

**MARCH 1995**

**U.S. DEPARTMENT OF ENERGY  
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE  
GOLDEN, COLORADO**

**ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE  
OPERABLE UNIT NO. 11  
WEST SPRAY FIELD**

**COLORADO DEPARTMENT OF PUBLIC  
HEALTH AND ENVIRONMENT  
SOURCE AREA DELINEATION AND  
RISK-BASED CONSERVATIVE SCREEN  
AND  
ENVIRONMENTAL PROTECTION AGENCY  
AREA OF CONCERN DELINEATION**

**DRAFT LETTER REPORT**

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## LIST OF ACRONYMS

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AOC	area of concern
ARARs	applicable or relevant and appropriate requirements
CDPHE	Colorado Department of Public Health and Environment
COC	contaminant of concern
CSF	cancer slope factor
DOE	U S Department of Energy
EPA	U S Environmental Protection Agency
FS	feasibility study
HHRA	human health risk assessment
IHSS	individual hazardous substance site
LHSU	lower hydrostratigraphic unit
OU	operable unit
PCOC	potential contaminant of concern
PPRG	Programmatic Preliminary Remediation Goal
QC	quality control
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RFI	RCRA Facility Investigation
RI	Remedial Investigation
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
TIC	tentatively identified compound
UHSU	upper hydrostratigraphic unit
UTL	upper tolerance limit
VOC	volatile organic compound
WSF	West Spray Field

## EXECUTIVE SUMMARY

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This document presents the results of the Colorado Department of Public Health and Environment (CDPHE) Risk-Based Conservative Screen for Operable Unit No 11 (OU 11), West Spray Field (WSF), at the U S Department of Energy (DOE) Rocky Flats Environmental Technology Site (RFETS) in Golden, Colorado. The WSF includes one individual hazardous substance site (IHSS), IHSS 168, where periodic spray application of excess liquids pumped from Solar Evaporation Ponds took place between April 1982 and October 1985.

The CDPHE Risk-Based Conservative Screen was developed to support the CDPHE evaluation of contaminant source area(s), which may be classified as low-hazard areas that warrant no further action, areas that require further evaluation in a baseline Human Health Risk Assessment (HHRA), or high-hazard areas that warrant potential early action. The source area(s) in the CDPHE screen are used to identify area(s) of concern (AOC) for evaluation in the HHRA portion of the Combined Phases Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Remedial Investigation (RI) for OU 11. In the RFI/RI report, a baseline HHRA is conducted for each AOC.

The CDPHE Risk-Based Conservative Screen includes the following six steps:

- Step 1—Identify potential contaminants of concern (PCOCs)
- Step 2—Identify source area(s)
- Step 3—Identify risk-based concentrations (RBCs)
- Step 4—Calculate RBC ratio sums for each source area
- Step 5—Compare RBC ratio sums to CDPHE Conservative Screen decision criteria
- Step 6—Identify AOC(s) for HHRA

In Step 1 of the CDPHE screen for OU 11, PCOCs were identified using soil data from the surface to a depth of 12 feet and upper hydrostratigraphic unit (UHSU) ground water data. Candidate PCOCs are defined as metals, inorganic compounds, and radionuclides significantly

above background levels as determined by statistical tests described in Gilbert (1993) and organic target analytes detected above analytical detection limits. The final identification of PCOCs is subject to professional review of the test results and graphic presentations of the data.

The PCOCs identified in soil (0 to 12 feet) were americium-241, plutonium-239/240, tritium, and nitrate/nitrite. No PCOCs were identified in UHSU ground water.

In Step 2, inorganic PCOC concentrations or activities above the background arithmetic mean plus two standard deviations were plotted on maps and a source area was identified based on the distribution of the PCOCs (Figures 3-1, 3-2, 3-3, and 3-4). (No organic analytes were identified as PCOCs.) A source area is defined as any area containing concentrations or activities of inorganic PCOCs above the background arithmetic mean plus two standard deviations and/or organic PCOC concentrations above reporting limits. One source area was identified in OU 11. The OU 11 source area is outlined on Figure 3-5 based on PCOC distributions.

In Step 3, carcinogenic and noncarcinogenic RBCs were identified for each PCOC. Chemical-specific RBCs, referred to as Programmatic Preliminary Remediation Goals (PPRGs), are presented in the Final Rocky Flats Programmatic Risk-Based Preliminary Remediation Goals Revision 2 (DOE 1995). The RBCs [PPRGs] identified for the OU 11 CDPHE screen are based on residential exposure to soil.

In Step 4, maximum detected concentrations or activities of PCOCs were compared to RBCs. The following ratio was calculated for each PCOC in the OU 11 source area:

$$RBC \text{ Ratio} = \frac{\text{maximum detected concentration/activity}}{\text{risk-based concentration [PPRG]}}$$

PCOC-specific ratios were then summed to yield carcinogenic and noncarcinogenic total ratio sums. A summary of the total ratio sums for the OU 11 source area is shown in Table ES-1.

**Table ES-1  
Summary of Total Ratio Sums for OU 11**

Source Area	Medium	Carcinogenic Ratio Sum	Noncarcinogenic Ratio Sum
OU 11	Soil (0 to 12 feet)	0.82	0.000084
<b>TOTAL RATIO SUM*</b>		<b>0.82</b>	<b>0.000084</b>

\*Assuming long-term residential exposure to maximum detected concentrations/activities

In Step 5, the following CDPHE Conservative Screen decision criteria were used to classify the OU 11 source area

- If the ratio sum  $\geq 100$ , indicating a potential health hazard assuming long-term exposure to maximum detected concentrations/activities, a voluntary corrective action (early action) or a baseline HHRA will be conducted
- If  $1 < \text{ratio sum} < 100$ , a baseline HHRA must be conducted
- If the ratio sum  $\leq 1$ , indicating a low-hazard source area, no further action may be recommended, pending evaluation of incremental risk from dermal exposure

The OU 11 source area had a carcinogenic total ratio sum less than 1 (0.82) and a noncarcinogenic total ratio sum less than 1 (0.000084). Therefore, the OU 11 source area is a candidate for no action based on the CDPHE Conservative Screen decision criteria. An evaluation of dermal contact with PCOCs in surface soil in the OU 11 source area is presented in Appendix E. Results of this evaluation confirm that dermal exposure is not a significant exposure pathway for OU 11 and that OU 11 is a candidate for no action in accordance with the CDPHE/EPA/DOE Risk Assessment Agreement (CDPHE/EPA/DOE 1994) (Figure 1-2).

In Step 6, AOCs are identified as one or several source areas located close together that exceed the CDPHE Conservative Screen decision criteria. AOCs are identified to support the HHRA in the RFI/RI Report. Results of the comparison of OU 11 total ratio sums to CDPHE Conservative Screen decision criteria indicate no action at OU 11, therefore, no AOCs are identified at OU 11 and a baseline risk assessment is not warranted.

**INTRODUCTION**

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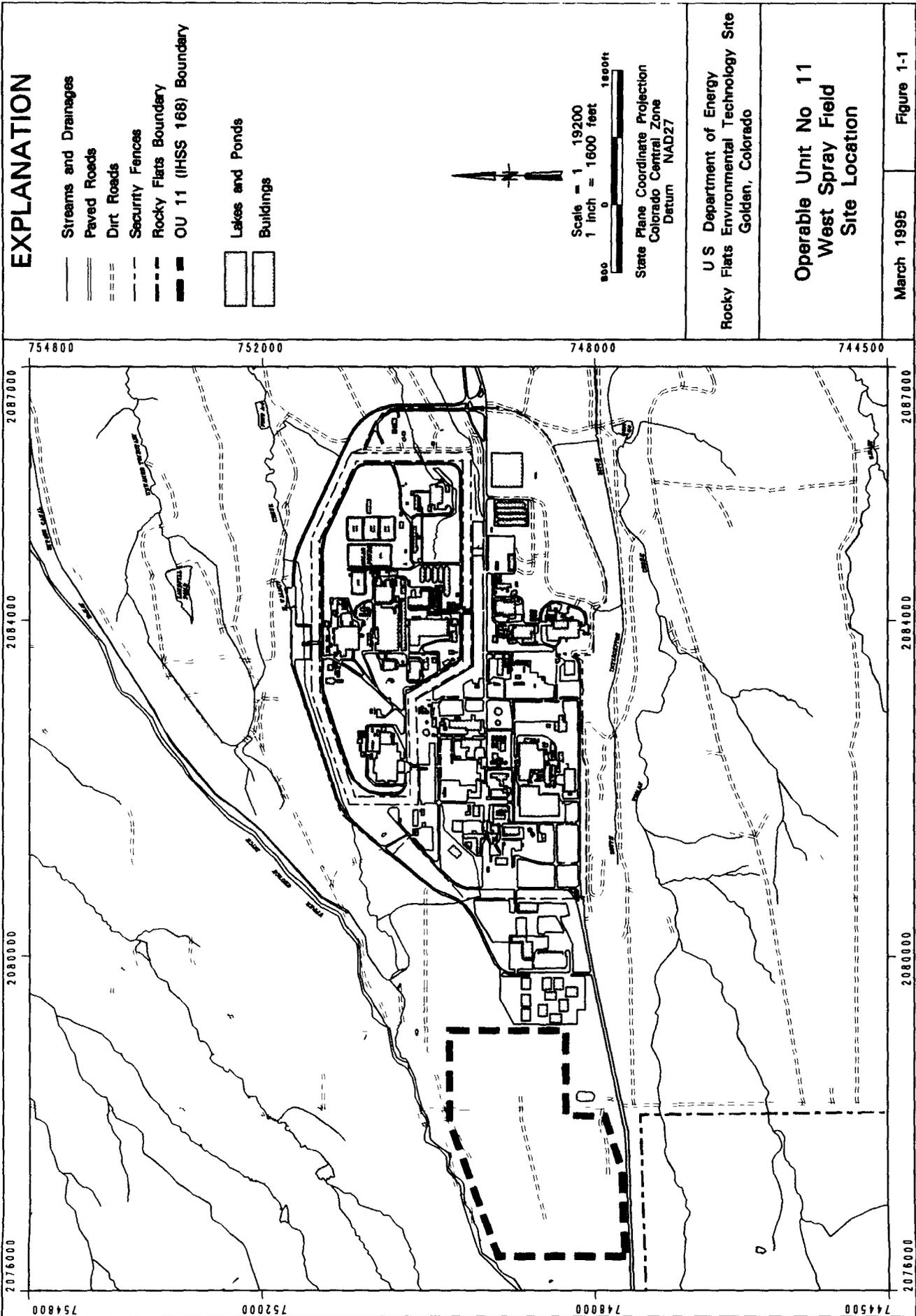
This document presents the results of the Colorado Department of Public Health and Environment (CDPHE) Risk-Based Conservative Screen for Operable Unit No 11 (OU 11), West Spray Field (WSF), at the U S Department of Energy (DOE) Rocky Flats Environmental Technology Site (RFETS) in Golden, Colorado

The WSF includes one individual hazardous substance site (IHSS) IHSS 168 The WSF (IHSS 168) is located on the west side of RFETS and covers an area of approximately 105.1 acres (Figure 1-1) Between April 1982 and October 1985, three areas of the WSF were used for periodic spray application of excess liquids pumped from Solar Evaporation Ponds 207-B Center and 207-B North Pond 207-B Center was a repository for effluent from the Sewage Treatment Plant (STP), which processes sanitary waste from the Industrial Area Pond 207-B North was a repository for water from the STP and the interceptor trench system The interceptor trench system was installed to collect ground water and seepage from the hillside north of the Solar Evaporation Ponds and water from Building 771 and 774 footing drains The approximate combined spray area was 41.3 acres (DOE 1994a)

Aerial photos indicate that a fourth area on the eastern edge of the WSF received occasional spray applications between April 1982 and October 1982 Construction of the 130 Series buildings began in October 1982 and ended all spraying in this area As suggested by the spray volumes prior to October 1982, this fourth area received relatively minor spray applications (OU 11 Combined Phases RFI/RI, draft in progress)

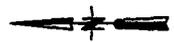
The CDPHE Risk-Based Conservative Screen was developed to support the CDPHE evaluation of source area(s) which may be classified as

- low hazard areas that warrant no further action
- areas that require further evaluation in a baseline Human Health Risk Assessment (HHRA)
- high hazard areas that warrant potential early action



# EXPLANATION

- Streams and Drainages
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings



Scale = 1 19200  
 1 inch = 1800 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

Operable Unit No 11  
 West Spray Field  
 Site Location

March 1995

Figure 1-1

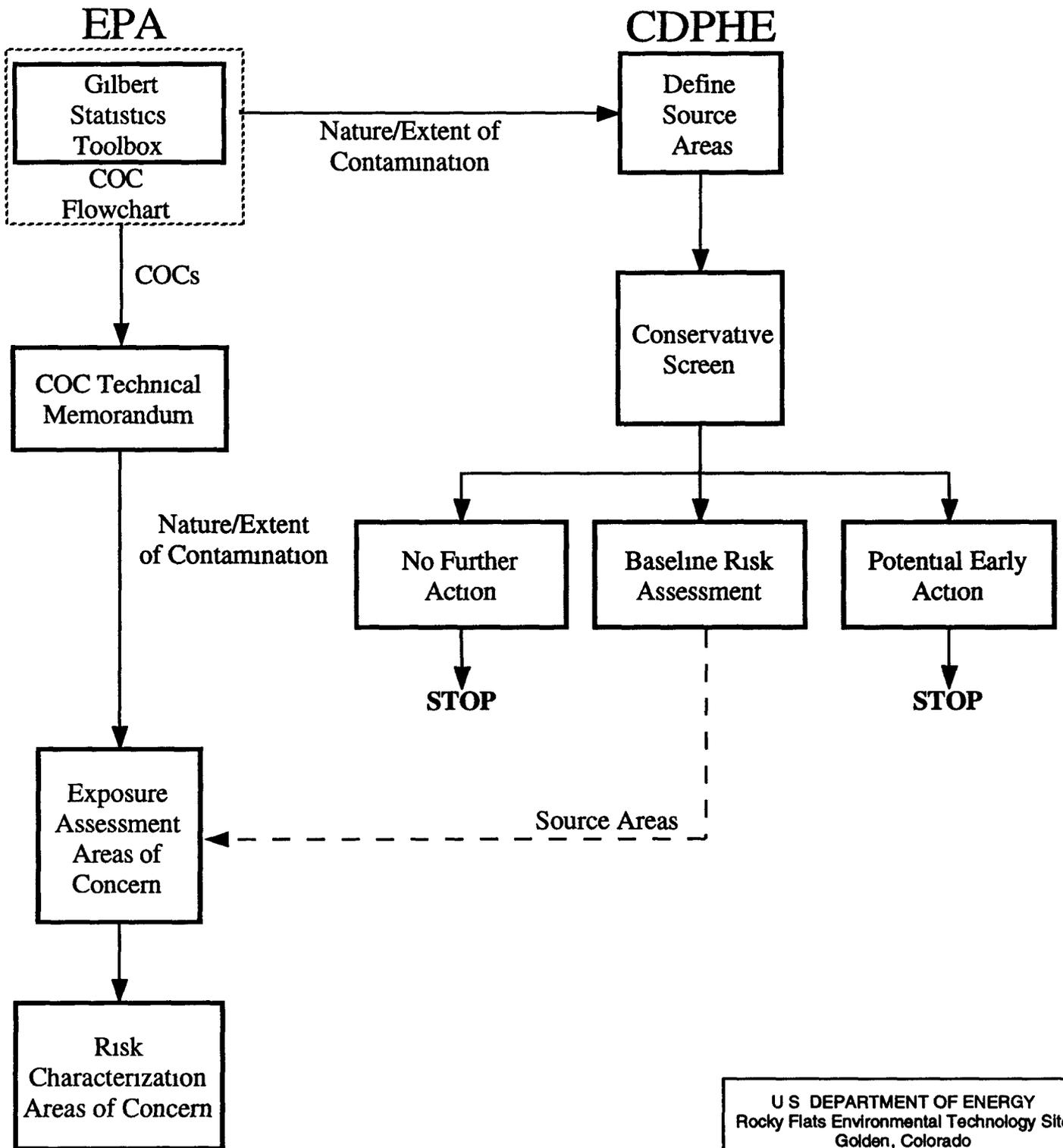
The source area(s) in the CDPHE screen are used to identify area(s) of concern (AOC), which are defined as one or several source areas located close together that exceed the CDPHE Conservative Screen decision criteria. Each AOC is evaluated in the baseline HHRA portion of the Combined Phases Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Remedial Investigation (RI) for OU 11. In the RFI/RI report, a baseline HHRA will be conducted for each AOC.

Guidance for data aggregation for risk assessment and for the CDPHE screen is provided in a memorandum from DOE (1994b) and in documents prepared jointly by CDPHE, U.S. Environmental Protection Agency (EPA), and DOE (CDPHE/EPA/DOE 1994). The CDPHE screen compares maximum detected concentrations or activities of potential contaminants of concern (PCOCs) in each source area to health risk-based concentrations (RBCs) for contaminants in applicable media. The resulting PCOC-specific ratios are then summed. If the sum of the ratios is less than or equal to 1, the source area is a candidate for no further action. If the ratio sum exceeds 1, the source area is subject to further evaluation, either in a baseline HHRA or as a candidate for early action. Therefore, the CDPHE Risk-Based Conservative Screen can be used to identify no-further-action source areas, potential early action source areas, and source areas that can be combined into AOCs for evaluation in the baseline HHRA.

The CDPHE Risk-Based Conservative Screen does not replace contaminant of concern (COC) selection, exposure pathway analysis, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis that are required in an HHRA and are used to support risk management decisions. The relationship of the HHRA to the CDPHE screen is illustrated in Figure 1-2. The COC Technical Memorandum for OU 11 will not be written due to the results of the OU 11 CDPHE Conservative Screen, which show that a Baseline Risk Assessment is not warranted.

The process used to conduct the CDPHE Risk-Based Conservative Screen is illustrated in Figure 1-3. Steps in the screen are listed below.

**Step 1—Identify PCOCs** PCOCs are identified as organic target analytes detected above reporting limits and metals, inorganic compounds, and radionuclides significantly above background levels based on statistical evaluation (Gilbert 1993). The PCOC determination is made on the basis of statistical comparison of OU 11 soil and ground water sample data to background data and on professional judgment and geochemical analyses.



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CDPHE\EPA\DOE Risk  
 Assessment Agreement

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Figure 1-2

**STEP 1 Identify PCOCs**  
 Compare OU 11 data to background  
 (Gilbert Methodology)

**STEP 2 Identify Source Area(s)**  
 source area = any area containing organic  
 PCOCs above reporting limits and/or  
 inorganic PCOCs above the background  
 mean plus two standard deviations

**STEP 3 Identify RBCs**  
 Use PPRGs calculated for RFETS based on direct  
 residential exposure parameters, ingestion,  
 inhalation, and external exposure, and 1E-06 excess  
 lifetime cancer risk or hazard index of 1

**STEP 4 Calculate RBC Ratio Sums for each Source Area**

$$\text{RBC Ratio Sum} = \sum_{j=1}^m \left( \sum_{i=1}^n \left( \frac{\text{Maximum Detected Concentration or Activity } ij}{\text{RBC}_i} \right) \right)$$

i = PCOC  
 j = medium

**STEP 5 Compare RBC Ratio Sums to CDPHE  
 Conservative Screen Decision Criteria**

Ratio Sum ≤ 1      1 < Ratio Sum < 100      Ratio Sum ≥ 100

Assess  
 Dermal  
 Exposure

No Further  
 Action

Baseline Risk  
 Assessment

Potential  
 Early Action

**STEP 6 Identify AOCs for HHRA**  
 AOC = one or more Source Areas located  
 close together

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**Step 2—Identify Source Area(s)** A source area is defined as any area containing organic PCOCs above reporting limits and/or inorganic PCOCs at concentrations or activities above the background arithmetic mean plus two standard deviations

**Step 3—Identify RBCs** Carcinogenic and noncarcinogenic RBCs are identified for each PCOC RBCs are health-protective contaminant concentrations in a medium, calculated using conservative assumptions regarding exposure, toxicity, and acceptable risk RBCs have been calculated specifically for RFETS and are presented in DOE (1995) These values, referred to as Programmatic Preliminary Remediation Goals (PPRGs), are used in the OU 11 CDPHE Risk-Based Conservative Screen

**Step 4—Calculate RBC Ratio Sums for Each Source Area** The ratio of the maximum detected concentration or activity to the corresponding RBC [PPRG] is calculated for each PCOC that occurs in the source area at concentrations or activities above background arithmetic mean plus two standard deviations (inorganics) or above detection limits (organics) Maximum detected concentrations or activities in soil are identified from samples collected to a depth of 12 feet, which is the depth recommended for use by CDPHE (CDPHE/EPA/DOE 1994) Maximum detected concentrations or activities in ground water are identified from unfiltered samples collected from the upper hydrostratigraphic unit (UHSU) The contaminant-specific ratios are then summed for each medium, resulting in a carcinogenic and noncarcinogenic subtotal ratio sum for each medium Subtotal ratio sums are then added to yield a carcinogenic and noncarcinogenic total ratio sum for residential exposure

**Step 5—Compare RBC Ratio Sums to CDPHE Conservative Screen Decision Criteria** The ratio sums calculated in Step 4 are used to designate each source area as a candidate for no further action, for further evaluation in the baseline HHRA, or for possible early action For source areas with ratio sums less than or equal to 1, DOE may pursue a no-further-action alternative Source areas with ratio sums between 1 and 100 will be evaluated in the baseline HHRA For source areas with ratio sums greater than or equal to 100, DOE may pursue a voluntary early action alternative or evaluate the source area further in the baseline HHRA

**Step 6—Identify AOCs for HHRA** As stated earlier, an AOC is a source area or group of source areas located close together that exceed the CDPHE Conservative Screen decision criteria A baseline HHRA will be conducted for each AOC EPA then reviews

and approves AOC delineation. The baseline HHRA will assess exposure to COCs that are identified following EPA- and CDPHE-approved procedures

The following sections describe the application and results of each step of the OU 11 CDPHE Risk-Based Conservative Screen

## IDENTIFICATION OF POTENTIAL CONTAMINANTS OF CONCERN

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Step 1 of the CDPHE Risk-Based Conservative Screen identifies PCOCs for OU 11. PCOCs are defined as (1) metals, inorganic compounds, and radionuclides present at significantly higher concentrations or activities on the site than in media from background locations and (2) organic compounds present at detectable concentrations. Comparisons with the background media were performed using the statistical methods described in *Statistical Comparisons of Site-to-Background Data in Support of RFI/RI Investigations* (EG&G 1994a) and summarized briefly below (Section 2.3).

The following section describes the data analysis and background comparison methods used to identify PCOCs for OU 11 and the resultant list of PCOCs.

### 2.1 Data Used for Comparisons to Background

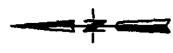
Analytical data from environmental samples collected during the OU 11 Combined Phases RFI/RI and from samples collected during sitewide monitoring programs were used to characterize contamination at OU 11. Three media were sampled during the OU 11 Combined Phases investigation: surficial soils, subsurface geologic materials, and ground water. Sampling locations are shown on Figure 2-1. The number of samples, sampling locations, and other features of the sampling and analytical program are discussed in the Technical Memorandum *Revised Field Sampling Plan and Data Quality Objectives OU 11* (DOE 1994b). The following is a brief summary of the sampling and analytical programs and the types of data used for comparison to background.

#### 2.1.1 Surficial Soil

Soil samples were collected from 53 locations during June and July of 1994. Most of these locations are within IHSS 168, but 12 are downgradient (east) of the IHSS boundary. All samples were collected in areas of potential spray contact, along discharge channels, or at pipeline junctures. The sampled areas were selected through review of historical information, including aerial photographs, and a field reconnaissance.

# EXPLANATION

- 1994 Borehole
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drains
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings
- Channel (20)
- Non-Channel (28)
- Pipeline Junctions (5)



Scale = 1" = 8400 feet  
1 inch = 700 feet



State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

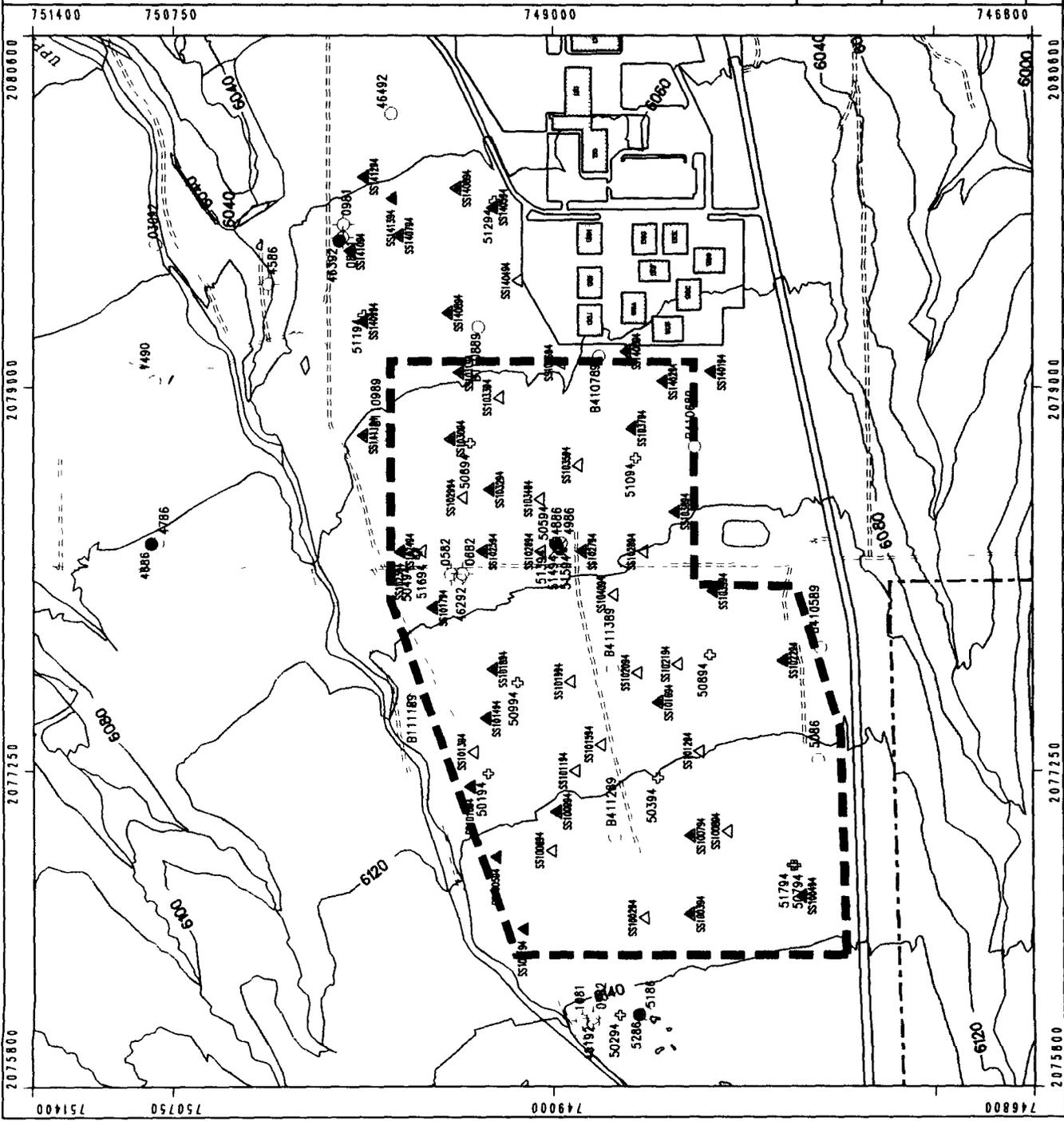
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OU 11--West Spray Field

Sampling Locations

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Figure 2-1



The soil samples were collected from depths of 0 to 2 inches by the modified "Rocky Flats Method" described in the EG&G SOP GT 08, Surface Soil Sampling (EG&G 1991) Use of this method was consistent with other soil sampling programs conducted at RFETS, including background soil sampling programs (EG&G 1994b)

Soil samples collected from test pits during a 1988 investigation were not used because these samples were not comparable to the 1994 samples or background soil samples The 1988 samples were collected from the 0- to 2-foot-depth interval, the 1994 and background soil samples were collected from the 0- to 2-inch interval

The soil samples were analyzed for radionuclides, metals, and nitrate Although volatile and semivolatile organic compounds (VOCs and SVOCs) may also have been present in sprayed liquids, the properties of these compounds combined with the application method used (spraying) make their current detection in surface soils unlikely In addition, previous sampling and analysis of soils within IHSS 168 showed no evidence for the presence of VOCs in those samples (DOE 1994b)

An analysis of the quality of data was performed and determined that data from the surface soil samples collected during 1994 are fully usable per the data quality objectives stated in the Technical Memorandum Revised Field Sampling Plan and Data Quality Objectives OU 11 (DOE 1994b) The precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters of the data were assessed with the following results Precision of metal and radionuclide analyses varies Antimony, copper, molybdenum, nickel, selenium, thallium, tin, and all the radionuclide results have been further qualified as estimated results because precision goals for these analytes were not met Results for surface soil samples are considered accurate, representative, complete, and fully comparable given the data quality objectives for the OU 11 RFI/RI

## 2.1.2 Subsurface Geologic Materials

Seventeen boreholes were drilled within and adjacent to IHSS 168 during the RFI/RI (July through September 1994) Borehole samples from Rocky Flats Alluvium were collected during drilling at each of these locations Samples were collected at 2-foot increments at depths of less than 12 feet below ground surface and at 6-foot increments from 12 feet to the depth of the water table (saturated geologic materials) Two types of samples were collected (1) 3-inch-long discrete samples collected in stainless-steel sleeves for analyses of VOCs and (2)

composited samples (2- and 6-foot increments) collected from the core barrel for analyses of radionuclides, metals, SVOCs, and other parameters. Previous drilling and borehole sampling in the vicinity of OU 11 provided additional analytical data from boreholes 46292, 46392, and 46492. Over 120 samples from Rocky Flats Alluvium were analyzed for SVOCs and VOCs, and over 200 samples were analyzed for other parameters (metals, radionuclides).

An analysis of the quality of data was performed and determined that data from the subsurface soil samples collected during the OU 11 RFI/RI are fully usable per the data quality objectives given in the Technical Memorandum Revised Field Sampling Plan and Data Quality Objectives (DOE 1994b). The PARCC parameters were assessed with the following results. Precision was evaluated for metals, radionuclides, and SVOCs and was variable. Results for aluminum, arsenic, chromium, cobalt, copper, lead, lithium, manganese, molybdenum, nickel, and all radionuclides have been further qualified as estimated results because precision goals for these analytes were not met. Results for nitrate/nitrite and di-n-butyl phthalate were also qualified as estimates based on their poor precision. Results for subsurface soil samples are considered accurate, representative, complete, and fully comparable given the data quality objectives for the OU 11 RFI/RI.

### 2.1.3 Ground Water

Ground water samples were collected during the Combined Phases RFI/RI and also during ongoing quarterly monitoring of existing wells in the vicinity of OU 11. Quarterly samples of UHSU ground water collected from the first quarter of 1990 through the third quarter of 1994 were included in the data set. Data from 14 wells within IHSS 168, including 9 wells installed during the fall of 1994, and from 10 wells downgradient of IHSS 168, including 2 wells installed in 1994, were included in the data set used to describe ground water from the UHSU.

Criteria for selecting the locations for new well installations included locating wells within areas that received direct spray application, proximity to previously detected contaminants, and projections of shallow ground water.

One objective of the OU 11 RFI/RI was to investigate and identify perched zones of ground water present above the UHSU water table. A number of boreholes were drilled in areas where perched ground water was thought to be present. No saturated zones were encountered at depths above the water table but geologic materials were found to be variably saturated and capable of yielding ground water to a monitoring well. Three monitoring wells were installed at shallow

depths to monitor and access variably saturated zones above the water table. Eight monitoring wells were installed in saturated portions of the UHSU. The new wells were sampled once following their installation, additional samples are being collected quarterly for analysis. Only a few samples were collected from the variably saturated zone due to the low production of these wells. Review of the chemical data from the variably saturated zone indicated that this water is not, in general, chemically distinct from ground water from the saturated portions of the UHSU. The number of samples available from the variably saturated zone is not sufficient to perform statistical comparisons to the background data for ground water. Therefore, data from the samples collected in the variably saturated zone have been added to the larger data set from samples collected in saturated portions of the UHSU. Over 250 samples of UHSU ground water were included in the data evaluated for OU 11.

The majority of ground water samples used in the OU 11 RFI/RI and in background comparisons were collected during sitewide ground water monitoring programs and not during the OU 11 investigation. The quality of ground water data collected between 1990 and 1994 was described in the Groundwater Geochemistry Report (EG&G 1995). The PARCC parameters reported in that document were compared to the data quality objectives for the OU 11 RFI/RI to determine the usability of ground water data. The precision of metal, radionuclide, and water-quality parameter analyses is fair and in some cases does not meet the precision goals for OU 11. However, these data are considered usable as estimated results. Precision for SVOCs and VOCs was not evaluated given the high percentage of non-detectable values in the database. Representativeness of ground water data is good and meets OU 11 goals. Analyses of trip blanks and field blanks reveal that acetone, carbon disulfide, dichloromethane, methylene chloride, toluene, and 2-butanone were present. These compounds may have been introduced during shipping, handling, or preparation of samples. The ground water data are complete and fully comparable.

#### 2.1.4 Background Data

Background data from locations given in the Background Geochemical Characterization Report (DOE 1993) made up the background database used for UHSU ground water and subsurface geologic materials. Background ground water samples collected from first quarter 1990 through second quarter 1993 were extracted from the Rocky Flats Environmental Database System (RFEDS) and compose the background data set. Samples of geologic materials were collected from background locations in 1991.

Background surficial soils were not described in the Background Geochemical Characterization Report (DOE 1993) Background soils were collected and analyzed separately in support of remedial investigations at OU 1 and OU 2 These soils were collected during 1991 and 1992 from 18 locations in the Rock Creek drainage north of the Industrial Area (EG&G 1994b) Analytical results from these samples were extracted from RFEDS and compose the background-soil data set

## 2.2 Data Review and Cleanup

Data collected during the OU 11 RFI/RI, quarterly ground water monitoring programs, and background characterization programs were received in electronic format from RFEDS and systematically reviewed and organized to achieve a standard format for each record. Identical data-cleanup routines were used to format data from the site and from the background locations. These routines, described in detail in Appendix A, are based in part from guidance received from EG&G (1994c) The OU 11 data-cleanup routines are briefly summarized below.

Site data used in the OU 11 CDPHE screen were extracted from RFEDS on December 21, 1994 In addition to the analytical data from environmental samples, the RFEDS data includes information such as field measurements, quality control (QC) samples, and analytical results for sample dilutions RFEDS contains all validated and unvalidated results Prior to evaluating the data, the entire database was reformatted and made internally consistent by the following steps

1. Records reported with undefined units, laboratory qualifiers, or validation codes; blank results or unit fields, and non-radionuclide results equal to zero were researched If a resolution was not possible, these records were labeled as unusable
2. Tentatively identified compound (TIC) records were labeled based on a result type of TIC or laboratory qualifier of "A" or "N "
3. Unvalidated result values, detection limits, and units were replaced with validated result values, detection limits, and units if validated data were included with the record
4. Result values were converted to consistent units of measurement for each group of analytes of each media type

- 5 A usability category was assigned based on validation codes and laboratory qualifiers (refer to Appendix A)
- 6 Results that indicated detection of an analyte and results that indicated nondetects were labeled

An internally consistent database of supportable data, standardized units of measure, and unique records for each analyte for each sample was developed using these cleanup steps. Detect and nondetect criteria, quantity summaries, validation status, and usability status of the records were compiled from this database.

The following additional formatting steps were performed to produce the final "project" database for OU 11:

- 1 TIC records and records for analytes not included on the list of target analytes in the OU 11 Field Sampling Plan were removed
- 2 Records labeled as unusable or rejected were removed
- 3 Location descriptions and hydrostratigraphic and geologic unit labels were added to each record for use in aggregating comparable data

The end result is the project database from which all data used in site characterization, risk assessment, or data-quality evaluations are extracted. Two separate files, the "working" database (real-sample results) and the QC database (QC-sample results), were created from the project database as follows:

- 1 Records of real and duplicate sample pairs were identified and copied to the QC database, duplicate sample records were removed from the working database
- 2 Records for field blanks, trip blanks, equipment rinses, and matrix spikes were moved from the working database to the QC database

For each of these databases, duplicate records were identified and researched to determine which record to use based on the result type (for example, TRG [target], DIL [dilution], REP

[replicate], REX [re-extraction]), laboratory qualifier, and validation code Records not used were labeled as unusable

Data from the working database were used to perform statistical comparisons of site data to background data and to evaluate the nature and extent of contamination Data from the QC database were used to describe the quality of data collected for the Combined Phases RFI/RI in terms of data-quality indicators

Background data used for comparisons to OU 11 data were extracted from RFEDS in January 1995 These data were identical to the data used in the Background Geochemical Characterization Report (DOE 1993) except that some records previously identified as unusable due to missing information had been updated The updated records were more complete and therefore could be included in the database used to calculate summary statistics for background media (including upper tolerance limits [UTLs]) The background data were subject to the same cleanup routines as were the data collected at OU 11

Prior to performing the statistical comparisons, data from the working database were systematically reviewed to identify records for non-detects A new result value was assigned to the non-detect records for use in statistical summaries or comparison tests For use in statistical summaries, this value is one-half the reported detection limit and one-half the result when the CRDL is the reported detection limit (mean, standard deviation, etc ) (EG&G 1994c) For use in the statistical comparison tests, this value is the reported detection limit (Gilbert 1993)

### **2.3 Background Comparison**

Data from OU 11 samples collected during the Combined Phases RFI/RI were compared to data from background samples of like media The data from each media type were aggregated in comparable subsets for comparison to background data in order to meet each specific investigation objective and to identify PCOCs Summary statistics for site and background data sets are included in Appendix B

Qualitative comparisons of site data to background data were made for each media type sampled at OU 11 Graphic presentations of the data were used to evaluate the magnitude, variability, and distribution of concentrations for each analyte (Appendix D)

Chemical concentration data from various media sampled at OU 11 were statistically evaluated to identify analytes present at concentrations elevated relative to concentrations in the same media from background locations. Analytes with elevated concentrations in media from OU 11 were considered PCOCs as defined in EG&G (1994a). PCOCs were identified by comparison to background data using the statistical and qualitative methods outlined in Statistical Comparisons of Site-to-Background Data in Support of RFI/RI Investigations (EG&G 1994a). The site-to-background comparison methods were used to identify inorganic analytes and radionuclide PCOCs. Organic compounds were considered PCOCs if detected in samples from OU 11.

### 2.3.1 Data Aggregation for Background Comparison at OU 11

Prior to performing the statistical comparisons, data from each medium were aggregated so that the comparison results would address the specific objectives of the OU 11 RFI/RI, including providing a list of PCOCs. Data aggregation was based on the statistical assumption that all samples within a data set were independent but comparable and represented by a single population characterized by a fixed mean and variance.

Surficial soil samples from OU 11 comprise samples collected from two areas within IHSS 168 and east of IHSS 168. In both of these areas, surficial soil samples were collected from the 0- to 2-inch depth interval. Soil samples from these two areas are comparable to each other and directly comparable to background soils which were also collected from the 0- to 2-inch depth interval. To identify the PCOCs used in evaluations of risk to human health, the statistical comparison included all soil samples collected during the Combined Phases RFI/RI (IHSS 168 plus east of IHSS 168). Although the samples east of IHSS 168 are outside the boundaries of OU 11, the samples were included in the evaluation for PCOCs for the OU 11 CDPHE screen because they represent soils potentially affected by contaminants. Soils at the ground surface may have been contacted by wind-dispersed spray or dust, and soils at depth (less than 12 feet) may have received leakage from the historic pipelines.

Borehole samples were collected from 0 to 12 feet from 11 locations within IHSS 168 and 4 locations outside IHSS 168. The samples are from Rocky Flats Alluvium. To identify the PCOCs for the OU 11 CDPHE screen, analytical results from these samples were compared to results from analyses of samples of Rocky Flats Alluvium collected from background locations.

Ground water samples have been collected from wells screened in the UHSU and lower hydrostratigraphic unit (LHSU). Because these units comprise separate flow systems, the data were divided by hydrostratigraphic unit. Wells that screen the UHSU have been further subdivided into two areas: upgradient wells and wells within and downgradient of IHSS 168. Ground water samples from these areas are comparable but also constitute two populations: one not affected by sources at IHSS 168 and one potentially affected by sources at IHSS 168. PCOCs in UHSU ground water were identified for the OU 11 CDPHE screen by comparing unfiltered UHSU data from wells within and downgradient of IHSS 168 to sitewide background data.

