriging are met then the kriging estimator is a best linear unbiased estimator (B L U E) By using local estimation, there is no need to assume the same mean and covariance function over the entire study site

Weighted moving average methods are based on the intuitive notion that the data values closest to the block where the average is calculated should receive more weight than more distant points A problem with these methods is determining the appropriate weighting function Inverse distance or square inverse distance weighting are often used, but it is difficult to know which function is best Although kriging is a weighted moving average its weights λ_i are determined using the semi-variogram, which assures that the kriging estimator is B L U E Moreover, clustered data does not introduce a bias if kriging is used because kriging takes into account the spatial arrangement of the data. In addition, kriging permits one to estimate the variance of each estimated mean and hence to assess whether additional data are needed in a given area.

The semi-variogram calculations and the block kriging computations were performed by the GEO-EAS program (Englund and Sparks 1988)

The traditional method of mapping (hand-contouring or computer generated map) usually produces smooth contours that honor the data at known points This technique usually produces a fairly erratic contours Geostatistical techniques will produce a much smoother map that shows the

general trend of a given pollutant. A cross section through the traditional map will show the up and down necessary to fit a smooth curve through the data, whereas the kriged section line will show a broad general trend and differs from the data by an average amount corresponding to the nugget effect. Hence, one should not expect to see a kriged contoured map that precisely match all the observed points, but the best unbiased estimate of the general trend of Pu and Am in the soil environment east of RFP

SPATIAL DISTRIBUTION OF PU EAST OF ROCKY FLATS PLANT

The soil-Pu concentrations in soils east of Indiana street are depicted in Figure A-1 The soil-Pu distribution is highly skewed with large coefficient of variation (Figure A-2) A coefficient of variation greater than 100 percent indicates the presence of some few high sample values that may have a significant impact on the final estimates. Most spatial estimation techniques perform better if the distribution of data values is close to normal distribution. To achieve this end, the data was transformed using ln(X) function which greatly reduced the skewness and improved the coefficient of variation (Figure A-3) Because of the data transformation, lognormal kriging was performed. This involves estimating the semi-variogram and perform all the kriging calculations on the transformed data. Transforming the logarithmic kriging estimates back to the original scale gives estimates of median concentrations (Gilbert and Simpson, 1985) To backtransform the data to the original unit of concentrations in term of mean concentrations the following equation was employed

$$Z_i = e^{[\ln Y_i + \frac{1}{2}\sigma^2_{ki}]} \quad (4)$$

where Z_i= is the backtransform value for block i, Y_i is the log-kriged estimate, σ^2_{ki} is the kriging variance for the block estimate. The kriging variance for the block estimate was computed using the following equation

$$\sigma^2_k = 2\sum_{i=1}^{n} \lambda_i \gamma(x_i - x_{i+h}) - \sum_{i=1}^{n}\sum_{j=1}^{n} \lambda_i \lambda_j \gamma(x_i - x_j) \quad (5)$$

where $\gamma(x_i - x_{i+h})$ and $\gamma(x_i - x_j)$ are the values of the semi-variance between $x_i - x_{i+h}$ and $x_i - x_j$ respectively The square root of the kriging variance is analogous to the standard error of classical statistics. The weights λ_i and the kriging variance σ^2_k do not depend on the observed data values, but only on the semi-variogram and the distance h This is the reason why it is possible to compute

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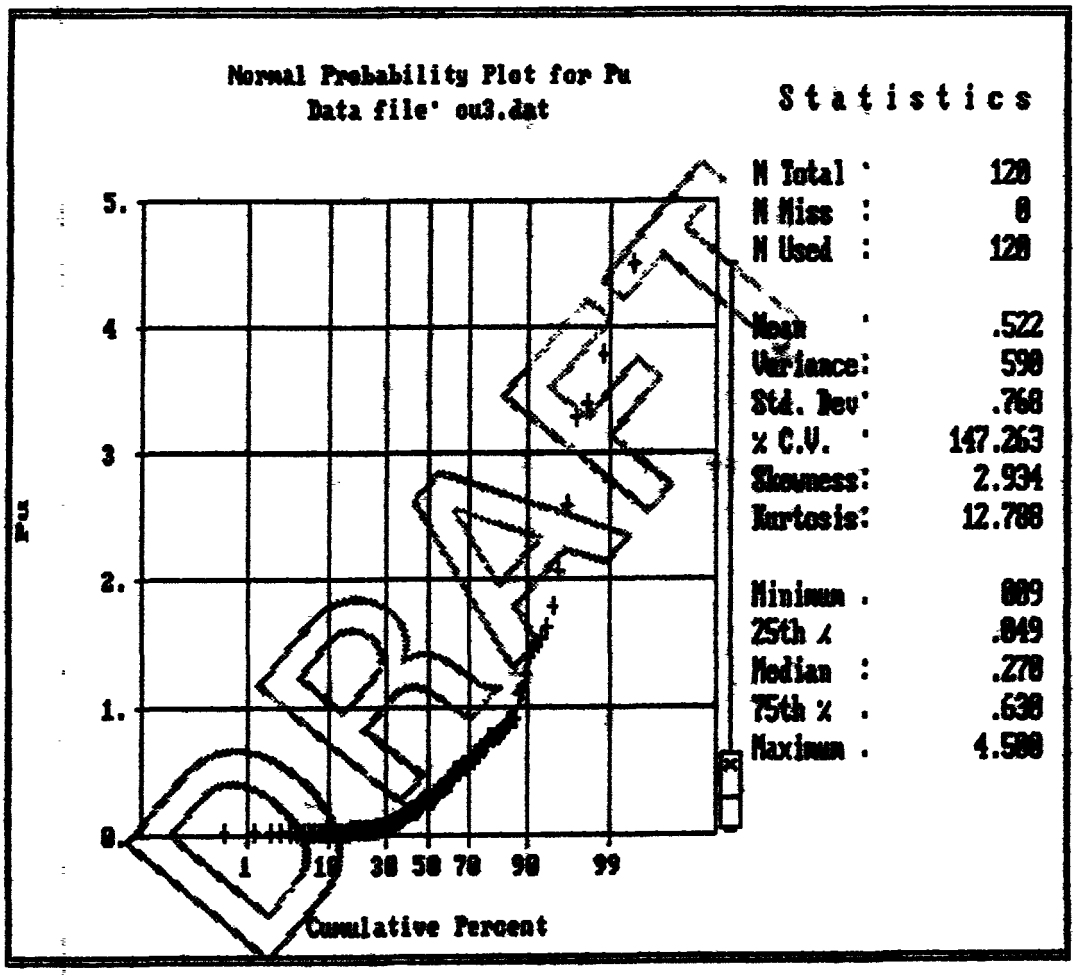

Figure A-2
NORMAL PROBABILITY PLOT FOR Pu CONCENTRATES (Pu/g) IN SOILS EAST OF INDIANA STREET

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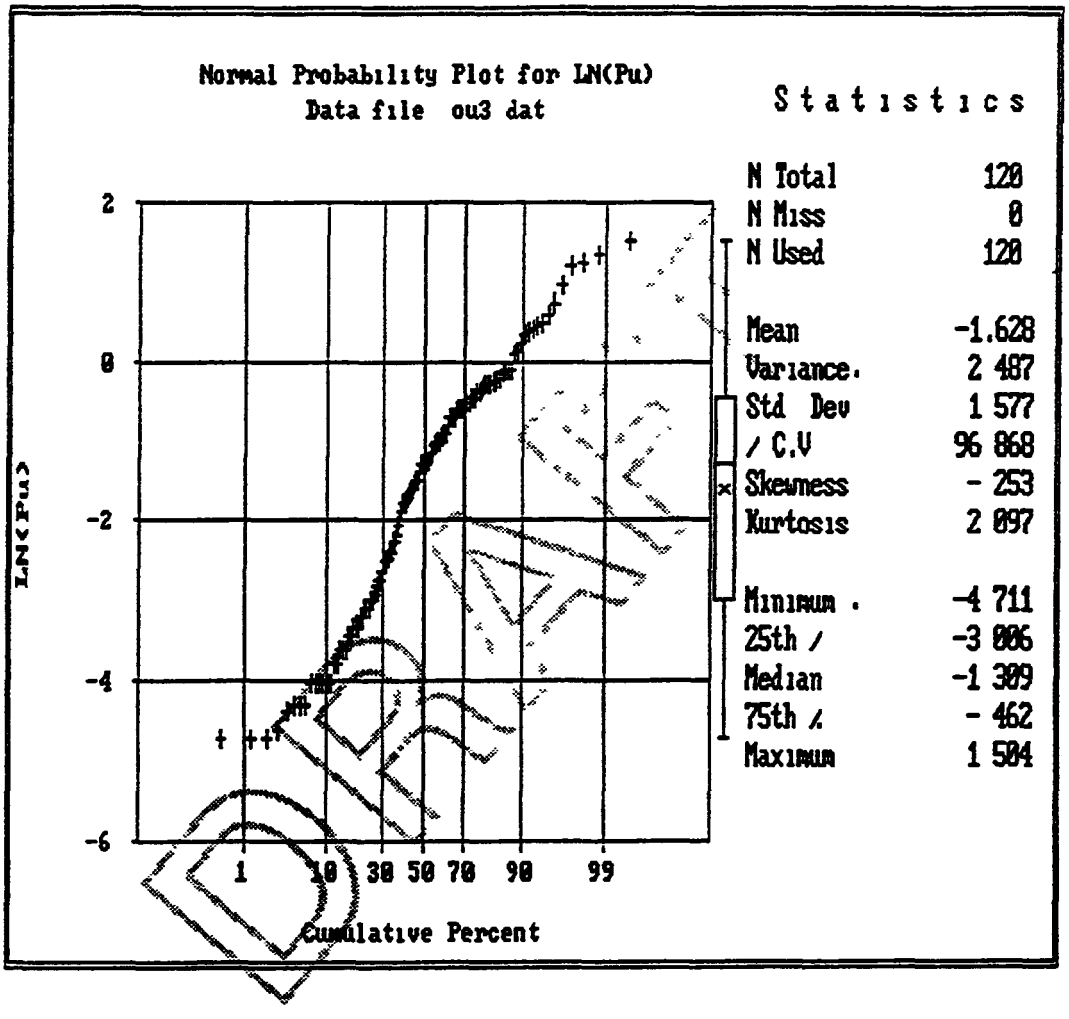

Figure A-3
LOG NORMAL PROBABILITY PLOT FOR Pu CONCENTRATIONS (Pu/g) IN SOILS EAST OF INDIANA STREET

the kriging variance for different sampling network designs and get a better notion of the trade offs between costs of sampling and benefits in terms of smaller kriging variance (optimal grid sampling)

If the spatial distribution of soil-Pu along the west-east transect from the 903 Pad followed the regionalized variable theory, then samples taken close to one another on average will be more similar than samples taken far apart. Thus, the longer the distances over which predictions are made the less reliable they are. The semi-variogram computation suggests an exponential model with nugget of 0.02, sill of 0.14 and a range of 1650 meter (Figure A-4) The exponential model was computed using the following formula:

$$\tau(h) = C_0 + C\{1 - \exp(h/a)\} \qquad (6)$$

where

h = lag interval,
C_0 = nugget variance
C = sill
A_0 = range.

The spatial variation of soil-Pu east of RFP did not change significantly with direction, which suggests that the semi-variogram is essentially isotropic.

Kriging estimates using the exponential model were computed for the soil-Pu east of RFP (Figure A-1). Plutonium concentrations higher than the recommended guideline by CDH (0.9 pCi/g) for residential areas were observed only near the eastern boundary of RFP The concentrations of Pu decrease rapidly with distance and in all directions. It should be noted, that Pu concentrations depicted in Figure A-1 represents the conditions that existed during 1971 to 1978 Figure A-5 illustrates the kriging standard of error estimates which are low in the center of the sampled area, and which verify the goodness-of-fit of the kriging estimates in this location. Large standard of error estimates were observed in the east, south and north to RFP which resulted from insufficient number of sample sites.

A maximum acceptable error of 0.41 pCi/g (see Figure A-6) was set, which seems reasonable followed the guideline of CDH for maximum allowable Pu concentration in soils of residential areas. This value is equivalent to a kriging variance of 0.168 which provides optimal sampling interval of 1750 m for the grid spacing for the proposed surficial soil sampling in OU 3. These calculations

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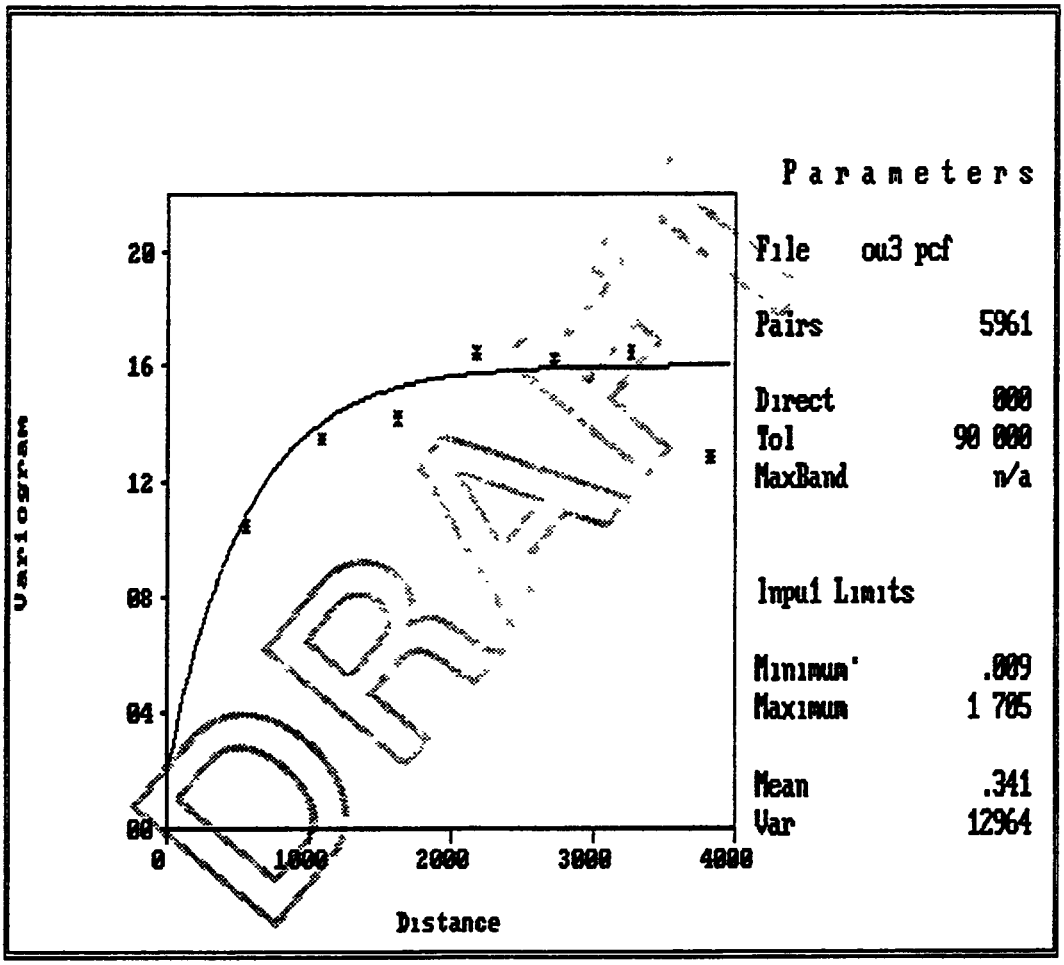

Figure A-4
ISOTROPIC VARIOGRAM OF Pu CONCENTRATIONS (Pu/g) IN SOILS EAST OF INDIANA STREET

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Kriging estimates produced from data file ou3.grd
Contours for KSDinpu1

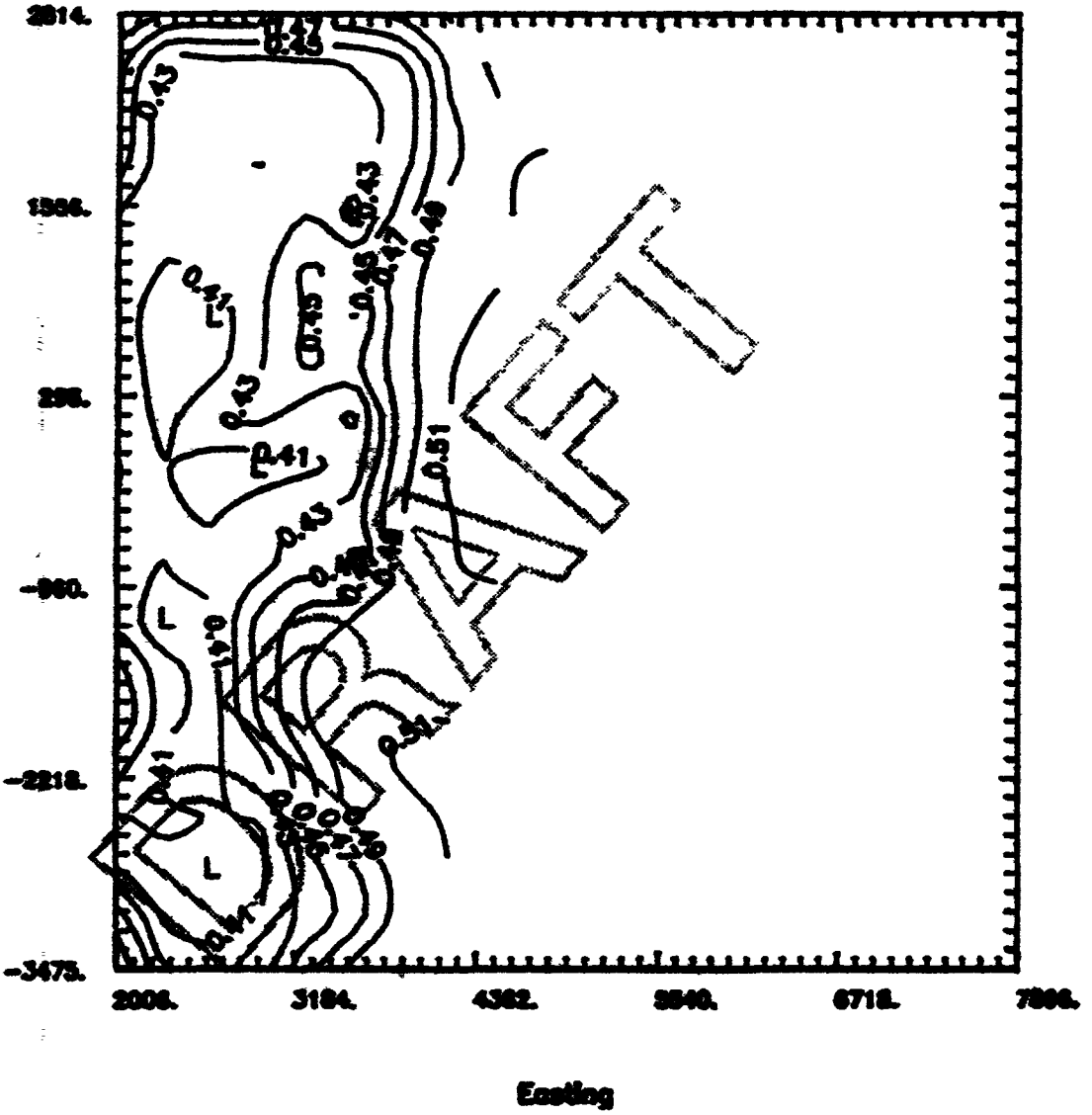

Figure A-5
KRIGING STANDARD OF ERROR ESTIMATES FOR Pu IN SOILS EAST OF INDIANA STREET

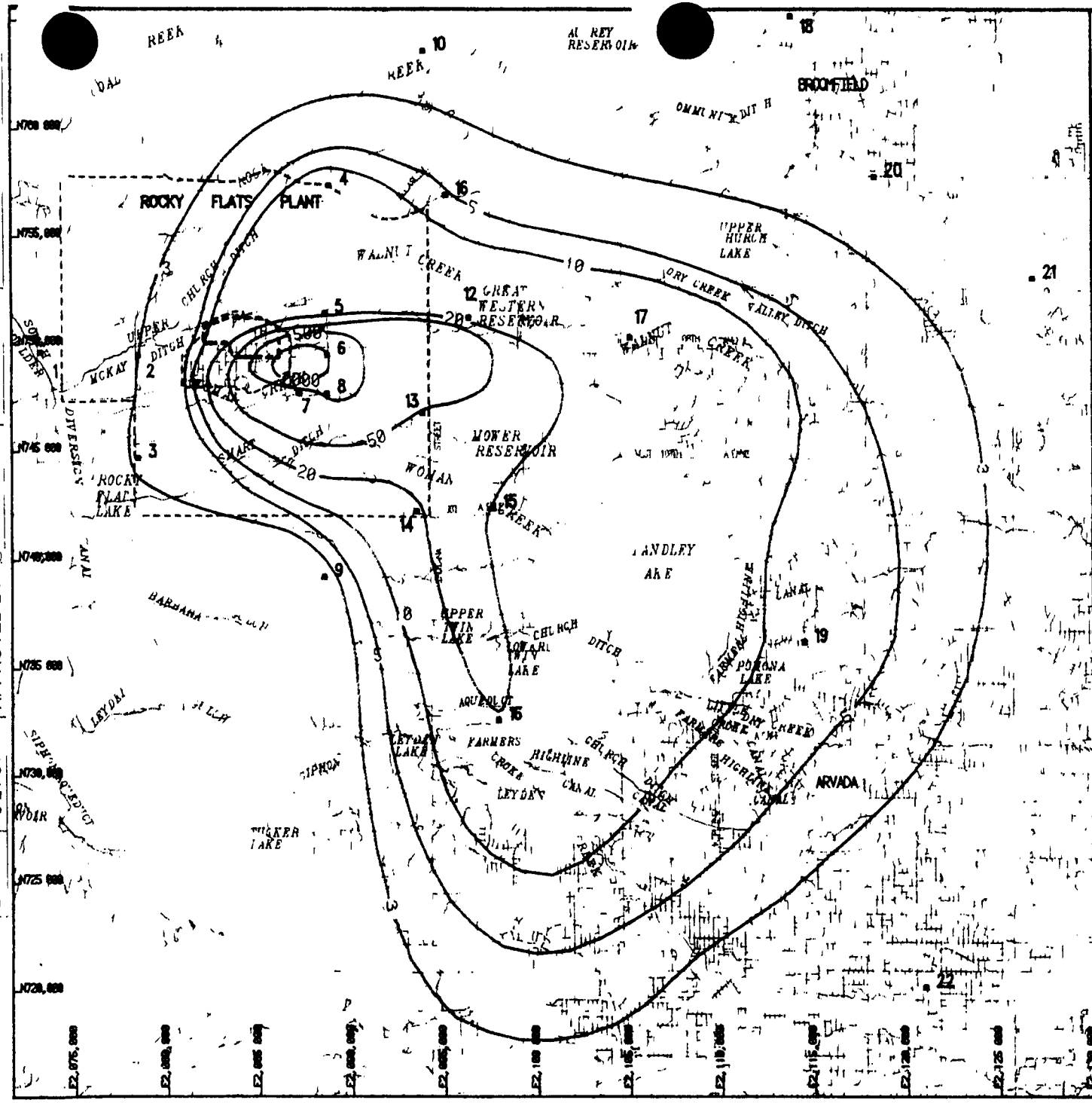

Figure A 6

PLUTONIUM-239 CONTOURS IN THE VICINITY OF THE ROCKY FLATS PLANT KREY AND HARDY (1970)

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were based in part on the RFP soil sampling technique where five sub-samples were collected from the corners and the center of two 1-meter squares, which are spaced 1 meter apart. The 10 subsamples were composited (5,000 cm^3) for radionuclides analyses Surficial soil sampling for Pu determination in the soils of OU 3 will follow the procedure recommended by CDH This soil sampling technique recommends the collection of twenty five sub-samples from a 10-acre area within a specified parcel of land to yield a single composite sample. The sample locations should be more or less evenly spaced within the area. The difference in block (area) size between the two techniques introduced some uncertainty in the above calculations. Hence, we recommend to reduce the optimal sampling interval for 1,000 m between 10-acre plots to facilitate a more conservative grid spacing for the surficial soil sampling of OU 3. Because the semi-variogram was isotropic, the 1,000 m grid space will be used in all directions in the soils of OU 3 east of RFP Krey and Hardy (1970) published a Pu-239 map that showed the location of the lowest Pu concentration (approximately 0 3 pCi/g) around RFP The boundaries for the surficial soil sampling plan for OU 3 east of RFP was determined on the basis of the smallest contour value in Krey and Hardy's map (Figure A-6)

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Plutonium 238 and 239/240 Testing of the Surface Soil on the Conda, Spicer and McKay Gravel Lease Properties, Rocky Flats West Buffer Zone

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Figure 2 Sampling Sectors and Sample Locations, Spicer and Conda Leases

Figure 3 Sampling Sectors and Sample Locations, McKay Lease

APPENDIX

Appendix 1 Laboratory Analytical Data and Chain of Custody Forms

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1 0 EXECUTIVE SUMMARY

Surface soils on three gravel lease properties located within the Rocky Flats West Buffer Zone were sampled and analyzed for the plutonium isotopes 238 and 239/240 (see Figure 1 for property location) Colorado Department of Health (CDOH) operating procedures for plutonium sampling were strictly followed (Reference Surface Soil Sample Collection, Version 1 0, July 10, 1989, CDOH) The laboratories used were sanctioned by EG&G (The Department of Energy's prime contractor for operating the Rocky Flats Nuclear Weapons Plant) with respect to QA/QC and laboratory analytical procedures EG&G personnel inspected Western Technologies, Inc (WT) field sampling protocol and approved the procedures

No plutonium isotopes were detected above the CDOH action level Plutonium concentrations in the surface soils on the subject properties are indicative of background levels resulting from atmospheric nuclear weapons testing

The following conclusions are reached

1 Plutonium concentrations in surface soils on the subject properties are below the CDOH action level (i e 2 0 disintegrations per minute per gram, which is equivalent to 9 pico Curies/gram) as put forth in "Rules and Regulations Pertaining to Radiation Control RH 4 35 1"

2 Mining and related construction activities on the subject properties will not require any special construction techniques or mitigation because plutonium concentrations are below the CDOH action level

3 Based on the data presented herein, no public health and safety hazard exists as a result of disturbing (e g mining, grading etc) the soils on the subject properties

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2 0 INTRODUCTION

Western Aggregates, Inc is contemplating sand and gravel mining on approximately 478 acres of land located on the Rocky Flats West Buffer Zone (Figure 1) The property is subdivided by the names of the owners of the gravel leases, Spicer, Conda, and McKay Surface soils were sampled and analyzed for the plutonium isotopes 238 and 239/240 to insure public, worker, and customer safety

The sampling program was in strict conformance with the Colorado Department of Health, Radiation Control Divisions' requirements as put forth in their document entitled "Surface Soil Sample Collection, Version 1 0, July 10, 1989" EG&G personnel approved the laboratories used, the sampling protocol and conducted field oversight of the sampling procedures. EG&G provided WT with a list of approved radionuclide laboratories from which Scientech, Inc. and Controls for Environmental Pollution, Inc. were selected. Two laboratories were selected at the recommendation of EG&G personnel for quality control purposes. A total of 54 soil samples were collected and analyzed (48 samples plus 6 split samples). The samples were collected from October 30 through November 1, 1990

3 0 PLUTONIUM SAMPLING

The gravel lease properties were divided into fifty (50) sectors, each containing approximately 10 acres (see Figures 2 and 3 for sector locations). The 160 acre Conda lease was divided into 16 sectors, designated as WAI-C-1 through WAI-C-16 The 128 acre McKay property was divided into 12 sectors, designated as WAI-M-1 through WAI-M-12. The 190 acre Spicer property was divided into 22 sectors, designated as WAI-S-1 through WAI-S-22.