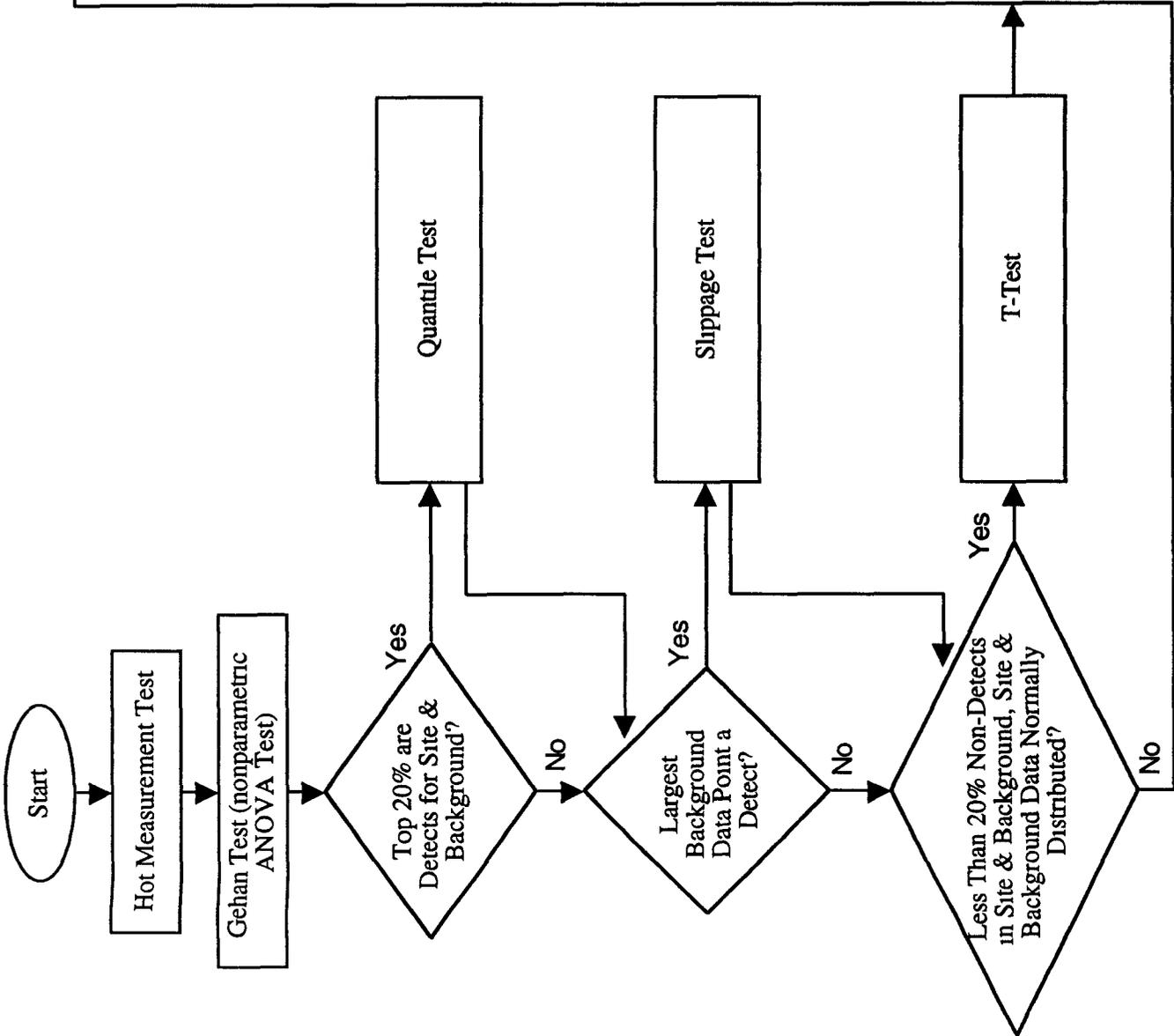
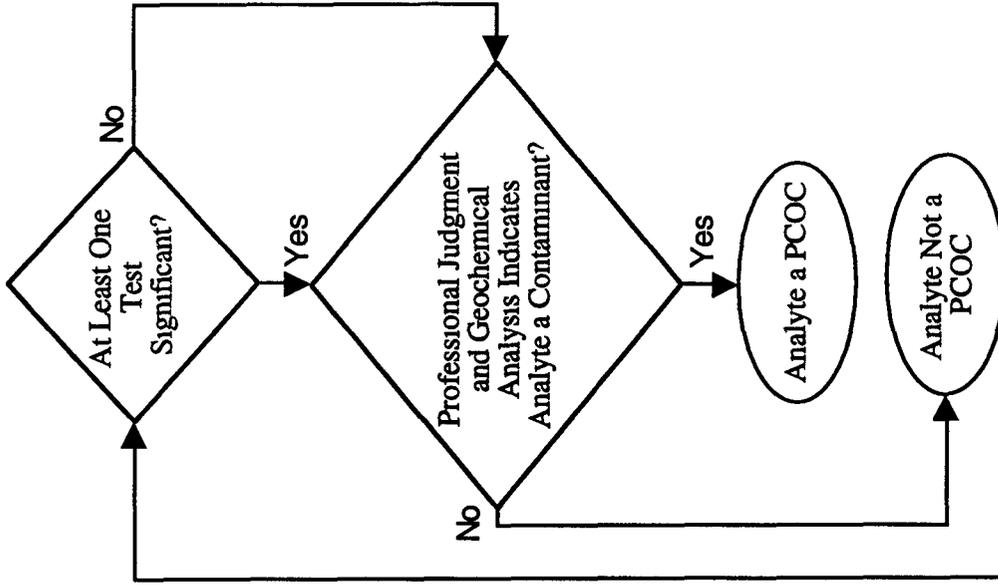
Table 2-1 presents the data sets used to perform background comparisons and identify the PCOCs in each medium.

**Table 2-1  
Data Aggregation for Background Comparisons to Support  
Site Characterization and Risk Assessment**

Media	OU 11 Data Set	Background Data Set
Surficial Soil	All samples collected within and east of IHSS 168 (0 to 2 inches)	OU 1 and OU 2 background soils (Rock Creek)
Subsurface Geologic Materials	Borehole samples of Rocky Flats Alluvium collected within and east of IHSS 168 (0 to 12 feet)	Sitewide background data for Rocky Flats Alluvium
Ground Water	UHSU samples from saturated media within and downgradient of IHSS 168	Sitewide background data for UHSU ground water

### 2.3.2 Statistical Analysis Procedures for PCOC Identification

The flow chart presented in Figure 2-2 illustrates the process for identifying PCOCs. The statistical methodology for site-to-background comparisons for inorganic analytes and radionuclides followed the procedures outlined in Statistical Comparisons of Site-to-Background Data in Support of RFI/RI Investigations (EG&G 1994a). This method, known as the "Gilbert methodology" (from Gilbert 1993), was used by mutual agreement among EPA, CDPHE, and DOE. The PCOC identification process for inorganic analytes consisted of the following steps: a hot-measurement test, the Gehan test, the Quantile test, the Slippage test, the t-test, and



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Operable Unit No 11 Draft Letter Report Background Comparison Methodology	
March 1995	Figure 2-2

professional judgment. Inorganic analytes having concentrations elevated relative to background concentrations, as indicated by the hot-measurement test or any one of the inferential statistical tests (Gehan, Quantile, Slippage, and t-test), are considered candidate PCOCs. Background comparison summaries for analytes in each medium are included in Appendix C. The five comparison tests are described below.

Chemical data from OU 11 were evaluated using a hot-measurement test, which compares each measurement with an upper tolerance limit (UTL) value for the corresponding analyte in the background data. The hot-measurement test is useful as a screening tool to ensure that unusually large measurements are adequately evaluated regardless of the output of the more formal inferential statistical tests. The UTL concentration used during comparison of site to background data was the  $UTL_{99/99}$  value in accordance with Rocky Flats guidance on statistical comparisons (EG&G 1994b). This UTL represents a value for which there is 99-percent confidence that the UTL is equal to or greater than the true 99th percentile of the background population. The UTL values for background data were calculated from the background data extracted from RFEDS in January 1995. The hot-measurement test is an indicator of possible hot spots (Gilbert 1993), however, with large sample sizes (100 to 300 samples) from the site, occasional UTL exceedances are expected because the UTL value includes only the 99th percentile of the background data.

In some cases, the concentrations of an analyte in the background population was not normally distributed. In these cases a log-normal  $UTL_{99/99}$  value was calculated and compared to the site data. This comparison resulted in the exclusion of some analytes as PCOCs (as noted in Appendix C).

Statistical inference tests (Gehan, Quantile, Slippage, and t-test) were used to compare the means and medians of the OU 11 and background populations. The null ( $H_0$ ) and alternative ( $H_a$ ) hypotheses used during the statistical analyses are as follows (Gilbert 1993).

$H_0$  Chemical concentrations within OU 11 are not significantly greater than those in the background area.

$H_a$  Chemical concentrations within OU 11 are significantly greater than those in the background area.

The nonparametric Gehan test (Palachek *et al.* 1993, Gehan 1965) can be used to evaluate data sets with multiple detection limits and nondetects and can be used regardless of the distribution of the data. The Gehan test is a generalization of the more common non-parametric ANOVA Wilcoxon Rank-Sum test. The Gehan test was performed for all analytes. The parametric ANOVA t-test was used only when background and site data contained less than 20 percent nondetects and normality assumptions based on the Shapiro-Wilk test were satisfied.

Other nonparametric tests used to compare background and site data included the Quantile and Slippage tests. The Slippage test consists of counting the number of OU measurements that exceed the maximum background measurement. If the number of measurements exceeding the maximum background measurement was greater than a critical value obtained from tables in Rosenbaum (1954), then the analyte was considered a candidate PCOC.

The Quantile test is similar to the Slippage test and was performed by listing the combined background and OU measurements from smallest to largest. The test counts the number of measurements from the OU that are among the largest measurements of the combined data sets. If the number of measurements is greater than a critical value, the analyte was considered a candidate PCOC. The largest measurement and critical values were determined from tables in Gilbert and Simpson (1992).

The inferential statistical tests (Gehan, Slippage, Quantile, and t-test) compare background and OU-wide concentration distributions. An analyte is considered to be present at significantly higher concentrations at the site than in the background media if any comparison test failed at the 0.05 significance level ( $p \leq 0.05$ ). The hot-measurement test compares each measurement to a corresponding  $UTL_{99/99}$  value. An analyte is considered a candidate PCOC if any site measurement exceeds the value of the background UTL. The difference in the two methods is that the inferential tests compare differences between population distributions and the hot-measurement test compares individual measurements to a single value. The hot-measurement test is not considered a formal statistical test because false positive and power requirements are not considered.

Organic analytes are considered candidate PCOCs if detected in media from the site. The error rates associated with PCOC identification for organic analytes are not known but they are dependent on the precision, accuracy, and representativeness of analytical data and will vary by analyte.

The final identification of PCOCs was subject to professional review of the test results and graphic presentations of the data. The professional judgment of the reviewer is required to consider other factors such as the spatial and temporal distribution of analytes, historic information regarding past operations at the site, inter-element correlations, mass-balance calculations, and knowledge of the hydrology, geochemistry, and geology of the site. The rationale for inclusion or exclusion of PCOCs based on professional judgment is provided in Appendix D.

#### 2.4 Summary of PCOCs for OU 11

Table 2-2 presents the PCOCs at OU 11. For the purpose of the OU 11 CDPHE screen, the surficial soil samples and subsurface geologic materials samples collected from 0 to 12 feet were combined as "soils."

**Table 2-2  
List of PCOCs at OU 11**

Surficial Soil (0 to 2 inches)	Subsurface Geologic Materials (0 to 12 feet)
Americium-241 Plutonium-239/240 Nitrate/Nitrite	Tritium Nitrate/Nitrite

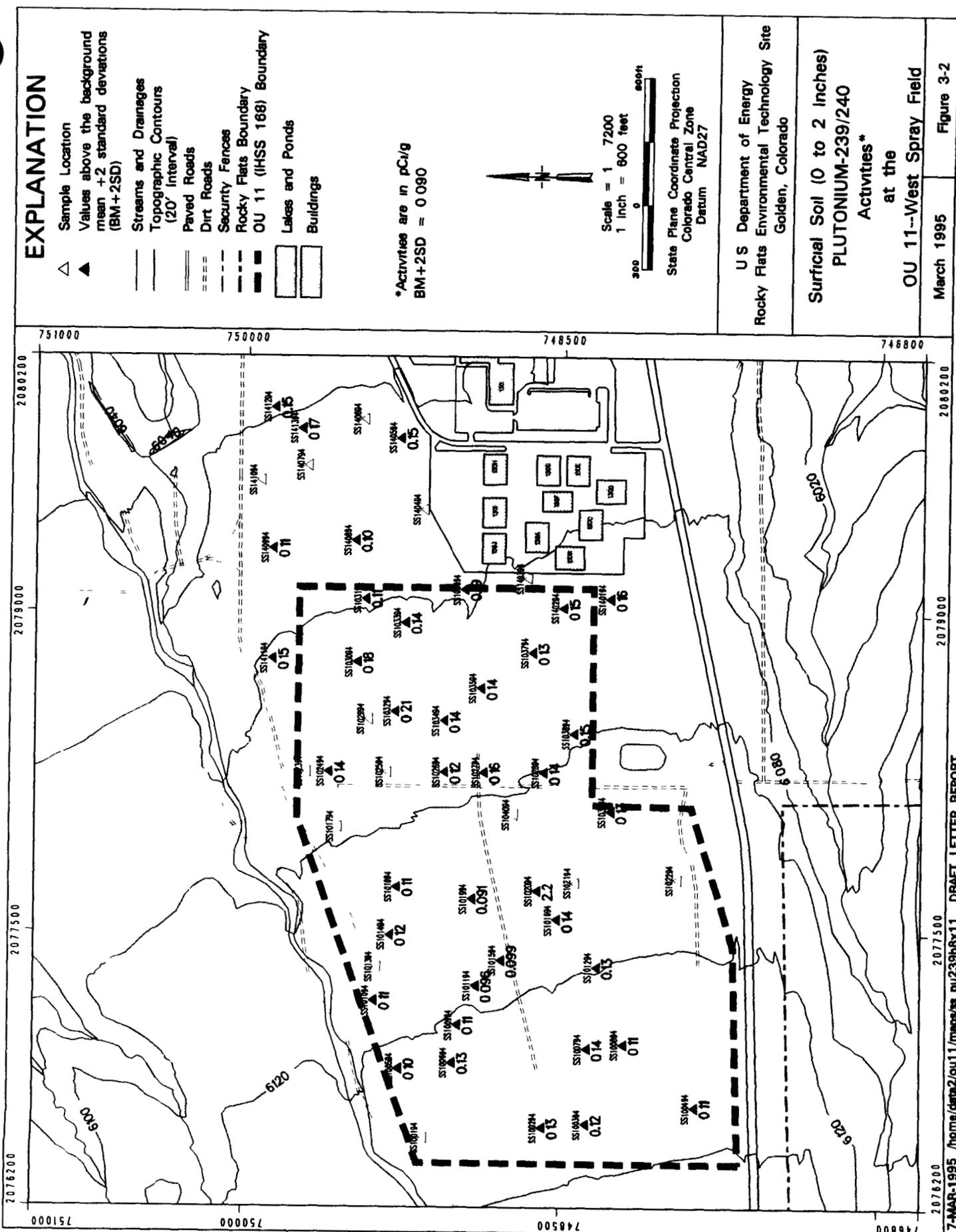
## IDENTIFICATION OF CONTAMINANT SOURCE AREA(S)

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A source area is defined as any area where concentrations or activities of PCOCs in any medium exceed an upper-bound estimate of the background range. The upper-bound estimate of the background range for metals, inorganic compounds, and radionuclides is defined as the background mean plus two standard deviations, detected organics are considered to be above background levels. The data analysis and background comparison methodology used to identify PCOCs for OU 11 are described in Section 2.0. Additional detail on the number of samples, sampling locations, and other features of the sampling and analytical program are discussed in the Technical Memorandum Revised Field Sampling Plan and Data Quality Objectives OU 11 (DOE 1994b) and in the Nature and Extent of Contamination section of the OU 11 Combined Phases RFI/RI (draft in progress).

The concentrations and distribution of PCOCs in OU 11 were evaluated to identify any source areas in OU 11. Based on the PCOC distributions, one OU 11 source area was identified. To identify the OU 11 source area, concentrations and activities of inorganic PCOCs above the background mean plus two standard deviations were plotted by medium. Figures 3-1, 3-2, and 3-3 delineate concentrations/activities of PCOCs (americium-241, plutonium-239/240, and nitrate/nitrite) in surficial soil (0 to 2 inches). Figures 3-4 and 3-5 present concentrations/activities and sample depths of PCOCs (nitrate/nitrite and tritium) in subsurface geologic materials (0 to 12 feet). The OU 11 source area is outlined on Figure 3-6.

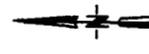




# EXPLANATION

- △ Sample Location
- ▲ Values above the background mean +2 standard deviations (BM+2SD)
- Streams and Drainages
- Topographic Contours (20' Interval)
- == Paved Roads
- Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Activities are in pCi/g  
 BM+2SD = 0.090



Scale = 1 / 7200  
 1 Inch = 600 feet

300 0 600ft

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

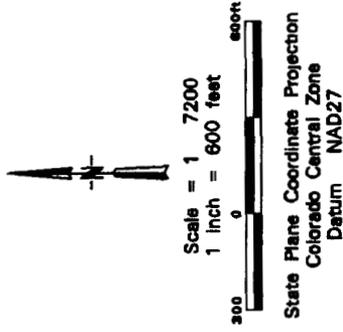
Surficial Soil (0 to 2 inches)  
 PLUTONIUM-239/240  
 Activities\*  
 at the  
 OU 11--West Spray Field

March 1995 Figure 3-2

# EXPLANATION

- △ Sample Location
- ▲ Values above the background mean +2 standard deviations (BM+2SD)
- Streams and Drainages
- Topographic Contours (20' interval)
- ==== Paved Roads
- ==== Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Concentrations are in mg/kg  
BM+2SD = 5



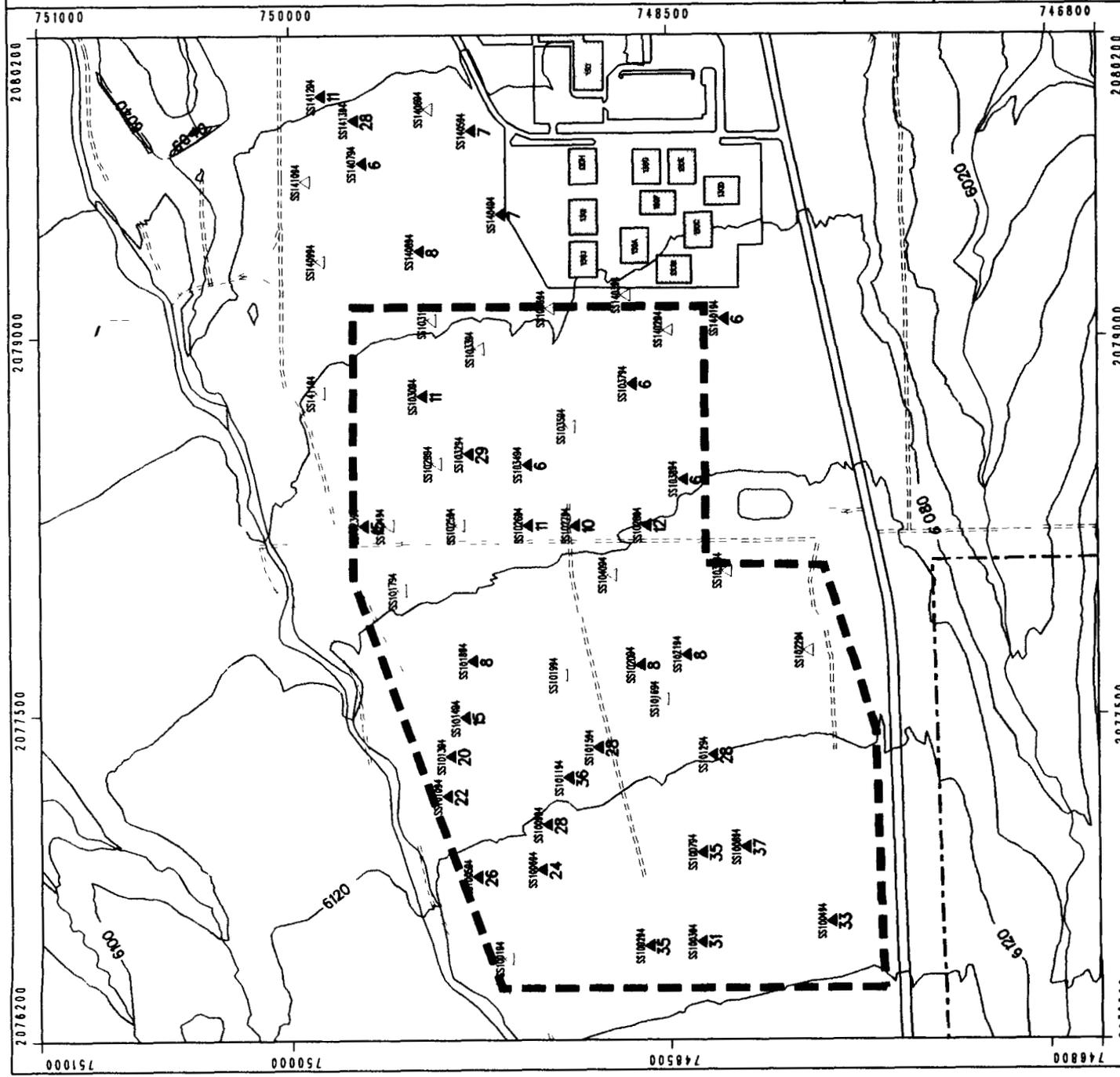
U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

Surficial Soil (0 to 2 inches)  
NITRATE/NITRITE  
Concentrations\*

at the  
OU 11--West Spray Field

March 1995

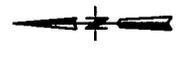
Figure 3-3



# EXPLANATION

- 1994 Borehole
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 383 pCi/L



Scale = 1/8400  
 1 inch = 700 feet

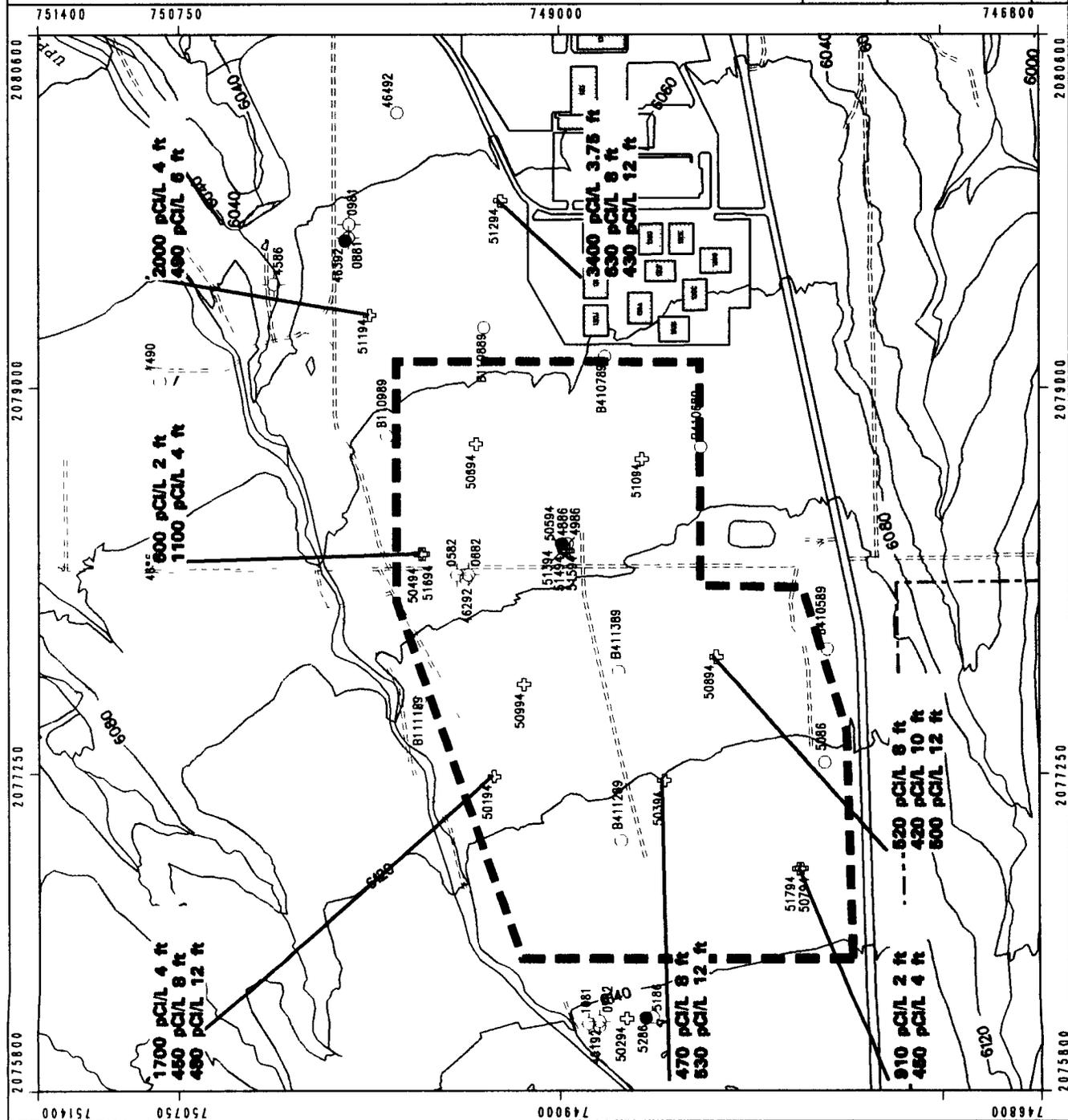


State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

US Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 TRITIUM  
 Activities\*  
 (and Sample Depths) in Subsurface  
 Geologic Materials (0 to 12 Feet)

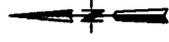
March 1995 Figure 3-4



# EXPLANATION

- ⊗ 1994 Borehole
- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊙ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' interval)
- ==== Paved Roads
- ==== Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Values above reporting limits



Scale = 1/8400  
1 inch = 700 feet

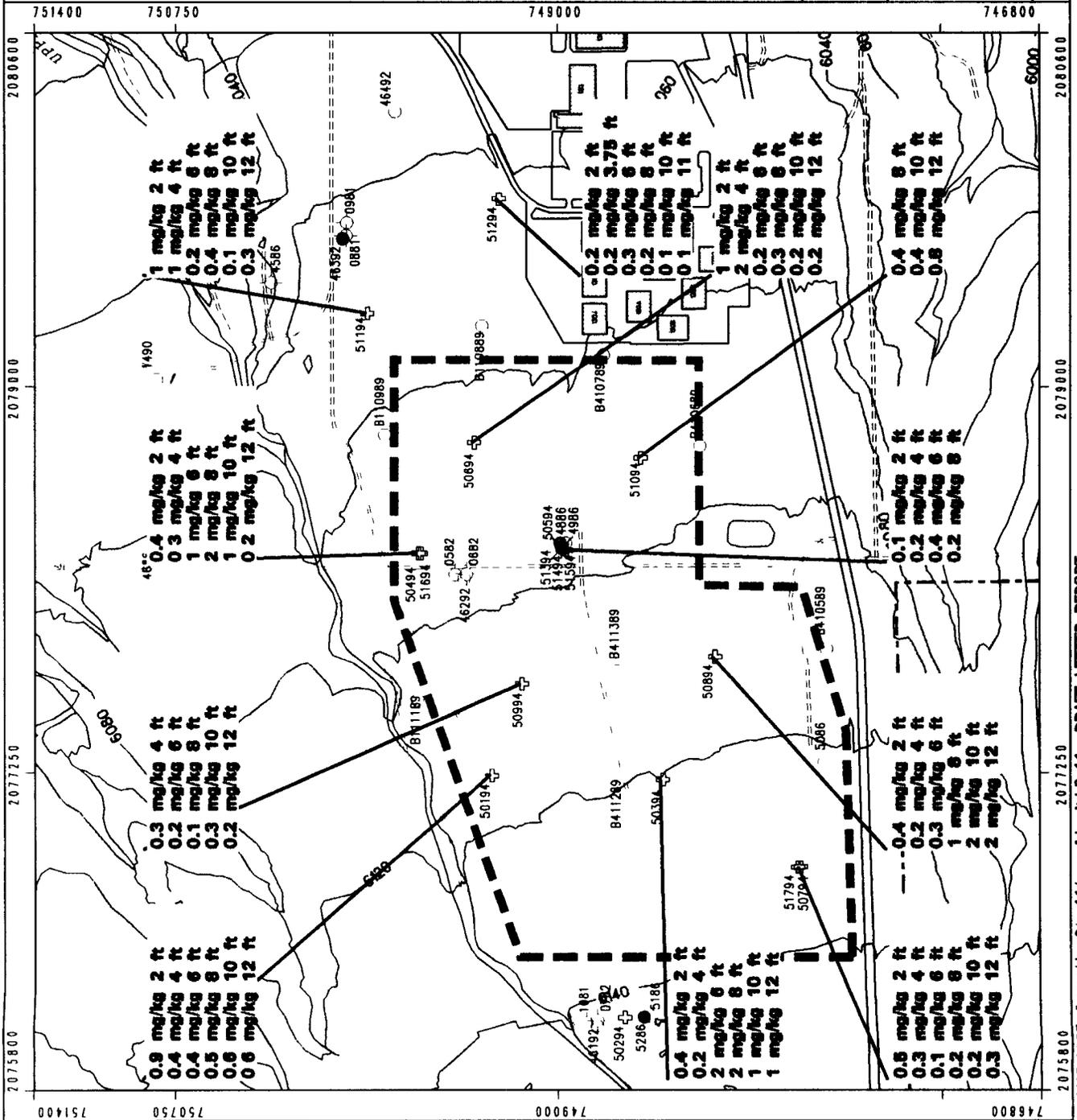


State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
NITRATE/NITRITE  
Concentrations\*  
(and Sample Depths) in Subsurface  
Geologic Materials (0 to 12 Feet)

March 1995 Figure 3-5





## IDENTIFICATION OF RISK-BASED CONCENTRATIONS

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RBCs are contaminant concentrations in media that are not expected to pose a health risk even under long-term exposure. They are calculated using conservative assumptions regarding exposure, toxicity, and acceptable risk. The purpose of developing contaminant-specific RBCs and comparing them to concentrations of PCOCs at each source area is to provide preliminary screening-level information on the relative magnitude of contaminant risk assuming long-term exposure to maximum detected concentrations. This information can be used in the preliminary selection of remedial alternatives prior to the completion of the HHRA and also can identify source areas where no further action is warranted. RBCs should not be used as a substitute for a complete HHRA, as stand-alone decision-making tools, or as site-specific cleanup levels.

RBCs specific to RFETS have been calculated assuming long-term residential exposure to different media (DOE 1995). These values, referred to as PPRGs, were used in the OU 11 CDPHE screen. PPRGs for contaminants in soil were calculated for residential receptors assuming multiple pathway exposure (ingestion, inhalation of particulates, and external radiation).

Separate PPRGs were calculated for carcinogenic and noncarcinogenic effects. PPRGs for carcinogens were calculated based on a one in one million (1E-06) excess cancer risk level. PPRGs for noncarcinogens were calculated based on a hazard quotient of 1 (DOE 1995). General equations for calculating PPRGs are

$$\text{Carcinogenic PPRG} = \frac{\text{Target Cancer Risk Level}}{\text{Intake Factor} \times \text{Cancer Slope Factor}}$$

$$\text{Noncarcinogenic PPRG} = \frac{\text{Target Hazard Index} \times \text{Reference Dose}}{\text{Intake Factor}}$$

The target cancer risk is equal to 1E-06 and the target hazard index is equal to 1. The reference doses (RfDs) and cancer slope factors (CSFs) are contaminant-specific EPA-established toxicity factors, they are presented in DOE (1995). Intake factors are an assumption of daily intake of a medium per kilogram body weight. The exposure parameters and other factors used to derive the intake factors for calculating PPRGs are discussed in detail in DOE (1995). All exposure assumptions are EPA standard default values (EPA 1991a) except where indicated in the PPRG document (DOE 1995).

## CALCULATION OF RISK-BASED CONCENTRATION RATIO SUMS

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The fourth step in the CDPHE screen is to divide the maximum concentration or activity of each PCOC in each medium in each source area by the contaminant-specific RBC [PPRG] for residential exposure to yield an RBC ratio, as shown in the following equation

$$RBC \text{ Ratio} = \frac{\text{Maximum detected concentration/activity}}{\text{Risk-based concentration [PPRG]}}$$

The contaminant-specific ratios in each source area and medium are then summed to provide a ratio sum (multiple-contaminant) for each medium. If a receptor is assumed to be exposed to more than one medium in a source area (for example, hypothetical residents are assumed to be simultaneously exposed to soil and ground water), the ratio sums for all relevant media are combined to provide a total ratio sum (multiple-contaminant, multiple-media) for that exposure scenario. PCOCs in OU 11 were identified in only one medium, soil, therefore, only one ratio sum was calculated. The residential scenario assumes that excavation has taken place prior to residential development and the resident may be exposed to soil to a depth of 12 feet (CDPHE/EPA/DOE 1994). Therefore, maximum detected concentrations or activities of PCOCs in soil were identified from samples collected from the surface to a depth of 12 feet.

The total ratio sums for carcinogenic or noncarcinogenic effects are an indication of potential risks to receptors, assuming long-term exposure to maximum detected concentrations or activities of PCOCs. For carcinogens, a total ratio sum less than or equal to 1 indicates a total excess lifetime cancer risk less than 1E-06 (one in one million) from long-term exposure to the maximum detected concentrations or activities of PCOCs in that source area. A total ratio sum for carcinogens that is greater than 1 but less than 100 indicates a total excess lifetime cancer risk between 1E-04 (one in 10 thousand) and 1E-06, which is the target cancer risk range that EPA has adopted to guide remedial decisions at hazardous waste sites (40 CFR 300). Where cancer risks estimated in a baseline HHRA do not exceed 1E-04, remediation is not generally warranted unless noncarcinogenic effects or ecological risks are significant (EPA 1991b). A total ratio sum for carcinogens that is greater than or equal to 100 indicates a potentially unacceptable cancer risk from long-term exposure to maximum detected concentrations or activities. For noncarcinogens, a ratio sum less than or equal to 1 indicates no toxic effects are

expected A noncarcinogenic total ratio sum greater than 1 indicates that there may be cause for concern for noncarcinogenic effects

The CDPHE Risk-Based Conservative Screen assumes that a long-term resident will be routinely exposed to the maximum concentrations or activities of contaminants found in each medium The screen does not confirm that an actual risk exists Ratio sums greater than 1 or 100 indicate that the area warrants further evaluation, but the ratio sums do not indicate that an actual health threat is present

If either the carcinogenic or noncarcinogenic total ratio sum is greater than or equal to 100 for a source area, that source area may be identified by DOE as a candidate for an early action. Source areas with ratio sums between 1 and 100 will be evaluated further in a baseline HHRA If both the carcinogenic and noncarcinogenic total ratio sums are less than or equal to 1, the source area is a candidate for no further action based on human health risk In this case, the incremental risk from dermal exposure is evaluated to confirm that the total ratio sums including dermal exposure are still less than 1

Ratios from the RBC screen for the OU 11 source area based on residential exposure are presented for carcinogens and noncarcinogens in Table 5-1. The total ratio sums are shown at the bottom of the table The carcinogenic total ratio sum for soil (0 to 12 feet) was 0.82, and the noncarcinogenic total ratio sum was 0.000084

**Table 5-1  
Risk-Based Concentration Screen for the OU 11 Source Area—Residential Exposure**

Potential Contaminant of Concern	Maximum Concentration or Activity (Max)	Location of Max	Residential PPRG <sup>1</sup>		Ratio of Max to PPRG	
			Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
<b>SOIL (0 to 12 feet)</b>						
<b>Radionuclides (pCi/g)</b>						
AMERICIUM-241	0.43	SS102094	2.37E+00	---	0.18	---
PLUTONIUM-239/240 <sup>2</sup>	2.2	SS102094	3.42E+00	---	0.64	---
TRITIUM	3.4	51294	1.47E+04	---	0.00023	---
<b>Other Parameters (mg/kg)</b>						
NITRATE/NITRITE <sup>3</sup>	37	SS100894	---	4.39E+05	---	0.000084
<b>TOTAL RATIO SUM</b>					<b>0.82</b>	<b>0.000084</b>

<sup>1</sup> Programmatic Preliminary Remediation Goals (PPRGs) are from DOE (February 1995). Residential soil PPRGs were used for analytes in soil (0 to 12 feet). PPRGs are reported in the units used for each analyte group.

<sup>2</sup> The PPRG for plutonium-240 was used because it is more conservative than the PPRG for plutonium-239.

<sup>3</sup> The PPRG for nitrate was used because nitrate is the dominant species present.

## COMPARISON OF RATIO SUMS TO CDPHE CONSERVATIVE SCREEN DECISION CRITERIA

The results of the CDPHE Risk-Based Conservative Screen are compared to decision criteria to determine the appropriate course of action for each medium in each source area. The decision criteria are

- If the ratio sum  $\geq 100$ , a voluntary corrective action (or early action) or a baseline HHRA will be performed
- If  $1 < \text{ratio sum} < 100$ , a baseline HHRA in accordance with Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) will be conducted
- If the ratio sum  $\leq 1$ , no further action may be warranted pending evaluation of potential risk from dermal exposure

Table 6-1 summarizes the total ratio sums for the OU 11 source area, assuming long-term residential exposure to maximum detected concentrations or activities of PCOCs. The OU 11 source area had a carcinogenic total ratio sum less than 1 (0.82) and a noncarcinogenic total ratio sum less than 1 (0.000084). Therefore, the OU 11 source area is a candidate for no action based on the CDPHE Conservative Screen decision criteria.

**Table 6-1  
Summary of Total Ratio Sums for OU 11**

Source Area	Medium	Carcinogenic Ratio Sum	Noncarcinogenic Ratio Sum
OU 11	Soil (0 to 12 feet)	0.82	0.000084
<b>TOTAL RATIO SUM*</b>		<b>0.82</b>	<b>0.000084</b>

\*Assuming long-term residential exposure to maximum detected concentrations/activities

As required for source areas for which no further action is indicated, the potential risk from dermal contact with soil must be evaluated (CDPHE/EPA/DOE 1994). Because no action is recommended for OU 11, an evaluation of dermal contact with PCOCs in soil in the OU 11 source area is included in Appendix E. In the evaluation of dermal contact, all maximum

concentrations or activities for PCOCs in surface soil (0 to 12 feet) in the OU 11 source area were below the dermal RBCs. Results of the comparison of concentrations and activities of PCOCs in OU 11 source area surface soil to dermal RBCs confirm that dermal exposure is not a significant exposure pathway for OU 11 and that OU 11 is a candidate for no action in accordance with the CDPHE/EPA/DOE risk assessment agreement (CDPHE/EPA/DOE 1994) (Figure 1-2)

**IDENTIFICATION OF AREA(S) OF CONCERN**

---

An AOC is defined as one or several source areas located close together that exceed the CDPHE Conservative Screen decision criteria. AOCs are identified to support the HHRA in the RFI/RI Report.

Results of the comparison of OU 11 total ratio sums to CDPHE Conservative Screen decision criteria indicate no action for the OU 11 source area, therefore, no AOCs are identified at OU 11, and a baseline risk assessment is not warranted.