Prior to sampling, WT personnel clearly marked each of the sector corners with survey lath and fluorescent paint. Twenty five (25) plutonium sampling locations were selected in each of the sectors based on the following criteria

- Sampling points were selected in relatively flat, open terrain. Special care was taken to avoid choosing sampling points near topographic features that would inhibit wind deposition of airborne plutonium from the Rocky Flats Plant.

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- Surface soil conditions appeared to have remained undisturbed for several years Soil was not sampled on two of the Conda sectors (WAI-C-2 and WAI-C-6) because these areas had been disturbed by recent mining activities

  Sampling locations were evenly spaced within each sector, except in sector WAI-S-22, which contained deeply incised surface drainages All sampling points were plotted in the field and are shown on Figures 2 and 3

Each sampling sector covers approximately 10 acres, although some are odd shaped due to the property boundary The sampling points shown on Figures 2 and 3 are approximately located as they were paced off in the field Neither the sampling sectors nor the sampling points were surveyed Soil samples were not collected from areas disturbed by on-going mining activities, roads, or steeply incised drainages

3 1 Plutonium Sampling Procedures

Forty eight (48) composite soil samples and six (6) split samples were collected for laboratory analysis Each of the samples were individually composited from soil collected at 25 sampling points located within each sector

The individual soil samples were collected using a stainless steel sampling device from the top 1/4 (0 25) inch of soil, within a surface area 2 inches wide and 2 3/8 (2 375) inches long WT personnel donned clean disposable latex gloves, and positioned the stainless steel template into the soil, so that the soil surface was even with the upper surface of the template The stainless steel sampling spade was placed at the opposite end from the curved sample collection scoop, and carefully drawn forward towards the curved end Special care was taken to assure that the entire volume (1/4 inch deep, 2 inches wide, and 2 3/8 inches long) was properly collected into the curved sample collection scoop The curved end of the template was gently placed into a plastic sample collection bag, and the sample was slowly poured into the bag Soil that adhered to the template was brushed into the container The composite sample container was sealed, and the sample location was plotted on the map WT personnel then proceeded to the next sample point

Split samples were collected from the following sectors, WAI-C-1, WAI-C-14, WAI-M-6, WAI-M-8, WAI-S-16, and WAI-S-22. The split samples were composited from 25 sample locations in each of these sectors using the above procedures At each sample point, the soil sample was divided evenly between two composite sample containers

The stainless steel template and spade were thoroughly cleaned before sampling each sector, using non-phosphate soap and triple rinsed with deionized water The 48 composite soil samples were labeled and sent to Scientech Laboratories in Carrollton, Texas, for analysis As a quality assurance measure, the six split samples were sent to CEP Laboratories in Santa Fe, New Mexico

4 0 PLUTONIUM SAMPLING RESULTS

The soil samples were analyzed for Plutonium 238 and 239/240 using alpha spectroscopy Table 1 summarizes the laboratory analytical data by lease property The Appendix contains the laboratory reports and chain of custody forms

The lower limit of detection (LLD) for the analytical procedures used varied from .05 pCi/gm to 4 pCi/gm. This is an important point because in all cases the LLD was sufficient to determine compliance with the CDOH action level.

Plutonium 238 (Pu 238) values ranged from 0 pCi/gm (not detected above the detection limit) to 550 pCi/gm (in Conda Lease Sector C-14). Plutonium 239/240 (Pu 239/240) values ranged from 0 pCi/gm to 695 pCi/gm (in McKay Lease Sector M-9). In no case were CDOH action levels exceeded.

Split sample results are reasonably consistent although C-14A and C-14B varied from 0 pCi/gm to 0 550 pCi/ gm respectively Conversations with Ms. Karen Schoendaller of EG&G revealed this is not uncommon, due to the non-homogenous nature of airborne deposition of plutonium. These results are not interpreted as laboratory problems.

5.0 CONCLUSIONS

All samples were collected using appropriate protocol and were analyzed by qualified laboratories The LLD was sufficient to determine compliance with CDOH action levels. The results are consistent with previous, limited sampling performed by the Department of Energy in the same general vicinity The results presented herein are believed to be an accurate representation of plutonium concentrations in surface soils on the subject property Plutonium concentrations are known to decrease dramatically with depth

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Based on the data presented in this report the following conclusions are reached

1 Plutonium concentrations in surface soils on the subject properties are below the CDOH action level (i e 2 0 disintegrations per minute per gram, which is equivalent to 9 pico Curies/gram) as put forth in "Rules and Regulations Pertaining to Radiation Control, RH 4 35 1"

2 Mining and related construction activities on the subject properties will not require any special construction techniques or mitigation because plutonium concentrations are below the CDOH action level

3 Based on the data presented herein, no public health and safety hazard exists as a result of disturbing (e g mining, grading etc) the soils on the subject properties

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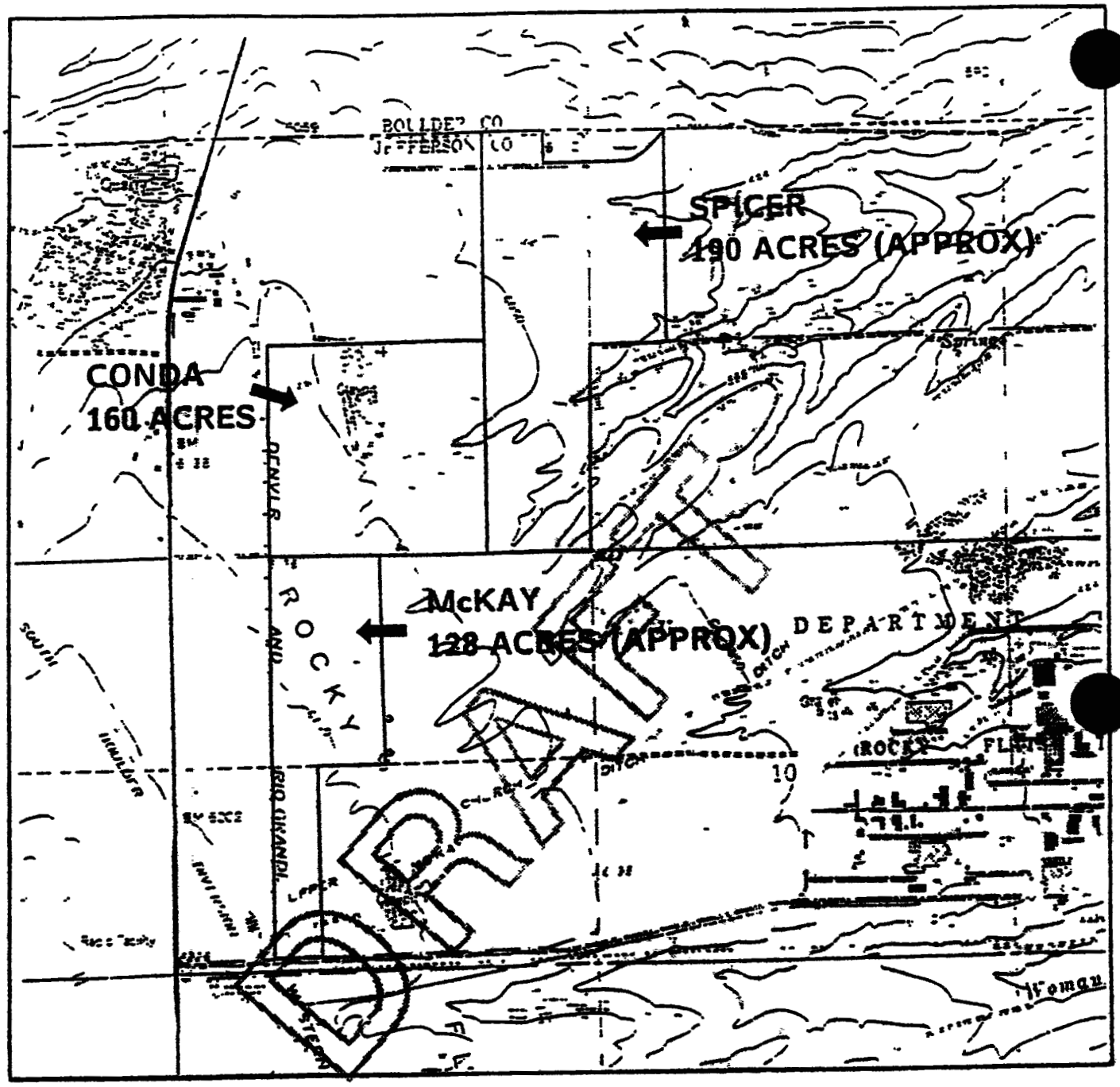
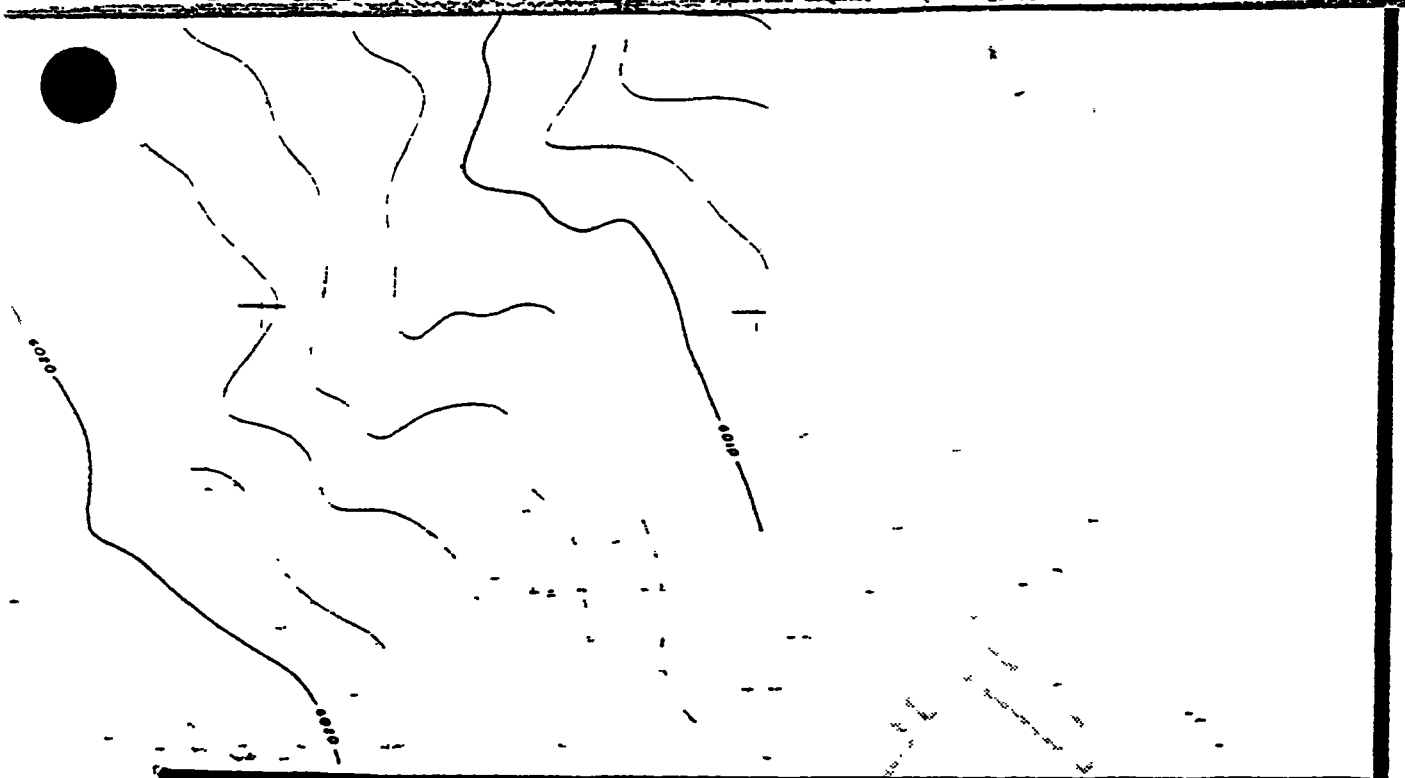


FIGURE 1: INDEX MAP OF GRAVEL LEASE PROPERTIES

Scale 1" = 2000'
Contour interval = 10 ft.

Project No 769-OK-077



WESTERN TECHNOLOGIES INC.

PLUTONIUM SAMPLING LOCATIONS

CONDA AND SPICER LEASES

PREPARED FOR

WESTERN AGGREGATES INC.

SCALE	DATE	PROJECT NO	FIGURE NO
1" = 200'	12-6-90	769-0K-077	2

Blueprint may unbound in report

WESTERN TECHNOLOGIES INC.

PLUTONIUM SAMPLING LOCATIONS

McKAY LEASE

PREPARED FOR

WESTERN AGGREGATES INC.

SCALE	DATE	PROJECT NO.	FIGURE NO.
1" = 300'	12-5-90	769-08-072	3

Blueprint map included in report.

APPENDIX

LABORATORY ANALYTICAL DATA AND CHAIN OF CUSTODY FORMS

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TABLE 1 Summary of Plutonium Test Results

SAMPLING LOCATIONS		ANALYTES (1)	
CONDA LEASE		Pu 238	Pu 239/240
SECTOR	C-1A (2)	0	0
	C-1B	<0 05	<0.05
	C-2	(3)	(3)
	C-3	0	0 0286
	C-4	0	0 0974
	C-5	0 0577	0 0019
	C-6	(3)	(3)
	C-7	0 147	0.0194
	C-8	0 204	0 0444
	C-9	0 0637	0.0021
	C-10	0	0
	C-11	0	0 151
	C-12	0.0883	0.221
	C-13	0 0579	0 232
	C-14A	0	0.141
	C-14B	0 550	0 268
	C-15	0.0088	0.141
	C-16	0.124	0.253
MCKAY LEASE		Pu 238	Pu 239/240
SECTOR	M-1	0 193	0.0551
	M-2	0.211	0.879
	M-3	0	0 424
	M-4	0	0 106
	M-5	0	0.193
	M-6A	0 0895	0 0501
	M-6B	0 270	0 070
	M-7	0	0 187
	M-8A	0	0 151
	M-8B	<0 05	<0 05
	M-9	0 0347	0 695
	M-10	0 0106	0.106
	M-11	0	0.0167
	M-12	0 285	0 327

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TABLE 1 (CONTINUED)

SPICER SECTOR	LEASE	Pu 238	Pu 239/240
	S-1	0 0103	0 175
	S 2	0	0
	S-3	0 0879	0 055
	S-4	0 0366	0 175
	S-5	0	0
	S-6	0	0 0602
	S-7	0	0.0498
	S 8	0	0 0398
	S-9	0 0159	0.143
	S-10	0	0 0167
	S-11	0	0
	S-12	0	0 0635
	S-13	0	0 0657
	S-14	0	0 0965
	S-15	0	0
	S-16A	0	0 0399
	S-16B	<0 05	<0 05
	S-17	0	0 0614
	S 18	0	0 0712
	S-19	0	0 0884
	S-20	0	0 152
	S-21	0	0 0334
	S-22A	0	0 0318
	S 22B	<0 05	0 290

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NOTES

(1) All units are in pico curies/gram (pCi/gm)

(2) Samples labelled A and B are split samples
Samples with the A designation were analyzed by Scientech, Inc
Samples with the B designation were analyzed by C E P, Inc
All other samples were analyzed by Scientech, Inc

(3) No samples collected in these sectors because soil was disturbed by recent mining activities

The Colorado Department of Health, Radiation Control Division, has established an action level for plutonium contamination of 2 0 disintegrations per minute per gram (dpm/gm) This is equivalent to 0 9 pCi/gm None of the 54 samples analyzed exceeded this standard

received
1-3-91

SCIENTECH INC.

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REPORT OF ANALYSIS

ANL JOB= 90-0843

12/28/90

WESTERN TECHNOLOGIES INC 10275

48 SOIL SAMPLES, DATE RECEIVED 11/15/90

SAMPLE I D	ANALYSIS	CONCENTRATION	ERROR EST	UNITS	LLD	UNITS
WAI-C-PU-	PU-238	0 00 E + 0	8 78 E - 2	pCi/g	2 E - 7	uCi/g
1A	PU-239	0 00 E + 0	8 01 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12932	PU-240	*				
WAI-C-PU-	PU-238	0 00 E + 0	3 57 E - 2	pCi/g	2 E - 7	uCi/g
3	PU-239	2 86 E - 2	8 97 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12933	PU-240	*				
WAI-C-PU-	PU-238	0 00 E + 0	7 79 E - 2	pCi/g	2 E - 7	uCi/g
4	PU-239	9 74 E - 2	9 00 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12934	PU-240	*				
WAI-C-PU-	PU-238	5 77 E - 2	2 [illegible] E - 1	pCi/g	3 E - 7	uCi/g
5	PU-239	1 90 E - [illegible]	1 [illegible] E - 1	pCi/g	2 E - 7	uCi/g
A N L 12935	PU-240	*				
WAI-C-PU-	PU-238	1 [illegible] E - 1	1 64 E - 1	pCi/g	2 E - 7	uCi/g
[illegible]	PU-239	[illegible] E - [illegible]	1 03 E - [illegible]	pCi/g	1 E - 7	uCi/g
A N L 12936	PU-240	*				
WAI-C-PU-	PU-238	2 04 E - 1	1 48 E - 1	pCi/g	1 E - 7	uCi/g
8	PU-239	1 44 E - 2	9 16 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12937	PU-240	*				
WAI-C-PU-	PU-238	6 31 E - 2	2 30 E - 1	pCi/g	3 E - 7	uCi/g
9	PU-239	2 10 E - 3	[illegible] 60 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12938	PU-240	*				
WAI-C-PU-	PU-238	0 00 E - 0	1 46 E - 1	pCi/g	3 E - 7	uCi/g
10	PU-239	0 00 E - 0	1 [illegible]4 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12939	PU-240	*				

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WAI-C-PU-	PU-238	0 00 E - 0	1 04 E - 1	pCi/g	2 E - 7	uCi/g
11	PU-239	1 5[illegible] E - 1	1 06 E - 1	pCi/g	1 E - 7	uCi/g
A N L 12940	PU-240	*				
WAI-C-PU-	PU-238	8 83 E - 2	1 87 E - 1	pCi/g	3 E - 7	uCi/g
12	PU-239	2 21 E - 1	[illegible] 71 E - [illegible]	pCi/g	2 E - 7	uC[illegible]/g
A N L 12941	PU-240	*				
[illegible]I-C-PU-	PU-238	5 79 E - 2	1 45 E - [illegible]	pCi/g	2 E - 7	uCi/g
	PU-239	2 32 E - 1	1 44 E - 1	pCi/g	2 E - 7	uC[illegible] g
A N L 12942	PU-240	*				
WAI-C-PU-	PU-238	0 00 E - 0	2 33 E - 2	pC[illegible]/g	4 E - 8	uCi/g
1-A	PU-239	1 41 E - 1	3 88 E - 2	pC[illegible]/g	3 E - 8	uC[illegible] g
A N L 12943	PU-240	*				
A[illegible]-C-PU-	PU-238	8 [illegible] E - 8	3 32 E - 2	pCi/g	3 E - 8	uC[illegible]/g
[illegible]5	PU-239	[illegible]	[illegible] 5[illegible] E - 2	pC[illegible]/g	4 E - 8	uC[illegible] g
A N L 129[illegible]	PU-240					
WAI-C-PU-	PU-238	[illegible] 2[illegible] E - [illegible]	5 [illegible]0 E - 2	pC[illegible]/g	6 E - 8	uC[illegible] g
[illegible]0	PU-239	[illegible] 53 E - [illegible]	4 90 E - 2	pC[illegible]/g	4 E - 8	C[illegible] g
A N L 12945	PU-240	*				
WAI- -PU-	PU-238	1 93 E - 1	[illegible] 91 E - 1	pCi/g	3 E - 7	C[illegible]/g
1	PU-239	5 5[illegible] E - 2	[illegible] 32 E - 1	pC[illegible]/g	2 E - 7	uC[illegible]/g
A N L 129[illegible]6	PU-240	*				
WAI-M-PU-	PU-238	2 [illegible]1 E - 1	1 86 E - [illegible]	pC[illegible]/g	3 E - 7	C[illegible]/g
2	PU-239	[illegible] 90 E - 2	[illegible] 32 E - 1	pCi/g	2 E - 7	uC[illegible] g
A N L 12947	PU-240	*				

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SAMPLE I D	ANALYSIS	CONCENTRATION	ERROR EST	UNITS	LLD	UNITS
WAI-V-PL-	PU-238	0 00 E + 0	2 20 E - 1	pCi/g	4 E - 7	uCi/g
3	PU-239	4 24 E - 1	2 63 E - 1	pCi/g	3 E - 7	uCi/g
A N L 12948	PU-240	*				
WAI-V-PL-	PU-238	0 00 E - 0	4 13 E - 2	pCi/g	8 E - 8	uCi/g
4	PU-239	1 06 E - 1	5 57 E - 2	pCi/g	6 E - 8	uCi/g
A N L 12949	PU-240	*				
WAI-V-PL-	PU-238	0 00 E - 0	5 40 E - 2	pCi/g	9 E - 8	uCi/g
5	PU-239	1 93 E - 1	7 09 E - 2	pCi/g	7 E - 8	uCi/g
A N L 12950	PU-240	*				
WAI-V-PL-	PU-238	8 35 E - 2	1 43 E - 1	pCi/g	2 E - 7	uCi/g
6A	PU-239	5 01 E - 2	1 27 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12951	PU-240	*				
WAI-V-PL-	PU-238	0 00 E - 0	1 41 E - 1	pCi/g	3 E - 7	uCi/g
7	PU-239	1 37 E - 1	1 53 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12952	PU-240	*				
WAI-V-PL-	PU-238	0 00 E - 0	1 81 E - 2	pCi/g	4 E - 8	uCi/g
8A	PU-239	1 31 E - 1	5 74 E - 2	pCi/g	3 E - 8	uCi/g
A N L 12953	PU-240	*				
WAI-V-PL-	PU-238	3 47 E - 2	2 10 E - 1	pCi/g	3 E - 7	uCi/g
9	PU-239	6 95 E - 1	2 64 E - 1	pCi/g	3 E - 7	uCi/g
A N L 12954	PU-240	*				
WAI-V-PL-	PU-238	1 06 E - 2	4 34 E - 2	pCi/g	5 E - 8	uCi/g
10	PU-239	1 06 E - 1	6 09 E - 2	pCi/g	4 E - 8	uCi/g
A N L 12955	PU-240	*				

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SAMPLE I D	ANALYSIS	CONCENTRATION	ERROR EST	UNITS	LLD	UNITS
WAI-W-PL-	PU-238	0 00 E - 0	3 14 E - 2	pCi/g	5 E - 8	uCi/g
11	PU-239	1 67 E - 2	3 68 E - 2	pCi/g	4 E - 8	uCi/g
A N L 12956	PU-240	*				
WAI-W-PL-	PU-238	2 85 E - 1	2 09 E - 1	pCi/g	3 E - 7	uCi/g
12	PU-239	3 27 E - 1	1 83 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12957	PU-240	*				
WAI-S-PL-	PU-238	1 03 E - 2	3 19 E - 2	pCi/g	5 E - 8	uCi/g
	PU-239	1 75 E - 1	4 74 E - 2	pCi/g	4 E - 8	uCi/g
A N L 12958	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 44 E - 2	pCi/g	3 E - 7	uCi/g
2	PU-239	0 00 E - 0	8 30 E - 2	pCi/g	2 E - 7	uCi/g
A N L 12959	PU-240	*				
WAI-S-PL-	PU-238	8 79 E - 2	5 56 E - 2	pCi/g	7 E - 8	uCi/g
3	PU-239	3 50 E - 2	4 25 E - 2	pCi/g	5 E - 8	uCi/g
A N L 12960	PU-240	*				
WAI-S-PL-	PU-238	3 66 E - 2	3 63 E - 2	pCi/g	5 E - 8	uCi/g
-	PU-239	1 75 E - 1	4 78 E - 2	pCi/g	4 E - 8	uCi/g
A N L 12961	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	8 51 E - 2	pCi/g	2 E - 7	uCi/g
5	PU-239	0 00 E - 0	7 02 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12962	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	8 08 E - 2	pCi/g	2 E - 7	uCi/g
6	PU-239	6 02 E - 2	8 76 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12963	PU-240	*				

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WAI-S-PL-	PU-238	0 00 E + 0	6 39 E - 2	pCi/g	1 E - 7	uCi/g
7	PU-239	4 98 E - 2	7 25 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12964	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	8 11 E - 2	pCi/g	2 E - 7	uCi/g
8	PU-239	3 98 E - 2	7 81 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12965	PU-240	*				
WAI-S-PL-	PU-238	1 59 E - 2	9 63 E - 2	pCi/g	2 E - 7	uCi/g
9	PU-239	1 43 E - 1	9 63 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12966.	PU-240	*				
WAI-S-PL-	PU-238	0 00 E + 0	7 85 E - 2	pCi/g	2 E - 7	uCi/g
10	PU-239	1 67 E - 2	7 68 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12967	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	8 67 E - 2	pCi/g	1 E - 7	uCi/g
11	PU-239	0 00 E - 0	7 63 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12968	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 26 E - 1	pCi/g	2 E - 7	uCi/g
12	PU-239	6 35 E - 2	1 47 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12969	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 22 E - 1	pCi/g	2 E - 7	uCi/g
13	PU-239	6 57 E - 2	1 17 E - 1	pCi/g	1 E - 7	uCi/g
A N L 12970	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 31 E - 1	pCi/g	2 E - 7	uCi/g
14	PU-239	9 65 E - 2	1 41 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12971	PU-240	*				

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SAMPLE I D	ANALYSIS	CONCENTRATION	ERROR EST	UNITS	LLD	UNITS
WAI-S-PL-	PU-238	0 00 E - 0	1 29 E - 1	pCi/g	2 E - 7	uCi/g
15	PU-239	0 00 E - 0	1 28 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12972	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	7 63 E - 2	pCi/g	2 E - 7	uCi/g
16A	PU-239	3 99 E - 2	7 68 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12973	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 15 E - 1	pCi/g	3 E - 7	uCi/g
17	PU-239	6 14 E - 2	1 46 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12974	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 15 E - 1	pCi/g	2 E - 7	uCi/g
18	PU-239	7 12 E - 2	1 16 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12975	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 40 E - 1	pCi/g	2 E - 7	uCi/g
19	PU-239	3 [illegible] E - 2	1 26 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12976	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 30 E - 1	pCi/g	3 E - 7	uCi/g
20	PU-239	1 58 E - 1	1 59 E - 1	pCi/g	2 E - 7	uCi/g
A N L 12977	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	7 50 E - 2	pCi/g	2 E - 7	uCi/g
21	PU-239	3 3[illegible] E - 2	3 02 E - 2	pCi/g	1 E - 7	uCi/g
A N L 12978	PU-240	*				
WAI-S-PL-	PU-238	0 00 E - 0	1 04 E - 1	pCi/g	2 E - 7	uCi/g
22A	PU-239	3 18 E - 2	9 96 E - 2	pCi/g	2 E - 7	uCi/g
A N L 12979	PU-240	*				

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M L Buvinghausen
Deputy Director, Laboratory