**REFERENCES**

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**APPENDIX A**

**Cleanup Routines for Analytical Data**

**APPENDIX A**  
**DATA MANIPULATION FOR RFI/RI REPORTS**  
**OU 11 RFI/RI - Combined Phases**

**I RFEDS EXTRACTION**

**A Run data\_chk prg to get an overview of the data Modifications to other programs (notably cleangen prg) may be necessary if there are new/unusual data**

- 1 Assigns an analytical group based on test group code: M for metals, P for pesticides, R for radionuclides, S for semivolatile organic compounds, V for volatile organic compounds, and W for water quality parameters**
- 2 Creates text files with the results of data checks**
  - a Unique sample types**
  - b Unique analyte names, by analytical group Used to identify multiple spellings of the same analyte**
  - c Unique QC codes for each sample type**
  - d Unique test group codes for each analytical group**
  - e Unique units for each analytical group and test group code**
  - f Unique result types for each analytical group and test group code.**
  - g Unique lab qualifiers for each analytical group and test group code**
  - h Unique validation codes for each analytical group and test group code**
  - i The total number of records and the total number of unique RFEDS sequence ids to check for duplicated records**
  - j Count the number of, and identify the records that have a blank result field**
  - k Count the number of, and identify the non-rads records that have a blank detection limit field**
- 3 Make any necessary changes to cleangen prg.**

**B Run generic cleanup routines program cleangen prg**

- 1 Appends basic records into the final format structures 94data\94final and historic\hstfinal**
- 2 Assigns total/dissolved, organic/inorganic based on test group code**
- 3 Filters out unusable data by assigning "reject" category**
  - a Blank results**
  - b Blank units**

- c Blank detection limit and non-rads analysis
  - d Unknown validation codes (C,P,S,B,N)
  - e Unknown units (DPM/SA,PCI/SA,ROM BA,UNKN)
  - f Unknown lab qualifiers (L,R,rad UE,organic E)
  - g Alpha characters in numeric field
  - h Tentatively identified compound (TIC) lab qualifiers (A, organic N)
- 4 Assigns a usability category based on validation codes and lab qualifiers
- a VALID
    - validation codes A,V
    - lab qualifiers blank,U
  - b ESTIMATE
    - validation codes A,J,V,JA
    - lab qualifiers +, \*, B, C, D, E(inorganic), F, G, H, I, J, N, S, UJ, UN, UW, UX, W, X, Y, Z
  - c REJECT
    - validation codes B,C,N,P,R,S
    - lab qualifiers E(organic),L,R,UE(rads)
  - d BLNK/Y VAL
    - validation codes Y,blank
    - lab qualifiers blank, +, \*, B, C, D, E(inorganic), F, G, H, I, J, N, S, U, UJ, UN, UW, UX, W, X, Y, Z
  - e CHECK
    - validation codes Z
    - lab qualifiers all except rejection qualifiers
- 5 Converts units so that all units for a given analyte will be consistent
- a Solids
 

metals or WQP	MG/KG
radionuclides	PCI/G
vocs, svocs, pest, herbs, pcbs,	UG/KG
  - b Liquids
 

rads	PCI/L
all other analytical groups	UG/L
  - c Convert DPM/L to PCI/L for "historical" rads results
- 6 Assigns detect/non-detect
- a Y(yes)
    - all rads
    - other analytical groups
      - validation codes blank,Y,J,A,V
      - lab qualifiers all except U, and those that reject the record

- b N (no)
  - All rejected records
  - Validation codes all
  - lab qualifiers U,JB

C Run new\_dlim prg to handle records with detection limits reported as CRDL (especially metals) instead of IDL Paul Gomez said that if the CRDL is reported as the detection limit, usually the IDL is reported in the result field Therefore when summing values for mean calculations, the non-detects should be 1/2 the result, not 1/2 the reported detection limit

- 1 If the reported detection limit is the CRDL for that analyte, the new detection limit field is filled with the converted result (nresult). Otherwise, the new detection limit field is filled with the reported, converted result

D Remove records for analytes not in the Target Analyte List in the OU 11 Work Plan using non\_tal prg

- 1 Marks non-tal records in the final structure files
- 2 Creates non-tal files containing those records removed 94data\non\_tal dbf and historic\non\_tal.dbf
- 3 Creates 94data and historic tal files to check the y\_n field to see if all analytes are represented 94data\94\_tal and historic\hst\_tal
- 4 Checks those non\_tal analytes that aren't labeled as TICs for detects
  - a Creates a list of detected analytes 94data\non\_tal txt and historic\non\_tal txt Includes the following fields location, s\_no, t\_g\_c, analyte, result, d\_limit, qual, valid

## II PROJECT DATABASE

A Run project prg to build the Project Database by appending records from 94data\94final dbf and historic\hstfinal dbf into ou11proj dbf

B Run ou11 specific cleanup program ou11\_cln prg

- 1 Labels hydrostratigraphic units for wells based on completion lithology
- 2 Identifies a location as within or outside of the IHSS boundaries

- 3 Labels the geologic unit for each borehole sample. (All samples from 1994 Field Season are Qrf )

C Run split prg to split the project database

- 1 Records labeled "CHECK" are removed to check\ou11\_chk dbf These records are checked by hand to see if they should be included in the "RI" database The Z validation code is assigned to those records which Quantalex is not under contract to validate, or (it appears) lab qa/qc records for which there is a target (I am still looking into this as sometimes this code is filled in by RFEDS before the record is validated )
- 2 Unusable records (category REJECT, usability REJECT) are removed to unusable\ou11\_rej dbf
- 3 Records labeled as "TIC" in the project database and in each of the non\_tal files (94data\non\_tal and historic\non\_tal) are removed to tic\ou11\_tic dbf
- 4 Records labeled as category QC and those real records that correspond to real/dup pairs with a usability code of VALID, ESTIMATE, or BLNK/Y VAL are removed to qc\ou11\_qc dbf
- 5 Records labeled as category REAL with a usability code of VALID, ESTIMATE, or BLNK/Y VAL are removed to ou11\_ri dbf

D The "RI" and "QC" databases are checked for lab qa/qc records that, if there is an associated target record, could make duplicate records for a given analyte The records not chosen are removed to lab\_qa dbf Run lab\_qa prg iteratively to remove duplicate records to lab\_qa dbf

- 1 Sorts file on s\_no+t\_g\_c+analyte+r\_type
- 2 If none of the records are validated  
keep the TRG record  
remove the other(s)
- 3 If one record is validated and the other(s) are not (i.e. valid is blank or Y)  
keep the validated record  
remove the other(s)

E If more than one record is validated the records are checked by hand and the decision to keep or remove is made on a record by record basis Those records removed from the data set using these steps are also stored in lab\_qa dbf

- 1 The simplest decision is made on the basis of validation code hierarchy. The record with the "lowest" validation code is removed, assuming the results are reasonable (i.e. have reasonable number of digits after the decimal place, no zero concentrations, etc.)

V Highest rank

A, JA Second highest

Y Third highest

Z,R Lowest rank (Note: split prg removes these records from the ou11\_r1 data set)

- 2 If the results look "reasonable" and the validation codes are identical, the record with the highest concentration is kept and the other removed, to be most conservative.
- 3 If the results are very different, the most acceptable record is used and the other(s) are removed. For example, there is a trg and dup record for americium 241, both validated with V, trg result = 0, dup result = .00517 pci/g. The dup record is kept, and the trg record removed.

F Run dupe prg to find those analytes that have 2 TRG, DUP, etc records for the same sample number

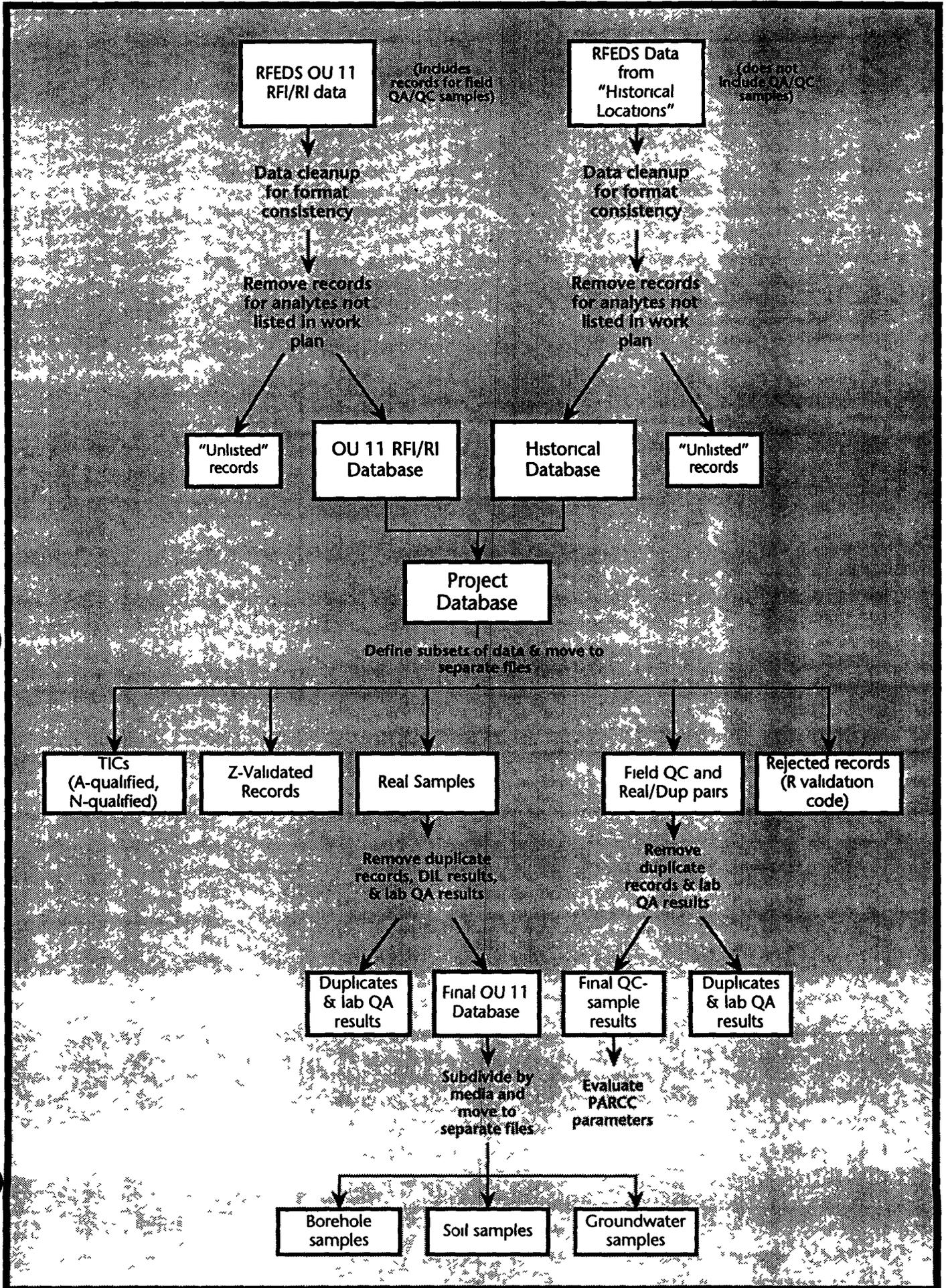
- 1 Flag the duped records

- 2 Set the filter to use only the flagged records

- 3 Use the same criteria as above to make decisions on the appropriate record to keep

G Run difunits prg to identify non-rads records where the detection limit is  $\geq 1000$  times the result. This situation suggests that the result and detection limit were reported in different units.

Figure A-1  
 Cleanup Routine for Analytical Data: Operable Unit No. 11



**APPENDIX B**

**Summary Statistics**

**Table B-1  
Summary Statistics for Surficial Soils in OU 11**

Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
<b>Metals</b>										
TOTAL	ALUMINUM	40 0000 - 40 0000	53/53	100 0	MG/KG	7340 00	19400 00	11700 00	3008 32	SS102994
TOTAL	ANTIMONY	12 0000 - 12 0000	3/53	5 7	MG/KG	2 50	3 50	1 68	0 78	SS103694
TOTAL	ARSENIC	2 0000 - 2 0000	53/53	100 0	MG/KG	4 00	13 10	7 58	1 58	SS102894
TOTAL	BARIIUM	40 0000 - 40 0000	53/53	100 0	MG/KG	86 80	199 00	124 71	21 64	SS102994
TOTAL	BERYLLIUM	1 0000 - 1 0000	53/53	100 0	MG/KG	0 50	1 10	0 66	0 14	SS140394
TOTAL	CADIUM	1 0000 - 1 0000	28/53	52 8	MG/KG	0 58	1 40	0 61	0 31	SS102994
TOTAL	CALCIUM	1000 0000 - 1000 0000	53/53	100 0	MG/KG	1540 00	6360 00	2520 38	700 35	SS140494
TOTAL	CESIUM	200 0000 - 200 0000	0/52	0 0						
TOTAL	CHROMIUM	2 0000 - 2 0000	53/53	100 0	MG/KG	9 30	22 70	12 95	3 16	SS102994
TOTAL	COBALT	10 0000 - 10 0000	53/53	100 0	MG/KG	4 90	11 20	6 45	1 29	SS102994
TOTAL	COPPER	5 0000 - 5 0000	53/53	100 0	MG/KG	9 60	88 10	13 95	10 74	SS140194
TOTAL	IRON	20 0000 - 20 0000	53/53	100 0	MG/KG	10800 00	23700 00	13488 68	2553 55	SS102994
TOTAL	LEAD	0 6000 - 0 6000	53/53	100 0	MG/KG	15 40	82 90	43 04	12 53	SS102894
TOTAL	LITHIUM	20 0000 - 20 0000	53/53	100 0	MG/KG	5 50	19 40	9 59	2 72	SS102894
TOTAL	MAGNESIUM	1000 0000 - 1000 0000	53/53	100 0	MG/KG	1280 00	2780 00	1696 42	338 34	SS102994
TOTAL	MANGANESE	3 0000 - 3 0000	53/53	100 0	MG/KG	206 00	558 00	316 26	65 31	SS102994
TOTAL	MERCURY	0 1000 - 0 1000	0/53	0 0						
TOTAL	MOLYBDENUM	40 0000 - 40 0000	11/53	20 8	MG/KG	0 63	2 60	0 80	0 48	SS102994
TOTAL	NICKEL	8 0000 - 8 0000	53/53	100 0	MG/KG	5 10	19 50	8 89	2 58	SS140494
TOTAL	POTASSIUM	1000 0000 - 1000 0000	53/53	100 0	MG/KG	1270 00	3960 00	1960 57	510 03	SS102994
TOTAL	SELENIUM	1 0000 - 1 0000	29/53	54 7	MG/KG	0 39	0 68	0 37	0 15	SS100194
TOTAL	SILVER	2 0000 - 2 0000	1/53	1 9	MG/KG	0 39	0 60	0 24	0 10	SS140194
TOTAL	SODIUM	1000 0000 - 1000 0000	53/53	100 0	MG/KG	39 30	172 00	74 61	24 85	SS140494
TOTAL	STRONTIUM	40 0000 - 40 0000	53/53	100 0	MG/KG	14 80	41 60	22 56	4 47	SS102894
TOTAL	THALLIUM	2 0000 - 2 0000	23/53	43 4	MG/KG	0 19	0 27	0 16	0 06	SS140894
TOTAL	TIN	40 0000 - 40 0000	17/53	32 1	MG/KG	2 40	4 90	2 16	1 06	SS103994
TOTAL	VANADIUM	10 0000 - 10 0000	53/53	100 0	MG/KG	23 20	50 80	29 54	5 76	SS102994
TOTAL	ZINC	4 0000 - 4 0000	53/53	100 0	MG/KG	22 40	70 00	42 94	9 09	SS102894
<b>Radionuclides</b>										
TOTAL	AMERICIUM-241	0 006 - 0 097	53/53	100 0	PCI/G	0 009	0 43	0 04	0 06	SS102094
TOTAL	PLUTONIUM-239/240	0 002 - 0 041	53/53	100 0	PCI/G	0 013	2 2	0 2	0 3	SS102094
TOTAL	URANIUM-233,-234	0 010 - 0 13	53/53	100 0	PCI/G	1 3	4 3	2 0	0 6	SS140194
TOTAL	URANIUM-235	0 009 - 0 15	53/53	100 0	PCI/G	0 013	0 30	0 09	0 06	SS100894
TOTAL	URANIUM-238	0 020 - 0 18	53/53	100 0	PCI/G	1 4	4 5	2 0	0 5	SS140194
<b>Other Parameters</b>										
TOTAL	% SOLIDS BY WEIGHT	0 1 - 0 1	1/1	100 0	%	89 0	89 0	89 0	NC	SS141394
TOTAL	CYANIDE	2 5 - 2 5	0/53	0 0						
TOTAL	NITRATE/NITRITE	0 1 - 0 1	53/53	100 0	MG/KG	2	37	13	11	SS100894

Table B-2  
Summary Statistics for Background Surficial Soils

Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Mean+2Std	UTL99	Max Locn
<b>Metals</b>												
TOTAL	ALUMINIUM	40 - 50	20/20	100 0	MG/KG	7420	21800	13339	3273	19884	25879	RA004
TOTAL	ANTIMONY	12 - 50	0/20	0 0								
TOTAL	ARSENIC	2 - 3	20/20	100 0	MG/KG	2 2	8 7	6	2	10	13	RA002
TOTAL	BARIUM	10 - 40	20/20	100 0	MG/KG	120	470	200	87	373	532	SS204693
TOTAL	BERYLLIUM	1 - 5	11/20	55 0	MG/KG	0 44	1 1	1 5	0 9	3 3	5 0	RA002
TOTAL	CADMIUM	1 - 5	6/18	33 3	MG/KG	0 6	1 8	1	1	3	5	SS204493
TOTAL	CALCIUM	1000 - 1000	20/20	100 0	MG/KG	2260	13600	5412	2935	11283	16659	RA004
TOTAL	CESIUM	200 - 500	11/20	55 0	MG/KG	1 7	3	114	126	367	598	RA005
TOTAL	CHROMIUM	2 - 10	20/20	100 0	MG/KG	9	22	15	3	22	28	RA004
TOTAL	COBALT	10 - 10	20/20	100 0	MG/KG	4 8	24	8	4	16	24	SS204693
TOTAL	COPPER	5 - 10	20/20	100 0	MG/KG	7 7	22 2	13	4	22	30	RA002
TOTAL	IRON	20 - 20	20/20	100 0	MG/KG	10400	24900	15605	3509	22624	29052	RA001
TOTAL	LEAD	1 - 2	20/20	100 0	MG/KG	28 6	51	37	6	50	62	SS204393
TOTAL	LITHIUM	10 - 20	20/20	100 0	MG/KG	6 8	17 7	11	3	17	22	RA004
TOTAL	MAGNESIUM	1000 - 1000	20/20	100 0	MG/KG	1440	6380	2984	1236	5455	7718	RA004
TOTAL	MANGANESE	3 - 10	20/20	100 0	MG/KG	2 10	2220	433	435	1303	2100	SS204693
TOTAL	MERCURY	0 1 - 0 2	0/18	0 0								
TOTAL	MOLYBDENUM	20 - 40	1/20	5 0	MG/KG	1 4	2 7	5	5	14	23	RA003
TOTAL	NICKEL	8 - 20	19/20	95 0	MG/KG	7 8	18 7	12	3	19	26	SS204693
TOTAL	POTASSIUM	1000 - 1000	20/20	100 0	MG/KG	1950	5310	3085	810	4706	6190	RA002
TOTAL	SELENIUM	1 - 2	15/20	75 0	MG/KG	0 21	0 76	0 6	0 3	1 1	1 5	SS204193
TOTAL	SILVER	2 - 10	0/20	0 0								
TOTAL	SODIUM	1000 - 1000	11/20	55 0	MG/KG	56 9	249	291	198	688	1052	RA004
TOTAL	STRONTIUM	5 - 40	20/20	100 0	MG/KG	20 9	109	38	20	77	113	RA004
TOTAL	THALLIUM	2 - 2	6/20	30 0	MG/KG	0 21	0 41	0 2	0 1	0 4	0 6	RA003
TOTAL	TIN	40 - 100	8/20	40 0	MG/KG	21 5	41 9	30	11	51	70	RA004
TOTAL	VANADIUM	10 - 10	20/20	100 0	MG/KG	21 1	46 2	32	7	47	60	RA002
TOTAL	ZINC	4 - 10	20/20	100 0	MG/KG	41 4	90 2	57	11	79	99	RA002
<b>Radionuclides</b>												
TOTAL	AMERICIUM-241	0 000 - 0 020	20/20	100 0	PCI/G	-0 003	0 04046	0 019	0 010	0 039	0 058	RA002
TOTAL	GROSS ALPHA	1 6 - 2 5	10/10	100 0	PCI/G	14	28	21	4	30	43	SS204793
TOTAL	GROSS BETA	3 2 - 5 0	10/10	100 0	PCI/G	24	40	31	4	39	53	SS204293
TOTAL	PLUTONIUM-239/240	0 000 - 0 016	23/23	100 0	PCI/G	0 02518	0 10	0 05	0 02	0 09	0 13	SS204393
TOTAL	URANIUM-233-234	0 000 - 0 049	16/16	100 0	PCI/G	0 9219	1 472	1 1	0 2	1 5	1 8	RA009
TOTAL	URANIUM-235	0 000 - 0 057	16/16	100 0	PCI/G	0 01062	0 1393	0 047	0 034	0 115	0 187	RA002
TOTAL	URANIUM-238	0 000 - 0 045	16/16	100 0	PCI/G	0 8989	1 521	1 2	0 2	1 6	2 0	RA001
<b>Semivolatile Organic Compounds</b>												
TOTAL	1,2,4-TRICHLOROBENZENE	330 - 480	0/18	0 0								
TOTAL	1,2-DICHLOROBENZENE	330 - 480	0/18	0 0								
TOTAL	1,3-DICHLOROBENZENE	330 - 480	0/18	0 0								
TOTAL	1,4-DICHLOROBENZENE	330 - 480	0/18	0 0								
TOTAL	2,4,5-TRICHLOROPHENOL	1600 - 1600	0/12	0 0								
TOTAL	2,4,6-TRICHLOROPHENOL	330 - 330	0/12	0 0								
TOTAL	2,4-DICHLOROPHENOL	330 - 330	0/12	0 0								

Table B-2  
Summary Statistics for Background Surficial Soils

Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Mean+2Std	UTL99	Max Locn
TOTAL	2,4-DIMETHYLPHENOL	330 - 330	0/12	0.0								
TOTAL	2,4-DINITROPHENOL	1600 - 1600	0/12	0.0								
TOTAL	2,4-DINITROTOLUENE	330 - 480	0/18	0.0								
TOTAL	2,6-DINITROTOLUENE	330 - 480	0/18	0.0								
TOTAL	2-CHLORONAPHTHALENE	330 - 480	0/18	0.0								
TOTAL	2-CHLOROPHENOL	330 - 330	0/12	0.0								
TOTAL	2-METHYLNAPHTHALENE	330 - 480	0/16	0.0								
TOTAL	2-METHYLPHENOL	330 - 330	0/12	0.0								
TOTAL	2-NITROANILINE	1600 - 2400	0/18	0.0								
TOTAL	2-NITROPHENOL	330 - 330	0/12	0.0								
TOTAL	3,3'-DICHLOOROBENZIDINE	660 - 960	0/18	0.0								
TOTAL	3-NITROANILINE	1600 - 2400	0/18	0.0								
TOTAL	4,6-DINITRO-2-METHYLPHENOL	1600 - 1600	0/12	0.0								
TOTAL	4-CHLORO-3-METHYLPHENOL	330 - 330	0/12	0.0								
TOTAL	4-CHLOROANILINE	330 - 480	0/18	0.0								
TOTAL	4-CHLOROPHENYL PHENYL ETHER	330 - 480	0/18	0.0								
TOTAL	4-METHYLPHENOL	330 - 330	0/12	0.0								
TOTAL	4-NITROANILINE	1600 - 2400	0/18	0.0								
TOTAL	4-NITROPHENOL	1600 - 1600	0/12	0.0								
TOTAL	ACENAPHTHENE	330 - 480	0/18	0.0								
TOTAL	ACENAPHTHYLENE	330 - 480	0/18	0.0								
TOTAL	ANTHRACENE	330 - 480	0/18	0.0								
TOTAL	BENZO(a)ANTHRACENE	330 - 480	0/18	0.0								
TOTAL	BENZO(a)PYRENE	330 - 480	0/18	0.0								
TOTAL	BENZO(b)FLUORANTHENE	330 - 480	0/18	0.0								
TOTAL	BENZO(ghi)PERYLENE	330 - 350	0/14	0.0								
TOTAL	BENZO(k)FLUORANTHENE	330 - 480	0/18	0.0								
TOTAL	BENZOIC ACID	1600 - 1600	7/12	58.3	UG/KG	43	230	451	411	1273	2355	SS204293
TOTAL	BENZYL ALCOHOL	330 - 330	0/12	0.0								
TOTAL	BIS(2-CHLOROETHOXY)METHANE	330 - 480	0/18	0.0								
TOTAL	BIS(2-CHLOROETHYL)ETHER	330 - 480	0/18	0.0								
TOTAL	BIS(2-CHLOROISOPROPYL)ETHER	330 - 480	0/18	0.0								
TOTAL	BIS(2-ETHYLHEXYL)PHTHALATE	330 - 480	4/18	22.2	UG/KG	35	140	165	57	280	391	RA007
TOTAL	BUTYL BENZYL PHTHALATE	330 - 480	0/18	0.0								
TOTAL	CHRYSENE	330 - 480	0/18	0.0								
TOTAL	DI-n-BUTYL PHTHALATE	330 - 480	2/18	11.1	UG/KG	39	44	177	53	284	388	RA007
TOTAL	DI-n-OCTYL PHTHALATE	330 - 480	0/18	0.0								
TOTAL	DIBENZO(a,h)ANTHRACENE	330 - 480	0/18	0.0								
TOTAL	DIBENZOFURAN	330 - 480	0/18	0.0								
TOTAL	DIETHYL PHTHALATE	330 - 480	0/18	0.0								
TOTAL	DIMETHYL PHTHALATE	330 - 480	0/18	0.0								
TOTAL	FLUORANTHENE	330 - 480	0/18	0.0								
TOTAL	FLUORENE	330 - 480	0/18	0.0								
TOTAL	HEXACHLOROBENZENE	330 - 480	0/18	0.0								
TOTAL	HEXACHLOROBUTADIENE	330 - 480	0/18	0.0								
TOTAL	HEXACHLOROCYCLOPENTADIENE	330 - 480	0/18	0.0								
TOTAL	HEXACHLOROETHANE	330 - 480	0/18	0.0								

Table B-2  
Summary Statistics for Background Surficial Soils

To/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Mean+2Std	UTL99	Max Locn
TOTAL	INDENO(1,2,3-cd)PYRENE	330 - 480	0/18	0.0								
TOTAL	ISOPHORONE	330 - 480	0/18	0.0								
TOTAL	N-NITROSO-DI-n-PROPYLAMINE	330 - 480	0/18	0.0								
TOTAL	N-NITROSODIPHENYLAMINE	330 - 480	0/18	0.0								
TOTAL	NAPHTHALENE	330 - 480	0/18	0.0								
TOTAL	NITROBENZENE	330 - 330	0/12	0.0								
TOTAL	PENTACHLOROPHENOL	1600 - 1600	0/12	0.0								
TOTAL	PHENANTHRENE	330 - 480	0/18	0.0								
TOTAL	PHENOL	330 - 330	0/12	0.0								
TOTAL	PYRENE	330 - 480	0/18	0.0								
<b>Other Parameters</b>												
TOTAL	% SOLIDS BY WEIGHT	0.10 - 0.10	14/14	100.0	%	69.2	97.0	87.9	9.5	107.0	129.3	RA008
TOTAL	NITRATE/NITRITE	0.2 - 0.2	9/9	100.0	MG/KG	0.705	4.79	2.3	1.4	5.0	9.6	RA006

**Table B-3  
Summary Statistics for Subsurface Geologic Materials in IHSS 168 and Downgradient Wells (0 to 12 feet)**

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
<b>Metals</b>											
QRF	TOTAL	ALUMINIUM	40 0000 - 40 0000	72/73	98.6	MG/KG	2.60	18700	8060	3103	46292
QRF	TOTAL	ANTIMONY	12 0000 - 12 0000	1/73	1.4	MG/KG	2.60	330	2	1	50794
QRF	TOTAL	ARSENIC	2 0000 - 2 0000	73/73	100.0	MG/KG	1.3	980	4.2	1.8	50994
QRF	TOTAL	BARIUM	40 0000 - 40 0000	72/73	98.6	MG/KG	0.21	147.00	51	21	50194
QRF	TOTAL	BERYLLIUM	1 0000 - 1 0000	70/71	98.6	MG/KG	0.21	1.3	0.6	0.2	46292
QRF	TOTAL	CADMIUM	1 0000 - 1 0000	0/73	0.0						
QRF	TOTAL	CALCIUM	1000 0000 - 1000 0000	72/73	98.6	MG/KG	1.30	4850	1310	759	46392
QRF	TOTAL	CESIUM	200 0000 - 200 0000	6/67	9.0	MG/KG	1.1	3.7	4.2	0.9	46392
QRF	TOTAL	CHROMIUM	2 0000 - 2 0000	72/73	98.6	MG/KG	0.43	77.50	17.4	12.7	50494
QRF	TOTAL	COBALT	10 0000 - 10 0000	72/73	98.6	MG/KG	0.64	91.60	7	11	50194
QRF	TOTAL	COPPER	5 0000 - 5 0000	72/73	98.6	MG/KG	0.43	19.70	8.9	4.1	50194
QRF	TOTAL	IRON	20 0000 - 20 0000	72/73	98.6	MG/KG	5.40	22100	10131	3219	46292
QRF	TOTAL	LEAD	0 6000 - 1	73/73	100.0	MG/KG	3.5	17.50	7	3	51194
QRF	TOTAL	LITHIUM	20 0000 - 20 0000	70/73	95.9	MG/KG	0.21	10.80	4	2	50494
QRF	TOTAL	MAGNESIUM	1000 0000 - 1000 0000	72/73	98.6	MG/KG	3.00	3840	1056	510	46292
QRF	TOTAL	MANGANESE	3 0000 - 3 0000	72/73	98.6	MG/KG	0.21	885.00	168	128	51094
QRF	TOTAL	MERCURY	0 1000 - 0 1000	7/73	9.6	MG/KG	0.05	25.40	0.40	2.97	51494
QRF	TOTAL	MOLYBDENUM	40 0000 - 40 0000	35/73	47.9	MG/KG	0.63	15.60	2	2	50494
QRF	TOTAL	NICKEL	8 0000 - 8 0000	70/73	95.9	MG/KG	1.40	33.10	10	6	50794
QRF	TOTAL	POTASSIUM	1000 0000 - 1000 0000	64/73	87.7	MG/KG	83.60	1460.00	781	259	50194
QRF	TOTAL	SELENIUM	1 0000 - 1 0000	7/71	9.9	MG/KG	0.22	0.59	0.23	0.08	50694
QRF	TOTAL	SILVER	2 0000 - 2 0000	1/73	1.4	MG/KG	0.40	0.55	0	0	50394
QRF	TOTAL	SODIUM	1000 0000 - 1000 0000	73/73	100.0	MG/KG	20.60	965	116	146	46392
QRF	TOTAL	STRONTIUM	40 0000 - 40 0000	72/73	98.6	MG/KG	0.21	70.9	13.7	9.6	46392
QRF	TOTAL	THALLIUM	2 0000 - 2 0000	5/73	6.8	MG/KG	0.20	0.32	0.14	0.05	46292
QRF	TOTAL	TIN	40 0000 - 40 0000	16/73	21.9	MG/KG	2.00	46.5	3	7	46292
QRF	TOTAL	VANADIUM	10 0000 - 10 0000	72/73	98.6	MG/KG	0.43	46.30	21.4	7.5	50994
QRF	TOTAL	ZINC	4 0000 - 4 0000	67/73	91.8	MG/KG	0.43	46.4	12.4	6.3	46392
<b>Radionuclides</b>											
QRF	TOTAL	AMERICIUM-241	0 - 0.28	72/72	100.0	PCI/G	-0.014	0.077	0.010	0.015	50894
QRF	TOTAL	GROSS ALPHA	2 - 2.7	4/4	100.0	PCI/G	15.2	27.4	19.9	5.6	46292
QRF	TOTAL	GROSS BETA	2.5 - 5.9	5/5	100.0	PCI/G	3.998	26.5	16.7	8.4	46492
QRF	TOTAL	PLUTONIUM-239/240	0 0000 - 0 109	72/72	100.0	PCI/G	-0.004	0.69	0.01	0.08	50194
QRF	TOTAL	TRITIUM	310 - 1500	54/54	100.0	PCI/L	-13	3400	441	539	51294
QRF	TOTAL	URANIUM-233,234	0 013 - 0 17	71/71	100.0	PCI/G	0.444	3.2	1.5	0.5	51094
QRF	TOTAL	URANIUM-235	0 013 - 0 15	71/71	100.0	PCI/G	0	0.22	0.07	0.04	51494
QRF	TOTAL	URANIUM-238	0 013 - 0 17	71/71	100.0	PCI/G	0.432	3.1	1.5	0.5	51094

Table B-3  
 Summary Statistics for Subsurface Geologic Materials in IHSS 168 and Downgradient Wells (0 to 12 feet)

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
<b>Semivolatile Organic Compounds</b>											
QRF	TOTAL	1,2,4-TRICHLOROBENZENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	1,2-DICHLOROBENZENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	1,3-DICHLOROBENZENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	1,4-DICHLOROBENZENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2,4,5-TRICHLOROPHENOL	50 0000 - 1600 0000	0/67	0 0						
QRF	TOTAL	2,4,6-TRICHLOROPHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2,4-DICHLOROPHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2,4-DIMETHYLPHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2,4-DINITROPHENOL	50 0000 - 1600 0000	0/60	0 0						
QRF	TOTAL	2,4-DINITROTOLUENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2,6-DINITROTOLUENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2-CHLORONAPHTHALENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2-CHLOROPHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2-METHYLNAPHTHALENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	2-METHYLPHENOL	10 0000 - 330 0000	0/63	0 0						
QRF	TOTAL	2-NITROANILINE	50 0000 - 1600 0000	0/67	0 0						
QRF	TOTAL	2-NITROPHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	3,3'-DICHLOROBENZIDINE	20 0000 - 660 0000	0/63	0 0						
QRF	TOTAL	3-NITROANILINE	50 0000 - 1600 0000	0/60	0 0						
QRF	TOTAL	4,6-DINITRO-2-METHYLPHENOL	50 0000 - 1600 0000	0/66	0 0						
QRF	TOTAL	4-CHLORO-3-METHYLPHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	4-CHLOROANILINE	10 0000 - 330 0000	0/63	0 0						
QRF	TOTAL	4-CHLOROPHENYL PHENYL ETH	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	4-METHYLPHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	4-NITROANILINE	50 0000 - 1600 0000	0/67	0 0						
QRF	TOTAL	4-NITROPHENOL	50 0000 - 1600 0000	0/67	0 0						
QRF	TOTAL	ACENAPHTHENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	ACENAPHTHYLENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	ANTHRACENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BENZO(a)ANTHRACENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BENZO(a)PYRENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BENZO(b)FLUORANTHENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BENZO(g,h,i)PERYLENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BENZO(k)FLUORANTHENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BENZOIC ACID	50 0000 - 1600 0000	0/63	0 0						
QRF	TOTAL	BENZYL ALCOHOL	10 0000 - 330 0000	0/63	0 0						
QRF	TOTAL	BIS(2-CHLOROETHOXY)METHAN	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BIS(2-CHLOROETHYL)ETHER	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BIS(2-CHLOROISOPROPYL)ETHE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	BIS(2-ETHYL-HEXYL)PHTHALATE	10 0000 - 330 0000	27/67	40.3	UG/KG	36	140	119	66	50894
QRF	TOTAL	BUTYL BENZYL PHTHALATE	10 0000 - 330 0000	0/67	0 0						

**Table B-3**  
**Summary Statistics for Subsurface Geologic Materials in IHSS 168 and Downgradient Wells (0 to 12 feet)**

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
QRF	TOTAL	CHRYSENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	Di-n-BUTYL PHTHALATE	10 0000 - 330 0000	27/67	40 3	UG/KG	39	520	216	121	50394
QRF	TOTAL	Di-n-OCTYL PHTHALATE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	DIBENZO(a,h)ANTHRACENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	DIBENZOFURAN	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	DIETHYL PHTHALATE	10 0000 - 330 0000	2/67	3 0	UG/KG	190	240	166	42	50994
QRF	TOTAL	DIMETHYL PHTHALATE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	FLUORANTHENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	FLUORENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	HEXACHLOROBENZENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	HEXACHLOROBUTADIENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	HEXACHLOROCYCLOPENTADIE	10 0000 - 330 0000	0/61	0 0						
QRF	TOTAL	HEXACHLOROETHANE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	INDENO(1,2,3-cd)PYRENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	ISOPHORONE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	N-NITROSO-Di-n-PROPYLAMINE	330 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	N-NITROSODIPHENYLAMINE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	NAPHTHALENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	NITROBENZENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	PENTACHLOROPHENOL	50 0000 - 1600 0000	0/67	0 0						
QRF	TOTAL	PHENANTHRENE	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	PHENOL	10 0000 - 330 0000	0/67	0 0						
QRF	TOTAL	PYRENE	10 0000 - 330 0000	0/67	0 0						
<b>Volatile Organic Compounds</b>											
QRF	TOTAL	1,1,1-TRICHLOROETHANE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	1,1,2,2-TETRACHLOROETHANE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	1,1,2-TRICHLOROETHANE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	1,1-DICHLOROETHENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	1,2-DICHLOROETHENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	1,2-DICHLOROPROPANE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	2-BUTANONE	10 0000 - 10 0000	1/45	2 2	UG/KG	4	4	5	0	51494
QRF	TOTAL	2-HEXANONE	10 0000 - 10 0000	0/45	0 0						
QRF	TOTAL	4-METHYL-2-PENTANONE	10 0000 - 10 0000	0/45	0 0						
QRF	TOTAL	ACETONE	10 0000 - 10 0000	10/44	22 7	UG/KG	1	15	5	2	50994
QRF	TOTAL	BENZENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	BROMODICHLOROMETHANE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	BROMOFORM	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	BROMOMETHANE	10 0000 - 10 0000	0/55	0 0						
QRF	TOTAL	CARBON DISULFIDE	5 0000 - 5 0000	0/50	0 0						
QRF	TOTAL	CARBON TETRACHLORIDE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	CHLOROBENZENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	CHLOROETHANE	10 0000 - 10 0000	0/55	0 0						

**Table B-3  
Summary Statistics for Subsurface Geologic Materials in IHSS 168 and Downgradient Wells (0 to 12 feet)**

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
QRF	TOTAL	CHLOROFORM	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	CHLOROMETHANE	10 0000 - 10 0000	0/55	0 0						
QRF	TOTAL	DIBROMOCHLOROMETHANE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	ETHYLBENZENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	METHYLENE CHLORIDE	5 0000 - 5 0000	18/53	34 0	UG/KG	1	16	4	3	51194
QRF	TOTAL	STYRENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	TETRACHLOROETHENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	TOLUENE	5 0000 - 5 0000	22/55	40 0	UG/KG	1	25	3	3	51094
QRF	TOTAL	TOTAL XYLENES	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	TRICHLOROETHENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	VINYL ACETATE	10 0000 - 10 0000	0/55	0 0						
QRF	TOTAL	VINYL CHLORIDE	10 0000 - 10 0000	0/55	0 0						
QRF	TOTAL	cis-1,3-DICHLOROPROPENE	5 0000 - 5 0000	0/55	0 0						
QRF	TOTAL	trans-1,3-DICHLOROPROPENE	5 0000 - 5 0000	0/55	0 0						

**Other Parameters**

QRF	TOTAL	% SOLIDS BY WEIGHT	0 1 - 0 1	67/67	100 0	%	81 2	99 0	94 4	3 2	50194
QRF	TOTAL	CYANIDE	2 5 - 2 5	0/67	0 0						
QRF	TOTAL	NITRATE/NITRITE	0 1 - 0 1	61/67	91 0	MG/KG	0 1	2	1	1	50394

**Table B-4  
Summary Statistics for Subsurface Geologic Materials in Background Boreholes**

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Mean+2Std	UTL99	Max Locn
<b>Metals</b>													
RFA	TOTAL	ALUMINIUM	40 - 504	56/57	98.2	MG/KG	279	102000	13022	13838	40697	55484	B400289
RFA	TOTAL	ANTIMONY	12 - 40	8/46	17.4	MG/KG	1.9	5.2	5	5	14	20	B400389
RFA	TOTAL	ARSENIC	2 - 4.9	38/56	67.9	MG/KG	0.46	41.8	4	6	15	21	B200689
RFA	TOTAL	BARIIUM	40 - 96.8	48/57	84.2	MG/KG	14.9	777	82	103	288	398	B400289
RFA	TOTAL	BERYLLIUM	1 - 2.4	47/57	82.5	MG/KG	0.91	23.5	4	4	13	18	B400289
RFA	TOTAL	CADMIUM	1 - 2.4	5/44	11.4	MG/KG	0.16	1.5	1	0	1	2	B200589
RFA	TOTAL	CALCIUM	1060 - 2420	56/57	98.2	MG/KG	1130	157000	6419	20674	47767	69859	B200789
RFA	TOTAL	CAESIUM	200 - 484	0/57	0.0								
RFA	TOTAL	CHROMIUM	2 - 4.8	57/57	100.0	MG/KG	4	176	22	31	85	118	B400289
RFA	TOTAL	COBALT	10 - 24.2	18/57	31.6	MG/KG	3.8	16.6	7	7	20	27	B200589
RFA	TOTAL	COPPER	5 - 12.1	54/57	94.7	MG/KG	2.2	123	11	16	43	60	B400289
RFA	TOTAL	IRON	20 - 252	57/57	100.0	MG/KG	1300	132000	13968	16651	47270	65064	B400289
RFA	TOTAL	LEAD	1 - 6.1	56/56	100.0	MG/KG	2.6	39.8	9	7	23	30	B400289
RFA	TOTAL	LITHIUM	2.1 - 26.1	29/57	50.9	MG/KG	2	83.2	10	10	31	42	B400289
RFA	TOTAL	MAGNESIUM	1060 - 2420	53/57	93.0	MG/KG	606	32500	2686	4155	10997	15437	B400289
RFA	TOTAL	MANGANESE	3 - 7.3	57/57	100.0	MG/KG	26.6	3330	235	437	1109	1576	B400289
RFA	TOTAL	MERCURY	0.083 - 0.3	21/48	43.8	MG/KG	0.083	0.64	0.2	0.2	0.6	0.8	B200689
RFA	TOTAL	MOLYBDENUM	2.1 - 4.0	32/57	56.1	MG/KG	2.3	67.6	11	10	32	43	B400289
RFA	TOTAL	NICKEL	8 - 19.4	49/54	90.7	MG/KG	5.9	193	23	26	76	104	B400289
RFA	TOTAL	POTASSIUM	1060 - 2420	32/56	57.1	MG/KG	373	18700	1765	3118	8000	11360	B400289
RFA	TOTAL	SELENIUM	1 - 12.2	1/44	2.3	MG/KG	0.21	2.8	1	1	4	6	B200789
RFA	TOTAL	SILVER	2 - 4.8	14/50	28.0	MG/KG	0.53	40.9	2	6	14	21	B200689
RFA	TOTAL	SODIUM	1060 - 2420	7/57	12.3	MG/KG	102	310	269	291	852	1163	B200689
RFA	TOTAL	STRONTIUM	21.6 - 484	5/57	8.8	MG/KG	20.9	226	57	58	174	236	B200789
RFA	TOTAL	THALLIUM	2 - 20	3/41	7.3	MG/KG	0.21	0.4	0.8	1.6	4.0	6.0	B200689
RFA	TOTAL	TIN	10 - 48.4	10/56	17.9	MG/KG	20.2	312	21	41	103	147	B200689
RFA	TOTAL	VANADIUM	10 - 24.2	56/57	98.2	MG/KG	11.1	283	32	36	104	142	B400289
RFA	TOTAL	ZINC	4 - 9.7	56/56	100.0	MG/KG	0.52	486	30	64	157	226	B400289
<b>Radionuclides</b>													
RFA	TOTAL	AMERICIUM-241	0.002 - 0.04	14/14	100.0	PCI/G	-0.01	0.011	0.00	0.00	0.01	0.02	B200589
RFA	TOTAL	GROSS ALPHA	11 - 17	32/32	100.0	PCI/G	3	38	20	9	37	49	B200589
RFA	TOTAL	GROSS BETA	7 - 8	32/32	100.0	PCI/G	6	41	23	6	36	45	B200589
RFA	TOTAL	PLUTONIUM-239/240	0 - 0.009	57/57	100.0	PCI/G	-0.01	0.02	0.00	0.00	0.01	0.02	B200789
RFA	TOTAL	TRITIUM	250000 - 260000	32/32	100.0	PCI/L	-150.00	330.00	129.4	126.8	383.0	560.2	B400289
RFA	TOTAL	URANIUM-233,-234	0.1 - 0.1	44/44	100.0	PCI/G	0.2	1.99	1	0	1	2	B200589
RFA	TOTAL	URANIUM-235	0.1 - 0.1	44/44	100.0	PCI/G	0	0.1	0.0	0.0	0.1	0.1	B400289
RFA	TOTAL	URANIUM-238	0.1 - 0.1	44/44	100.0	PCI/G	0.2	1.1	1	0	1	1	B400389

**Table B-5  
Summary Statistics for UHSU Ground Water in IHSS 168 and Downgradient Wells**

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
<b>Metals</b>											
UHSU	TOTAL	ALUMINUM	18 - 200	78/81	96.3	UG/L	52.20	208000.00	7810	23212	5086
UHSU	TOTAL	ANTIMONY	17 - 60	8/80	10.0	UG/L	7	30.7	11	5	B111189
UHSU	TOTAL	ARSENIC	0.70 - 10	17/78	21.8	UG/L	0.70	5.9	1	1	B410689
UHSU	TOTAL	BARIIUM	2.1 - 200	77/81	95.1	UG/L	44.80	1040.00	100	119	5086
UHSU	TOTAL	BERYLLIUM	0.80 - 5	5/79	6.3	UG/L	0.80	16.40	1	2	5086
UHSU	TOTAL	CADMIUM	2 - 5	7/80	8.8	UG/L	1.00	3.50	1	1	B111189
UHSU	TOTAL	CALCIUM	17.4 - 5000	81/81	100.0	UG/L	10500	62200.00	25609	11394	5086
UHSU	TOTAL	CESIUM	500 - 1000	4/71	5.6	UG/L	23.00	80.00	117	128	B110889
UHSU	TOTAL	CHROMIUM	2.4 - 10	33/80	41.3	UG/L	2	208.00	10	24	5086
UHSU	TOTAL	COBALT	3.6 - 50	20/81	24.7	UG/L	2.00	68.00	4	8	5086
UHSU	TOTAL	COPPER	2 - 25	33/81	40.7	UG/L	1.00	191.00	9	21	5086
UHSU	TOTAL	IRON	4.7 - 100	79/81	97.5	UG/L	30.10	198000.00	7979	22169	5086
UHSU	TOTAL	LEAD	1.0 - 5	62/80	77.5	UG/L	1.00	59.80	4	7	5086
UHSU	TOTAL	LITHIUM	2 - 100	34/81	42.0	UG/L	2.80	134.00	6	15	5086
UHSU	TOTAL	MAGNESIUM	29.6 - 5000	79/81	97.5	UG/L	2110	37000.00	6063	4266	5086
UHSU	TOTAL	MANGANESE	1 - 15	78/81	96.3	UG/L	2	2710.00	257	415	5086
UHSU	TOTAL	MERCURY	0.20 - 0.20	6/81	7.4	UG/L	0.20	0.37	0.1	0.0	4986
UHSU	TOTAL	MOLYBDENUM	7 - 200	6/81	7.4	UG/L	2.00	8.20	3	2	B410589
UHSU	TOTAL	NICKEL	11 - 40	36/81	44.4	UG/L	2.00	155.00	11	18	5086
UHSU	TOTAL	POTASSIUM	776 - 5000	65/81	80.2	UG/L	518.00	25200.00	1739	2928	5086
UHSU	TOTAL	SELENIUM	1.1 - 5	11/80	13.8	UG/L	1	1.5	1	0	B410589
UHSU	TOTAL	SILVER	2.6 - 10	5/81	6.2	UG/L	2.00	9.40	2	1	B111189
UHSU	TOTAL	SODIUM	28.3 - 5000	81/81	100.0	UG/L	9570	25000	14440	3509	46392
UHSU	TOTAL	STRONTIUM	0.80 - 200	76/80	95.0	UG/L	55.10	269	144	63	B410789
UHSU	TOTAL	THALLIUM	1.7 - 10	1/81	1.2	UG/L	1	1.00	1	0	B111189
UHSU	TOTAL	TIN	18 - 200	8/80	10.0	UG/L	10.00	48.20	12	9	B111189
UHSU	TOTAL	VANADIUM	3 - 50	44/81	54.3	UG/L	2.00	349.00	15	40	5086
UHSU	TOTAL	ZINC	2.1 - 20	46/81	56.8	UG/L	1.30	405.00	26	46	5086
<b>Radionuclides</b>											
UHSU	TOTAL	AMERICIUM-241	0.000 - 0.038	185/185	100.0	PC/L	-0.004	0.191	0.006	0.018	B410689
UHSU	TOTAL	GROSS ALPHA	0 - 30	15/15	100.0	PC/L	0	300	50	91	51094
UHSU	TOTAL	GROSS BETA	0 - 20	15/15	100.0	PC/L	-0.536	220	37	64	51094
UHSU	TOTAL	PLUTONIUM-239/240	0 - 0.04	187/187	100.0	PC/L	-0.019	0.2541	0.003	0.019	5086
UHSU	TOTAL	TRITIUM	0 - 850	193/193	100.0	PC/L	-200	1535	126	185	B111189
UHSU	TOTAL	URANIUM-233,-234	0 - 0.6	16/16	100.0	PC/L	0.2412	12	3	3	51494
UHSU	TOTAL	URANIUM-235	0 - 0.6	16/16	100.0	PC/L	-0.0118	0.49	0.17	0.17	51094
UHSU	TOTAL	URANIUM-238	0 - 0.6	16/16	100.0	PC/L	0	12	3	4	51494

Table B-5  
 Summary Statistics for UHSU Ground Water in IHSS 168 and Downgradient Wells

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locon
<b>Semivolatile Organic Compounds</b>											
UHSU	TOTAL	1,2,4-TRICHLOROBENZENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	1,2-DICHLOROBENZENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	1,3-DICHLOROBENZENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	1,4-DICHLOROBENZENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2,4,5-TRICHLOROPHENOL	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	2,4,6-TRICHLOROPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2,4-DICHLOROPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2,4-DIMETHYLPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2,4-DINITROPHENOL	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	2,4-DINITROTOLUENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2,6-DINITROTOLUENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2-CHLORONAPHTHALENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2-CHLOROPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2-METHYLNAPHTHALENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2-METHYLPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	2-NITROANILINE	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	2-NITROPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	3,3'-DICHLOROBENZIDINE	19 - 20 0000	0/9	0 0						
UHSU	TOTAL	3-NITROANILINE	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	4,6-DINITRO-2-METHYLPHENOL	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	4-CHLORO-3-METHYLPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	4-CHLOROANILINE	10 0000 - 10 0000	0/7	0 0						
UHSU	TOTAL	4-CHLOROPHENYL PHENYL ETHER	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	4-METHYLPHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	4-NITROANILINE	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	4-NITROPHENOL	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	ACENAPHTHENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	ACENAPHTHYLENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	ANTHRACENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BENZO(a)ANTHRACENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BENZO(a)PYRENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BENZO(b)FLUORANTHENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BENZO(ghi)PERYLENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BENZO(k)FLUORANTHENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BENZOIC ACID	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	BENZYL ALCOHOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BIS(2-CHLOROETHOXY)METHANE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BIS(2-CHLOROETHYL)ETHER	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BIS(2-CHLOROISOPROPYL)ETHER	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	BIS(2-ETHYLHEXYL)PHTHALATE	10 0000 - 10 0000	3/9	33.3	UG/L	9	26	8	7	51294
UHSU	TOTAL	BUTYL BENZYL PHTHALATE	10 0000 - 10 0000	0/9	0 0						

Table B-5  
Summary Statistics for UHSU Ground Water in IHSS 168 and Downgradient Wells

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
UHSU	TOTAL	CHRYSENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	DI-n-BUTYL PHTHALATE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	DI-n-OCTYL PHTHALATE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	DIBENZO(a,h)ANTHRACENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	DIBENZOFURAN	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	DIETHYL PHTHALATE	9 7 - 10 0000	1/9	11 1	UG/L	10	26	7	7	46292
UHSU	TOTAL	DIMETHYL PHTHALATE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	FLUORANTHENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	FLUORENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	HEXACHLOROBENZENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	HEXACHLOROBUTADIENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	HEXACHLOROCYCLOPENTADIENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	HEXACHLOROETHANE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	INDENO(1,2,3-cd)PYRENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	ISOPHORONE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	N-NITROSO-DI-n-PROPYLAMINE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	N-NITROSODIPHENYLAMINE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	NAPHTHALENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	NITROBENZENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	PENTACHLOROPHENOL	48 - 50 0000	0/9	0 0						
UHSU	TOTAL	PHENANTHRENE	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	PHENOL	10 0000 - 10 0000	0/9	0 0						
UHSU	TOTAL	PYRENE	10 0000 - 10 0000	0/9	0 0						
<b>Volatile Organic Compounds</b>											
UHSU	TOTAL	1,1,1-TRICHLOROETHANE	0 1 - 10	0/204	0 0						
UHSU	TOTAL	1,1,2,2-TETRACHLOROETHANE	0 2000 - 10	0/204	0 0						
UHSU	TOTAL	1,1,2-TRICHLOROETHANE	0 3 - 10	0/204	0 0						
UHSU	TOTAL	1,1-DICHLOROETHENE	0 1 - 10	0/204	0 0						
UHSU	TOTAL	1,2,4-TRICHLOROBENZENE	0 2 - 0 5	0/60	0 0						
UHSU	TOTAL	1,2-DICHLOROBENZENE	0 1 - 0 5	0/60	0 0						
UHSU	TOTAL	1,2-DICHLOROETHENE	5 - 10	0/142	0 0						
UHSU	TOTAL	1,2-DICHLOROPROPANE	0 1 - 10	0/204	0 0						
UHSU	TOTAL	1,3-DICHLOROBENZENE	0 1 - 0 5	0/60	0 0						
UHSU	TOTAL	1,4-DICHLOROBENZENE	0 2 - 0 5	0/60	0 0						
UHSU	TOTAL	2-BUTANONE	10 - 10	2/96	2 1	UG/L	10	19	5	2	B410689
UHSU	TOTAL	2-HEXANONE	10 - 10	0/137	0 0						
UHSU	TOTAL	4-METHYL-2-PENTANONE	10 - 10	0/139	0 0						
UHSU	TOTAL	ACETONE	10 - 10	10/135	7 4	UG/L	1	31	5	3	B410789
UHSU	TOTAL	BENZENE	0 1 - 10	4/203	2 0	UG/L	0 1	7	2	1	B411389
UHSU	TOTAL	BROMODICHLOROMETHANE	0 2000 - 10	0/204	0 0						
UHSU	TOTAL	BROMOFORM	0 2 - 10	0/202	0 0						
UHSU	TOTAL	BROMOMETHANE	0 1 - 10	0/202	0 0						

**Table B-5  
Summary Statistics for UHSU Ground Water in IHSS 168 and Downgradient Wells**

Geo Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Max Locn
UHSU	TOTAL	CARBON DISULFIDE	5 - 10	1/142	0.7	UG/L	3	3	3	0	B411289
UHSU	TOTAL	CARBON TETRACHLORIDE	0.1 - 10	1/204	0.5	UG/L	0.1	2	2	1	4986
UHSU	TOTAL	CHLOROBENZENE	0.1 - 10	0/204	0.0						
UHSU	TOTAL	CHLOROETHANE	0.1 - 10	0/203	0.0						
UHSU	TOTAL	CHLOROFORM	0.1 - 10	10/203	4.9	UG/L	0.1	3	2	1	46392
UHSU	TOTAL	CHLOROMETHANE	0.2 - 10	0/202	0.0						
UHSU	TOTAL	CYANIDE	10 - 10	0/1	0.0						
UHSU	TOTAL	DIBROMOCHLOROMETHANE	0.2000 - 10	0/204	0.0						
UHSU	TOTAL	ETHYLBENZENE	0.1 - 10	1/204	0.5	UG/L	0.1	2	2	1	B110889
UHSU	TOTAL	HEXACHLOROBUTADIENE	0.2000 - 0.5	1/60	1.7	UG/L	0.1	0.1	0.1	0.0	46392
UHSU	TOTAL	METHYLENE CHLORIDE	0.1 - 10	26/203	12.8	UG/L	0.1	13	2	2	4986
UHSU	TOTAL	NAPHTHALENE	0.2000 - 0.5	0/59	0.0						
UHSU	TOTAL	STYRENE	0.1 - 10	0/204	0.0						
UHSU	TOTAL	TETRACHLOROETHENE	0.1 - 10	6/204	2.9	UG/L	0.1	2	2	1	4986
UHSU	TOTAL	TOLUENE	0.1 - 10	5/204	2.5	UG/L	0.1	3	2	1	B110889
UHSU	TOTAL	TOTAL XYLENES	0.5 - 10	1/145	0.7	UG/L	0.5	10	3	1	B110889
UHSU	TOTAL	TRICHLOROETHENE	0.1 - 10	2/204	1.0	UG/L	0.1	1	2	1	B110989
UHSU	TOTAL	VINYL ACETATE	10 - 10	0/131	0.0						
UHSU	TOTAL	VINYL CHLORIDE	0.2000 - 10	0/204	0.0						
UHSU	TOTAL	cis-1,3-DICHLOROPROPENE	0.1 - 10	0/198	0.0						
UHSU	TOTAL	trans-1,2-DICHLOROETHENE	0.1 - 5.0000	0/61	0.0						
UHSU	TOTAL	trans-1,3-DICHLOROPROPENE	0.3 - 10	0/197	0.0						
<b>Other Parameters</b>											
UHSU	TOTAL	CYANIDE	0.02 - 20000	9/192	4.7	UG/L	0.02	49.000	113	1017	B410689
UHSU	TOTAL	NITRATE/NITRITE	20.00 - 5000	203/209	97.1	UG/L	20.00	9800.0	1568	1604	50794

Table B-6  
Summary Statistics for UHSU Ground Water in Background Wells

Hydro Unit Tot/DIs	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Mean+2Std	UTL99	Max Locn
<b>Metals</b>												
UHSU TOTAL	ALUMINIUM	18 - 200 0000	141/165	85.5	UG/L	18	63900.00	3210	7419	18047	25837	B200589
UHSU TOTAL	ANTIMONY	17 - 60 0000	22/155	14.2	UG/L	7.00	86.60	13	10	32	42	B200589
UHSU TOTAL	ARSENIC	0.70 - 10 0000	18/162	11.1	UG/L	0.70	3.00	1	0	2	2	B200589
UHSU TOTAL	BARIIUM	2.1 - 200 0000	135/165	81.8	UG/L	25.90	752.00	101	75	252	331	B200589
UHSU TOTAL	BERYLLIUM	0.60 - 5 0000	7/165	4.2	UG/L	0.80	4.80	1	0	1	2	B200589
UHSU TOTAL	CADMIUM	2 - 6.2	14/165	8.5	UG/L	1.00	8.7	1	1	3	4	B202589
UHSU TOTAL	CALCIUM	17.4 - 5000 0000	165/165	100.0	UG/L	13400.00	186000.00	54916	30568	116053	148149	B201289
UHSU TOTAL	CESIUM	500 - 1000 0000	0/158	0.0								
UHSU TOTAL	CHROMIUM	2.0 - 10 0000	54/164	32.9	UG/L	2.00	729	11	57	125	185	B201189
UHSU TOTAL	COBALT	2.7 - 50 0000	22/165	13.3	UG/L	2.00	39.40	3	3	9	13	B200589
UHSU TOTAL	COPPER	2 - 25 0000	26/164	15.9	UG/L	1.00	105.00	6	10	27	37	B200589
UHSU TOTAL	IRON	4.7 - 100 0000	146/165	88.5	UG/L	6.50	97000.00	3618	9221	22061	31743	B200589
UHSU TOTAL	LEAD	0.80 - 5	96/164	58.5	UG/L	1.00	52.50	3	5	14	19	B200589
UHSU TOTAL	LITHIUM	2.0 - 100 0000	113/165	68.5	UG/L	1.1	266.00	23	48	120	170	B201289
UHSU TOTAL	MAGNESIUM	29.6 - 5000 0000	162/165	98.2	UG/L	2150.00	47900.00	10175	7652	25479	33514	B201289
UHSU TOTAL	MANGANESE	1 - 15 0000	141/165	85.5	UG/L	1	1950.00	86	180	446	635	B200589
UHSU TOTAL	MERCURY	0.2000 - 0.2000	4/165	2.4	UG/L	0.20	0.27	0.1	0.0	0.1	0.2	B200589
UHSU TOTAL	MOLYBDENUM	3.5 - 200 0000	23/164	14.0	UG/L	2.00	80.50	4	7	17	24	B203489
UHSU TOTAL	NICKEL	11 - 40 0000	34/162	21.0	UG/L	2.00	334	9	27	62	90	B201189
UHSU TOTAL	POTASSIUM	674 - 5000 0000	121/165	73.3	UG/L	243.00	8370.00	1308	1139	3587	4783	B200589
UHSU TOTAL	SELENIUM	1.4 - 5 0000	35/163	21.5	UG/L	1.00	456	7	40	86	127	B201189
UHSU TOTAL	SILVER	2.1 - 10 0000	14/163	8.6	UG/L	2.00	3.30	2	1	3	4	B401989
UHSU TOTAL	SODIUM	28.3 - 5000 0000	163/165	98.8	UG/L	4300	194000.00	29441	38577	106594	147100	B201289
UHSU TOTAL	STRONTIUM	0.80 - 200 0000	145/161	90.1	UG/L	46.30	1770.00	308	264	835	1112	B201289
UHSU TOTAL	THALLIUM	0.90 - 10 0000	14/165	8.5	UG/L	0.90	1.10	1	0	1	2	B102389
UHSU TOTAL	TIN	9.4 - 200 0000	12/160	7.5	UG/L	9.4	35.5	12	8	28	36	B400289
UHSU TOTAL	VANADIUM	3 - 50 0000	94/165	57.0	UG/L	2.00	167.00	9	18	45	63	B200589
UHSU TOTAL	ZINC	1.7 - 20 0000	80/165	48.5	UG/L	4.20	498.00	31	49	130	182	B400489
<b>Radionuclides</b>												
UHSU TOTAL	AMERICIUM-241	0.000 - 0.024	251/251	100.0	PCI/L	-0.00706	0.09698	0.01	0.01	0.03	0.04	B302989
UHSU TOTAL	GROSS ALPHA	0 - 7.6	38/38	100.0	PCI/L	0.6	362	40	88	216	329	B205589
UHSU TOTAL	GROSS BETA	0 - 7.8	32/32	100.0	PCI/L	-0.3	220	26	51	128	199	B205589
UHSU TOTAL	PLUTONIUM-239/240	0.000 - 0.03317	264/264	100.0	PCI/L	-0.005	0.2237	0.004	0.017	0.039	0.058	B302989
UHSU TOTAL	TRITIUM	0 - 780	316/316	100.0	PCI/L	-340	1447	98	165	427	600	B200789
UHSU TOTAL	URANIUM-233,-234	0 - 0.59	40/40	100.0	PCI/L	0	164	14	38	89	136	B205589
UHSU TOTAL	URANIUM-235	0 - 0.71	40/40	100.0	PCI/L	-0.01	7.74	0.6	1.7	4.0	6.1	B205589
UHSU TOTAL	URANIUM-238	0 - 0.75	48/48	100.0	PCI/L	0	108	8	23	54	81	B205589
<b>Volatile Organic Compounds</b>												
UHSU TOTAL	1,1,1-TRICHLOROETHANE	5 - 5	5/383	1.3	UG/L	2	8	3	0	3	3	5686
UHSU TOTAL	1,1,2,2-TETRACHLOROETHANE	0.2 - 5	2/390	0.5	UG/L	1	130	3	6	16	23	B200589
UHSU TOTAL	1,1,2-TRICHLOROETHANE	0.02 - 5	0/391	0.0								

Table B-6  
 Summary Statistics for UHSU Ground Water in Background Wells

Hydro Unit	Tot/Dis	Analyte	Det Lim Range	Freq Det	Percent Det	Units	Min Result	Max Detect	Mean Result	Std Dev	Mean+2Std	UTL99	Max Locn
UHSU	TOTAL	1,1-DICHLOROETHENE	0.05 - 5	2/391	0.5	UG/L	4	7	2	0	3	4	5586
UHSU	TOTAL	1,2-DICHLOROETHENE	5 - 100	0/390	0.0								
UHSU	TOTAL	1,2-DICHLOROPROPANE	5 - 5	1/391	0.3	UG/L	1	1	2	0	3	3	B305389
UHSU	TOTAL	2-BUTANONE	5 - 10	1/245	0.4	UG/L	2	2	5	0	6	6	B203189
UHSU	TOTAL	2-HEXANONE	0.02 - 10	1/359	0.3	UG/L	3	3	5	1	6	7	B201289
UHSU	TOTAL	4-METHYL-2-PENTANONE	10 - 10	1/386	0.3	UG/L	3	3	5	0	5	5	B201289
UHSU	TOTAL	ACETONE	5 - 10	32/366	8.7	UG/L	1	43	6	5	15	20	B302089
UHSU	TOTAL	BENZENE	5 - 20	2/391	0.5	UG/L	0.2	0.2	3	1	4	5	B302089
UHSU	TOTAL	BROMODICHLOROMETHANE	5 - 5	0/389	0.0								
UHSU	TOTAL	BROMOFORM	0.1 - 5	1/388	0.3	UG/L	2	2	2	0	3	3	B200689
UHSU	TOTAL	BROMOMETHANE	10 - 10	0/368	0.0								
UHSU	TOTAL	CARBON DISULFIDE	0.02 - 5	16/380	4.2	UG/L	0.7	31	3	2	7	9	B304889
UHSU	TOTAL	CARBON TETRACHLORIDE	5 - 10	6/380	1.6	UG/L	1	15	3	1	4	5	B400289
UHSU	TOTAL	CHLOROBENZENE	0.02 - 5	2/391	0.5	UG/L	2	2	2	0	3	3	B200789
UHSU	TOTAL	CHLOROETHANE	10 - 10	0/378	0.0								
UHSU	TOTAL	CHLOROFORM	5 - 5	6/391	1.5	UG/L	0.6	4	2	0	3	3	B202489
UHSU	TOTAL	CHLOROMETHANE	10 - 10	0/373	0.0								
UHSU	TOTAL	DIBROMOCHLOROMETHANE	5 - 10	0/390	0.0								
UHSU	TOTAL	ETHYLBENZENE	5 - 10	0/391	0.0								
UHSU	TOTAL	METHYLENE CHLORIDE	0.1 - 5	28/387	7.2	UG/L	1	25	3	2	7	10	B201289
UHSU	TOTAL	STYRENE	5 - 10	0/385	0.0								
UHSU	TOTAL	TETRACHLOROETHENE	5 - 5	8/385	2.1	UG/L	0.9	42	3	2	7	9	B405489
UHSU	TOTAL	TOLUENE	5 - 5	7/385	1.8	UG/L	0.4	6	2	0	3	3	B400289
UHSU	TOTAL	TOTAL XYLENES	5 - 5	0/373	0.0								
UHSU	TOTAL	TRICHLOROETHENE	5 - 5	22/385	5.7	UG/L	0.5	120	3	7	17	25	B305389
UHSU	TOTAL	VINYL ACETATE	10 - 10	0/347	0.0								
UHSU	TOTAL	VINYL CHLORIDE	10 - 10	0/384	0.0								
UHSU	TOTAL	cis-1,3-DICHLOROPROPENE	5 - 25	1/390	0.3	UG/L	3	3	3	1	5	6	B305389
UHSU	TOTAL	trans-1,2-DICHLOROETHENE	5 - 5	0/26	0.0								
UHSU	TOTAL	trans-1,3-DICHLOROPROPENE	5 - 5	0/377	0.0								
<b>Other Parameters</b>													
UHSU	TOTAL	CYANIDE	0.0072 - 10000	11/290	3.8	UG/L	0.0072	17.7000	57	506	1069	1601	B102289
UHSU	TOTAL	NITRATE/NITRITE	0 - 5000	306/357	85.7	UG/L	20.00	12000	1080	1735	4551	6373	B201289

**APPENDIX C**

**Background Comparison Summaries**

**Table C-1**  
**West Spray Field (OU 11)**  
**Background Comparison Summary for Surficial Soil (0 to 2 inches)**

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUANT	P_GEHAN	P_T	SIGNIFICANT	UTL <sub>9995</sub>	NGUTL	CANDIDATE PCOC
<b>Metals</b>												
ALUMINUM	20	53	100	100	1 00E+00	8 18E-01	9 93E-01	9 70E-01	N	25879	0	N
ANTIMONY	20	53	0	57	1 00E+00		5 00E-01		N	ND		(Y)
ARSENIC	20	53	100	100	1 91E-01	3 56E-01	6 90E-04	4 04E-04	Y	13	1	Y
BARIUM	20	53	100	100	1 00E+00	1 00E+00	1 00E+00	9 99E-01	N	532	0	N
BERYLLIUM	20	53	55	100	1 00E+00		9 59E-01		N	5	0	N
CADMIUM	18	53	33 3	52 8	1 00E+00		7 62E-01		N	5	0	N
CALCIUM	20	53	100	100	1 00E+00	1 00E+00	1 00E+00	1 00E+00	N	16659	0	N
CESIUM	20	52	55	0	1 00E+00		5 00E-01		N	598	0	N
CHROMIUM	20	53	100	100	7 26E-01	9 36E-01	9 99E-01	9 95E-01	N	28	0	N
COBALT	20	53	100	100	1 00E+00	9 84E-01	9 43E-01	9 18E-01	N	24	0	N
COPPER	20	53	100	100	7 26E-01	9 99E-01	7 96E-01	3 79E-01	N	30	1	Y
IRON	20	53	100	100	1 00E+00	1 00E+00	9 98E-01	9 90E-01	N	29052	0	N
LEAD	20	53	100	100	9 46E-02	1 47E-01	1 02E-02	8 04E-03	Y	62	4	Y
LITHIUM	20	53	100	100	7 26E-01	9 84E-01	9 94E-01	9 85E-01	N	22	0	N
MAGNESIUM	20	53	100	100	1 00E+00	1 00E+00	1 00E+00	1 00E+00	N	7718	0	N
MANGANESE	20	53	100	100	1 00E+00	9 36E-01	8 22E-01	8 76E-01	N	2100	0	N
MERCURY	18	53	0	0	1 00E+00				N	ND		N
MOLYBDENUM	20	53	5	20 8	1 00E+00		6 22E-01		N	23	0	N
NICKEL	20	53	95	100	7 26E-01		1 00E+00	1 00E+00	N	26	0	N
POTASSIUM	20	53	100	100	1 00E+00	1 00E+00	1 00E+00	1 00E+00	N	6190	0	N
SELENIUM	20	53	75	54 7	1 00E+00		9 94E-01		N	15	0	N
SILVER	20	53	0	1 9	1 00E+00		5 00E-01		N	ND		(Y)
SODIUM	20	53	55	100	1 00E+00		9 94E-01		N	1052	0	N
STRONTIUM	20	53	100	100	1 00E+00	1 00E+00	1 00E+00	9 99E-01	N	113	0	N
THALLIUM	20	53	30	43 4	1 00E+00		9 82E-01		N	0 6	0	N
TIN	20	53	40	32 1	1 00E+00		1 00E+00		N	70	0	N
VANADIUM	20	53	100	100	7 26E-01	9 08E-01	9 77E-01	9 15E-01	N	60	0	N
ZINC	20	53	100	100	1 00E+00	1 00E+00	1 00E+00	1 00E+00	N	99	0	N

**Table C-1**  
**West Spray Field (OU 11)**  
**Background Comparison Summary for Surficial Soil (0 to 2 inches)**

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUANT	P_GEHAN	P_T	SIGNIFICANT	UTL <sub>99/99</sub> *	NGUTL	CANDIDATE PCOC
<b>Radionuclides</b>												
AMERICIUM-241	20	53	100	100	2.93E-04	1.83E-03	1.33E-05	1.50E-03	Y	0.058	5	Y
GROSS ALPHA	10		100		1.00E+00	1.00E+00	5.00E-01		N	43	0	N
GROSS BETA	10		100		1.00E+00	1.00E+00	5.00E-01		N	53	0	N
PLUTONIUM-239/240	23	53	100	100	2.62E-08	3.11E-04	5.02E-08	8.35E-03	Y	0.13	24	Y
URANIUM-233,-234	16	53	100	100	2.56E-12	1.10E-02	1.37E-09		Y	1.8	33	Y
URANIUM-235	16	53	100	100	7.82E-02	1.03E-01	4.49E-04	1.56E-03	Y	0.187	4	Y
URANIUM-238	16	53	100	100	1.07E-11	1.10E-02	1.25E-09		Y	2	20	Y
<b>Other Parameters</b>												
CYANIDE	0	53		0						NA		N
NITRATE/NITRITE	9	53	100	100	3.40E-04	1.01E-01	1.29E-04		Y	9.6	22	Y

\* Metal and other parameter concentrations reported in milligram per kilogram, radionuclide activities reported in picocuries per gram

**Definitions**

- N\_B = Number of background samples
- N\_S = Number of site samples
- DTF\_B = Detection frequency in background samples
- DTF\_S = Detection frequency in site samples
- P\_SLIP = p-value, Slippage test
- P\_QUANT = p-value, Quantile test (performed only when the largest 20% of the combined background and site data are detected)
- P\_GEHAN = p-value, Gehan test
- P\_T = p-value, Student's t-test (performed only when data contained less than 20% nondetects and normality assumptions based on the Shapiro-Wilk test were satisfied)
- SIGNIFICANT = Shading in formal statistical test columns indicates a significant difference between background and OU 11 data (p ≤ 0.05)
- UTL<sub>99/99</sub> = 99 percent upper tolerance limit of background data at the 99 percent confidence level
- NGUTL = Number of site sample results > UTL<sub>99/99</sub>
- NA = Analyte not included in background, UTL<sub>99/99</sub> not calculated
- ND = Analyte not detected in background, UTL<sub>99/99</sub> not calculated
- PCOC = Potential chemical of concern
- (Y) = Analyte not detected or not included in background but was detected at OU 11, therefore analyte identified as a candidate PCOC

**Table C-2**  
**West Spray Field (OU 11)**  
**Background Comparison Summary for Subsurface Geologic Material (Qrf, 0 to 12 feet)**

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUANT	P_GEHAN	P_T	SIGNIFICANT	UTL <sub>9998</sub> *	NGUTL	CANDIDATE PCOC
<b>Metals</b>												
ALUMINIUM	57	73	98.2	98.6	1 00E+00	1 00E+00	9 99E-01	9 95E-01	N	55484	0	N
ANTIMONY	46	73	17.4	1.4	1 00E+00		9 99E-01		N	20	0	N
ARSENIC	56	73	67.9	100	1 00E+00		2 42E-03		Y	21	0	Y
BARIUM	57	73	84.2	98.6	1 00E+00	9 97E-01	9 99E-01	9 84E-01	N	398	0	N
BERYLLIUM	57	71	82.5	98.6	1 00E+00	1 00E+00	1 00E+00	1 00E+00	N	18	0	N
CADMIUM	44	73	11.4	0	1 00E+00		9 99E-01		N	2	0	N
CALCIUM	57	73	98.2	98.6	1 00E+00	1 00E+00	1 00E+00	9 66E-01	N	69859	0	N
CESIUM	57	67	0	9	1 00E+00		5 00E-01		N	ND		(Y)
CHROMIUM	57	73	100	98.6	1 00E+00	3 47E-01	7 23E-01	8 63E-01	N	118	0	N
COBALT	57	73	31.6	98.6	1 00E+00		2 82E-01		N	27.4	1	Y
COPPER	57	73	94.7	98.6	1 00E+00	3 47E-01	6 87E-01	8 61E-01	N	60	0	N
IRON	57	73	100	98.6	1 00E+00	9 97E-01	9 76E-01	9 54E-01	N	65064	0	N
LEAD	56	73	100	100	1 00E+00	9 89E-01	6 48E-01	9 71E-01	N	30	0	N
LITHIUM	57	7	50.9	95.9	1 00E+00		1 00E+00		N	42	0	N
MAGNESIUM	57	73	93	98.6	1 00E+00	1 00E+00	1 00E+00	9 98E-01	N	15437	0	N
MANGANESE	57	73	100	98.6	1 00E+00	9 65E-01	6 23E-01	8 65E-01	N	1576	0	N
MERCURY	48	73	43.8	9.6	6 03E-01		1 00E+00		N	0 795	1	Y
MOLYBDENUM	57	73	56.1	47.9	1 00E+00		1 00E+00		N	43	0	N
NICKEL	54	73	90.7	95.9	1 00E+00	1 00E+00	1 00E+00	1 00E+00	N	104	0	N
POTASSIUM	56	73	57.1	87.7	1 00E+00	1 00E+00	1 00E+00		N	11360	0	N
SELENIUM	44	71	2.3	9.9	1 00E+00		4 72E-01		N	6	0	N
SILVER	50	73	28	1.4	1 00E+00		1 00E+00		N	21	0	N
SODIUM	57	73	12.3	100	1 00E+00		7 21E-01		N	1163	0	N
STRONTIUM	57	7	8.8	98.6	1 00E+00		8 29E-01		N	236	0	N
THALLIUM	41	7	7.3	6.8	1 00E+00		9 60E-01		N	6	0	N
TIN	56	73	17.9	21.9	1 00E+00		9 93E-01		N	147	0	N
VANADIUM	57	73	98.2	98.6	1 00E+00	9 97E-01	9 98E-01	9 79E-01	N	142	0	N
ZINC	56	73	100	91.8	1 00E+00	1 00E+00	1 00E+00	9 77E-01	N	226	0	N

Table C-2  
West Spray Field (OU 11)

Background Comparison Summary for Subsurface Geologic Material (Qrf, 0 to 12 feet)

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUANT	P_GEHAN	P_T	SIGNIFICANT	UTL <sub>99.99</sub> *	NGUTL	CANDIDATE PCOC
<b>Radionuclides</b>												
AMERICIUM-241	14	72	100	100	3.82E-03	2.72E-02	1.73E-05		Y	0.021	5	Y
GROSS ALPHA	32	4	100	100	1.00E+00	7.02E-01	5.20E-01	5.15E-01	N	49	0	N
GROSS BETA	32	5	100	100	1.00E+00	1.00E+00	9.59E-01	9.25E-01	N	45	0	N
PLUTONIUM-239/240	57	72	100	100	1.71E-01	1.90E-01	1.18E-04	1.06E-01	Y	0.016	6	Y
TRITIUM	32	54	100	100	1.13E-06	6.35E-05	2.22E-07	7.03E-05	Y	560.2	8	Y
URANIUM-233,-234	44	71	100	100	6.19E-03	5.56E-06	2.22E-15	0.00E+00	Y	1.66	24	Y
URANIUM-235	44	71	100	100	2.08E-03	3.91E-03	2.70E-11	8.94E-12	Y	0.105	13	Y
URANIUM-238	44	71	100	100	4.44E-15	2.03E-07	0.00E+00	0.00E+00	Y	1.269	52	Y
<b>Other Parameters</b>												
CYANIDE	0	67		0						NA		N
NITRATE/NITRITE	0	37		91						NA		(Y)

\* Metal and other parameter concentrations reported in microgram per liter; radionuclide activities reported in picocuries per liter

**Definitions**

N\_B = Number of background samples

N\_S = Number of site samples

DTF\_B = Detection frequency in background samples

DTF\_S = Detection frequency in site samples

P\_SLIP = p-value, Slippage test

P\_QUANT = p-value, Quantile test (performed only when the largest 20% of the combined background and site data are detects)

P\_GEHAN = p-value, Gehan test

P\_T = p-value, Student's t-test (performed only when data contained less than 20% nondetects and normality assumptions based on the Shapiro-Wilk test were satisfied)

SIGNIFICANT = Significant difference from background based on one or more of the formal statistical tests (p ≤ 0.05)

UTL<sub>99.99</sub> = 99 percent upper tolerance limit of background data at the 99 percent confidence level

NGUTL = Number of site sample results > UTL<sub>99.99</sub>

NA = Analyte not included in background, UTL<sub>99.99</sub> not calculated

ND = Analyte not detected in background, UTL<sub>99.99</sub> not calculated

PCOC = Potential chemical of concern

(Y) = Analyte not detected or not included in background but was detected at OU 11, therefore analyte identified as a candidate PCOC

**Table C-3**  
**West Spray Field (OU 11)**  
**Background Comparison Summary for UHSU Ground Water (Total Analytes)**

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUANTIP	GEHAN	P_T	SIGNIFICANT	UTL <sub>95%</sub>	NGUTL	CANDIDATE PCOG
<b>Metals</b>												
ALUMINUM	165	81	85.5	96.3	3.29E-01	4.66E-04	1.49E-07	4.26E-02	Y	25837	1	Y
ANTIMONY	155	80	14.2	10	1.00E+00		6.22E-01		N	42	0	N
ARSENIC	162	78	11.1	21.8	1.00E+00		8.39E-02		N	2	3	Y
BARIUM	165	81	81.8	95.1	3.29E-01		9.81E-01	5.37E-01	N	331	2	Y
BERYLLIUM	165	79	4.2	6.3	3.24E-01		1.54E-01		N	2	2	Y
CADMIUM	165	80	8.5	8.8	1.00E+00		8.07E-01		N	4	0	N
CALCIUM	165	81	100	100	1.00E+00	1.00E+00	1.00E+00	1.00E+00	N	148149	0	N
CESIUM	158	71	0	5.6	1.00E+00		1.12E-03		Y	ND		(Y)
CHROMIUM	164	80	32.9	41.3	1.00E+00		1.04E-01		N	185	1	Y
COBALT	165	81	13.3	24.7	3.29E-01		1.24E-02		Y	13	1	Y
COPPER	164	81	15.9	40.7	3.31E-01		7.65E-04		Y	37	1	Y
IRON	165	81	88.5	97.5	3.29E-01	4.66E-04	1.78E-07	4.63E-02	Y	31743	1	Y
LEAD	164	80	58.5	77.5	3.28E-01	3.38E-02	4.19E-02		Y	19	2	Y
LITHIUM	165	81	68.5	42	1.00E+00		1.00E+00		N	170	0	N
MAGNESIUM	165	81	98.2	97.5	1.00E+00	1.00E+00	1.00E+00	1.00E+00	N	33514	1	Y
MANGANESE	165	81	85.5	96.3	3.29E-01	9.11E-08	2.56E-08	2.97E-04	Y	635	9	Y
MERCURY	165	81	2.4	7.4	3.29E-01		3.30E-02		Y	0.2	6	Y
MOLYBDENUM	164	81	14	7.4	1.00E+00		8.48E-01		N	24	0	N
NICKEL	162	81	21	44.4	1.00E+00		3.77E-05		Y	90	1	Y
POTASSIUM	165	81	73.3	80.2	3.29E-01		1.34E-01		N	4783	4	Y
SELENIUM	163	80	21.5	13.8	1.00E+00		1.00E+00		N	127	0	N
SILVER	163	81	8.6	6.2	1.00E+00		5.78E-01		N	4	1	Y
SODIUM	165	81	98.8	100	1.00E+00	1.00E+00	8.75E-01	1.00E+00	N	147100	0	N
STRONTIUM	161	80	90.1	95	1.00E+00	1.00E+00	1.00E+00	1.00E+00	N	1112	0	N
THALLIUM	165	81	8.5	1.2	1.00E+00		9.79E-01		N	2	0	N
TIN	160	80	7.5	10	1.00E+00		4.74E-02		Y	36	3	Y
VANADIUM	165	81	57	54.3	3.29E-01		2.11E-02		Y	63	2	Y
ZINC	165	81	48.5	56.8	1.00E+00	9.80E-01	7.95E-01		N	182	1	Y

**Table C-3**  
**West Spray Field (OU 11)**  
**Background Comparison Summary for UHSU Ground Water (Total Analytes)**

ANALYTE	N_B	N_S	DTF_B	DTF_S	P_SLIP	P_QUANT	P_GEHAN	P_T	SIGNIFICANT	UTL <sub>99%</sub> *	NGUTL	CANDIDATE PCOC
<b>Radionuclides</b>												
AMERICIUM-241	251	185	100	100	1 79E-01	9 51E-01	9 79E-01	3 60E-01	N	0 04	4	Y
GROSS ALPHA	38	15	100	100	1 00E+00	3 75E-01	4 10E-01	3 58E-01	N	329	0	N
GROSS BETA	32	15	100	100	1 00E+00	3 97E-01	5 27E-01		N	199	1	Y
PLUTONIUM-239/240	264	187	100	100	4 15E-01	9 32E-01	9 57E-01	7 23E-01	N	0 058	1	Y
TRITIUM	316	193	100	100	3 79E-01	6 04E-01	5 41E-02	4 59E-02	Y	600	3	Y
URANIUM-233,-234	40	16	100	100	1 00E+00	7 42E-01	6 68E-01	8 54E-01	N	136	0	N
URANIUM-235	40	16	100	100	1 00E+00	7 42E-01	4 56E-01		N	6 1	0	N
URANIUM-238	46	16	100	100	1 00E+00	7 20E-01	5 54E-01		N	81	0	N
<b>Other Parameters</b>												
CYANIDE	290	192	3 8	4 7	1 00E+00		3 61E-02		Y	1601	0	Y
NITRATE/NITRITE	357	209	85 7	97 1	1 00E+00		5 56E-01	6 91E-01	N	6373	5	Y

\* Metal and other parameter concentrations reported in microgram per liter; radionuclide activities reported in picocuries per liter

**Definitions**

- N\_B = Number of background samples
- N\_S = Number of site samples
- DTF\_B = Detection frequency in background samples
- DTF\_S = Detection frequency in site samples
- P\_SLIP = p-value, Slippage test
- P\_QUANT = p-value, Quantile test (performed only when the largest 20% of the combined background and site data are detects)
- P\_GEHAN = p-value, Gehan test
- P\_T = p-value, Student's t-test (performed only when data contained less than 20% nondetects and normality assumptions based on the Shapiro-Wilk test were satisfied)
- Shading in formal statistical test columns indicates a significant difference between background and OU 11 data ( $p \leq 0.05$ )
- SIGNIFICANT = Significant difference from background based on one or more of the formal statistical tests ( $p \leq 0.05$ )
- UTL<sub>99%</sub> = 99 percent upper tolerance limit of background data at the 99 percent confidence level
- NGUTL = Number of site sample results > UTL<sub>99%</sub>
- Shading in the NGUTL column indicates one or more exceedances of the UTL<sub>99%</sub>
- NA = Analyte not included in background, UTL<sub>99%</sub> not calculated
- ND = Analyte not detected in background, UTL<sub>99%</sub> not calculated
- PCOC = Potential chemical of concern
- (Y) = Analyte not detected or not included in background but was detected at OU 11, therefore analyte identified as a candidate PCOC

**APPENDIX D**

**Use of Professional Judgment and Geochemical Analyses to Identify PCOCs**

## Appendix D

# Use of Professional Judgment and Geochemical Analyses to Identify PCOCs

### Introduction

The initial step in identification of PCOCs is to analyze the detections of chemicals at the site through inferential statistical methods. The chemicals identified through statistical tests as different from background were then subjected to professional review of the test results and review of the graphic presentations of the data. The professional judgment of the reviewer is required to consider additional factors such as the spatial and temporal distribution of analytes, historic information regarding past operations at the site, inter-element correlations, mass-balance calculations, and knowledge of the hydrology, geochemistry, and geology of the site. The rationale for the final list of PCOCs based on professional judgment is provided in the following section.