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CHAIN OF CUSTODY RECORD

JOB NO: 769-OK-077

PROJECT NAME: WAI- CONDA/McKAY/SPICER

SAMPLERS (SIGNATURE): David P Schwieger

SAMPLE IDENTIFICATION	DATE	TIME	COMP.	GRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL-SCOOP	SOIL AUGER	SPLIT-SPOON	CDH SAMPLER	Pu 238,239/240	REMARKS (PHYSICAL APPEARANCE, etc)	LABORATORY IDENTIFICATION
WAI-C-Pu-1A	10/30		X		CONDA - SECTOR 1	1					X	X	SOIL	
WAI-C-Pu-3	10/30		X		CONDA - SECTOR 3	1					X	X		
WAI-C-Pu-4	10/30		X		CONDA - SECTOR 4	1					X	X		
WAI-C-Pu-5	10/31		X		CONDA - SECTOR 5	1					X	X		
WAI-C-Pu-7	10/30		X		CONDA - SECTOR 7	1					X	X		
WAI-C-Pu-8	10/30		X		CONDA - SECTOR 8	1					X	X		
WAI-C-Pu-9	10/31		X		CONDA - SECTOR 9	1					X	X		
WAI-C-Pu-10	10/31		X		CONDA - SECTOR 10	1					X	X		
WAI-C-Pu-11	11/1		X		CONDA - SECTOR 11	1					X	X		
WAI-C-Pu-12	10/31		X		CONDA - SECTOR 12	1					X	X		
WAI-C-Pu-13	10/31		X		CONDA - SECTOR 13	1					X	X		
WAI-C-Pu-14A	10/31		X		CONDA - SECTOR 14	1					X	X		
WAI-C-Pu-15	10/31		X		CONDA - SECTOR 15	1					X	X		
WAI-C-Pu-16	10/31		X		CONDA - SECTOR 16	1					X	X		

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
David P Schwieger	11/13						
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE	TIME	REMARKS	
						• 0.2 pCi/g LLD • 30-45 DAY TURN AROUND	

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~~Phoenix, Arizona 85036~~
~~602-437-3737~~
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SUITE 40
GOLDEN [redacted] 80401
303-23[redacted]-2991

White-Testing Laboratory; Yellow-Field Sampler; Pink-Department [redacted]

CHAIN OF CUST[illegible] RECORD

JOB NO: 769-OK-077

PROJECT NAME: WAI - CONDA / McKAY / SPICER

SAMPLERS (SIGNATURE): Ford F Schweger

SAMPLE IDENTIFICATION	DATE	TIME	COMP	CRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	SOIL AUGAR	SPLIT SPOON	CDH SAMPLER	Pu 238, 239/240	REMARKS (PHYSICAL APPEARANCE etc)	LABORATORY IDENTIFICATION
WAI-M-Pu-1	11/1		X		McKay-SECTOR 1	1					X	X	SOIL	
WAI-M-Pu-2	↓		X		McKay-SECTOR 2	1					X	X	↓	
WAI-M-Pu-3			X		McKay-SECTOR 3	1					X	X		
WAI-M-Pu-4			X		McKay-SECTOR 4	1					X	X		
WAI-M-Pu-5			X		McKay-SECTOR 5	1					X	X		
WAI-M-Pu-6A			X		McKay-SECTOR 6	1					X	X		
WAI-M-Pu-7			X		McKay-SECTOR 7	1					X	X		
WAI-M-Pu-8A			X		McKay-SECTOR 8	1					X	X		
WAI-M-Pu-9			X		McKay-SECTOR 9	1					X	X		
WAI-M-Pu-10			X		McKay-SECTOR 10	1					X	X		
WAI-M-Pu-11			X		McKay-SECTOR 11	1					X	X		
WAI-M-Pu-12	↓		X		McKay-SECTOR 12	1					X	X		

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
Ford F. Schweger	11/13						
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE	TIME		

REMARKS
- 0.2 pCi/g LLD
- 30-45 Day Turn Around

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~~P.O. Box 21387~~
~~Phoenix, Arizona 85036~~
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13949 W COLFAX
SUITE 140
GOLDEN, CO 80401
303-233-7991

White-Testing Laboratory Yellow-Field Sampler Pink Department Job File

CHAIN OF CUSTODY RECORD

JOB NO: 769-OK-077

PROJECT NAME: WAI - Conda / McKay / Spicer

SAMPLERS (SIGNATURE): David P. Schwieger

SAMPLE IDENTIFICATION	DATE	TIME	COMP.	CRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	SOIL AUGAR	SPLIT SPOON	CDH Sampler	Pu 238, 239/240	REMARKS (PHYSICAL APPEARANCE, etc)	LABORATORY IDENTIFICATION
WAI-S-Pu-1	10/30		X		Spicer - Sector 1	1					X	X	Soil	
WAI-S-Pu-2	10/30		X		Spicer - Sector 2	1					X	X		
WAI-S-Pu-3	10/30		X		Spicer - Sector 3	1					X	X		
WAI-S-Pu-4	10/30		X		Spicer - Sector 4	1					X	X		
WAI-S-Pu-5	10/30		X		Spicer - Sector 5	1					X	X		
WAI-S-Pu-6	10/31		X		Spicer - Sector 6	1					X	X		
WAI-S-Pu-7	10/30		X		Spicer - Sector 7	1					X	X		
WAI-S-Pu-8	10/30		X		Spicer - Sector 8	1					X	X		
WAI-S-Pu-9	10/31		X		Spicer - Sector 9	1					X	X		
WAI-S-Pu-10	10/31		X		Spicer - Sector 10	1					X	X		
WAI-S-Pu-11	10/30		X		Spicer - Sector 11	1					X	X		
WAI-S-Pu-12	10/30		X		Spicer - Sector 12	1					X	X		
WAI-S-Pu-13	10/31		X		Spicer - Sector 13	1					X	X		
WAI-S-Pu-14	10/31		X		Spicer - Sector 14	1					X	X		
WAI-S-Pu-15	10/31		X		Spicer - Sector 15	1					X	X		
WAI-S-Pu-16A	10/31		X		Spicer - Sector 16	1					X	X		

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
David P. Schwieger	11/13						
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE	TIME		

REMARKS
- 0.2 pCi/g LLD
- 30-45 Day Turn Around

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~~P.O. Box 21387~~
~~Phoenix, Arizona 85036~~
602 437 3737

13945 W. Colfax
Suite [illegible]40
Golden, Co 80401
303 [illegible] 2991

White-Testing Laboratory; Yellow Field Sampler Pink Department Job File

CHAIN OF CUSTODY RECORD

JOB NO: 769-OK-077

PROJECT NAME: WAI - CONDA / McKAY / SPICER

SAMPLERS (SIGNATURE): David P. Schwiegers

SAMPLE IDENTIFICATION	DATE	TIME	COMP	CRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	SOIL AUGAR	SPLIT SPOON	CDH SAMPLER	Pu 238, 239/240	REMARKS (PHYSICAL APPEARANCE etc)	LABORATORY IDENTIFICATION
WAI-S-Pu-17	10/31		X		SPICER - SECTOR 17	1					X	X	SOIL	
WAI-S-Pu-18	↓		X		SPICER - SECTOR 18	1					X	X	↓	
WAI-S-Pu-19	↓		X		SPICER - SECTOR 19	1					X	X	↓	
WAI-S-Pu-20	↓		X		SPICER - SECTOR 20	1					X	X	↓	
WAI-S-Pu-21	↓		X		SPICER - SECTOR 21	1					X	X	↓	
WAI-S-Pu-22A	↓		X		SPICER - SECTOR 22	1					X	X	↓	

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
David P. Schwiegers		11/13					
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE	TIME		

REMARKS
- 0.2 pCi/g LLD
- 30-45 Day Turn Around

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Golden, Co 80401
303 232-7971

White–Testing Laboratory Yellow Field Sampler Pink Department Job File

Controls for Environmental Pollution, Inc
[illegible] 000/545 2188 • FAX 505 982 9709

Controls for Environmental
Pollution, Inc
P O Box 5351
Santa Fe, NM 87502
Attn James J Mueller
Phone (505) 982-9841

Western Technologies, Inc
10947 West Colfax Avenue #110
Golden, CO 80401

Attn David P Schwieger
Invoice Number

Order # 90-11-314
Date 12/10/90 10 34
Work ID Environmental
Date Received 11/14/90
Date Completed 12/03/90

DRAFT

SAMPLE IDENTIFICATION

Sample Number	Sample Description
01	WAI-C-PU-1B CONDA-SEC 1
03	WAI-M-PU-6B McKay-Sec 6
05	WAI-S-PU-16B Spicer-Sec 16
02	WAI-C-PU-14B Conda-Sec 14
04	WAI-M-PU-8B McKay-Sector 8
06	WAI-S-PU-22B Spicer-Sec 22

Remainder of sample(s) for routine analysis will be disposed of three weeks from final report date Sample(s) for bacteria analysis only, will be disposed of immediately after analysis This is not applicable if other arrangements have been made

Certified By

received
12-90

Controls for Environmental Pollution, Inc
[illegible] 800/545 2180 • FAX 505 302

TEST RESULTS BY SAMPLE

Sample 01A WAI-C-PU-1B Sonda-Sec 1 Collected 10/30/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0.05	0.05	pCi/gram		
Plutonium-239/240	<0.05	0.05	pCi/gram		

Sample 02A WAI-C-PU-1B Sonda-Sec 14 Collected 10/31/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	0.55±0.18	0.05	pCi/gram		
Plutonium-239/240	0.26±0.08	0.05	pCi/gram		

Sample 03A WAI-M-PU 8B McKay Sec 6 Collected 11/01/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	0.27±0.06	0.05	pCi/gram		
Plutonium-239/240	0.07±0.05	0.05	pCi/gram		

Sample 01A WAI-M-PU-8B McKay-Sector 8 Collected 11/01/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0.05	0.05	pCi/gram		
Plutonium-239/240	<0.05	0.05	pCi/gram		

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[illegible] OUT OF STATE 800/545-2108 • FAX 505 982 9289

Sample 05A WAI-S-PU-16B Spicer-Sec 15 Collected 10/31/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0 05	0 05	pCi/gram		
Plutonium-239/240	<0 05	0 05	pCi/gram		

Sample 06A WAI-S PU-22B Spicer Sec 22 Collected 10/31/90

Test Description	Result	Limit	Units	Analyzed	By
Plutonium-238	<0 05	0 05	pCi/gram		
Plutonium-239/240	0 29 ±0 11	0 05	pCi/gram		

DRAFT

CHAIN OF CUSTODY RECORD

JOB NO: 769-OK-077

PROJECT NAME: WAI - CONDA / McKAY / SPICER

SAMPLERS (SIGNATURE): David P Schwieger

SAMPLE IDENTIFICATION	DATE	TIME	COMP	GRAB	SAMPLE LOCATION	NUMBER OF CONTAINERS	VACSAM	SOIL SCOOP	SOIL AUGER	SPLIT-SPOON	CDH Sampler	Pu 238, 239/240	REMARKS (PHYSICAL APPEARANCE etc.)	LABORATORY IDENTIFICATION
WAI-C-Pu-1B	10/30		X		CONDA - SECTOR 1	1					X	X	Soil	
WAI-C-Pu-14B	10/31		X		CONDA - SECTOR 14	1					X	X		
WAI-M-Pu-6B	11/1		X		McKAY - SECTOR 6	1					X	X		
WAI-M-Pu-8B	11/1		X		McKAY - SECTOR 8	1					X	X		
WAI-S-Pu-16B	10/31		X		SPICER - SECTOR 16	1					X	X		
WAI-S-Pu-22B	10/31		X		SPICER - SECTOR 22	1					X	X		

RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
David P. Schwieger	11/13						
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)	RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED BY (SIGNATURE)
RELINQUISHED BY (SIGNATURE)	DATE	TIME	RECEIVED FOR LABORATORY BY (SIGNATURE)	DATE	TIME	REMARKS	
			Kelly Ortega	11/14/90	9:30	• 0.2 piCu/g LLD • 2-3 WEEK TURN AROUND	

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~~Phoenix, Arizona 85036~~
~~602-417-3717~~

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GOLDEN, CO 80401
303-233 2491