### Methodology

In general, the method for identifying chemicals at OU 11 was to compare the concentrations of chemicals in media from the site to their concentrations in media from background locations. The *Background Geochemical Characterization Report* (DOE, 1993) characterizes ground water and subsurface geologic materials from unaffected areas. Background soils are currently described by a suite of soil samples collected from 18 locations within the Rock Creek drainage north of the Industrial Area. The inferential statistical methods described in *Statistical Methods for Site-to-Background Comparisons in Support of RFI/RI Investigations* (EG&G, 1994a) were used to compare the site and background data sets and to identify those chemicals present at significantly higher concentrations in OU 11 media than in the background media.

Following the background comparison tests, chemical data were also reviewed to describe the spatial and temporal distribution of the chemical at OU 11 and to assess whether or not the distributions are indicative of contamination associated with the source at OU 11. The potential for artifact due to false positives (contamination introduced in field or laboratory) and outlier values was also carefully evaluated. These methods are consistent with EPA- and CDPHE-approved guidance from DOE for the identification of PCOCs at Rocky Flats (EG&G, 1994a).

Professional judgment was applied to determine if a chemical should be identified as a PCOC when one or more of the following conditions existed:

- 1 Statistical tests identify differences in data sets
- 2 No pattern observed in the distribution (i.e., temporal, spatial) or detection of the chemical that could be related to sources on the site
- 3 Naturally occurring concentration variations, of similar magnitude, also documented in media from background areas

- 4 Well construction or sampling effects influence chemical concentrations (samples not representative)
- 5 False positives or high bias documented in analytical database
- 6 Lack of association with wastes generated and disposed at Rocky Flats site

Professional judgment was applied on a case-by-case basis for each analyte considered. Figures are located at the end of this appendix and are referenced in the text. Figures are in sequential order as referenced. The rationale used to identify chemicals as PCOCs for OU 11 is presented in the following sections. The PCOCs are listed in Table D-1.

## D.1 Metals

### Total Aluminum

Total aluminum was detected in 78 of 81 samples in OU 11 ground water, with one UTL exceedance. The mean concentration is 7810  $\mu\text{g/L}$  with a minimum concentration of 52.2  $\mu\text{g/L}$  and a maximum detection of 208,000  $\mu\text{g/L}$ . Statistical comparisons reveal that the distribution of total aluminum in OU 11 ground water is significantly different than in background ground water. Total aluminum failed the Quantile, Gehan, and T-tests (Table C-3). In addition, one value (208,000  $\mu\text{g/L}$ ) exceeded the background UTL of 25,837  $\mu\text{g/L}$  for total aluminum. Review of histograms and box-and-whisker plots of total aluminum in ground water reveal that the distributions of total aluminum in the background and OU 11 data sets are similar (Figures D-1 and D-2). It appears that the statistically significant difference is attributable to the presence of one anomalously high value in the OU 11 data set.

Detections of total aluminum in ground water are present throughout OU 11 (Figure D-3). Concentrations of total aluminum are generally well below the background UTL with the exception of one detection at well 5086. Review of total aluminum data from well 5086 indicates that the concentrations measured from the February 1992 sample are anomalous. No other concentrations approaching the same level (208,000  $\mu\text{g/L}$ ) have been measured in samples from well 5086 (Figure D-4). This sample also had an extremely high TSS content (1,900  $\mu\text{g/L}$ ). The TSS content is more than two orders of magnitude higher than typical TSS contents in samples from well 5086. Because of the high TSS content, this sample is not representative of ground water from the UHSU, and results from the sample should not be used to determine maximum concentrations in the UHSU. Removal of results for this nonrepresentative sample from the database would result in no UTL exceedances for total aluminum in OU 11 UHSU ground water.

Aluminum concentrations are elevated with respect to background only in the ground water media. If elevated aluminum concentrations in ground water were related to OU 11 spray operations, concentrations of total aluminum would be elevated in both surficial soils and subsurface geologic materials. However, the distributions of total aluminum in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2).

Total aluminum in ground water is not included in the PCOC list because there are no spatial or temporal patterns to the detection of elevated aluminum concentrations, the one UTL exceedance occurs in a nonrepresentative sample, and no other media in OU 11 have elevated concentrations of aluminum

#### Antimony

Antimony was detected in three of 53 surficial soil samples (<6 percent) in the OU 11 area. All the detections were at the edge of the OU or downwind. No antimony detections were within spray areas. The detections ranged in value from 3 mg/kg to 3.5 mg/kg. The locations of these detections are shown in Figure D-5. Antimony was not detected in the background data set so the inferential statistical tests were not considered valid (100 percent nondetections). However, the range of detection limits for the background data set was 12 to 50 mg/kg. All the site detections were below the lowest detection limit for the background data.

The low concentrations of the three detected values and a lack of spatial correlation with spray activities does not support antimony as a site contaminant. Antimony is not included on the list of PCOCs.

#### Arsenic

Arsenic was detected in all 53 surficial soil samples collected at OU 11. The background UTL value of 13 mg/kg was exceeded in only one of the detections, which reported a value of 13.1 mg/kg. The locations of the samples and arsenic concentrations are shown in Figure D-6. The one UTL exceedance occurs at the southern end of spray area 2.

Arsenic failed the Gehan and T-tests, indicating that the concentrations in OU 11 soils are significantly different from the concentrations in background. However, the box-and-whisker plot (Figure D-7) indicates that the statistical tests may be skewed due to the large number of undetected values in the background data set.

The distribution of arsenic is consistent with a natural source for the metal, and not consistent with spray activities. There are low concentrations of arsenic in every sample, rather than high concentrations in sprayed areas. In addition, a recent study by the US Geological Survey reported a range of 0.6 to 22 mg/kg for arsenic concentrations in baseline surficial soils along the Colorado Front Range (Severson and Tourtelot, 1994). Detections at the site do not support arsenic as a contaminant at OU 11 spatially, and arsenic is not on the PCOC list for subsurface soils.

Arsenic was detected at concentrations exceeding the UTL in 4 of 78 ground water samples at (5 percent) OU 11. The UTL is 2 µg/L and the four detections were at 2.1, 3.9, 4.0 and 5.9 µg/L. The locations of the four detections are shown in Figure D-8B. Arsenic failed the UTL exceedance test. However, the frequency histogram (Figure D-8) does not indicate significant differences between the site and the background data sets.

The arsenic detections show no temporal or spatial pattern. The four exceedances occurred in three different wells (4986, 46492, and B410689) at three different dates. There is no recurrence.

in wells and no association between detections and spray activities. The exceedances were in one well on the southern edge of OU 11 and in one well more than 1,000 feet down gradient of the OU. The other two exceedances were in well 4986, located in spray area 2. The time series plots (Figure D-9) visually support the lack of temporal consistency.

Similar arsenic concentrations (2.7 to 5.4 µg/L) detected in well 5286, upgradient of OU 11, indicate a lack of correlation between spray activities and arsenic detections in ground water. Arsenic has not been included on the list of PCOCs because the random nature of the few detections does not indicate contamination.

### Barium

Barium was detected in 77 of 81 ground water samples at the site. Two of these detections exceeded the background UTL value of 331 µg/L. The two detections were at well 5086 (1040 µg/L) and at well 46292 (378 µg/L). Figure D-10 shows the locations of these detections. Barium did not fail the inferential statistical tests but the exceedances did require additional consideration. The highest exceedance, in well 5086, is of questionable validity due to the elevated TSS levels of that particular 1992 sample. The time series plots (Figure D-11) graphically illustrate the spurious nature of the values. All subsequent detections in the well have been below the UTL value. The exceedance in well 46292 is also well illustrated in the time series plot. The first sample taken from the well, shortly after well installation in 1992, had the highest barium concentration. All subsequent detections have been below the UTL value.

There have been two isolated detections of barium above the UTL in ground water at OU 11 (2.7 percent). One detection was of questionable validity and the other has not recurred since 1992. There is no evidence of site contamination and barium is not included on the PCOC list.

### Beryllium

Beryllium was detected in only 5 of 79 ground water samples (6 percent) in OU 11, with 2 detections exceeding the UTL value. The mean concentration is 1 µg/L with a minimum concentration of 0.8 µg/L and a maximum detection of 16.4 µg/L. Statistical comparisons reveal that the distribution of total beryllium in OU 11 ground water is not significantly different than in background ground water. Beryllium failed the background UTL test (Table C-3). A review of histograms for beryllium in ground water show that the distributions of beryllium in the background and OU 11 data sets are very similar (Figure D-12) excepting the presence of one anomalously high value in the OU 11 data set.

Elevated detections of beryllium in ground water occur sporadically in OU 11 (Figure D-13). Concentrations of beryllium are generally well below the background UTL with the exception of two detections at wells 5086 and 46292. Review of beryllium data from well 5086 indicates that the concentrations measured from the February 1992 sample are anomalous. No other detections of beryllium have been measured in samples from well 5086 as shown in the time series plot for beryllium in well 5086 (Figure D-14). The one sample from 5086 in which beryllium was detected above the background UTL had an extremely high TSS content (1,900 mg/L) (see discussion of total aluminum). Because of the high TSS content, this sample is not

representative of ground water from the UHSU, and results from the sample should not be used. Subsequent results for the well support this conclusion.

The only other ground water sample exceeding the background UTL for beryllium was collected from well 46492 located downgradient of OU 11. The concentration in this sample (2.1 µg/L) exceeds the background UTL (2.0 µg/L) by a small amount, and there are no other elevated concentrations of beryllium near well 46492 (Figure D-13). In addition, well 46292 is not in an area formerly used for spray application of wastes. Thus, the spatial detection of beryllium exceedances does not suggest that spray activities at OU 11 have elevated the beryllium concentrations in ground water.

Beryllium concentrations are elevated with respect to background only in ground water. If beryllium concentrations in ground water were related to OU 11 spray operations, concentrations of beryllium would be elevated in surficial soils and subsurface geologic materials as well. However, the detections of beryllium in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2). Thus, the detection of beryllium in ground water does not appear to be related to the historic spray activities at OU 11.

Beryllium in ground water is not included in the PCOC list because distributions of beryllium concentrations in the background and OU 11 data sets are similar as evidenced by statistical comparisons, there are no spatial or temporal patterns to the detection of elevated beryllium concentrations, one of the two UTL exceedances occurs in a nonrepresentative sample, and other media in OU 11 do not have elevated concentrations of beryllium.

### Cesium

Cesium was not associated with site history and was not detected in surficial soils. Cesium was detected in OU 11 boreholes in 6 of 67 samples (9 percent). The range of concentrations detected at OU 11 was 0.77 to 6.6 mg/kg. The locations of these detections are shown in Figure D-15. Only two of the detections are within spray areas, the other four detections are downgradient several hundred feet. Furthermore, the detections were not contiguous within each borehole.

The inferential statistical tests were inapplicable for cesium in subsurface soils because no detections of cesium were reported in the background data set. The background data set reported detection limits ranging from 200 to 484 mg/kg, whereas the maximum OU 11 detection was 6.6 mg/kg. The histogram (Figure D-16) illustrates discrepancies in detection limits.

Due to the erratic nature of the detections and the extremely low concentrations present at the site, cesium was not deemed indicative of contamination and was not included on the PCOC list.

Cesium was detected in 4 of 71 ground water samples (<6 percent) at OU 11. The locations of the detections are as shown in Figure D-17.

The inferential statistical tests were not appropriate for cesium in ground water because the background data set did not detect cesium. The range of detection limits for the background set was 500 to 1,000 µg/L, while the maximum detection at OU 11 was 80 µg/L. There is no statistical indication that the OU 11 data set varies from the background data set. The frequency histogram (Figure D-18) depicts no significant differences.

Spatially the individual detections of cesium in ground water show no correlation with historic spray activities. Two of the detections are outside the OU to the north and south and the other two detections are downgradient. Cesium was detected once in well 5286, upgradient of the OU, as well. Temporally, detections of cesium have been isolated and never recurrent in one well. In addition, the cesium detections in OU 11 ground water are not correlated with the isolated detections in subsurface soils. No exceedances of the UTL for cesium in ground water have been detected since 1991.

The low concentrations and erratic nature of the cesium detections in ground water at OU 11 are not indicative of contamination and cesium has not been included on the PCOC list.

### Chromium

Chromium was detected in 33 of 80 ground water samples at the site. One of the 80 samples (1.25 percent) contained a chromium concentration of 208 µg/L, slightly exceeding the background UTL value of 185 µg/L. The maximum concentration detected in the background ground water was 729 µg/L. The UTL exceedance was in well 5086, shown in Figure D-19. Chromium failed none of the statistical tests but the one UTL exceedance required further consideration. As illustrated in the time series plots (Figure D-20), chromium is detected consistently below 25 µg/L at the site, with the exception of the February 1992 value of 208 µg/L. This value is of questionable validity because it has not recurred in the well and the particular sample contained TSS values orders of magnitude greater than normal. The high TSS content indicates the sample is not representative of site ground water and should not be used to identify contamination. Chromium has not been detected at the site in consistent or elevated levels, and chromium has not been included on the PCOC list for any media.

### Cobalt

One detection of 73 analyses (1.4 percent) exceeded the background UTL for cobalt in subsurface geologic materials. The exceedance is shown on Figure D-21, borehole 50194. The background UTL value is 27 mg/kg, and the one OU 11 exceedance is 91.6 mg/kg.

The isolated detection exceeding the UTL was the only statistical difference in the data set. The histogram (Figure D-22) and the box-and-whisker plot (Figure D-23) do not display differences between the site and background data sets. Cobalt occurs at OU 11 in concentration distributions that reflect the background data. The one UTL exceedance occurs on the northern edge of spray area 1.

Cobalt is not evident in the surficial soils, and its random distribution in the subsurface parallels the randomness of the background data set. The one UTL exceedance does not indicate

contamination at the site but rather a spurious data point, and cobalt is not included on the PCOC list for subsurface soils

Cobalt has been detected in ground water at OU 11 in 20 of 81 samples. Only one of these detections exceeded the background UTL of 13  $\mu\text{g/L}$ . Figure D-24 shows the detection of cobalt in well 5086, just south of OU 11 spray area 1.

The histogram (Figure D-25) for cobalt does not illustrate any differences in the background and OU 11 data sets. Review of the time series plots (Figure D-26) for cobalt reveal a maximum, anomalous concentration of cobalt in one sample at one well. All cobalt detections through time have occurred at values less than 10  $\mu\text{g/L}$ , except the February 1992 detection, exceeding 60  $\mu\text{g/L}$ . This one value is associated with high TSS content in the water sample, rendering that particular sample of questionable value. The high TSS value is also associated with several other anomalously high single detections of metals, further compromising the validity of the sample. Subsequent sampling of the well has not detected either the high TSS or the high metal values. Removal of this invalid sample from the data set would result in no UTL exceedances for cobalt and cobalt has not been included on the PCOC list for ground water.

#### Copper

Copper was detected in all 53 of the surficial soils samples collected at OU 11. Of these detections, only one value exceeded the background UTL value of 30 mg/kg. A value of 881 mg/kg was detected in a sample just outside the southeast corner of OU 11. Figure D-27 shows the location of the elevated detection of copper at the site.

Copper did not fail any of the inferential statistical tests but was investigated because of the one value exceeding the UTL. The frequency histogram (Figure D-28) and box-and-whisker plot (Figure D-29) support the statistics results with the conclusion that the data sets are not significantly different but that there was one anomalous detection. If the detection was associated with spray history, it would be reasonable to expect to see an increasing concentration of copper in spray areas, or along the wind dispersion path. The distribution of copper concentrations instead reflects low-level, random values indicative of the background. The isolated exceedance of copper in surficial soils is not considered site contamination, and copper has not been included on the PCOC list for surficial soils.

Copper was detected in ground water in 33 of 81 samples at OU 11. Only one of these detections, 191  $\mu\text{g/L}$  in well 5086, exceeded the background UTL value of 37  $\mu\text{g/L}$ . The locations of copper detections are shown on Figure D-30. Aside from the one exceedance, the copper detections in ground water at the site have ranged in concentration from 1  $\mu\text{g/L}$  to 31  $\mu\text{g/L}$ . Copper failed the Gehan test due to the one isolated exceedance. The exceedance in well 5086 occurred in 1992 and as the time series plots (Figure D-31) illustrate, has not recurred in the well or in the OU since 1992. The elevated exceedance is of questionable validity because the TSS content of the sample was elevated by more than two orders of magnitude, and many other metals have elevated values in this one sample. The sample is not representative of ground water quality and should not be relied upon to identify contamination. The time series plots (Figure

D-31) for the remainder of the copper detections reveal minor fluctuations below the UTL, which are similar to those for the background data set

The only UTL exceedance of copper is in a sample of questionable validity. The one exceedance does not reflect site contamination, and copper has not been included on the PCOC list for any media

### Iron

Iron was detected in 79 of 81 samples in OU 11 UHSU ground water, but only one sample exceeded the UTL value. The mean concentration of the samples is 7979 µg/L, with a minimum result of 30.1 µg/L and maximum detection of 198,000 µg/L. Statistical comparisons reveal that the distribution of iron in OU 11 ground water is statistically different than in background ground water. Iron failed the Quantile, Gehan, and T-tests (Table C-3). However, review of histograms and box-and-whisker plots for total iron in ground water shows that the distributions of total iron in the background and OU 11 data sets are relatively similar (Figures D-32 and D-33).

Concentrations of total iron are generally well below the background UTL of 31,743 µg/L with the exception of one detection at well 5086 (Figure D-34). Review of iron data from well 5086 indicates that the concentrations measured from the February 1992 sample are anomalous. No other concentrations approaching the same level (198,000 µg/L) have been measured in samples from well 5086 as shown in the time series plot for iron in well 5086 (Figure D-35). The one sample from 5086 in which iron was detected had an extremely high TSS content (1,900 mg/L) (see discussion of total aluminum). Because of the high TSS content, this sample is not representative of ground water from the UHSU. Removal of results for this nonrepresentative sample from the database would result in no UTL exceedances for iron in OU 11 UHSU ground water. Subsequent samples from the same well have not exceeded the UTL value.

Iron in ground water is not included in the PCOC list because there are no spatial or temporal patterns to the elevated iron concentrations, one UTL exceedance occurs in a nonrepresentative sample, and no other media in OU 11 have elevated concentrations of iron.

### Lead

Lead was detected in all 53 of the surficial soil samples at OU 11. Only four of these (7.6 percent) occurred at concentrations greater than the background UTL. The UTL value of 62 mg/kg was exceeded in four detections ranging from 62.8 to 82.9 mg/kg. One of the four exceedances occurred in an area east and south of all known spray activities (Figures D-36).

Lead failed the Gehan and T-tests due to the four UTL exceedances. The frequency of detections (100 percent) and the range of detections do not differ from the background data set. The range in background is 26.6 mg/kg to 51 mg/kg and the range at OU 11 is 15.4 mg/kg to 82.9 mg/kg.

The pattern of distribution of lead is random and not associated with spray activities. The pattern shown is indicative of naturally occurring lead in soils. This is supported by a comparison with the baseline range of concentrations in Front Range soils, which is 9.7 to 130 mg/kg (Severson

and Tourtelot, 1994) The maximum concentration at OU 11 of 82.9 mg/kg lead is 36 percent lower than the maximum reported in Front Range soils Lead has not been included on the PCOC list for soils because the detections at the OU reflect background conditions, not widespread site contamination

Lead has been detected in ground water at OU 11 in 62 of 80 samples The background UTL value of 19 µg/L was exceeded only twice (<3 percent), in well 46292 at a value of 27.4 µg/L and in well 5086 at a value of 60 µg/L These detections occurred in 1992 All other detections have been below the UTL since 1990 The UTL exceedances are plotted on Figure D-37

Lead failed the statistical tests (Gehan and Quantile) due to these two exceedances Review of the frequency histogram (Figure D-38) does not reveal a data set that is significantly different from the background data set The time series plots for lead (Figure D-39) illustrate the nature of the detections The exceedance in well 46292 is not in an area of direct spray application As the time series plot shows, the high concentration has not been repeated in the well since September of 1992 In fact, lead values in the well have shown a steady decrease since the elevated value was detected

The elevated detection in well 5086 is, as with other metals, associated with one sampling round that is of questionable quality The February, 1992 sample from this well had an erratically high TSS value As the time series plot illustrates, the detection is not representative of ground water quality, and the concentration has not been repeated since 1992 The subsequent detections in the well have been consistently close to 0 µg/L

Because the only two detections of lead exceeding the UTL are not recurrent, and the two detections are not spatially associated with each other or with spray activities, the lead detections are not considered to be indicative of site contamination, and lead has not been included on the PCOC list for ground water

### Magnesium

Magnesium was detected in 79 of 81 samples in OU 11 ground water, but only one detection (1.2 percent) exceeded the UTL value The mean result is 6063 µg/L with a minimum concentration of 2110 µg/L and maximum detection of 37,000 µg/L Statistical comparisons reveal that the distribution of magnesium in OU 11 ground water is not significantly different than the distribution in background ground water Magnesium passed all of the inferential statistical tests (Table C-3), but one sample exceeded the UTL Review of histograms for magnesium in ground water show that the distributions of total magnesium in the background and OU 11 data sets are very similar (Figures D-40 and D-41) aside from the one anomalously high value in the OU 11 data set

Concentrations of magnesium are well below the background UTL (33,514 µg/L) with the exception of one detection at well 5086 (Figure D-42) Review of magnesium data from well 5086 indicates that the concentration measured from the February 1992 sample are anomalous No other detections of magnesium have been measured in samples from well 5086 this is shown in the time series plot for magnesium in well 5086 (Figure D-43) The one sample from 5086 in

which magnesium was detected had an extremely high TSS content (1,900 mg/L) (see discussion of total aluminum) Because of the high TSS content, this sample is not representative of ground water from the UHSU Subsequent samples from this well have been below the UTL value Removal of results for this nonrepresentative sample from the database would result in no UTL exceedances for total magnesium in OU 11 UHSU ground water

The magnesium concentration is elevated with respect to background only in ground water If the elevated magnesium concentration in ground water were related to OU 11 spray operations, concentrations of magnesium would also be elevated in surficial soils and subsurface geologic materials However, the distributions of magnesium in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2) Thus, the detection of magnesium in ground water does not appear to be related to the historic spray activities at OU 11

Magnesium in ground water is not included in the PCOC list because distributions of magnesium concentrations in the background and OU 11 data sets are not statistically different as evidenced by the comparative statistical tests, there are no spatial or temporal patterns to the detection of elevated magnesium concentrations, the one UTL exceedance occurs in a nonrepresentative sample, and no other media in OU 11 have elevated concentrations of magnesium

#### Manganese

Total manganese was detected in 78 of 81 samples in OU 11 ground water Nine of these samples (11 percent) exceeded the background UTL value The mean result is 257  $\mu\text{g/L}$  with a minimum concentration of 2  $\mu\text{g/L}$  and maximum detection of 2,710  $\mu\text{g/L}$  Statistical comparisons reveal that the distribution of total manganese in OU 11 ground water is significantly different than in background ground water Total manganese failed the Quantile, Gehan, and T-tests (Table C-3), and nine samples exceeded the UTL value Review of histograms for total manganese in ground water show that total manganese concentrations differ in OU 11 ground water (Figures D-44 and D-45) The detection of manganese at concentrations above background is problematic because manganese is not associated with past production, waste-generation, or waste-disposal activities at the Rocky Flats Plant

The spatial distribution of manganese in ground water indicates that high concentrations of manganese are confined to three wells within IHSS 168 (Figure D-46) Samples from well B411289 consistently contain higher-than-background concentrations of total and dissolved manganese, and one sample from well 46292 exceeded the background UTL (635  $\mu\text{g/L}$ ) Concentrations of total manganese also exceeded the background UTL in a sample from well 5086 However, this sample had an extremely high TSS content and is not representative of ground water from the UHSU (see discussion of total aluminum). Samples from other wells within and downgradient of IHSS 168 have total manganese concentrations within the range for background ground water

Other sitewide and OU-specific studies of ground-water chemistry provide (1) several possible mechanisms for manganese enrichment of ground water and (2) explanations for exceedances of background concentrations of manganese in ground water

The recent Sitewide Groundwater Geochemistry Report (EG&G, 1995) includes a map of average manganese concentrations in UHSU ground water across the Rocky Flats site. The map shows areas of high and low concentration which are not consistently associated with areas of industrial or waste-disposal activities. The report describes the UHSU ground water as undersaturated with respect to manganese oxides and manganese hydroxides. Because UHSU ground water is undersaturated with respect to manganese-bearing mineral phases, ground water tends to dissolve those phases and receive manganese from the surrounding geologic materials (manganese enrichment) rather than precipitate them and lose manganese (depletion). Therefore, in the presence of manganese-bearing mineral phases, geochemical models predict that ground water will show an increase in manganese concentration through time due to the natural dissolution process.

Studies of the detection of manganese in ground water from OU 1 (DOE, 1994) indicate that natural variations in the manganese concentration of ground water may not have been detected by the background monitoring-well network. Small-scale "plumes" of manganese have been identified and attributed to natural variability. No such "plumes" were identified by the background characterization of UHSU ground water. Therefore, the background database may not fully represent the range of naturally occurring manganese concentrations in ground water from Rocky Flats.

Several lines of reasoning were presented at OU 2 to identify manganese as naturally occurring (EG&G, 1994b). First, manganese showed no distribution pattern related to sources of contamination at OU 2. Second, dissolution of manganese by ground water in the subsurface was proposed as a possible mechanism for natural manganese variation in ground water at OU 2.

Manganese concentrations are elevated with respect to background only in ground water. If elevated manganese concentrations in ground water were related to OU 11 spray operations, concentrations of total manganese would also be elevated in the pathways, surficial soils and subsurface geologic materials. However, the distributions of total manganese in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2). Thus, the detection of manganese in OU 11 ground water does not appear to be related to the historic spray activities at OU 11.

Total manganese in ground water is not included in the PCOC list because manganese is not associated with past production or waste-disposal at Rocky Flats, there is no consistent spatial pattern to the detection of elevated manganese concentrations, there is strong evidence that the elevated manganese concentrations are the result of natural processes, natural variations in the manganese concentration in ground water may not have been detected by the background monitoring-well network, and no other media in OU 11 have elevated concentrations of manganese.

### Mercury

Mercury exceeded the background UTL in one of 73 borehole samples (1.3 percent) at OU 11. The single exceedance of 25 mg/kg is shown in Figure D-47. Mercury failed none of the inferential statistical tests but the one exceedance directed further consideration. The frequency

histogram (Figure D-48) does not indicate significant differences from the background data set and the single isolated detection does not indicate site contamination. The closest borings are within 10 feet of boring 51494 and did not contain elevated mercury nor did other samples within boring 51494. The exceedance appears to be a spurious data point not associated with spray activities and mercury is not included in the PCOC list for subsurface soils.

Mercury was detected in 6 of 81 ground water samples (7 percent) at the site. These detections exceeded the background UTL of 0.20 µg/L. The locations of the detections are shown in Figure D-49. Three of the detections are in known spray areas, and three of the detections are outside spray areas. The exceedances ranged in value from 0.21 µg/L to 0.37 µg/L. Mercury failed the Gehan test due to these UTL exceedances. The exceedances are only slightly greater than the UTL and the frequency histogram does not indicate a data set significantly different from background (Figure D-50). The highest mercury value was at well 4986. The time series plots (Figure D-51) illustrate levels of mercury consistently at the detection limits with the exception of the 0.37 µg/L (slightly above the detection limit) in well 4986 in January of 1993. The maximum detection in background was 0.27 µg/L, which also exceeds the UTL and is larger than five of the six OU 11 exceedances. The elevated detection in well 4986 was not detected in wells within 10 feet of this well, in borehole samples from the well or in surficial soil samples. It appears to be an anomalous exceedance. Total mercury has not been reported in this well since January 1993. However, dissolved mercury values have been reported through October 1994 and are all at the detection limit.

The isolated detections of mercury do not indicate ground water contamination at the site and mercury is not included in the PCOC list for ground water.

#### Total Nickel

Total nickel was detected in 36 of 81 samples in OU 11 ground water with one exceedance of the background UTL. The mean concentration is 11 µg/L with a minimum concentration of 2 µg/L and maximum detection of 155 µg/L. Statistical comparisons reveal that the distribution of total nickel in OU 11 ground water is significantly different than in background ground water. Total nickel failed the Gehan test (Table C-3) due to the one value exceeding the background UTL for total nickel. Review of histograms and box-and-whisker plots of total nickel in ground water reveal that the distributions of total nickel in the background and OU 11 data sets are similar and outliers are present in both data sets (Figure D-52).

Concentrations of total nickel are generally well below the background UTL (90 µg/L) with the exception of one detection at well 5086 (Figure D-53). Review of total nickel data from well 5086 indicates that the concentrations measured from the February 1992 sample are anomalous. No other concentrations approaching the same level (155 µg/L) have been measured in samples from well 5086 (Figure D-54). This sample also had an extremely high TSS content (1,900 mg/L) (see discussion of total aluminum). Because of the high TSS content, this sample is not representative of ground water from the UHSU, and results from the sample should not be used. Removal of results for this nonrepresentative sample from the database would result in no UTL exceedances for total nickel in OU 11 UHSU ground water.

The nickel concentration is elevated with respect to background only in ground water. If the elevated nickel concentration in ground water were related to OU 11 spray operations, concentrations of total nickel would be elevated in both surficial soils and subsurface geologic materials. However, the distributions of total nickel in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2).

Total nickel in ground water is not included in the PCOC list because there are no spatial or temporal patterns to the detection of elevated nickel concentrations, the one UTL exceedance occurs in a nonrepresentative sample, and no other media in OU 11 have elevated concentrations of nickel.

### Potassium

Total potassium was detected in 65 of 81 samples in OU 11 ground water, with 4 exceedances of the background UTL (4.9 percent). The mean concentration is 739  $\mu\text{g/L}$  with a minimum concentration of 518  $\mu\text{g/L}$  and maximum detection of 25,200  $\mu\text{g/L}$ . Statistical comparisons reveal that the distribution of total potassium in OU 11 ground water is not significantly different than in background ground water. Total potassium passed the Gehan test (Table C-3), but four samples exceeded the UTL of 4,783  $\mu\text{g/L}$ . Review of histograms and box-and-whisker plots of total potassium in ground water reveal that the distributions of total potassium in the background and OU 11 data sets are similar (Figures D-55 and D-56).

The elevated concentrations of total potassium occur in samples from wells upgradient of, downgradient of, and within IHSS 168 (Figure D-57). Concentrations of total potassium in OU 11 are generally well below the background UTL with the exception of one sample from well 5086, and three samples from well 46492. The sample from well 5086 is associated with high TSS and is not representative of UHSU ground water (see discussion of total aluminum). Elevated concentrations of total potassium also occur upgradient of OU 11 in wells 5286 and 46192. The spatial distribution of the elevated concentrations is not consistent with the areas of spray application (well 46492 is located more than 1000 feet downgradient of the nearest spray area). Therefore, the elevated levels of potassium in ground water do not appear to be related to historic waste disposal practices at OU 11.

Potassium concentrations are elevated with respect to background only in ground water. If elevated potassium concentrations in ground water were related to OU 11 spray operations, concentrations of total potassium would be elevated in surficial soils and subsurface geologic materials as well. However, the distributions of total potassium in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2). Thus, the detection of potassium in OU 11 ground water does not appear to be related to the historic spray activities at OU 11.

Total potassium in ground water is not included in the PCOC list because distributions of total potassium concentrations in the background and OU 11 data sets are similar as evidenced by comparative statistical tests, there is no spatial pattern to the detection of elevated potassium.

concentrations that is consistent with spray operations at OU 11, and no other media in OU 11 have elevated concentrations of potassium

### Silver

Silver was detected in one of 53 surficial soil samples (1.8 percent) at OU 11. The location of the detection is shown in Figure D-58. Silver was not detected in background soils samples, rendering the statistical tests invalid (using 100 percent nondetection results). However, the single silver detection at OU 11 does not render the data sets statistically different. The frequency histogram (Figure D-59) illustrates the similarity of the data sets.

The detection at OU 11 was of 0.60 mg/kg. The detection limits of the background set ranged from 2 to 10 mg/kg. The silver detection does not correlate with areas of spray activity and is not indicative of soils contamination. Silver was not included on the PCOC list for soils.

Silver was detected in five of 81 ground water samples (6 percent) from OU 11. Only one of these detections exceeded the background UTL value of 4 µg/L. The location of the exceedance is shown in Figure D-60. The silver value reported in this detection was 9.4 µg/L.

The inferential statistical tests did not indicate any significant difference between background and the OU 11 site detections of silver. The frequency histogram (Figure D-61) supports a conclusion of no statistical differences. The one detection of silver which exceeds the UTL is located upgradient and removed from spray activities. Additionally, the detection has not been repeated in subsequent sampling events in well B111189 and has not been detected in neighboring wells or in soils media. The detection of silver appears to be an erratic detection not indicative of contamination and silver has not been included on the PCOC list for ground water.

### Tin

Total tin was detected in only 8 of 80 samples in OU 11 ground water (10 percent), with three values (3.7 percent) exceeding the UTL value. The mean result is 12 µg/L with a minimum concentration of 10 µg/L and maximum detection of 48.2 µg/L. Statistical comparisons reveal that the distribution of total tin in OU 11 ground water is significantly different than in background ground water. Total tin failed the Gehan test (Table C-3). Review of histograms and box-and-whisker plots of total tin in ground water reveals that the median of the OU 11 data for total tin in ground water is lower than that of background (Figures D-62 and D-63).

The concentrations of total tin exceeded the background UTL of 36 µg/L in three samples from OU 11. The UTL exceedances occurred once in three separate wells (4886, B111189, and B411389) (Figure D-64). The magnitudes of the exceedances ranged from 1.1 to 1.3 times the background UTL value. Time series plots of tin concentration at these three wells (Figure D-65) show that total tin does not recur consistently at concentrations above the background UTL value or at detectable concentrations. In addition, tin exceeds the background UTL in a total of three samples from wells 5186 and 5286 located upgradient of OU 11.

The tin exceedances occurred only in OU 11 ground water. If elevated tin concentrations in ground water were related to OU 11 spray operations, concentrations of total tin would be elevated in surficial soils and subsurface geologic materials as well. However, the distributions of total tin in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2). Thus, the detection of tin in ground water does not appear to be related to the historic spray activities at OU 11.

Total tin in UHSU ground water is not included in the PCOC list because it is not consistently detected at concentrations above the detection limit or the background UTL and no other media in OU 11 have elevated concentrations of tin.

### Vanadium

Total vanadium was detected in 44 of 81 samples in OU 11 ground water with two exceedances of the UTL (2.4 percent). The mean result was 15 µg/L with a minimum concentration of 2 µg/L and maximum detection of 349 µg/L. Statistical comparisons reveal that the distribution of total vanadium in OU 11 ground water is significantly different than in background ground water. Total vanadium failed the Gehan test due to the two exceedances (Table C-3). Review of histograms and box-and-whisker plots of total vanadium in ground water reveals that the distribution of vanadium in site and background ground water are similar (Figures D-66 and D-67).

The concentrations of total vanadium exceeded the background UTL of 63 µg/L in two samples from two separate wells in OU 11 (5086 and 46292) (Figure D-68). The sample from well 5086 had anomalously high TSS content and is not representative of UHSU ground water (see discussion of total aluminum). The value is not recurring. Well 46292 is not in an historic spray application area suggesting this anomalously high value is not related to previous waste disposal activities. The high value has not recurred in the well since 1992. In addition, three samples from well 5286 located upgradient of OU 11 also contained concentrations higher than the background UTL for total vanadium.

Vanadium exceedances occurred only in ground water. If elevated vanadium concentrations in ground water were related to OU 11 spray operations, concentrations of total vanadium would be elevated in surficial soils and subsurface geologic materials as well. However, the distributions of total vanadium in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2). Thus, the detection of vanadium in OU 11 ground water does not appear to be related to the historic spray activities at OU 11.

Total vanadium in UHSU ground water is not included in the PCOC list because it is not consistently detected at elevated concentrations within OU 11, there is no spatial pattern to the detection of elevated vanadium concentrations, and other media in OU 11 do not have elevated concentrations of vanadium.

## Zinc

Total zinc was detected in 46 of 81 samples in OU 11 ground water with one exceedance of the UTL value (12 percent). The mean concentration was 26 µg/L with a minimum concentration of 13 µg/L and maximum detection of 405 µg/L. Statistical comparisons reveal that the distribution of total zinc in OU 11 ground water is not significantly different than in background ground water (Table C-3). Review of histograms and box-and-whisker plots for total zinc in ground water show that the distributions of total zinc in the background and OU 11 data sets are very similar excepting the presence of one anomalously high value in the OU 11 data set (Figures D-69 and D-70).

Review of total zinc data from well 5086 indicates that the concentrations measured from the February 1992 sample are anomalous. No other detections of zinc have been measured in samples from well 5086 as shown in the time series plot for zinc in well 5086 (Figure D-71). The one sample from 5086 in which zinc was detected had an extremely high TSS content (1,900 mg/L) (see discussion of total aluminum). Because of the high TSS content, this sample is not representative of ground water from the UHSU. Removal of results for this nonrepresentative sample from the database would result in no UTL exceedances for total zinc in OU 11 UHSU ground water.

Zinc concentrations are elevated with respect to background only in one sample of OU 11 ground water. If elevated zinc concentrations in ground water were related to OU 11 spray operations, concentrations of total zinc would be elevated in surficial soils and subsurface geologic materials as well. However, the distributions of total zinc in surficial soils and subsurface geologic materials do not fail any statistical tests when compared to their respective background data sets (Tables C-1 and C-2). Thus, the single detection of zinc in OU 11 ground water does not appear to be related to the historic spray activities at OU 11.

Total zinc in ground water is not included in the PCOC list because distributions of total zinc concentrations in the background and OU 11 data sets are similar as evidenced by comparative statistical tests, there are no spatial or temporal patterns to the detection of elevated zinc concentrations, the one UTL exceedance occurs in a nonrepresentative sample, and no other media in OU 11 have elevated concentrations of zinc.

## **D.2 Radionuclides**

### Plutonium-239/240, Americium-241

Plutonium and americium are presented together since americium is a decay product of plutonium. Plutonium and americium surficial soil concentrations were identified as greater than background by the Slippage, Quantile, Gehan, and T tests (Table C-1). Plutonium exceeded the UTL in 24 samples (45 percent), and americium exceeded the UTL in 5 samples (9 percent). Subsurface soil concentrations for plutonium were identified as greater than background by the Gehan test and six exceedances (8 percent) of the UTL. Subsurface soil concentrations for americium were identified as greater than background by the Slippage, Quantile, and Gehan tests and five exceedances (7 percent) of the UTL (Table C-2). However, the histogram and box-and-

whisker plot presented in Figures D-72 and D-73 show no significant difference in the distributions of activities between OU 11 and background geologic materials. Americium and plutonium are not identified as greater than background by the inferential statistical tests for ground water, but are present in samples at activities exceeding the background UTL values (Table C-3). Americium-241 exceeded the background UTL in four samples (2 percent), plutonium in one sample (0.5 percent). In the case of americium-241, the exceedances ranged in magnitude from two to five times the background UTL value.

As presented in Figures D-74 and D-75, the concentrations of plutonium and americium in surficial soil are generally of the same order of magnitude, slightly elevated above background, and may roughly coincide with the areas used for spray application. The areas downgradient and outside of the spray areas also exhibit similar concentrations, indicating that windblown material from the east (e.g., plant fires and the 903 pad) may also be the source.

The maximum surficial soil concentrations of plutonium and americium shown on Figures D-74 and D-75 are 2.2 and 0.43 pCi/g, respectively. Both of these maximums occurred at the same location, SS102094, and are several times higher than the next highest reported values. The next highest reported values are not collocated, the concentration of Pu-239,240 is 0.21 pCi/g located in the spray area at SS103294 and the concentration of Am-241 is 0.096 pCi/g located at SS140394 located outside of the spray area. This indicates that the maximums for plutonium and americium are isolated events and are not representative of the data sets at OU 11.

An additional source of background data is the Background Soils Characterization Project (BSCP) (DOE, 1995). The reported range of Pu-239,240 is 0.026 to 0.1 pCi/g, and the range for Am-241 is 0.0095 to 0.036 pCi/g. Most of the OU 11 sample data lie near the upper end of these ranges, indicating a small difference between the sample data and background.

Plutonium and americium activities in subsurface geological materials occasionally exceed the background UTL (Figure D-76) value. The variation of activity with depth was examined for a pattern consistent with spray application and infiltration. Plutonium and americium tend to have low mobility and maximum activities are expected to occur at shallow depths near the contaminant source, in this case the spray application areas. As shown in Figures D-76, D-76B, and D-77, plutonium activities vary randomly with depth and the maximum activities of the two radionuclides are not collocated, as expected if they originate from the same source material. Therefore, americium-241 and plutonium-239,240 were not identified as PCOCs in subsurface geologic materials.

The sample results for Pu-239,240 in UHSU ground water are shown in Figure D-78. The values show no pattern of contamination. Similar results are shown for Am-241 in Figure D-79.

The maximum activity of plutonium-239,240 and one americium-241 UTL exceedance occurred in the same sample. The sample was collected from well 5086 and had a very high total suspended solids (TSS) content (1,900 mg/L). The TSS content is more than two orders of magnitude higher than typical TSS contents in samples from well 5086. Because of the high TSS content, this sample is not representative of ground water from the UHSU, the results from this sample should not be used to determine maximum concentrations in the UHSU. Plutonium-

239,240 was not identified as a ground water PCOC because this questionable sample represented the only UTL exceedance from OU 11

The maximum activity of americium-241 occurred in ground water from B410689. Two samples collected from B410689 in 1990 had total americium-241 activities that exceeded the background UTL value. This well is located along the south-eastern boundary of IHSS 168, more than 1,000 feet downgradient of the nearest spray area (Figure D-79). Americium-241 activities at this location have not been consistently elevated with respect to background since 1990 (Figure D-80). The average activity at B410689 is 0.022 pCi/L, approximately one half the background UTL (0.04 pCi/L). Given erratic low activities of americium-241 since 1990 at this location, low activities through time at other locations, and absence of elevated plutonium (parent radionuclide to americium) activities in ground water, americium-241 was not identified as a ground water PCOC.

In summary, Pu-239,240 and Am-241 are found in low concentrations near the upper range of background in surficial soils. For this reason, Pu-239,240 and Am-241 are identified as PCOCs for surficial soils. Pu-239,240 and Am-241 sample results for subsurface soil and ground water do not indicate contamination of these media. Therefore, Pu-239,240 and Am-241 were not identified as PCOCs for subsurface soil and ground water.

### Tritium

Based on the results of the Slippage, Quantile, Gehan, and T tests, tritium activities in the geologic materials from OU 11 are statistically different than in geologic materials from background locations (Table C-2). Eight of the 124 tritium measurements (6 percent) from geologic materials exceed the background UTL value of 560.2 pCi/g. Tritium activity appears to be correlated with depth (Figure D-81), the highest activities occur in samples collected within 10 feet of the ground surface. Even though tritium has not been associated with liquid wastes pumped to the West Spray Field, the apparent correlation of tritium with depth supported including it as a subsurface soil PCOC.

Three of the 193 tritium measurements (1.5 percent) from OU 11 ground water exceed the background UTL value of 600 pCi/L (Table C-3). The three exceedances occur in ground water from three different monitor wells, B110889, B111189, and B410589 (Figure D-82), and their magnitudes range from 1.3 to 2.6 times the background UTL value. Given the poor precision (average difference for duplicate samples is 25 relative percent difference, EG&G, 1995) of tritium measurements at low activities, these exceedances may not be significant. Repeat sampling at these three locations demonstrates that the exceedances are also not recurrent through time.

High-precision analyses of tritium in ground water have been performed as part of a stable-isotopic study presented in the Groundwater Geochemistry Report (EG&G, 1995). The study included samples from UHSU monitoring wells located within OU 11. The average tritium content in ground water from monitoring wells in OU 11 ranged from less than 2.6 pCi/L to 137.8 pCi/L. The reproducibility (precision) of individual tritium measurements included in the study was  $\pm 6.5$  pCi/L. Based on these results and the lack of temporal patterns of tritium

activity in ground water at OU 11, as shown in Figure D-83 tritium was not identified as a PCOC in ground water

Based on the results of statistical tests and the decreasing concentrations with depth, tritium is identified as a subsurface soil PCOC Tritium was not identified as a PCOC in ground water because the sample results are similar to background and there is no observable temporal pattern

Uranium-233,234, Uranium-235, Uranium-238

Uranium surficial soil concentrations were identified as greater than background by the Slippage, Quantile, Gehan, and T tests, with results varying by isotope (Table C-1) Uranium exceeded the background UTL in 33 samples for U-233,234, 4 samples for U-235, and 20 samples for U-238 Subsurface soil concentrations for uranium were identified as greater than background by the Slippage, Quantile, Gehan, and T tests, and 13 to 52 exceedances of the UTL (Table C-2) Uranium in ground water is not identified as greater than background by the inferential statistical tests or any exceedances of the background UTL values

As presented in Figures D-84, D-85, and D-86, the concentrations of the uranium isotopes in surficial soil are generally of the same order of magnitude, in the upper range of background, and appear to roughly coincide with the areas used for spray application However, the areas down gradient of the spray areas also exhibit similar concentrations, indicating that the uranium may also be natural

Recent background data from the BSCP (DOE, 1995) are compared to OU 11 data for the uranium isotopes in the table below As presented in Figures D-84, D-85, and D-86, most of the OU 11 sample data are within the upper end of the BSCP sample data

**Uranium Detection Ranges**

Uranium Isotope	BSCP Background Range (pCi/g)	OU 11 Sample Range (pCi/g)
U-233,234	0.6 - 3.1	1.3 - 4.3
U-235	0.11 - 0.34	0.013 - 0.3
U-238	0.74 - 2.6	1.4 - 4.5

Uranium isotopes are present at activities exceeding the UTL in samples of geologic materials from background areas However, patterns of spatial distribution are not consistent with origination of the uranium from a spray source at the ground surface, indicating that the source may be natural

Naturally occurring uranium-rich rocks are known to be present in the Rocky Flats Alluvium The uranium used at the Rocky Flats Plant to make nuclear weapons parts was enriched or depleted in U-235 Through analysis of the isotopic ratios of environmental samples, uranium used at Rocky Flats may be distinguished from naturally occurring uranium

Naturally occurring uranium is composed of three principal isotopes, U-238, U-235, and U-234, which are found in the proportions listed below. Of these, U-235 is the fissile material (capable of spontaneous chain reaction) used in nuclear reactors and nuclear weapons. However, U-235 occurs in such low proportions that it often requires enrichment in this isotope to be used in commercial reactors or nuclear weapons. The isotopic separation process used in the United States over the past few decades, gaseous diffusion, results in uranium enriched in both U-235 and U-234. The byproduct of the enrichment process is natural uranium that is depleted of the U-235 and U-234 isotopes. The percentages of each isotope by weight for natural, commercial, weapons, and depleted uranium are presented below for comparison.

### Typical Isotopic Abundances by Weight

Isotope	Natural <sup>1</sup>	Commercial <sup>1</sup>	Weapons <sup>2</sup>	Depleted <sup>1</sup>
U-238	0.992739	0.9701	0.0532	0.9975
U-235	0.007204	0.0296	0.9324	0.0025
U-234	0.000057	0.0003	0.0101	0.000005

1 DOE, 1988

2 DOE, EIS 1990

Uranium has been used since the initial operation of the RFP to make weapons parts. Enriched and depleted uranium metal were used to make weapons parts, and depleted uranium was processed to make armor plates for M1A1 tanks (CDH, 1992). In addition, U-233, a man-made fissile isotope, was also used from the late 1950s to the early 1970s (CDH, 1992). The presence of uranium has been identified in the Solar Evaporation Ponds, and consequently may have been sprayed in OU 11. By comparing isotopic ratios of natural uranium and environmental samples, the presence of enriched uranium can be identified.

To compare isotopic ratios, the ratio of the number of atoms of each isotope is used. The ratio of U-234 to U-238 changes more dramatically with enrichment than the ratio of U-235 to U-238, therefore, the ratio of U-234 to U-238 is generally used in isotopic ratio analysis. If laboratory results are reported in percent weight, as in the table above, the isotopic ratio is calculated as follows:

$$\frac{N_1}{N_2} = \frac{\frac{(\text{weight } N_1) (\text{Avagadro's Number})}{N_1 \text{ atomic weight}}}{\frac{(\text{weight } N_2) (\text{Avagadro's Number})}{N_2 \text{ atomic weight}}}$$

Where

$N_1$  = Number of atoms of first isotope (e g , U-234)

$N_2$  = Number of atoms of second isotope (e g , U-238)

$N_1$  atomic weight = Atomic weight of first isotope (g/mole)

$N_2$  atomic weight = Atomic weight of second isotope g/mole)

Avagadro's Number =  $6.02 \times 10^{23}$  atoms/mole

For the percentages presented above, the isotopic ratios of U-234 to U-238 are:

- natural ( $5.84 \times 10^{-5}$ )
- commercial enriched approx 3 percent ( $3.14 \times 10^{-4}$ )
- weapons enriched approx 93 percent ( $1.9 \times 10^{-1}$ )
- depleted ( $5.09 \times 10^{-6}$ )

The isotopic ratio spans approximately four orders of magnitude, depending on the degree of enrichment. Thus, the U-234/U-238 ratio is a sensitive indicator of enrichment.

If laboratory results are reported in activity units such as picocuries per gram (pCi/g), the isotopic ratio is calculated as follows:

$$\frac{N_1}{N_2} = \frac{(A_1)(A_1 \text{ half-life})}{(A_2)(A_2 \text{ half-life})}$$

Where

$A_1$  = Activity of first isotope (pCi/g)

$A_1$  half-life = Radioactive half-life of first isotope (years)

$A_2$  = Activity of second isotope (pCi/g)

$A_2$  half-life = Radioactive half-life of second isotope (years)

The half-lives for U-234 and U-238 are  $2.45 \times 10^5$  years and  $4.47 \times 10^9$  years respectively (DOE, 1988)

Due to the analysis technique, laboratory results report U-233 and U-234 together, as U-233,234. Therefore, a distinction between U-233 and U-234 cannot be made from this data. However, an increase in the isotopic ratio of U-233,234 to U-238 still indicates the presence of technologically enhanced uranium. It should be noted that enriched and depleted uranium could be present in

amounts such that the isotopic ratio is similar to natural uranium, however, the probability is very low, since the isotopic ratio spans approximately four orders of magnitude

Isotopic ratios for surficial soil and borehole data are presented in Figures D-87 and D-88, respectively. For comparison, isotopic ratios for natural, commercial, and depleted uranium are also presented. Weapons grade uranium was not presented as its isotopic ratio, 0.19, is off scale. The error associated with each OU 11 environmental sample is shown as error bars for each result. As illustrated, only naturally occurring uranium is identified in OU 11 environmental samples. Therefore, uranium-233,234, uranium-235, and uranium-238 were not identified as surficial soil or subsurface soil PCOCs.

### D.3 Semivolatiles

#### Bis(2-ethylhexyl) phthalate

Bis(2-ethylhexyl) phthalate, a common laboratory contaminant (EPA, 1989), was reported above the detection limit in a number of subsurface geologic material samples in the 0- to 12-foot depth interval (27 out of 67, 40 percent detection). The magnitude of concentrations above the detection limit range from 36  $\mu\text{g}/\text{kg}$  (Well 50194 and 50794) to 140  $\mu\text{g}/\text{kg}$  (Well 50894) with a mean concentration of 119  $\mu\text{g}/\text{kg}$ . Bis(2-ethylhexyl) phthalate has been found above the detection limit at 10 of the 11 sampling locations and at many of the sampled depth intervals. Figure D-89 shows the detected concentrations of Bis(2-ethylhexyl) phthalate in subsurface geologic materials in the 0 to 12 foot depth interval. Well 51194 was the only location where Bis(2-ethylhexyl) phthalate was not detected in the subsurface geologic material. Bis(2-ethylhexyl) phthalate was also detected in 51294, which is downgradient of IHSS 168 and outside the spraying area. The concentrations in 51294 range from 37 to 75  $\mu\text{g}/\text{kg}$  in the 0 to 12 foot depth interval.

Bis(2-ethylhexyl) phthalate was detected in three out of nine UHSU ground water samples taken from the IHSS 168 and the downgradient sampling locations during only one round of sampling. Only a subset of the ground water wells were sampled for semi-volatile chemicals (46292, 46392, and 46492 in September 1992, 50194, 50794, 50994, 51094, 51294, and 51494 in August 1994). No detections were reported in the three wells sampled in 1992 (42692, 46392, 46492) while detections were reported in three of the six wells sampled in 1994 (see Figure D-90). The highest detected concentration, 26  $\mu\text{g}/\text{L}$ , was found away from spray areas in a downgradient well, 51294. The other two detections, both 9  $\mu\text{g}/\text{L}$  and both estimated values below the detection limit (qualified with a J), were found in IHSS 168 (50994 and 51094) over 1300 feet from 51294 and 1100 feet from each other. Bis(2-ethylhexyl) phthalate was not detected in Well 51494 ground water which is located between 50994 and 51094 (Figure D-90).

Bis(2-ethylhexyl) phthalate is considered by EPA to be a common laboratory contaminant along with toluene, acetone, methylene chloride, 2-butanone, and other phthalate esters (EPA, 1989, EPA, 1992, EPA, 1988a, EPA, 1988b). Bis(2-ethylhexyl) phthalate is a plasticizer and can be introduced into analytical samples from bottles or other plastic equipment. Bis(2-ethylhexyl) phthalate can be found in analytical ground water samples at concentrations around 10  $\mu\text{g}/\text{L}$  at

varying degrees of detection. Concentrations of 50 µg/L or greater typically represent non-laboratory contamination (Gala, 1995). Analytical samples for soil media can typically contain Bis(2-ethylhexyl) phthalate levels up to 100 µg/kg, possibly 200 µg/kg, at varying degrees of detection due to laboratory or field contamination. The levels found in the subsurface geologic materials samples and ground water samples are within these typical ranges (see Table D-2 and D-3).

The levels of Bis(2-ethylhexyl) phthalate due to laboratory contamination can vary according to the size of the laboratory (Gala, 1995). Assessment of blank contamination is hindered by the few field blanks collected for ground water. Additionally, the laboratory reported few B-qualified data. Larger laboratories tend to prepare the method blank samples more carefully and since less levels of Bis(2-ethylhexyl) phthalate are found in method blanks the analytical samples are not qualified with a B (indicating blank contamination).

The assessment of the OU 11 analytical data, including the QA/QC information, showed that many common laboratory contaminants were detected in a great proportion of samples (see discussion below). This shows a trend of possible contaminant introduction into analytical samples in the laboratory or during the field investigation activities. Possible field-related sources include plastic sleeves and other plastic equipment used in the sampling of the well. The equipment rinse samples for background ground water and OU 11 borehole samples showed low levels of Bis(2-ethylhexyl) phthalate. Bis(2-ethylhexyl) phthalate was detected in 7 out of 30 equipment rinse samples that were collected during the sampling of the subsurface geologic materials boreholes. The detected concentrations levels ranged from 2 to 36 µg/L with a mean of 6 µg/L. Bis(2-ethylhexyl) phthalate was detected in 11 percent of the RFETS-sitewide equipment rinses associated with the background samples (concentration = 2 µg/L). The presence in the equipment rinse samples suggest Bis(2-ethylhexyl) phthalate may have been introduced into the samples during the field activities and the concentration levels are not representative of site conditions.

In the OU 11 subsurface geologic materials and ground water data sets only the common laboratory contaminants are detected frequently. On average the chemicals classified as common laboratory contaminants were detected in 14 percent of the samples, across both media. However, besides the common laboratory contaminants, very few organic chemicals (11) were detected and only at a rate of 1.7 percent, nearly ten times lower than the common laboratory contaminants. Table D-2 presents a summary of the frequency of detection and the magnitude of concentrations for the common laboratory contaminants and the other organic chemicals that have been positively detected. Only chloroform (5 detections out of 116 samples) and trichloroethene (1/115) were detected in subsurface geologic materials samples. Benzene (4/203), carbon disulfide (1/142), carbon tetrachloride (1/204), chloroform (10/203), ethylbenzene (1/204), hexachlorobutadiene (1/60), tetrachloroethene (6/204), total xylenes (1/145), and trichloroethene (2/204) were positively detected in ground water samples. Table D-2 also shows that the common laboratory contaminants are found at low concentrations near the detection limit. Their frequent appearance in the environmental medium of OU 11 and in background and other OUs (for an example see Table D-3), indicates these chemicals have likely been introduced in field sampling or laboratory analysis activities.

Information from other data sets were reviewed to assess the detection and magnitude of Bis(2-ethylhexyl) phthalate in soil and ground water media. Table D-3 summarizes several RFETS-related Bis(2-ethylhexyl) phthalate data sets, including OU 11, RFETS-sitewide summaries, and OU 2. Bis(2-ethylhexyl) phthalate was detected in 9 out of 40 OU 2 surficial soil samples (23 percent detections) at a range of 49J to 110J  $\mu\text{g}/\text{kg}$ . Bis(2-ethylhexyl) phthalate was found in background surficial soil samples at levels similar to OU 11 levels (4 out of 18 samples, 22 percent detections, 35J to 140  $\mu\text{g}/\text{kg}$ , DL = 330  $\mu\text{g}/\text{kg}$ ). The sitewide detection frequency of Bis(2-ethylhexyl) phthalate in ground water is 23 percent, similar to OU 11 and the range of concentrations (1 to 130  $\mu\text{g}/\text{L}$ ) bounds the OU 11 ground water concentrations of 9J to 26  $\mu\text{g}/\text{L}$ . The similarity in the detection frequency and range of concentrations between OU 11, OU 2, overall sitewide, and background levels indicates the detection of Bis(2-ethylhexyl) phthalate in OU 11 is not likely due to environmental contamination unique to OU 11 (i.e., similar levels are found due to introduced contamination).

Based on the evidence presented in the previous paragraphs, Bis(2-ethylhexyl) phthalate is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

#### D1-n-butyl phthalate

D1-n-butyl phthalate, a common laboratory contaminant (EPA, 1989), was detected in 40 percent (27 of 67) of the subsurface geologic materials samples (see Figure D-91) at concentrations ranging from 39 to 520  $\mu\text{g}/\text{kg}$  with a mean concentration of 216  $\mu\text{g}/\text{kg}$ . The detection limits range from 10 to 330  $\mu\text{g}/\text{kg}$ . If the levels in the subsurface geologic materials were attributable to non-laboratory contamination, one would likely expect vertical migration to ground water and, therefore, expect to see some detections in ground water. D1-n-butyl phthalate (DBP) has been detected in samples from greater than 65 feet below ground surface, however, there are no detections of DBP in ground water.

EPA considers acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters to be common laboratory contaminants (EPA, 1989, EPA, 1992). In the OU 11 subsurface geologic materials and ground water data sets only the common laboratory contaminants are detected frequently. On average the chemicals classified as common laboratory contaminants were detected in 14 percent of the samples, across both media. However, besides the common laboratory contaminants, very few organic chemicals (11) were detected and only at a rate of 1.7 percent, nearly ten times lower than the common laboratory contaminants. Table D-2 presents a summary of the frequency of detection and the magnitude of concentrations for the common laboratory contaminants and the other organic chemicals that have been positively detected. Only chloroform (5 detections out of 116 samples) and trichloroethene (1/115) were detected in subsurface geologic materials samples. Benzene (4/203), carbon disulfide (1/142), carbon tetrachloride (1/204), chloroform (10/203), ethylbenzene (1/204), hexachlorobutadiene (1/60), tetrachloroethene (6/204), total xylenes (1/145), and trichloroethene (2/204) were positively detected in ground water samples. Table D-2 also shows that the common laboratory contaminants are found at low concentrations near the detection limit. Their frequent appearance in the environmental medium of OU 11 and in background and other OUs (for an example see

Table D-2), indicates these chemicals have likely been introduced in field sampling or laboratory analysis activities

Based on the evidence presented in the previous paragraphs, di-n-butylphthalate is not included as a PCOC in OU 11 subsurface geologic materials or ground water

#### Diethyl phthalate

Diethyl phthalate, a common laboratory contaminant (EPA, 1989), was detected 2 times in 67 samples (3 percent detections) of geologic materials (Figure BH-8) Diethyl phthalate was detected twice in the 0 to 12 foot depth interval (in wells 50394 and 50994) More frequent detections would be expected in this interval, due to vertical migration processes, if surface application of sprayed wastes were the source Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989) The concentrations range from 190 to 240  $\mu\text{g}/\text{kg}$  with a mean concentration of 166  $\mu\text{g}/\text{kg}$  Diethylphthalate was detected only once in ground water (26  $\mu\text{g}/\text{L}$ ) in Well 46292, however, samples were collected from the wells during only one sampling round (September 1992) A subset of the ground water wells were sampled for semi-volatile chemicals (46292, 46293, and 46492 in September 1992, 50194, 50794, 50994, 51094, 51294, and 51494 in August 1994) Overall, diethyl phthalate was detected in ground water in 1 of 9 samples (11 percent detections) in IHSS 168 and downgradient of IHSS 168 The low detection frequencies indicate diethyl phthalate is not likely due to environmental contamination

EPA considers acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters to be common laboratory contaminants (EPA, 1989, EPA, 1992) In the OU 11 subsurface geologic materials and ground water data sets only the common laboratory contaminants are detected frequently On average the chemicals classified as common laboratory contaminants were detected in 14 percent of the samples, across both media However, besides the common laboratory contaminants, very few organic chemicals (11) were detected and only at a rate of 1.7 percent, nearly ten times lower than the common laboratory contaminants Table D-2 presents a summary of the frequency of detection and the magnitude of concentrations for the common laboratory contaminants and the other organic chemicals that have been positively detected Only chloroform (5 detections out of 116 samples) and trichloroethene (1/115) were detected in subsurface geologic materials samples Benzene (4/203), carbon disulfide (1/142), carbon tetrachloride (1/204), chloroform (10/203), ethylbenzene (1/204), hexachlorobutadiene (1/60), tetrachloroethene (6/204), total xylenes (1/145), and trichloroethene (2/204) were positively detected in ground water samples Table D-2 also shows that the common laboratory contaminants are found at low concentrations near the detection limit Their frequent appearance in the environmental medium of OU 11 and in background and other OUs (for an example see Table D-3), indicates these chemicals have likely been introduced in field sampling or laboratory analysis activities

Based on the above evidence comparing frequency of detections, diethyl phthalate is not included as a PCOC in OU 11 subsurface geologic materials or ground water

## D.4 Volatiles

### 2-Butanone

2-Butanone was detected once out of 45 samples (2 percent detections) of subsurface geologic materials (4 µg/kg in Well 51494) If the analyte was present due to vertical migration of surface applied contamination, more frequent detections would be expected than were reported 2-Butanone is also reported in the trip and field blanks sitewide (see page 2-5) 2-Butanone was detected in two ground water samples from 96 OU 11 samples (2 percent detections) The two samples were collected in 1990 from 2 different wells (19 µg/L in B411389 and 10 µg/L in B410689) (See Figure D-92) Repeated sampling and analysis of ground water from the same wells and adjacent wells during the 1991 to 1994 sampling activities has not confirmed the presence of 2-butanone in ground water (Figure D-93) The low detection frequency indicates the presence of 2-butanone is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods

EPA considers acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters to be common laboratory contaminants (EPA, 1989, EPA, 1992) In the OU 11 subsurface geologic materials and ground water data sets only the common laboratory contaminants are detected frequently On average the chemicals classified as common laboratory contaminants were detected in 14 percent of the samples, across both media However, besides the common laboratory contaminants, very few organic chemicals (11) were detected and only at a rate of 1.7 percent, nearly ten times lower than the common laboratory contaminants Table 5 presents a summary of the frequency of detection and the magnitude of concentrations for the common laboratory contaminants and the other organic chemicals that have been positively detected Only chloroform (5 detections out of 116 samples) and trichloroethene (1/115) were detected in subsurface geologic materials samples Benzene (4/203), carbon disulfide (1/142), carbon tetrachloride (1/204), chloroform (10/203), ethylbenzene (1/204), hexachlorobutadiene (1/60), tetrachloroethene (6/204), total xylenes (1/145), and trichloroethene (2/204) were positively detected in ground water samples Table D-2 also shows that the common laboratory contaminants are found at low concentrations near the detection limit Their frequent appearance in the environmental medium of OU 11 and in background and other OUs (for an example see page 2-5 and Table D-3), indicates these chemicals have likely been introduced in field sampling or laboratory analysis activities

Based on the evidence presented in the previous paragraphs, 2-butanone is not included as a PCOC in OU 11 subsurface geologic materials or ground water

### Acetone

Acetone, a common laboratory contaminant, was frequently detected in the geologic materials sampled (10 of 44 samples, 23 percent detections) (Figure D-94) The concentration levels ranged from 1 to 15 µg/kg with a mean concentration of 5 µg/kg (acetone has a reported detection limit of 10 µg/kg) All but one of the detectable results were reported as estimated concentrations below the detection limit (J-qualified results)

Acetone was detected in 10 of 135 samples (7 percent detections) of ground water from OU 11 (see Figure D-95). Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989). Six of the results were accompanied by qualifiers indicating that acetone had also been detected in the lab blanks (B qualified, considered estimated concentrations), the other four detected results were reported at concentrations below the detection limit (J-qualified). Acetone has been detected in 1990 and 1991 and has not routinely occurred in any well, as shown in Figure D-96. It does not occur in consecutive quarters at wells that have been sampled repeatedly. When acetone has been detected, the time-series plots show no consistent pattern of detection through time. Additionally, acetone is detected in trip and field blanks of ground water samples sitewide (see page 2-5).

EPA considers acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters to be common laboratory contaminants (EPA, 1989, EPA, 1992). In the OU 11 subsurface geologic materials and ground water data sets only the common laboratory contaminants are detected frequently. On average the chemicals classified as common laboratory contaminants were detected in 14 percent of the samples, across both media. However, besides the common laboratory contaminants, very few organic chemicals (11) were detected and only at a rate of 1.7 percent, nearly ten times lower than the common laboratory contaminants. Table D-2 presents a summary of the frequency of detection and the magnitude of concentrations for the common laboratory contaminants and the other organic chemicals that have been positively detected. Only chloroform (5 detections out of 116 samples) and trichloroethene (1/115) were detected in subsurface geologic materials samples. Benzene (4/203), carbon disulfide (1/142), carbon tetrachloride (1/204), chloroform (10/203), ethylbenzene (1/204), hexachlorobutadiene (1/60), tetrachloroethene (6/204), total xylenes (1/145), and trichloroethene (2/204) were positively detected in ground water samples. Table D-2 also shows that the common laboratory contaminants are found at low concentrations near the detection limit. Their frequent appearance in the environmental medium of OU 11 and in background and other OUs (for an example see Table D-3), indicates these chemicals have likely been introduced in field sampling or laboratory analysis activities.

Based on the evidence presented in the previous paragraphs, acetone is not retained as a PCOC in OU 11 subsurface geologic materials and ground water.

### Benzene

Benzene was detected in 4 of a total of 203 (2 percent detection frequency) ground-water samples from the first quarter 1990 through the third quarter 1994. Two of the samples that showed detections were collected during 1990 from wells B411389 and B110989, shown on Figure D-97. These samples had reported benzene concentrations of 7 and 1  $\mu\text{g/L}$ . These two wells are separated by a distance of 1500 feet. Benzene was not detected in well 4986, located between these two wells, indicating that there is no correlation between the two detections. Furthermore, benzene has not been detected in any of the samples from these two wells since 1990. Figure D-98 shows a time series plot of the data from wells B411389, B110989, and 4986. Because these detections occurred only once and have not been repeated since 1990, the reported concentrations of 7 and 1  $\mu\text{g/L}$  are not considered indicative of environmental contamination.

Analysis of the two samples collected during September 1994 from wells 50394 and 51294 indicate benzene concentrations of 0.2 and 0.1 µg/L, respectively. These wells are separated by a distance of 2700 feet. Well 50394 is located within IHSS 168 in an area of historical spray activity, while well 51294 is located down gradient of IHSS 168 approximately 800 feet outside of any spray areas. Benzene was not detected in wells 411389 or 410789, located between wells 50394 and 51294. Therefore, there appears to be no correlation between the measurements of the two wells, nor any relation to the spray areas.

If the source of benzene in ground water was the infiltration of applied spray liquids, benzene would be expected to have left traces in the geologic materials. However, benzene was not detected in samples of geologic materials collected from the borehole drilled at 50394 or 51294. In addition, benzene was not detected in any other borehole at OU 11. This indicates it is unlikely that the source of benzene in ground water was due to spray field activities.

When a chemical has a low frequency of detection and the few detections have values close to the detection limit, it is less certain that measured values indicate environmental contamination. In this case, the detection limits for the benzene data set range from 0.1 to 10 µg/L, compared to the detections of 0.1 and 0.2. Because these detections are in the lower range of the detection limits and the detection frequency is only 2 percent, it is questionable that these detections indicate benzene contamination in ground water.

Benzene was also reported at a concentration of 0.2 µg/L in one of the background wells, B302089, located south of Woman creek. Although the detection of benzene in background wells is not a common detection, this does illustrate that when it occurs, the concentration may be expected to be low and within the range of detection limits.

These findings indicate that the detection of benzene at OU 11 is limited to four samples that show no recurrence, pattern, or trend in time, are spatially separate, and are not related to spray field activities. Furthermore, the detected values are within the range of detection limits, and a similar value was detected in background wells. Therefore, benzene is not identified as a ground water PCOC for OU 11.

### Carbon Disulfide

Carbon disulfide was not detected above the reported detection limit in 50 subsurface geologic material samples but was detected once in 142 ground water samples (1 percent detections). Carbon disulfide was detected only once in 13 samples from well B411289 (within IHSS 168) (see Figure D-99). Carbon disulfide was also detected once out of 14 samples from a well located upgradient of the IHSS. These are the only samples from OU 11 containing detectable concentrations of carbon disulfide. Repeated sampling and analysis of water from well B411289 has not verified the single 1992 detection of carbon disulfide (see Figure D-100). For this well, the time-series plot shows no consistent pattern of detection through time. The low detection frequency indicates the presence of carbon disulfide is not likely due to environmental contamination but represents an individual artifact of the sampling and analysis methods.

Based on the above evidence, carbon disulfide is not included as a PCOC in OU 11 subsurface geologic materials or ground water

#### Carbon Tetrachloride

Carbon tetrachloride was not detected above the reported detection limit in 50 subsurface geologic material samples. Carbon tetrachloride was detected only once in 204 samples of UHSU ground water from OU 11 (detected in a 1990 sample from well 4986) (see Figure D-101). Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989). Carbon tetrachloride was also detected once out of 17 samples from a well located upgradient of the IHSS. The detection of carbon tetrachloride has not been verified by repeated sampling of either well. For wells where carbon tetrachloride has been detected, the time-series plots show no consistent pattern of detection through time. The low detection frequency indicates the presence of carbon tetrachloride is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods.

Based on this evidence, carbon tetrachloride is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

#### Chloroform

Chloroform was not detected in ground water in IHSS 168. However, chloroform was detected down gradient of IHSS 168 in low concentrations in 10 of 10 samples from bedrock well 46392, shown in Figure D-102. Sample data from well 46392, along with data from other wells outside of IHSS 168, was examined to identify the likely source of chloroform.

Well 46392 was installed in July 1992 and is screened across weathered bedrock from 65 to 80 feet below the ground surface. As shown in Figure D-103, the concentration of chloroform in ground water from well 46392 has decreased through time from a high of 3 µg/L for a period of approximately seven months after well installation (July 1992 through February 1993) to 0.63 µg/L in October 1994. This trend suggests that the source responsible for these concentrations is undergoing depletion through dilution, volatilization, or other mechanisms.

Well 46392 was installed adjacent to two older abandoned wells, 0881 and 0981. Due to the close proximity, sample data from these older wells was reviewed for a possible history of chloroform detections in the area. RFEDS records for these wells indicate that chloroform was not detected in ground water from those wells during the period from August 1986 through May 1992. Figure D-104 presents the time series plots of the detection limits, which was typically 5 µg/L. The lack of detection from this earlier data indicates that either (1) there was no chloroform prior to May 1992, or (2) if present, chloroform was below 5 µg/L. This information, coupled with the information on decreasing concentrations in well 46392, suggests that the source was small and localized near well 46392.

Records of the installation and development of well 46392 were examined to identify possible sources of chloroform. Drilling records show that a thread compound ("King Stuff") and drilling

mud were added to the borehole during drilling in June 1992. Product information supplied by the manufacturer of "King Stuff" does not indicate chloroform as a constituent, however, the detection limit for the product test was 0.5 µg/kg, two orders of magnitude higher than the sample data from OU 11. It should be noted that this product was deemed unsatisfactory after this particular application at well 46392 and was not used at the site again.

Analyses of two samples collected from drum cuttings recovered at well 46392 confirm the presence of chloroform in those materials. The cuttings are composed of geologic materials, ground water, drilling mud, and other products such as traces of thread compound. Samples of these cuttings were analyzed for chloroform, with results of 45 and 96 µg/kg. These results can be compared to the concentration in ground water to determine if the source of chloroform is solely from the chloroform in the ground water, or if the geologic materials or the drilling products are likely sources. To compare the concentration of chloroform in cuttings to the concentration in ground water, it is necessary to convert from µg/kg to µg/L. Conservatively assuming that the cuttings are saturated and have a density similar to water alone, 1.0 kg/L, the concentrations of chloroform in drill cuttings are converted to ground water values of approximately 45 and 96 µg/L. These values are more than an order of magnitude greater than the ground water concentration of 3 µg/L, indicating that a source other than ground water is likely. Chloroform was not detected in any geologic materials at OU 11, and it is unlikely that it is the source of chloroform for this well. Eliminating the ground water and the geologic materials as likely sources, it is likely that chloroform was inadvertently introduced in the drilling mud, thread compound, or other products.

There are only two other bedrock wells in the vicinity of well 46392, well 4886 and well 5286. As shown in Figure D-102, well 4886 is located in the middle of IHSS 168, approximately 1700 feet up gradient of well 46392. Chloroform has not been detected in this well. Well 5286 is up gradient of the spray activities in IHSS 168, approximately 3800 feet from well 46392. Chloroform was detected at 0.2 µg/L in 1 of 9 samples from well 5286. Time series plots of the data for wells 4886 and 5286 are presented in Figure D-105. The results from these two up gradient wells indicate that there is no ground water source of chloroform contamination in IHSS 168.

Spray activities at IHSS 168 were considered as a possible source of chloroform. Chloroform is volatile and has a moderate water solubility of 0.5 percent. Moderate volatilization would be expected during spraying or while on the ground surface. Chloroform that may have reached ground water after volatilization is likely to have left traces in the moisture content of subsurface soils. However, soil samples at IHSS 168 did not indicate that chloroform was present, making it unlikely that spraying is the origin of the chloroform.

These findings indicate that the presence of chloroform east of OU 11 is confined to one location, that the source was small, and that concentrations are decreasing with time. The lack of detections in soil and ground water in IHSS 168 indicate that chloroform is unlikely to have any relation to West Spray Field activities and is instead an artifact of well construction. Therefore, chloroform is not identified as a ground water PCOC for OU 11.

### Ethylbenzene

Ethylbenzene was detected (2 µg/L) in one ground water sample collected from B110889 in October 1992 (1 of 204 samples, <1 percent detections) and has not been detected in any other sample from that well. Ethylbenzene has never been detected in ground water from other monitoring wells in OU 11 (see Figure D-106). In well B110889, the time-series plot shows no consistent pattern of detection through time. Ethylbenzene was not detected in any of the 50 subsurface geologic materials samples. If the ethylbenzene was associated with spray activities, more frequent detections would be expected in the subsurface, due to vertical migration of surface applied contamination. Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989). The low detection frequency indicates the presence of ethylbenzene is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods.

Based on this evidence, ethylbenzene is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

### Hexachlorobutadiene

Hexachlorobutadiene was detected in ground water from Well 46392 located downgradient of IHSS 168 (1 of 60 samples, 2 percent detections) (see Figure D-107). The reported concentration was below the detection limit (J-qualified). Hexachlorobutadiene has not been detected in any other sample from that well and has never been detected in ground water from other monitoring wells in OU 11. Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989). Hexachlorobutadiene was not detected in any of the 67 subsurface geologic materials samples for OU 11. If elevated concentrations in ground water were related to OU 11 spraying operations, concentrations of hexachlorobutadiene would be elevated in subsurface geologic materials as well. The low detection frequency indicates the presence of hexachlorobutadiene is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods.

Based on this evidence, hexachlorobutadiene is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

### Methylene Chloride

Methylene chloride, a common laboratory contaminant, was frequently detected (18 out of 53 samples, 34 percent detections) in geologic materials with concentrations ranging from 1 to 16 µg/kg and a mean concentration of 4 µg/kg (see Figure D-108). Methylene chloride was present at concentrations above the detection limit (not J-qualified by laboratory) at depths from 15 to 70 feet below the ground surface. Methylene chloride was not detected in field QC samples (equipment rinsates).

Methylene chloride was detected more frequently in UHSU ground water from OU 11 than any of the other organic compounds. In 26 of 203 samples (13 percent detections), methylene chloride was reported above the detection limit (Figure D-109). Seven of the methylene chloride results were B-qualified, indicating the presence of laboratory contamination. In samples of UHSU ground water from background monitoring wells, methylene chloride is detected with the same frequency (11 percent) as is observed in the monitoring wells within OU 11 (13 percent). The concentrations of methylene chloride (0.3 to 13 µg/L) are typically below the reported detection limits (0.1 to 10 µg/L). However, detections of methylene chloride are not consistent through time. For wells where methylene chloride has been detected, time-series plots (Figure D-110) show no consistent pattern of detection through time. Additionally, methylene chloride is detected in field and trip blanks of ground water samples sitewide (see page 2-5). The low detection frequency indicates the presence of methylene chloride is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods.

EPA considers acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters to be common laboratory contaminants (EPA, 1989, EPA, 1992). In the OU 11 subsurface geologic materials and ground water data sets only the common laboratory contaminants are detected frequently. On average the chemicals classified as common laboratory contaminants were detected in 14 percent of the samples, across both media. However, besides the common laboratory contaminants, very few organic chemicals (11) were detected and only at a rate of 1.7 percent, nearly ten times lower than the common laboratory contaminants. Table D-2 presents a summary of the frequency of detection and the magnitude of concentrations for the common laboratory contaminants and the other organic chemicals that have been positively detected. Only chloroform (5 detections out of 116 samples) and trichloroethene (1/115) were detected in subsurface geologic materials samples. Benzene (4/203), carbon disulfide (1/142), carbon tetrachloride (1/204), chloroform (10/203), ethylbenzene (1/204), hexachlorobutadiene (1/60), tetrachloroethene (6/204), total xylenes (1/145), and trichloroethene (2/204) were positively detected in ground water samples. Table 5 also shows that the common laboratory contaminants are found at low concentrations near the detection limit. Their frequent appearance in the environmental medium of OU 11 and in background and other OUs (for an example see Table 4), indicates these chemicals have likely been introduced in field sampling or laboratory analysis activities.