White Testing Laboratory Yellow Field Sampler Pink, Department Job File

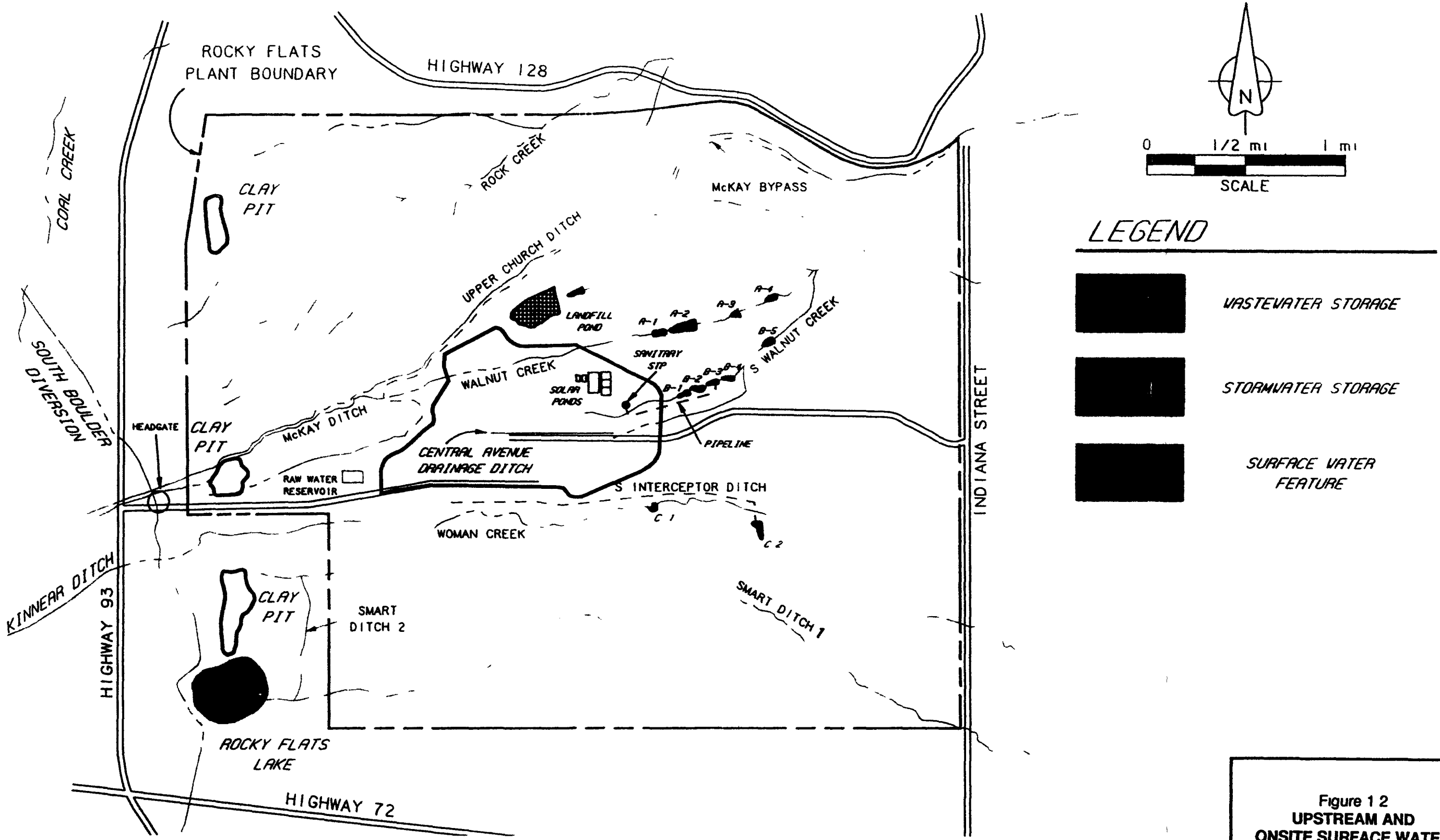


Figure 1 2
UPSTREAM AND ONSITE SURFACE WATER FEATURES

SOURCE DRAFT ROCKY FLATS SURFACE WATER MANAGEMENT PLAN MARCH 1991

DRAWN	CHECKED BY		DRAWING NUMBER
KRONER 6-12-91	APPROVED BY	CJR 06 12 91 / CJR 06 12 91	30-B14

492381

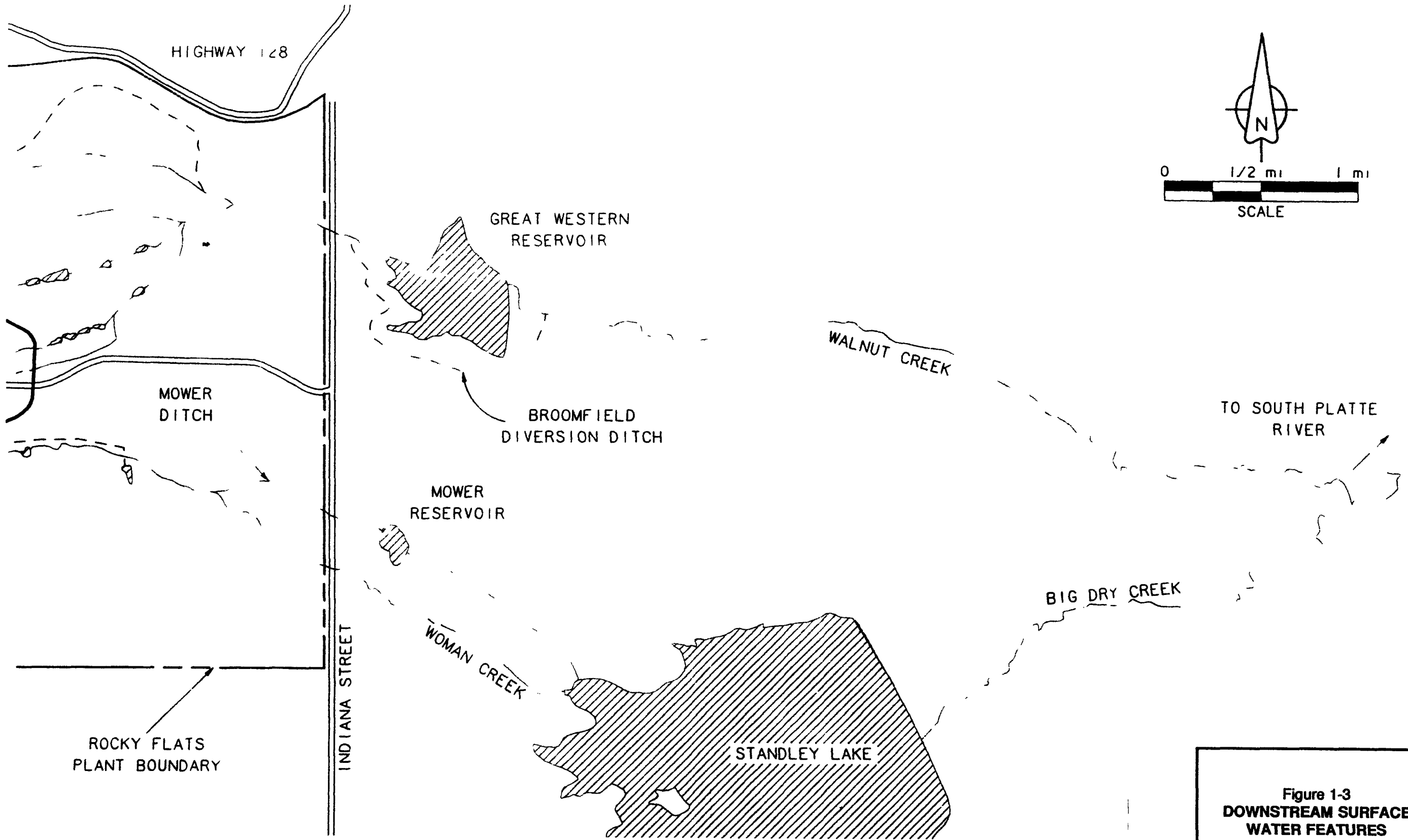


Figure 1-3
DOWNSTREAM SURFACE WATER FEATURES

SOURCE DRAFT ROCKY FLATS SURFACE WATER MANAGEMENT PLAN MARCH 1991

DRAWN BY	KRONER 6-12-91	CHECKED BY	CJR 06 2-91	DRAWING NUMBER	30 -B15
		APPROVED BY	CJR 06 12 91		