Based on the evidence presented in the previous paragraphs, methylene chloride is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

#### Tetrachloroethene

Tetrachloroethene was detected in 6 of 204 samples (3 percent detections) of UHSU ground water from OU 11 (see Figure D-111). Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989). Two of these samples (2 and 0.3 µg/L) were collected from the same well, 4986, but tetrachloroethene has not been detected in samples from that well since October 1992. Both concentrations were reported as estimated results below the detection limit (J-qualified). The other four samples are from four different wells located downgradient of IHSS 168 (46392, 46492, B110989, and B410789). At three of

these locations, tetrachloroethene was not detected in any of the subsequent ground water samples. At one location, B410789, PCE was detected in February 1994 and subsequent results are currently unavailable to verify its presence. In addition, tetrachloroethene was not detected in any of the 55 subsurface geologic materials samples collected at various depths to 105 feet during the 1994 sampling activities. If the detections in ground water were attributed to non-laboratory contamination, detections in the subsurface materials would likely exist. The low detection frequency indicates the presence of tetrachloroethene is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods.

Tetrachloroethene is not included as a PCOC in OU 11 subsurface geologic materials and ground water.

### Toluene

Toluene, a common laboratory contaminant, was frequently detected in the geologic materials sampled (22 of 55 samples, 40 percent detections) (see Figure D-112). The concentrations ranged from 1 to 25  $\mu\text{g}/\text{kg}$  with a mean concentration of 3  $\mu\text{g}/\text{kg}$ . However, all the concentrations are below 10  $\mu\text{g}/\text{kg}$  with the exception of the maximum of 25  $\mu\text{g}/\text{kg}$  at the 2-foot interval in well 51094. Most values are below the detection limit of 5  $\mu\text{g}/\text{kg}$ .

Toluene has been detected in 5 of 204 samples (3 percent detections) of UHSU ground water from IHSS 168 and downgradient wells (Figure D-113). Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989). In fact, toluene is reported in trip and field blank samples sitewide (see page 2-5). Toluene was detected once (1  $\mu\text{g}/\text{L}$ , J-qualified) in a 1990 sample from well B411389 and has not been detected at this location again (Figure D-114). Time-series plots show no consistent pattern of detection through time. A water sample collected from well 50394 in September 1994 had a toluene concentration of 0.2  $\mu\text{g}/\text{L}$  (J-qualified). If the concentration levels in the subsurface geologic materials are attributable to non-laboratory contamination, one would likely expect the frequent presence of the contaminant in ground water. However, there are few detections of toluene in ground water (3 percent detections). The low detection frequency indicates the presence of toluene is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods.

EPA considers acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters to be common laboratory contaminants (EPA, 1989, EPA, 1992). In the OU 11 subsurface geologic materials and ground water data sets only the common laboratory contaminants are detected frequently. On average the chemicals classified as common laboratory contaminants were detected in 14 percent of the samples, across both media. However, besides the common laboratory contaminants, very few organic chemicals (11) were detected and only at a rate of 1.7 percent, nearly 10 times lower than the common laboratory contaminants. Table D-2 presents a summary of the frequency of detection and the magnitude of concentrations for the common laboratory contaminants and the other organic chemicals that have been positively detected. Only chloroform (5 detections out of 116 samples) and trichloroethene (1/115) were detected in subsurface geologic materials samples. Benzene (4/203), carbon disulfide (1/142), carbon

tetrachloride (1/204), chloroform (10/203), ethylbenzene (1/204), hexachlorobutadiene (1/60), tetrachloroethene (6/204), total xylenes (1/145), and trichloroethene (2/204) were positively detected in ground water samples. Table D-2 also shows that the common laboratory contaminants are found at low concentrations near the detection limit. Their frequent appearance in the environmental medium of OU 11 and in background and other OUs (for an example see Table D-3), indicates these chemicals have likely been introduced in field sampling or laboratory analysis activities. Toluene is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

#### Total Xylenes

Total Xylenes were not detected in subsurface geologic materials (0 detections out of 55) from samples collected during the 1994 sampling activities. Total xylenes were detected in a sample collected from B110889, downgradient of IHSS 168, in October 1992 (see Figure D-115) and has not been detected in any other sample from that well. Xylene has never been detected in ground water from monitoring wells within IHSS 168 (1 detection out of 145 samples, <1 percent detections). The time-series plot shows no consistent pattern of detection through time. Chemicals that are infrequently detected (less than 1 in 20) may be artifacts in the data due to sampling, analytical, or other problems, and therefore may not be related to site operations or disposal activities (EPA, 1989). If elevated concentrations in ground water were related to OU 11 spraying operations, concentrations of total xylenes would be elevated in subsurface geologic materials as well. The low detection frequency indicates the presence of total xylenes is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods. Total xylenes is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

#### Trichloroethene

Trichloroethene (TCE) was not detected in the subsurface geologic materials sample. TCE was detected in only two ground water samples out of 204 samples (1 percent detections) taken from 1990 to 1994 (See Figure D-116). The maximum concentration was reported in Well B110989 from a sample collected in March 1990. A concentration of 0.1 µg/L was detected in Well B410789 from a sample collected in February 1994. Previous samples from these wells (collected quarterly since 1989) do not contain detected concentrations of TCE, and TCE has never been detected in ground water from other monitoring wells within OU 11. The time-series plots show no consistent pattern of detection through time. The low detection frequency indicates the presence of trichloroethene is not likely due to environmental contamination but represents an artifact of the sampling and analysis methods. Trichloroethene is not included as a PCOC in OU 11 subsurface geologic materials or ground water.

### **D.5 Other Parameters**

#### Cyanide

Cyanide was detected in 11 of 287 ground water samples at the site (< 4 percent). Figure D-117 shows the cyanide detections at the site. Cyanide failed the Gehan statistical test, but there are

questions regarding the validity of the statistical tests for cyanide. The background data set included three undetected records with a result and detection limit of 10,000 µg/L. It appears that the detection limits were erroneously reported because the detection limits for the remainder of the set are 10 µg/L. It is likely that the actual detection limit should be 10 µg/L, however, the error skews the data set so that no background comparison can be performed.

The maximum detection at OU 11 was 49 µg/L in well B410589, on the southern edge of OU 11. The maximum result in the background data set is 17.7 µg/L. Four of the cyanide detections are below the background maximum, and four of the detections are outside the area of spray activities. Additionally, cyanide was not detected at significant concentrations in surficial soils or subsurface soils. The site history does not relate cyanide to the spray activities and the detections of cyanide (3 percent of total samples) in ground water are not reflective of contamination nor is there supporting detections of cyanide through the soils media. Cyanide has not been included on the list of PCOCs for ground water.

#### Nitrate/Nitrite

Levels of nitrate/nitrite in surficial soils are not high, but they do exceed the background values by one order of magnitude. The maximum nitrate/nitrite detection at OU 11 is 37 mg/kg while the background maximum detection is 7 mg/kg. Nitrate/nitrite was detected at concentrations exceeding the background UTL value of 9.6 mg/kg in 22 of the 53 surficial soil samples collected (41 percent). Nitrate/nitrite failed the Slippage and Gehan tests in surficial soils. The results of these tests are verified graphically in the frequency histogram and the box-and-whisker plot (Figures D-118 and D-119), each of which illustrate distributions significantly different from background. The detections of nitrate/nitrite are plotted on Figure D-120. The distribution of nitrate/nitrite generally coincide with historic spray activities, historic pipeline juncture locations or locations down-wind of spray activities.

The liquids from the Solar Evaporation Ponds sprayed at OU 11 have been historically associated with nitrate/nitrite. Based on the spatial distribution of nitrate/nitrite, the statistical comparison results and the site history, nitrate/nitrite is included on the list of PCOCs for surficial soils.

Nitrate/nitrite was detected in subsurface materials throughout the site. It was detected in 61 of 67 samples (91 percent) at very low concentrations. However, nitrate/nitrite was not analyzed for in the background data set so inferential statistical tests and background comparisons cannot be completed. The maximum detection in subsurface soils can be compared to the surficial soils UTL as a frame of reference. The maximum concentration in subsurface is 2 mg/kg. The surficial soils UTL is 9.6 mg/kg. The nitrate/nitrite exists in the surficial soils and exists at low concentrations in borehole samples. There is no strong correlation between spray areas and subsurface nitrate/nitrite detection. Figure D-121 shows the subsurface detections. However, because nitrate/nitrite is associated with OU 11 history and is included as a PCOC in surficial soils, it will also be considered a PCOC in the subsurface. This is a conservative inclusion because the highest detection is three times less than the surficial UTL value.

Nitrate/nitrite was detected at concentrations greater than the background UTL value (6,373 µg/L) in only 5 of 209 ground water samples from OU 11 (2 percent). Four of the 5 detections

are from one well (4986) in the center of spray area 2. The other detection was detected at well 50794, more than 1000 feet southwest, in spray area 1. The five detections exceeded the UTL by 27 µg/L to 3427 µg/L. Four of these exceedances were by less than 100 µg/L (<10 percent). The maximum detection of nitrate/nitrite in the OU 11 vicinity was actually upgradient of the OU at a concentration substantially higher than the site detections, but still only twice the background UTL value. Figure D-122 shows the nitrate/nitrite detections at the site and upgradient.

Nitrate/nitrite in ground water did not fail any of the inferential statistical tests, indicating that the OU 11 concentrations are not statistically different from the background data set detections. The histogram and box-and-whisker plots (Figures D-123 and D-124) graphically support the statistical results.

The observation that the well with 4 of the 5 nitrate/nitrite detections is in the center of spray area 2 may indicate an association with the spray activities. However, time series plots (Figure D-125) illustrate erratic concentrations, randomly occurring over time. This pattern is not indicative of even low-level contamination in the ground water system. The majority of the fluctuations shown are below the background UTL. An additional observation on the nitrate/nitrite in ground water is that all of the five detections fall below the range of values detected in the background wells. The range of detections at OU 11 is 6400 to 9800 µg/L. The background detections range from 9300 µg/L to 12,000 µg/L. Finally, the ground water detections are not correlated with the maximum concentrations in the subsurface, as would be expected with contaminant migration. In conclusion, the detections of nitrate/nitrite in OU 11 ground water are not indicative of wide-spread site contamination and the analyte is not included on the PCOC list for ground water.

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**Table D-1  
Risk-Based Concentration Screen for the OU 11 Source Area  
Residential Exposure**

Potential Contaminant of Concern	Maximum Concentration or Activity (Max)	Location of Max	Residential PPRG		Ratio of Max to PPRG	
			Carcinogen	Non-Carcinogen	Carcinogen	Non-Carcinogen
<b>SOIL (0 to 12 feet)</b>						
<b>Radionuclides (pCi/g)</b>						
AMERICIUM-241	0.43	SS102094	2.37E+00	—	0.18	—
PLUTONIUM-239/240 <sup>2</sup>	2.2	SS102094	3.42E+00	—	0.64	—
TRITIUM	3.4	51294	1.47E+04	—	0.00023	—
<b>Other Parameters (mg/kg)</b>						
NITRATE/NITRITE <sup>3</sup>	37	SS100894	—	4.39E+05	—	0.000084

**TOTAL RATIO SUM**      **0.82**      **0.000084**

<sup>1</sup> Programmatic Preliminary Remediation Goals (PPRGs) are from DOE (February 1995). Residential soil PPRGs were used for analytes in soil (0 to 12 feet). PPRGs are reported in the units used for each analyte group.

<sup>2</sup> The PPRG for plutonium-240 was used because it is more conservative than the PPRG for plutonium-239.

<sup>3</sup> The PPRG for nitrate was used because nitrate is the dominant species present.

**Table D-2  
Volatile and Semivolatile Chemical Results from OU 11**

Chemical	Data Set	Number of Detects	Number of Samples	Detection Frequency	Detection Limit	Concentration			Units
						Minimum	Mean	Maximum	
<b>Common Laboratory Contaminants</b>									
2-Butanone	Ground Water	2	96	2%	10	10	5	19	µg/L
Acetone	Ground Water	10	135	7%	10	1	5	31	µg/L
Bis(2-ethylhexyl) Phthalate	Ground Water	3	9	33%		9J	8	26	µg/L
Di-n-butyl Phthalate	Ground Water	0	9	0%	10				µg/L
Diethyl Phthalate	Ground Water	1	9	11%	10	26	26	26	µg/L
Dimethyl Phthalate	Ground Water	0	9	0%	10				µg/L
Methylene Chloride	Ground Water	26	203	13%	10	0.1	2	13	µg/L
Toluene	Ground Water	5	204	2%	10	0.1	2	3	µg/L
<b>Subsurface Geologic Materials</b>									
2-Butanone	Subsurface Geologic Materials	1	45	2%	10	4	5	4	µg/kg
Acetone	Subsurface Geologic Materials	10	44	23%	10	1	5	15	µg/kg
Bis(2-ethylhexyl) Phthalate	Subsurface Geologic Materials	27	67	40%	10-330	36	119	140	µg/kg
Di-n-butyl Phthalate	Subsurface Geologic Materials	27	67	40%	10-330	39	216	520	µg/kg
Diethyl Phthalate	Subsurface Geologic Materials	2	67	3%	10-330	190	166	240	µg/kg
Dimethyl Phthalate	Subsurface Geologic Materials	0	67	0%	10-330				µg/kg
Methylene Chloride	Subsurface Geologic Materials	18	53	34%	5	1	4	16	µg/kg
Toluene	Subsurface Geologic Materials	22	55	40%	5	1	3	25	µg/kg

Table D-2  
Volatile and Semivolatile Chemical Results from OU 11

Chemical	Data Set	Number of Detects <sup>a</sup>	Number of Samples <sup>b</sup>	Detection Frequency <sup>c</sup>	Detection Limit	Concentration			Units
						Minimum <sup>d</sup>	Mean <sup>e</sup>	Maximum <sup>d</sup>	
Other Chemicals									
Benzene	Ground Water	4	203	2%	1-10	0.1	2	7	µg/L
Carbon Disulfide	Ground Water	1	142	1%	5-10	3	3	3	µg/L
Carbon Tetrachloride	Ground Water	1	204	0%	1-10	0.1	2	2	µg/L
Chloroform	Ground Water	10	203	5%	1-10	0.1	2	3	µg/L
Ethylbenzene	Ground Water	1	204	0%	1-10	0.1	2	2	µg/L
Hexachlorobutadiene	Ground Water	1	60	2%	2-5	0.1	0.1	0.1	µg/L
Tetrachloroethene	Ground Water	6	204	3%	1-10	0.1	2	2	µg/L
Total Xylenes	Ground Water	1	145	1%	5-10	0.5	3	10	µg/L
Trichloroethene	Ground Water	2	204	1%	1-10	0.1	2	1	µg/L
Chloroform	Subsurface Geologic Materials	0	55	0%	5				µg/kg
Trichloroethene	Subsurface Geologic Materials	0	55	0%	5				µg/kg

<sup>a</sup> Summary statistics were calculated using ground water and subsurface geologic materials from IHSS 168 UHSU (sampled in 1990 through 1994) and downgradient wells (sampled in 1994).

<sup>b</sup> The minimum value represents the minimum concentration regardless if the sample is a detection or a nondetection.

<sup>c</sup> The mean value was calculated using one half the sample quantitation limit for nondetections.

<sup>d</sup> The maximum value represents the maximum detected concentration in the data set.

Table D-3  
Summary of Bis(2-ethyl hexyl) phthalate

Data Set	Medium	Number of Detects <sup>a</sup>	Number of Samples <sup>a</sup>	Detection Frequency	Concentration			Units
					Minimum <sup>a,b</sup>	Mean <sup>a,c</sup>	Maximum <sup>a,d</sup>	
OU 11 UHSU IHSS 168 and Downgradient Ground Water	Ground Water	3	9	33%	9J	8	26	µg/L
RFETS Sitewide Ground Water	Ground Water	68	298	23%	1	-	130	µg/L
Background Ground Water	Ground Water	no data		-				
OU 11 Subsurface Geologic Materials	Soil	37	138	27%	36	140	140	µg/kg
RFETS Sitewide Surficial soil	Soil			-				µg/kg
Background Surficial soil	Soil	4	18	22%	35	-	140	µg/kg
OU 2 Surficial soil Data	Soil	9	40	23%	49	-	110	µg/kg
RFETS Sitewide Ground Water Equipment Rinsate	QA/QC	1	11	9%	2	2	2	µg/L
OU 11 Subsurface Geologic Materials Equipment Rinsate	QA/QC	7	30	23%	2	6	36	µg/L
RFETS Sitewide Equipment Rinsate	QA/QC			-				µg/L

<sup>a</sup> Summary statistics were calculated using ground water and subsurface geologic materials from IHSS 168 UHSU (sampled in 1990 through 1994) and downgradient wells (sampled in 1994)

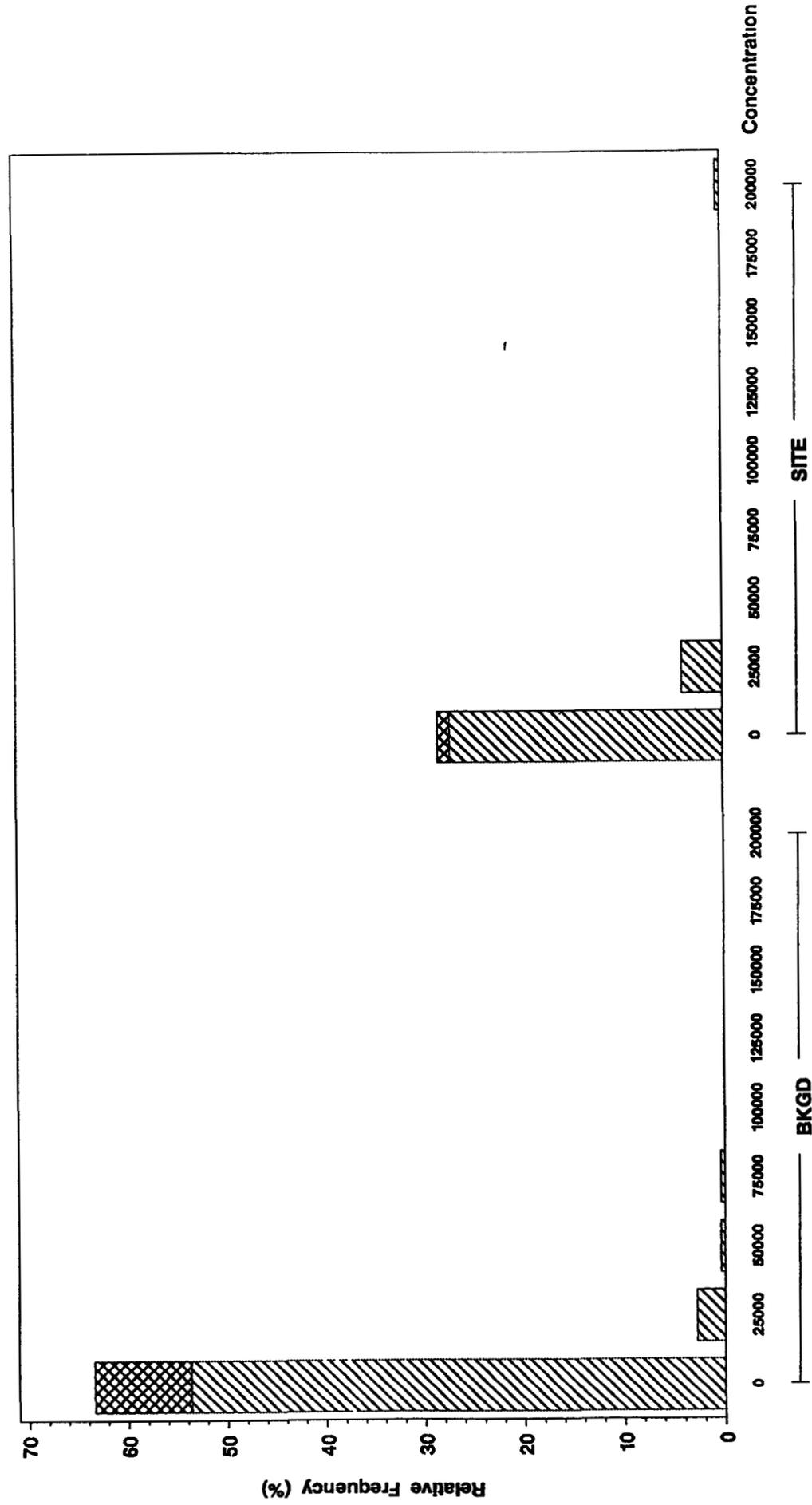
<sup>b</sup> The minimum value represents the minimum concentration regardless if the sample is a detection or a nondetection.

<sup>c</sup> The mean value was calculated using one half the sample quantitation limit for nondetections.

<sup>d</sup> The maximum value represents the maximum detected concentration in the data set.

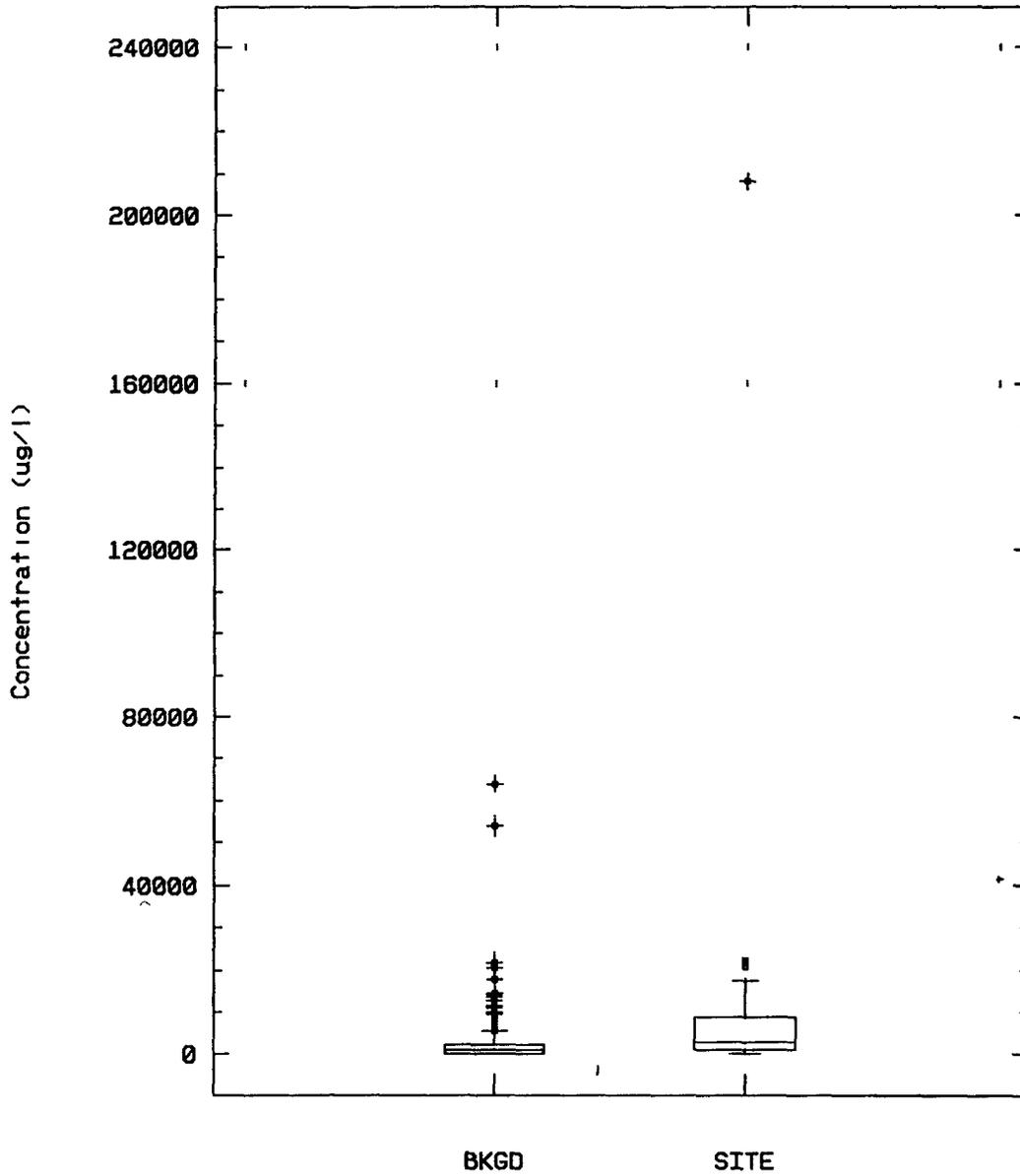
Figure D-1

# Background vs OU11 UHSU Groundwater Frequency Histogram ALUMINUM (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

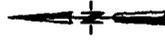
Figure D-2  
Background vs OU11 UHSU Groundwater  
Aluminum in Groundwater (Total)



# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 18047



Scale = 1" = 8400 feet  
 1 inch = 700 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U.S. Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 ALUMINUM  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-3

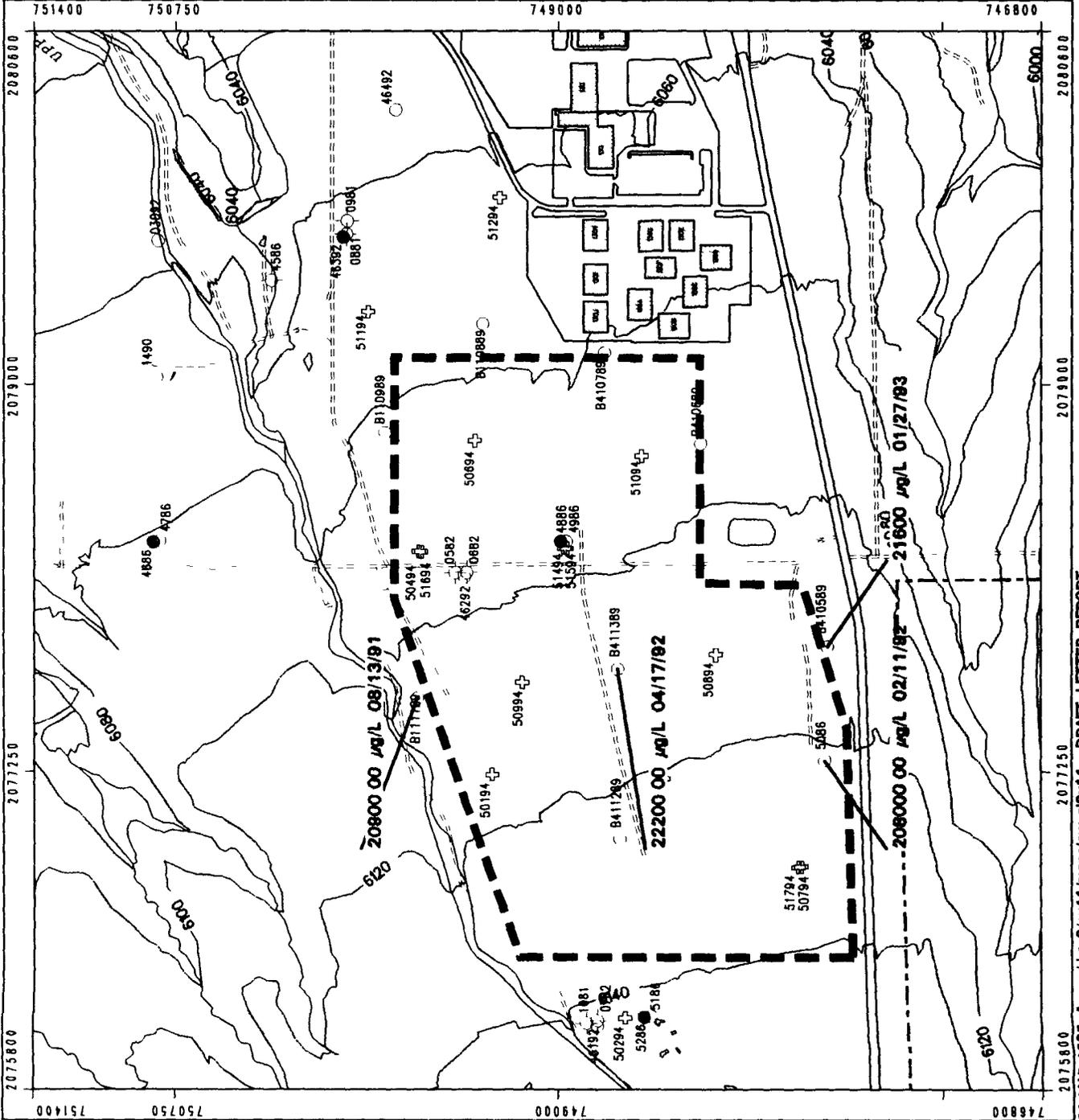
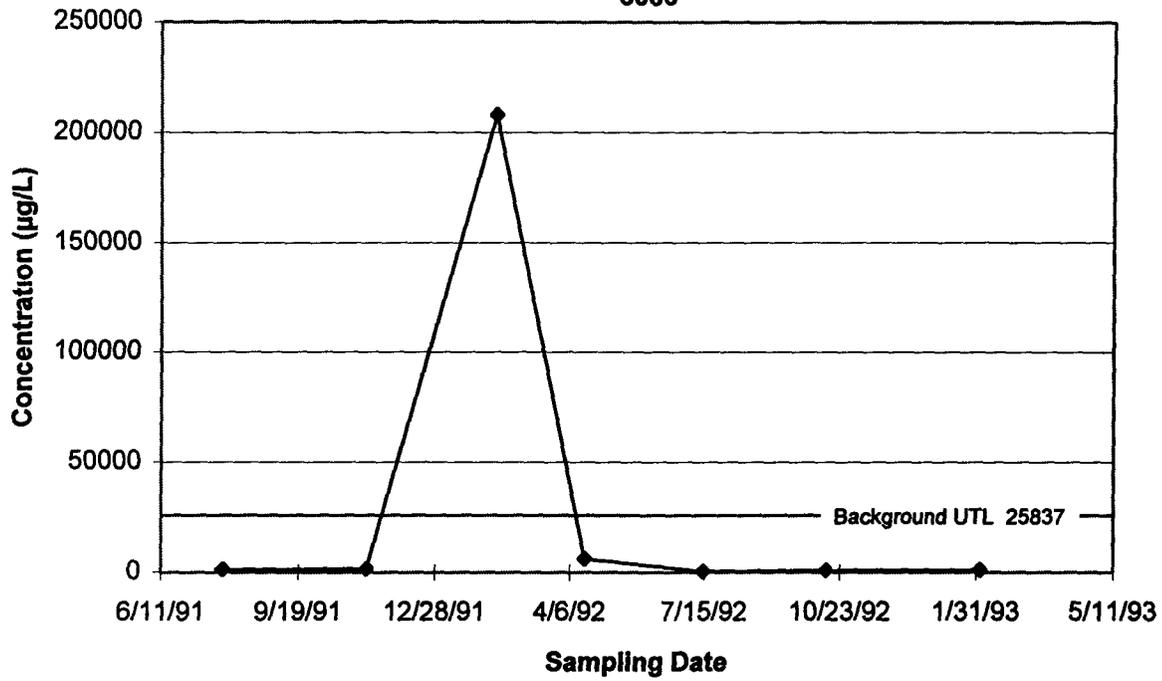


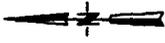
Figure D-4  
Time Series Plot - Total Aluminum  
5086



● Hit - Y  
○ Hit - N



# EXPLANATION

<ul style="list-style-type: none"> <li>△ Sample Location</li> <li>▲ Values above the background mean +2 standard deviations (BM+2SD)</li> <li>— Streams and Drainages</li> <li>--- Topographic Contours (20' Interval)</li> <li>== Paved Roads</li> <li>--- Dirt Roads</li> <li>- - - Security Fences</li> <li>- - - Rocky Flats Boundary</li> <li>▬ OU 11 (IHSS 168) Boundary</li> <li>▭ Lakes and Ponds</li> <li>▭ Buildings</li> </ul>	<p>*Concentrations are in mg/kg BM+2SD = 10</p>	 <p>Scale = 1 7200 1 inch = 600 feet</p> 
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State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

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U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

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Surficial Soil (0 to 2 inches)  
ARSENIC  
Concentrations \*  
at the  
OU 11--West Spray Field

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March 1995 Figure D-6

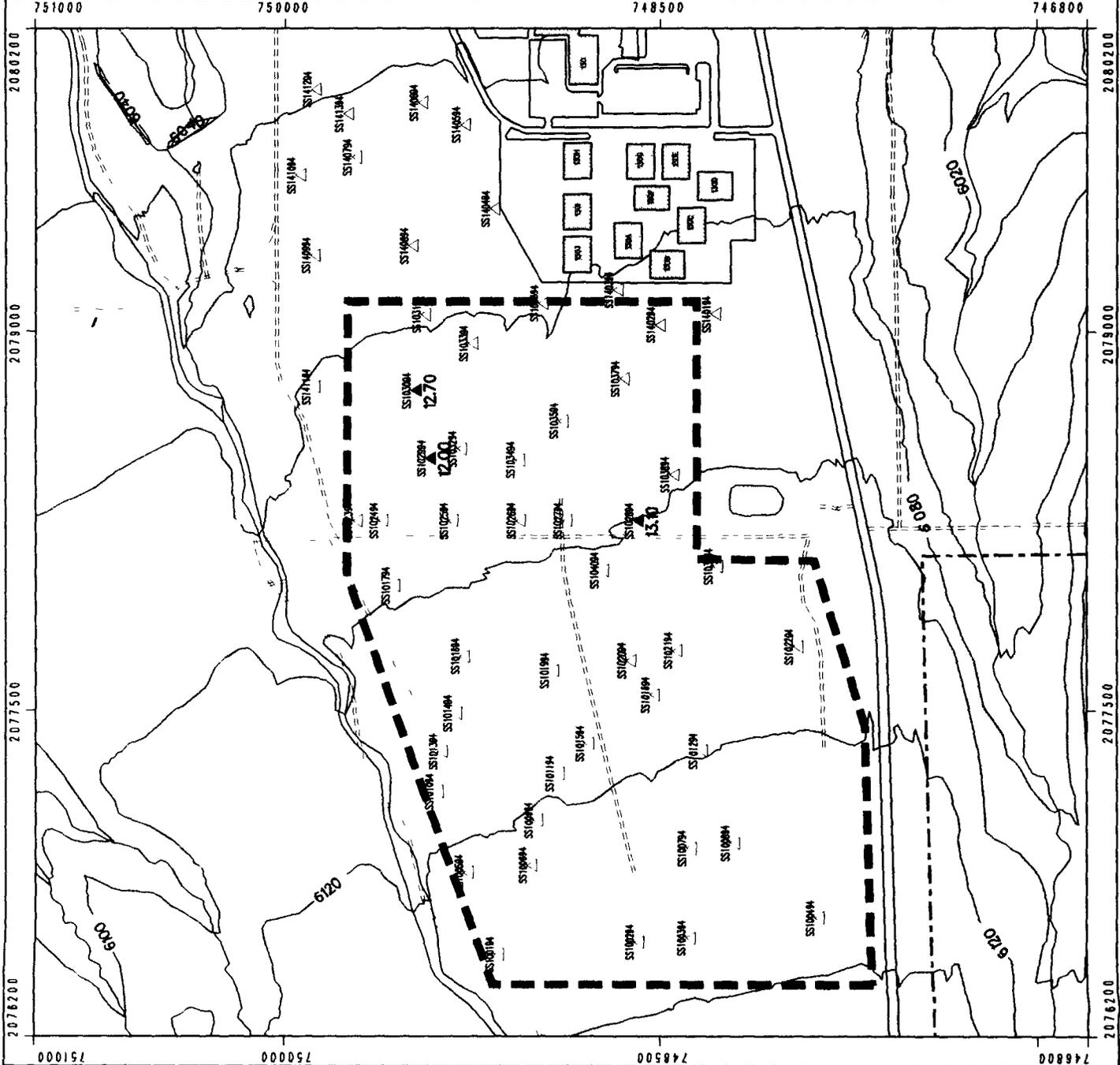


Figure D-7  
Background vs OU11 Surface Soil  
Arsenic in Surface Soil (0 to 2 inches)

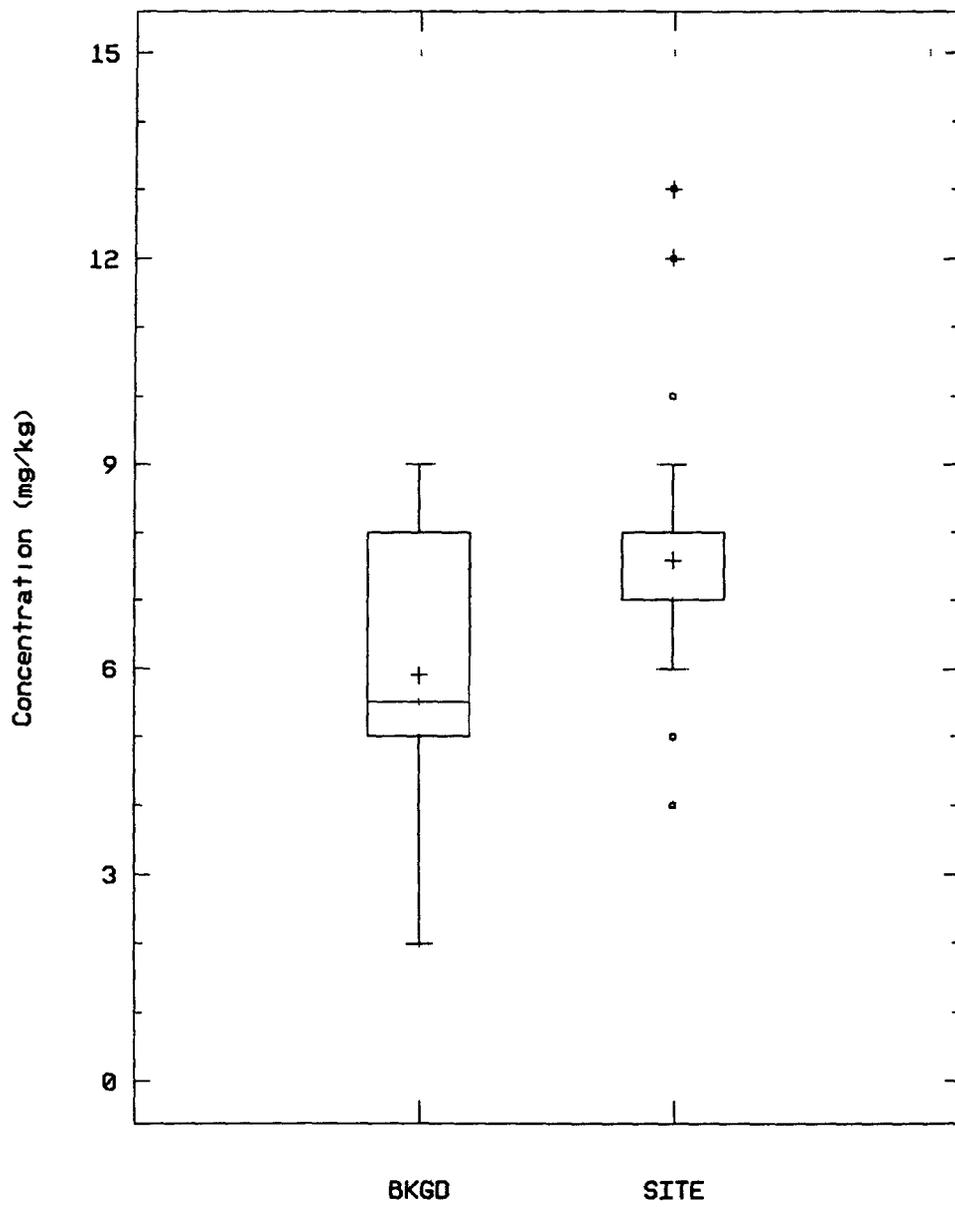
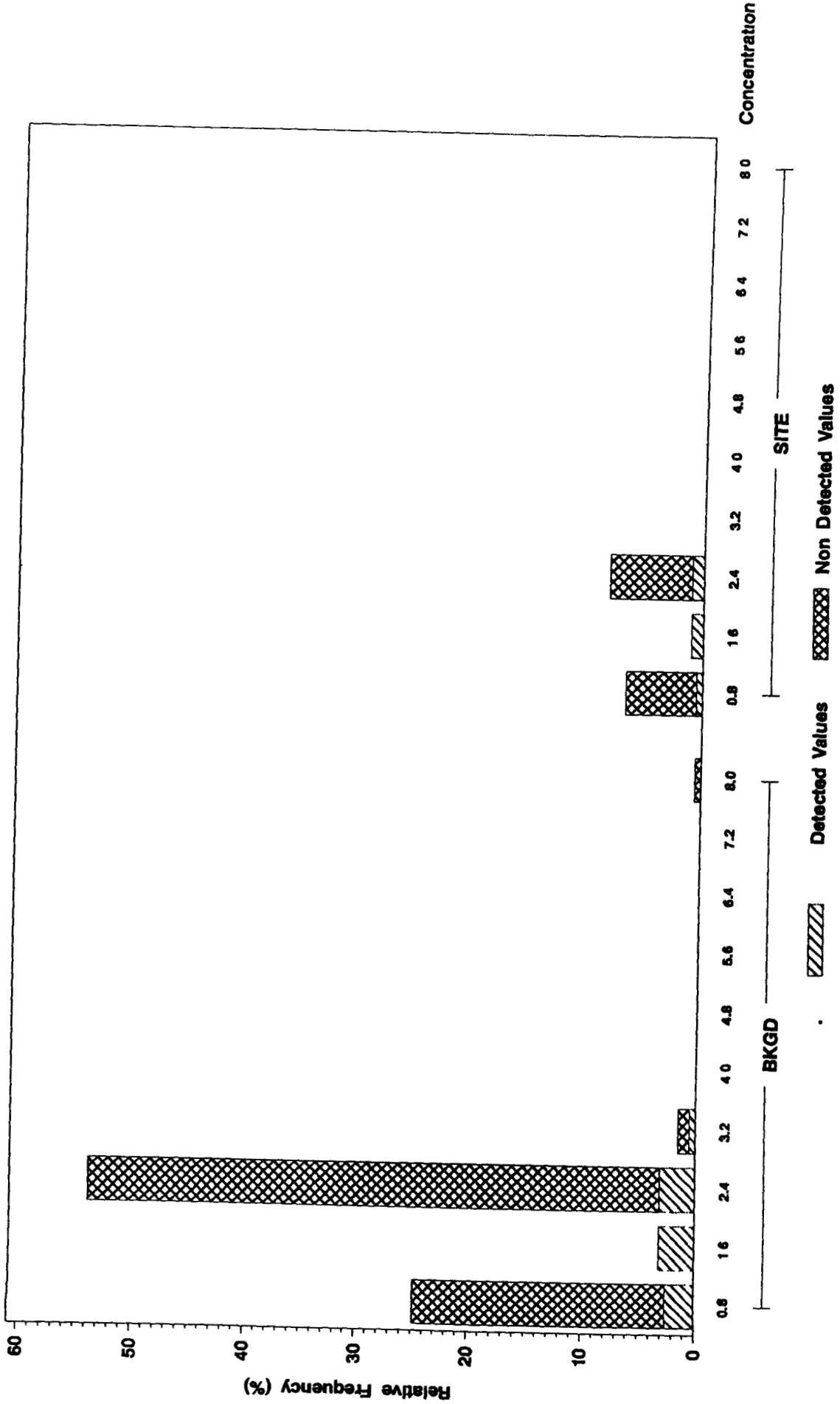