402381

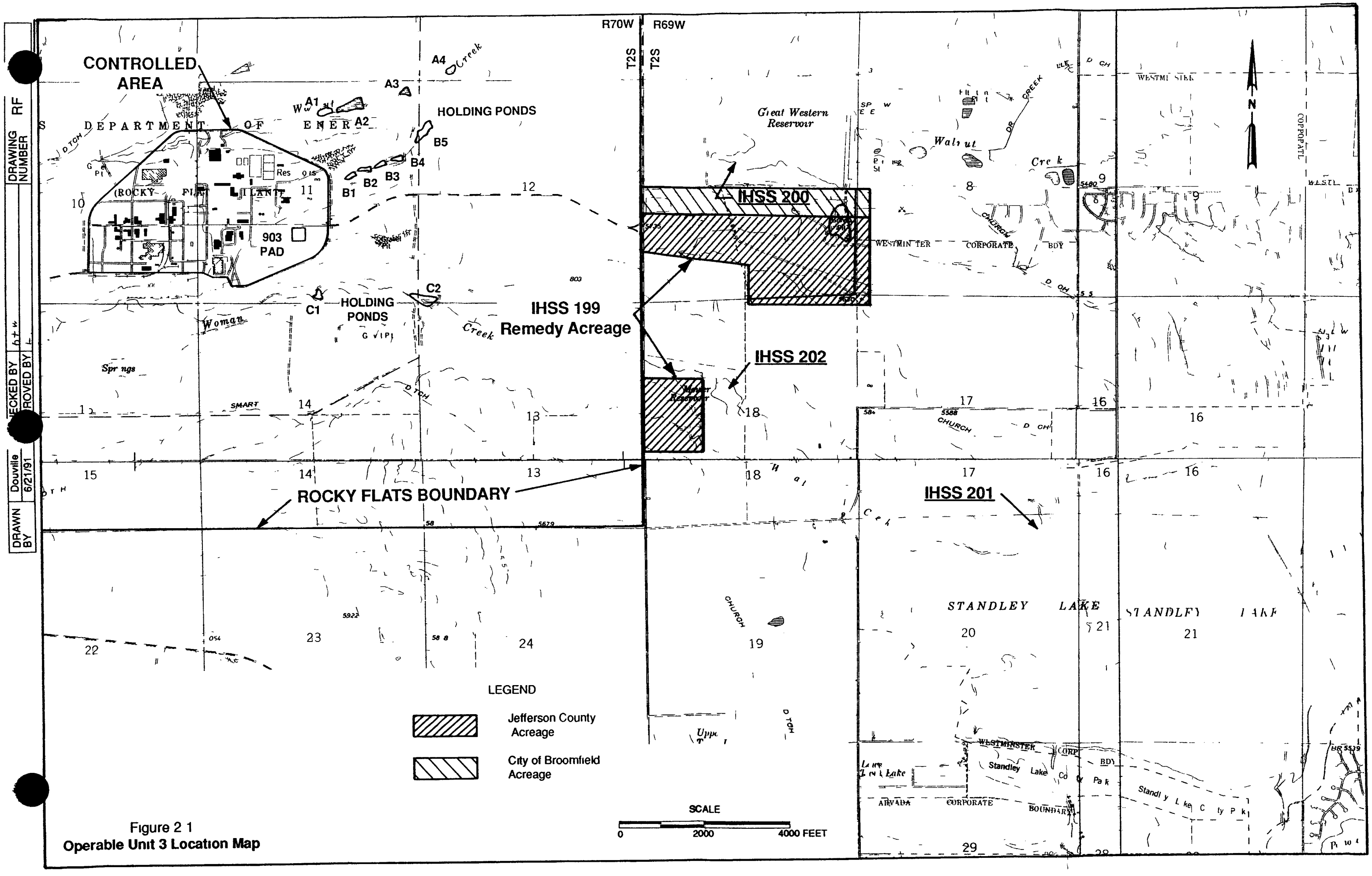


Figure 2 1
Operable Unit 3 Location Map

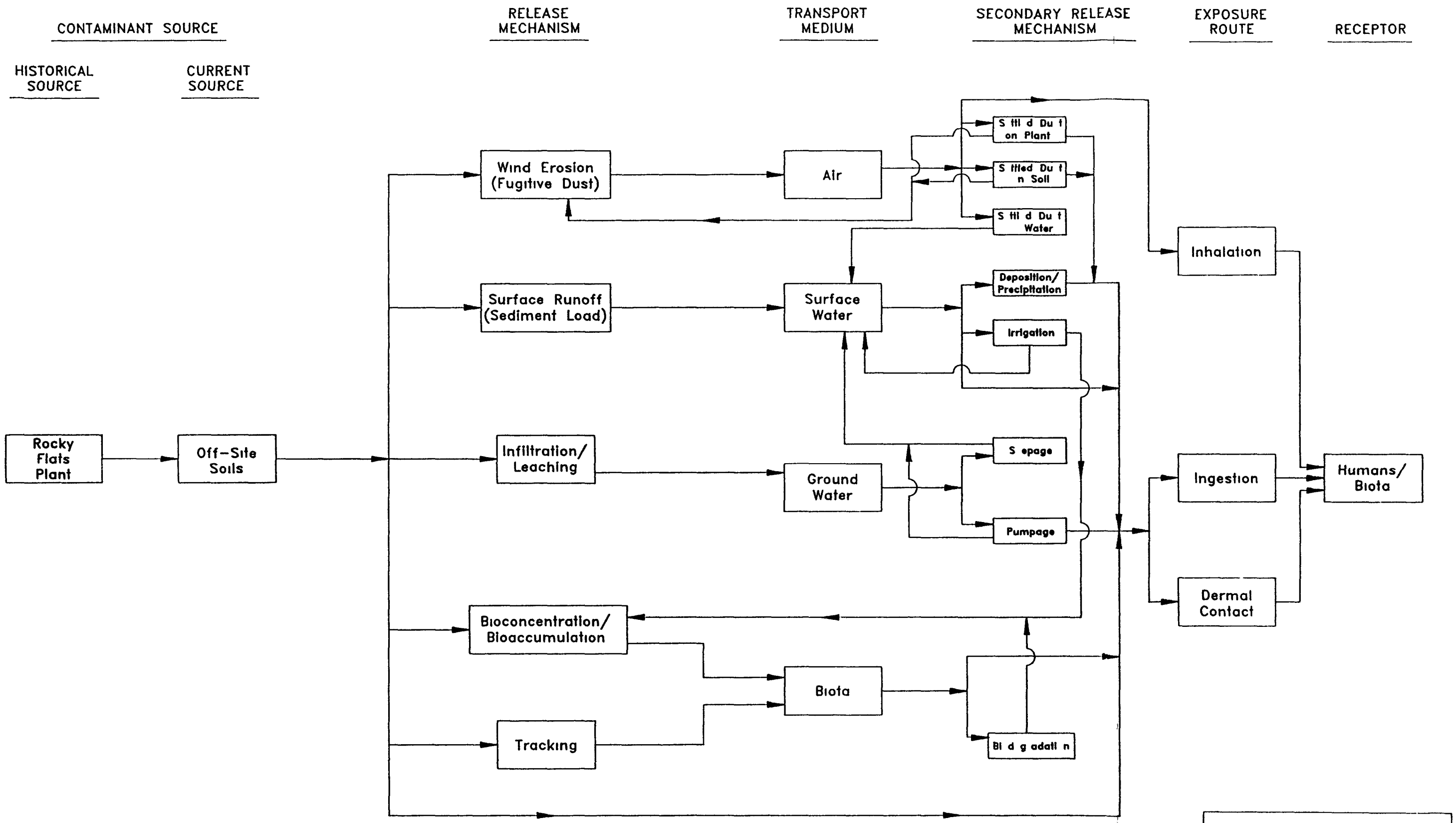


FIGURE 2-8

GENERAL CONCEPTUAL MODEL FOR SITE 199

RITA HYNA 6/20/91 | CHECKED BY CJR | APPROVED BY CJR | DRAWING NUMBER 304-B16

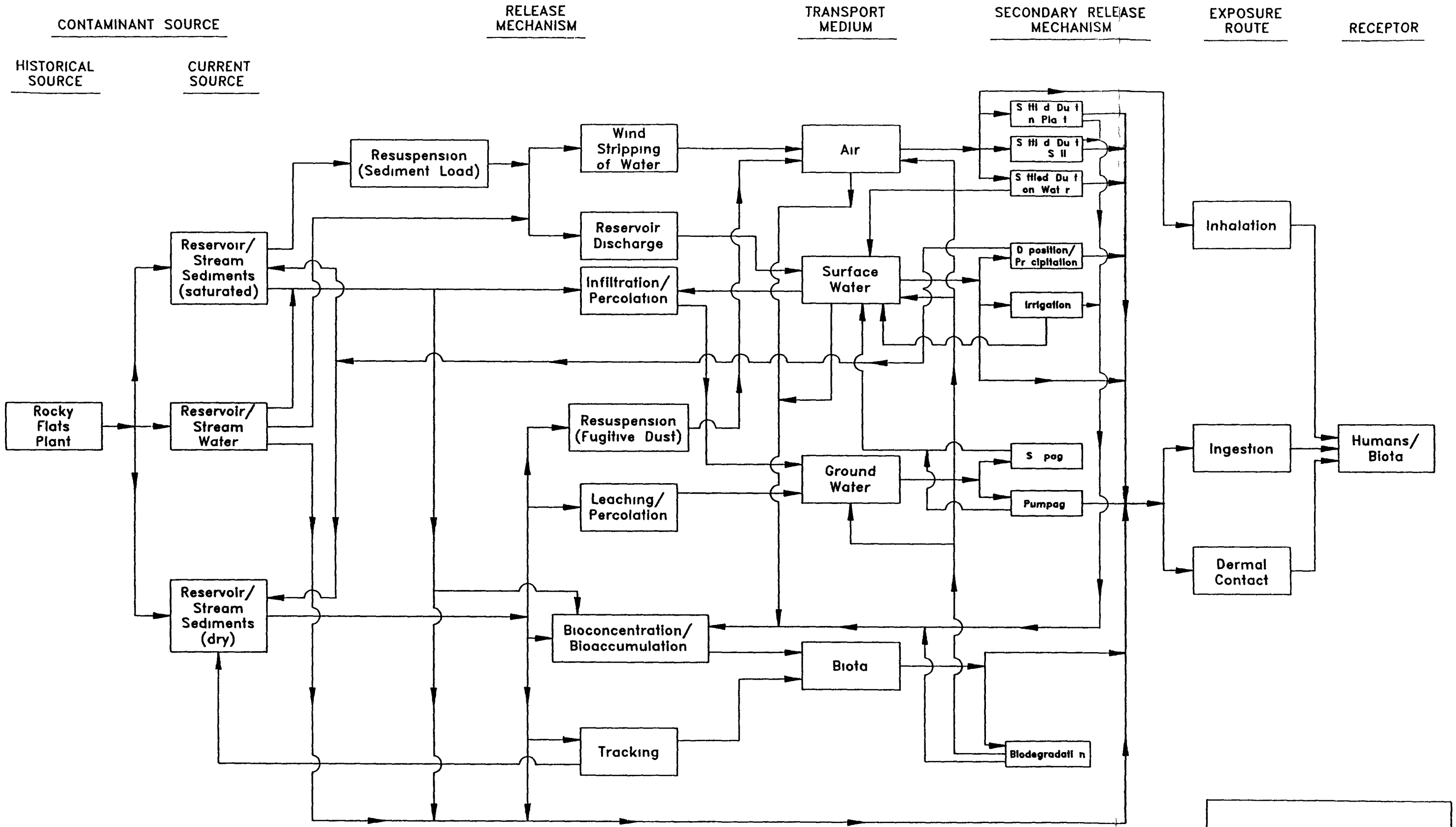


FIGURE 2-9

GENERAL CONCEPTUAL MODEL FOR SITES 200-202

DRAWING NUMBER	06 21 91	06 21 91
CHECKED BY	CJR	CJR
APPROVED BY		
RITA HYNA 6/21/91		

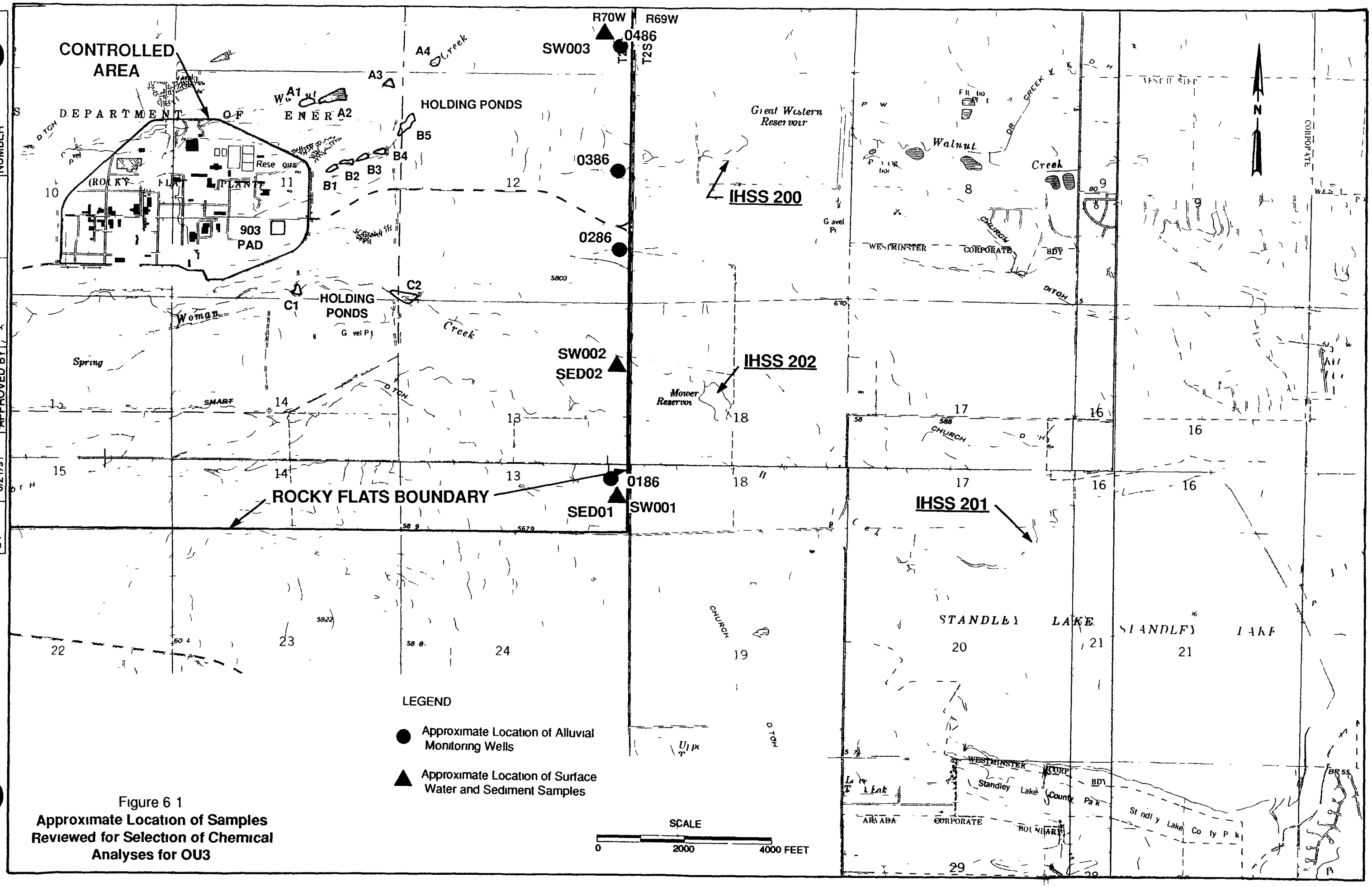


Figure 6 1
Approximate Location of Samples Reviewed for Selection of Chemical Analyses for OU3

DRAWING NUMBER RF10
CHECKED BY
APPROVED BY
Douville 6/21/91
DRAWN BY

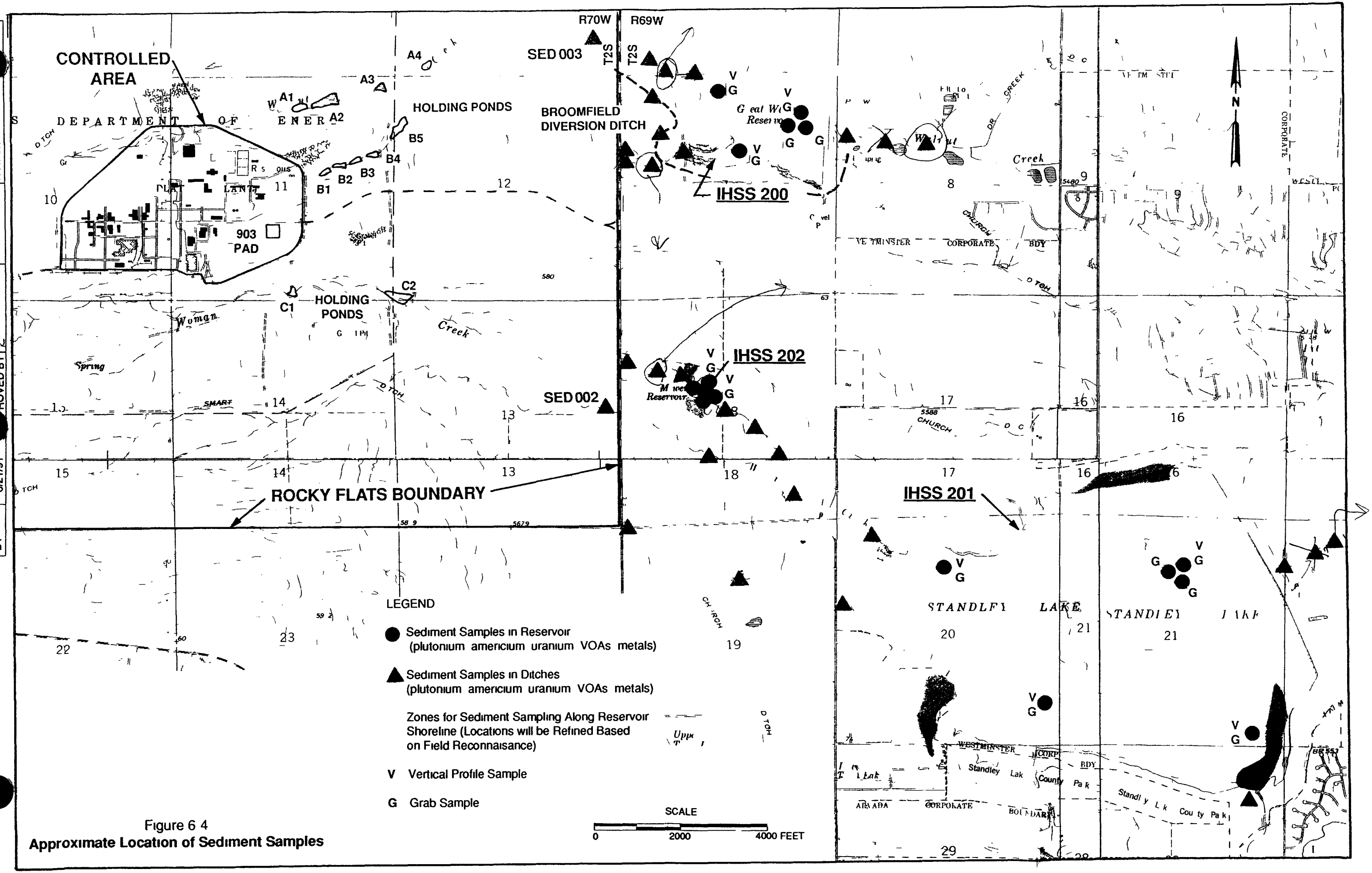


Figure 6 4
Approximate Location of Sediment Samples

DRAWN BY	Douville 6/21/91
CHECKED BY	
APPROVED BY	
DRAWING NUMBER	RF

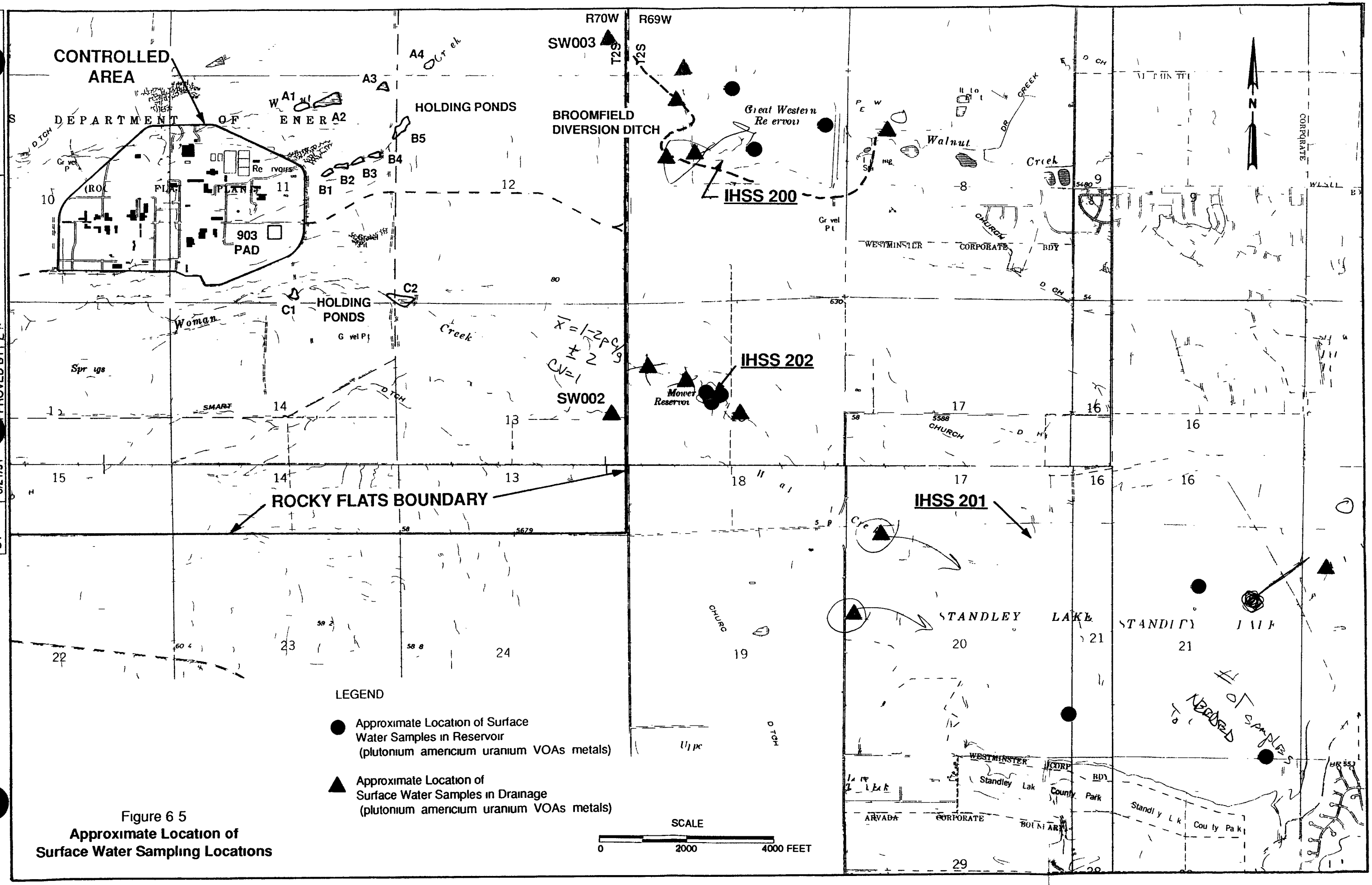


Figure 6 5
Approximate Location of Surface Water Sampling Locations

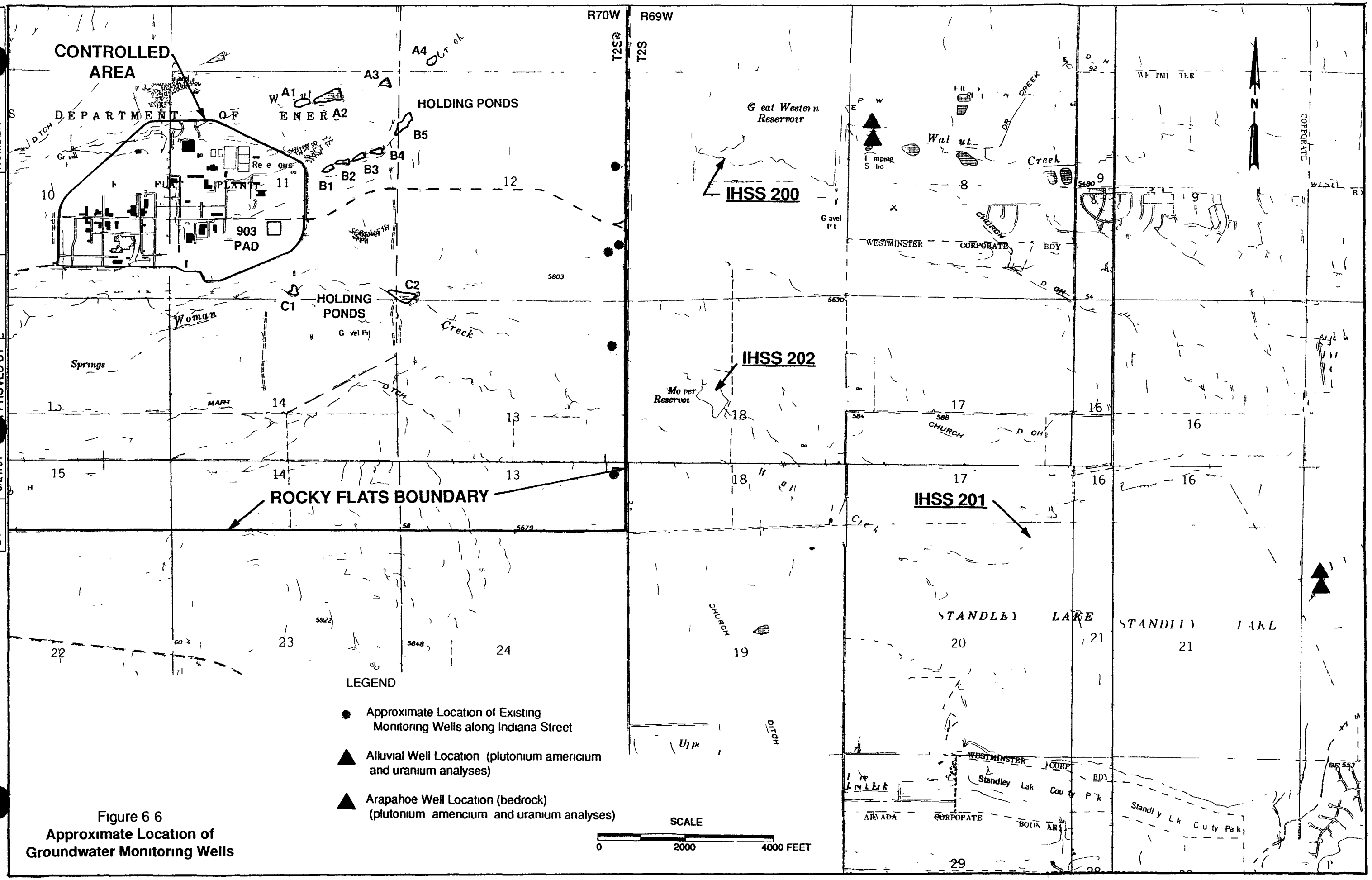


Figure 6 6
Approximate Location of Groundwater Monitoring Wells

DRAWING NUMBER RF1

CHECKED BY

APPROVED BY

DRAWN BY Douville 6/21/91

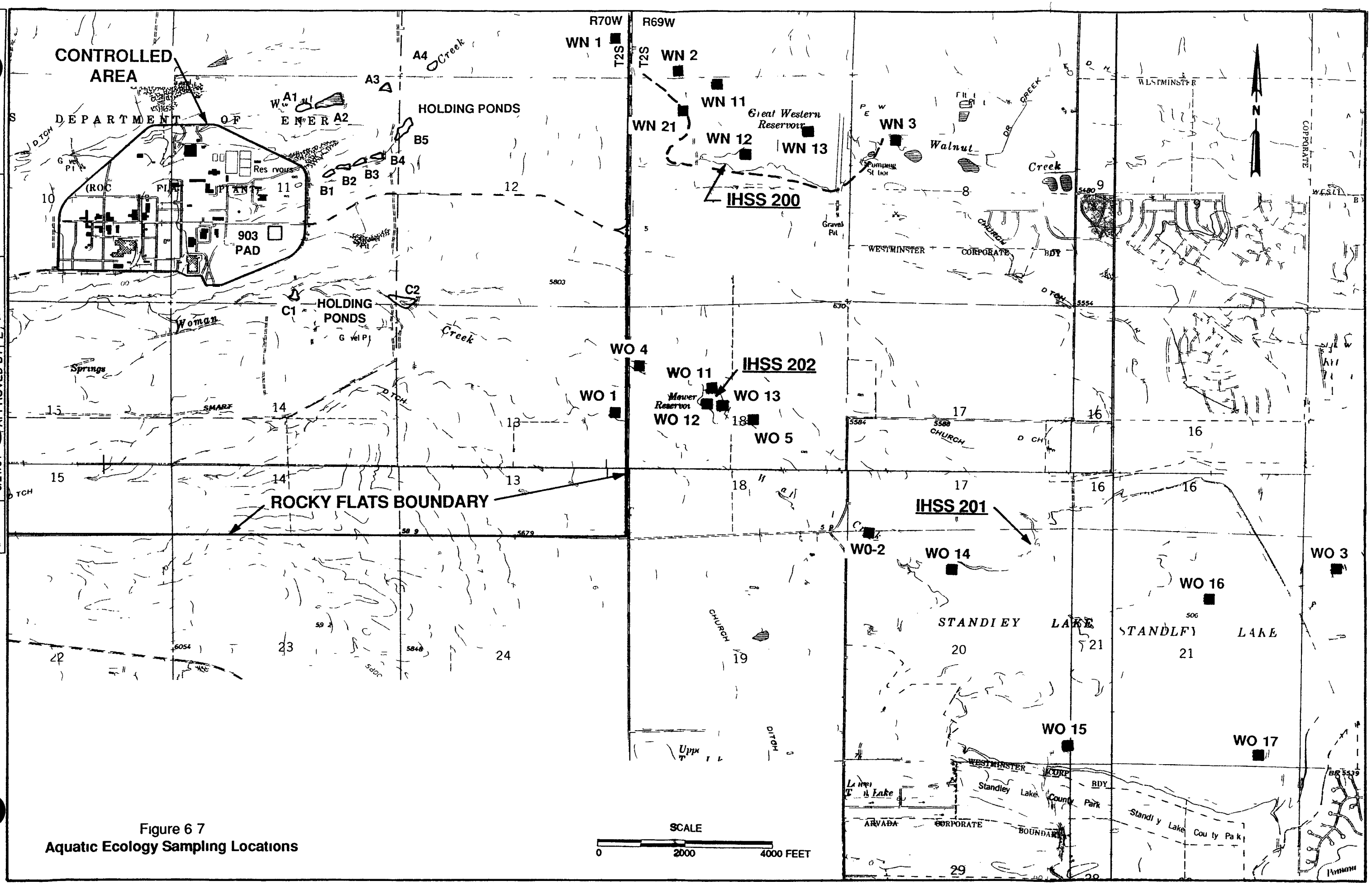
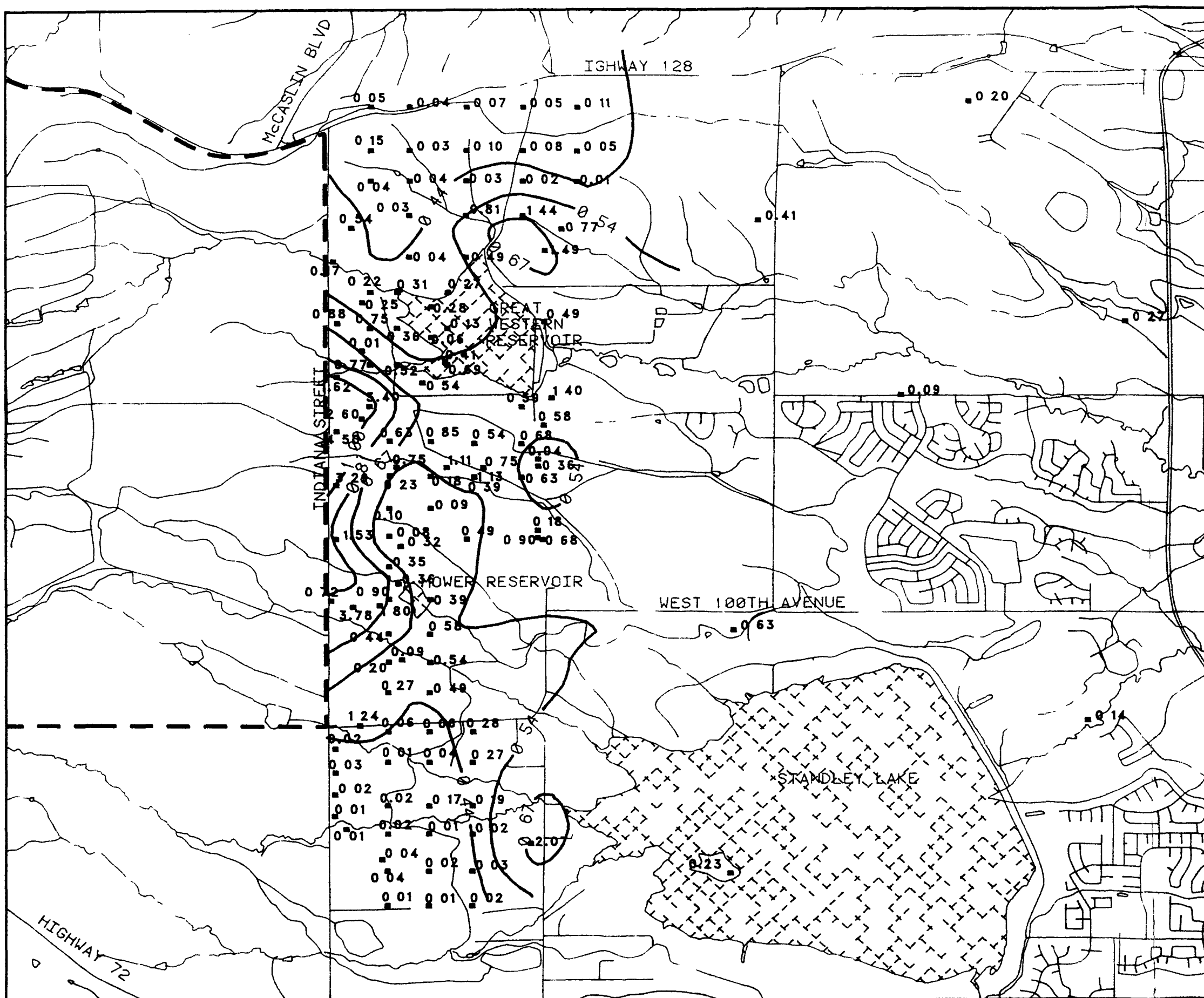


Figure 6 7
Aquatic Ecology Sampling Locations

DRAWN BY Douville 6/21/91
CHECKED BY
APPROVED BY
DRAWING NUMBER RF A



MAP LEGEND

CONTOURS OF SOIL-PU CONCENTRATIONS (pCi/g)

ROCKY FLATS PLANT BOUNDARY

APPROXIMATE SAMPLE LOCATIONS AND VALUES (pCi/g)

0 feet 1725 3450

U S DEPARTMENT of ENERGY

Rocky Flats Plant
Golden Colorado

KRIGING ESTIMATES FOR PLUTONIUM LEVELS IN SOILS EAST OF INDIANA BASED ON 1971 1975-1978 STUDIES

FIGURE A-1