Figure  
**Background vs OU11 UHSU Groundwater**  
 Frequency Histogram  
**ARSENIC ( $\mu\text{g/l}$ ) in Groundwater (Total)**

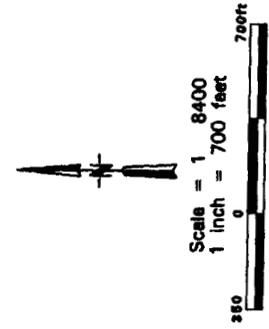


SITE = Wells in IHSS 168

# EXPLANATION

- ⊕ 1984 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊙ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- ==== Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OUI1 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 2



State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU11--West Spray Field  
 ARSENIC  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-8b

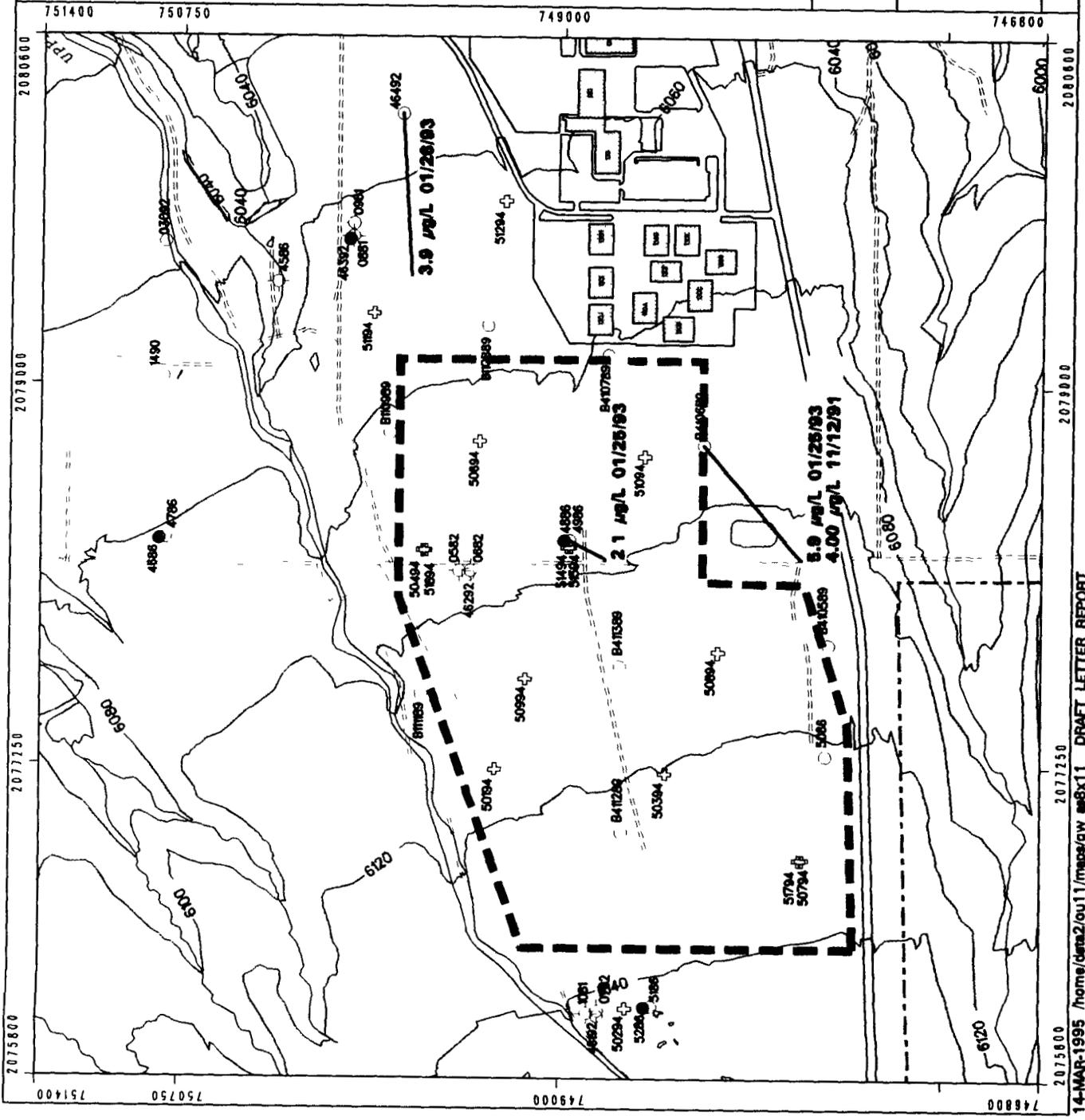
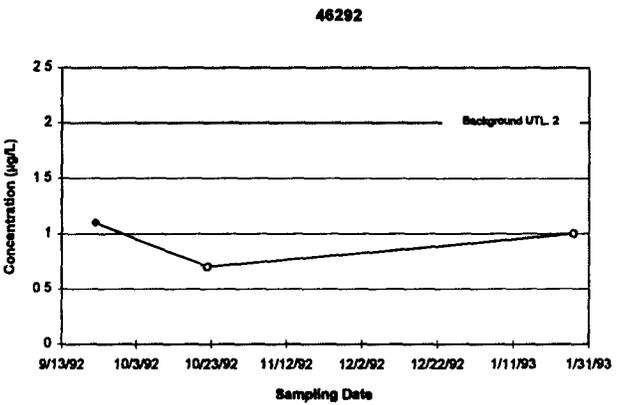
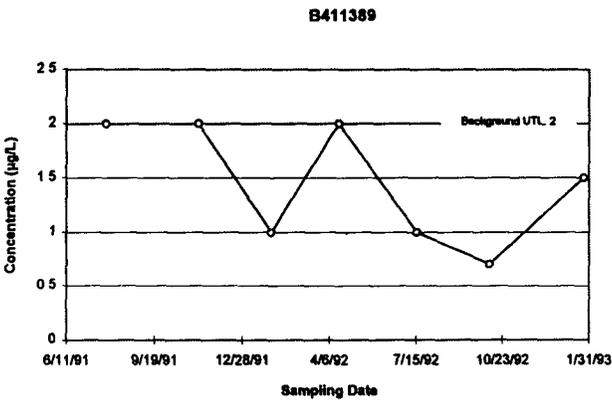
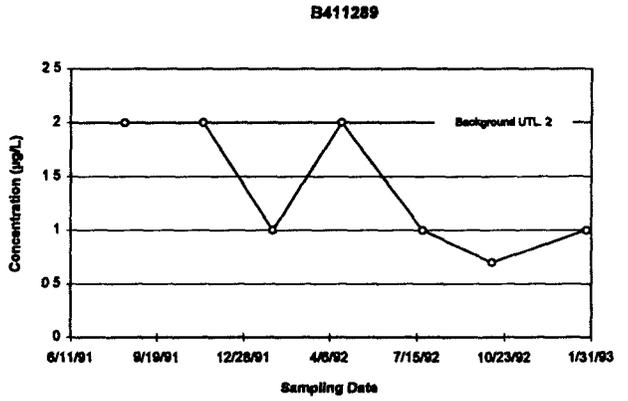
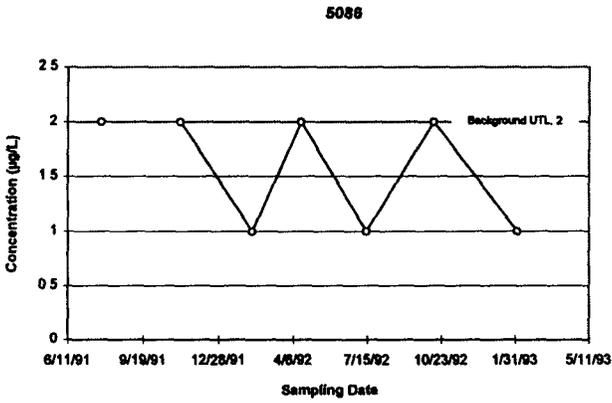
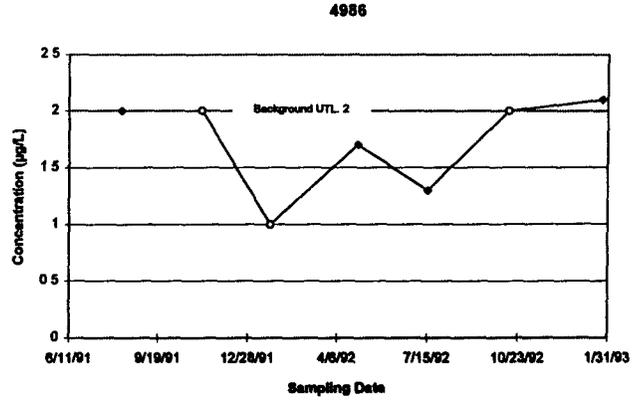
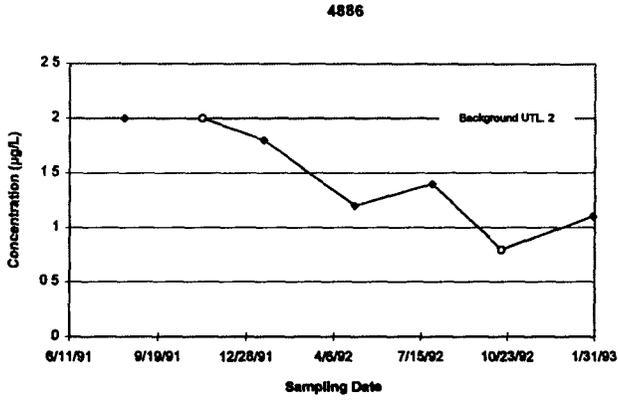


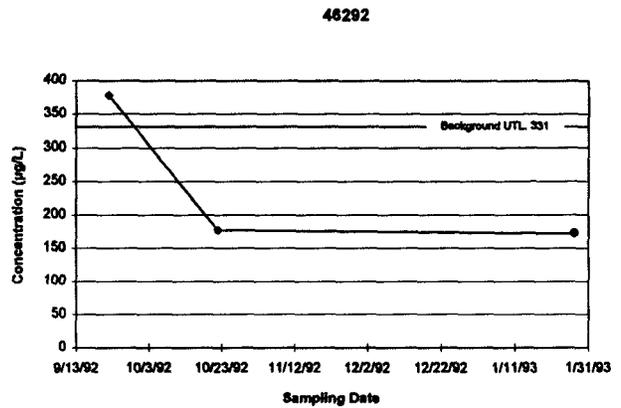
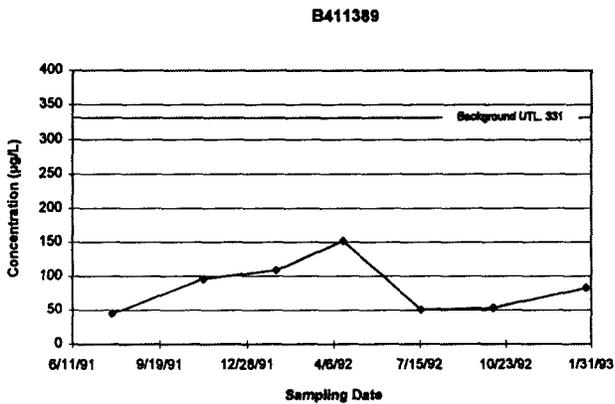
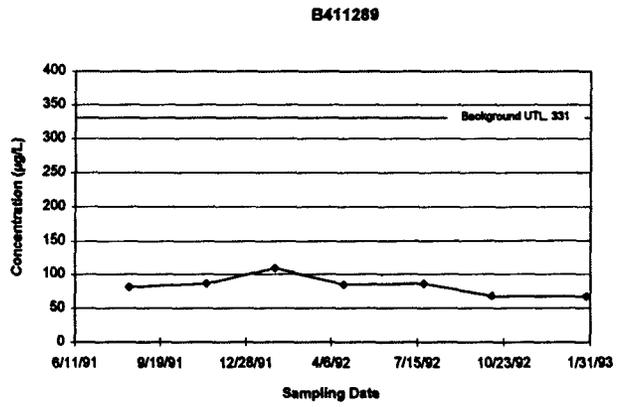
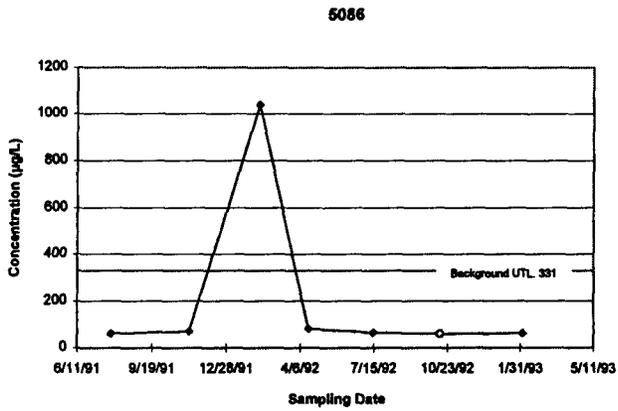
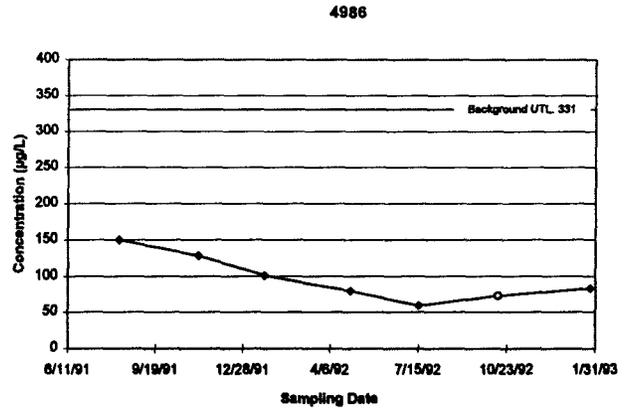
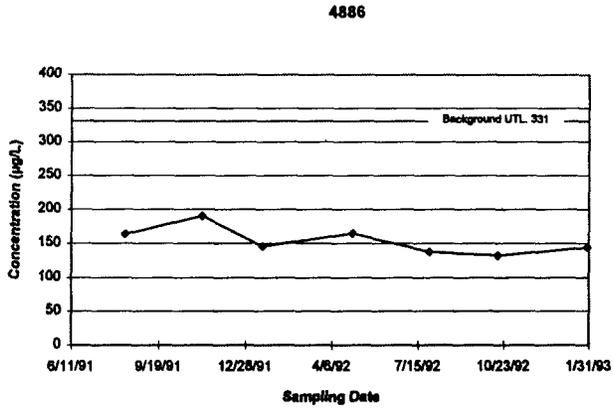
Figure D-9  
Time Series Plots - Total Arsenic



◆ Hit - Y  
○ Hit - N

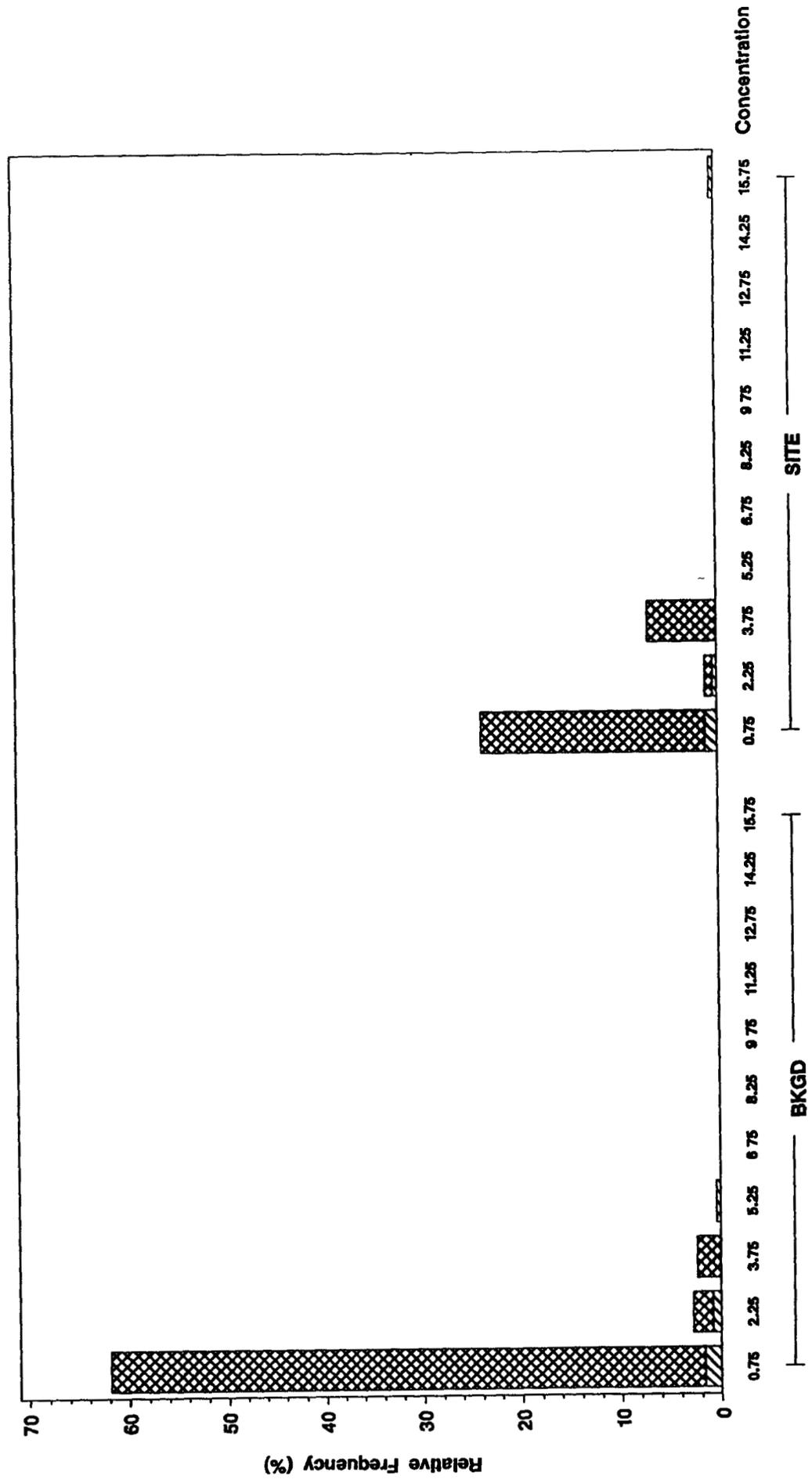


**Figure D-11**  
**Time Series Plots - Total Barium**



● Hit - Y  
○ Hit - N

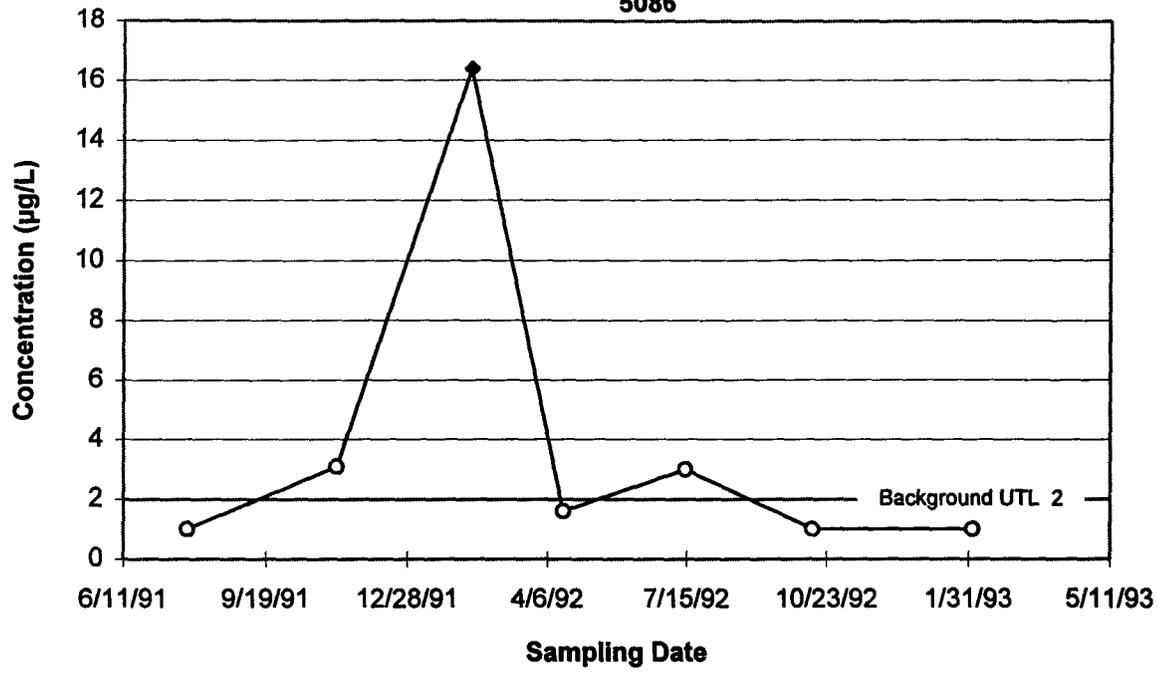
Figure D-12  
**Background vs OU11 UHSU Groundwater**  
 Frequency Histogram  
**BERYLLIUM (ug/l) in Groundwater (Total)**



SITE = UHSU samples from saturated media within and downgradient of IHSS 168



Figure D-14  
Time Series Plot - Total Beryllium  
5086

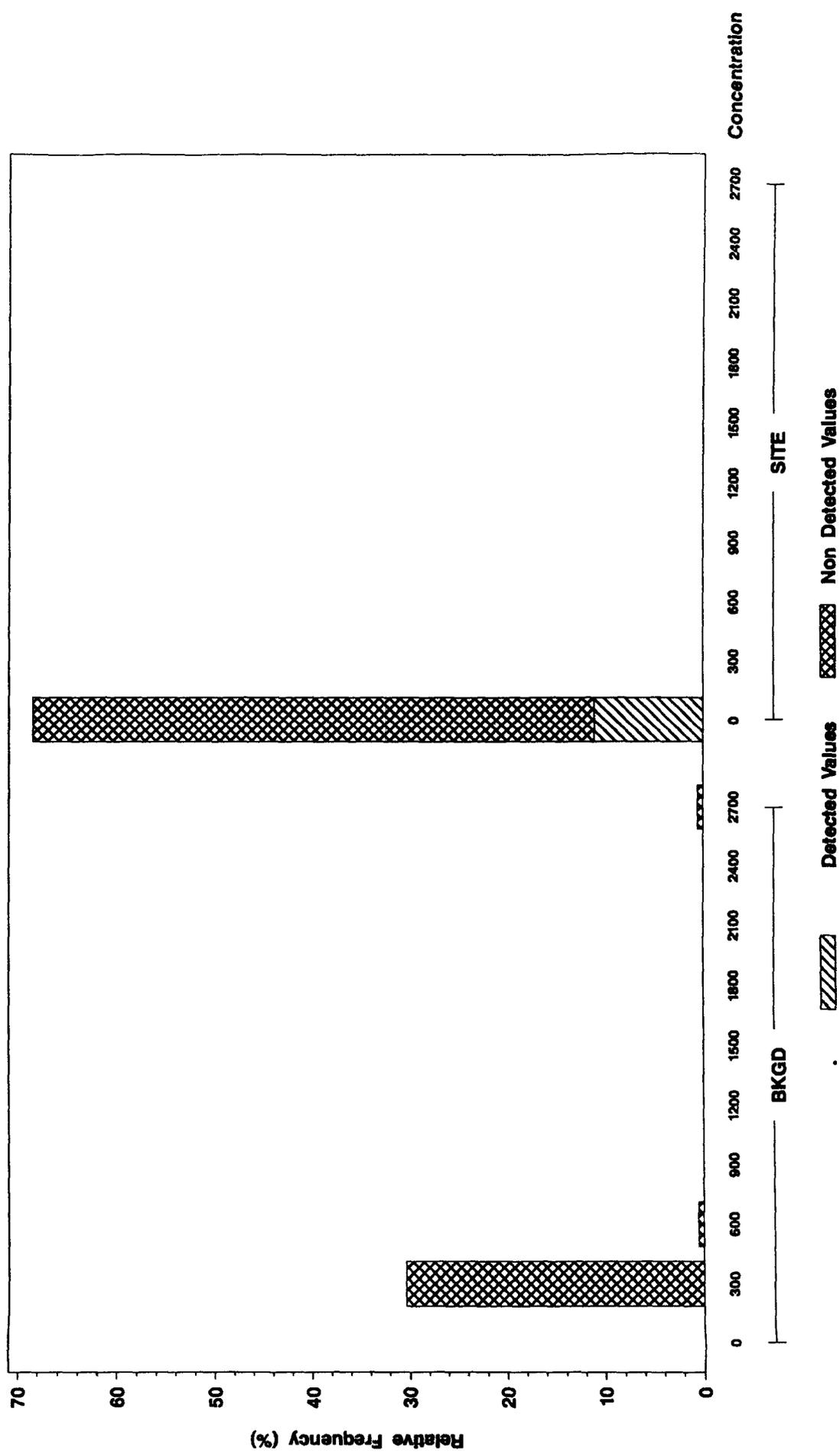


◆ Hit - Y  
○ Hit - N



# Background (subsurface geologic material) Qrf vs OU11 Qrf

Figure D.3  
 Frequency Histogram  
 CESIUM (mg/kg) in Qrf  
 (0 to 12 feet)

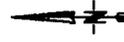


SITE = Boreholes within IHSS 168

# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above reporting limits



Scale = 1/8400  
1 inch = 700 feet

State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U.S. Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
CESIUM  
Concentrations\*  
(and Sample Dates) in  
UHSU Ground Water

March 1995 Figure D-17

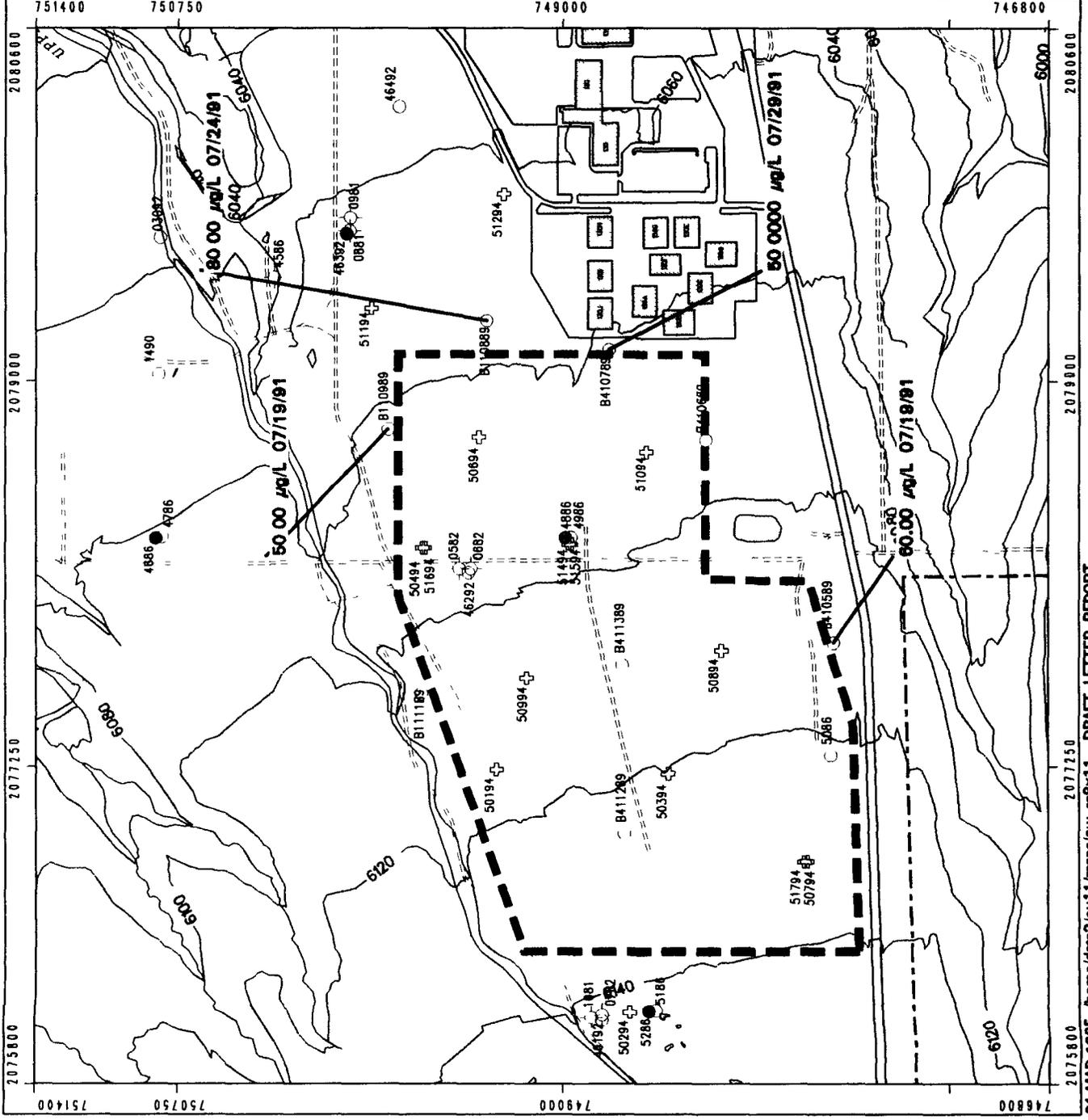
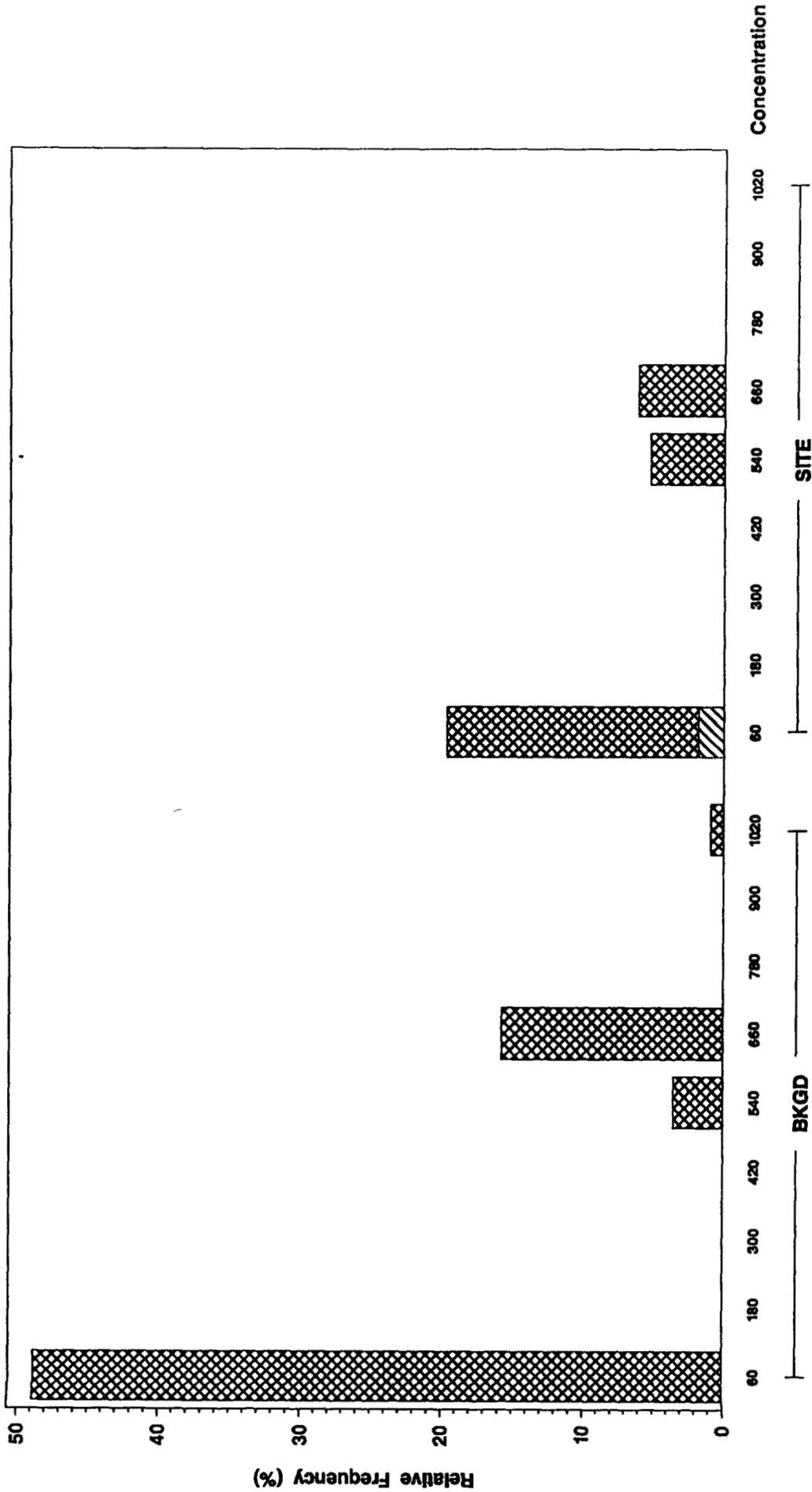


Figure 18

# Background vs OU11 UHSU Groundwater Frequency Histogram CESIUM (ug/l) in Groundwater (Total)

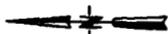


SITE = UHSU samples from saturated media within and downgradient of IHSS 168

# EXPLANATION

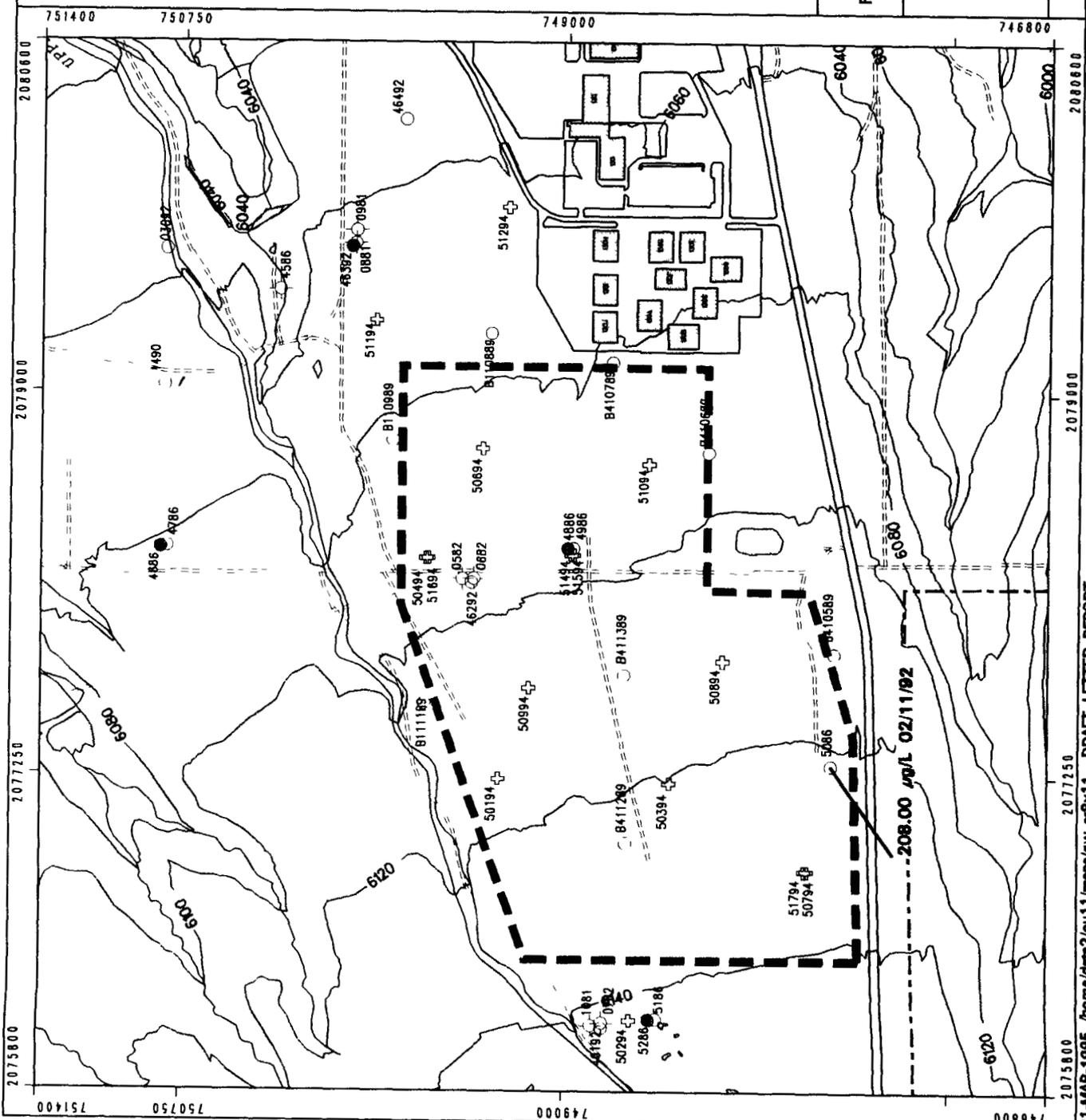
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 125



Scale = 1/8400  
 1 inch = 700 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

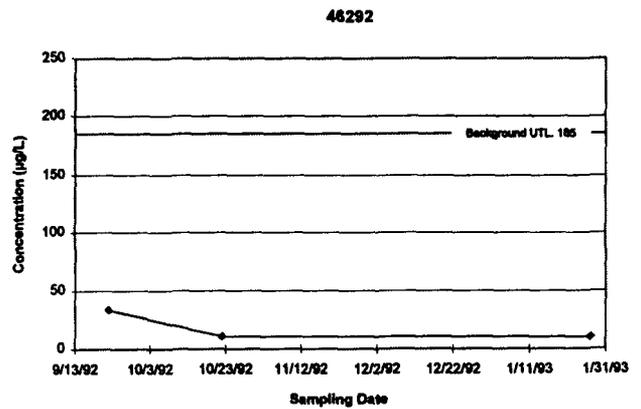
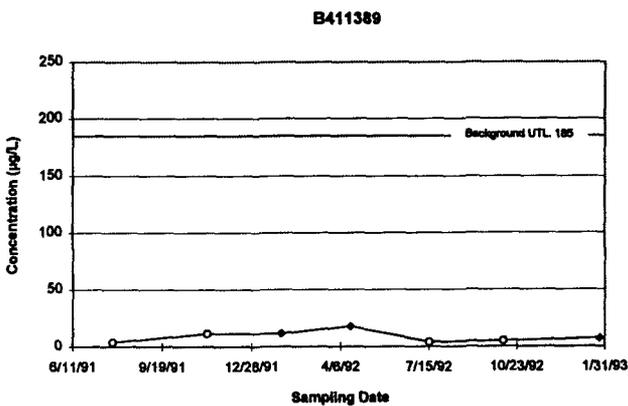
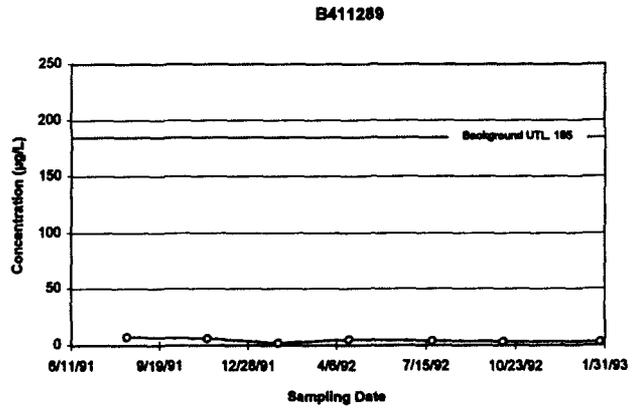
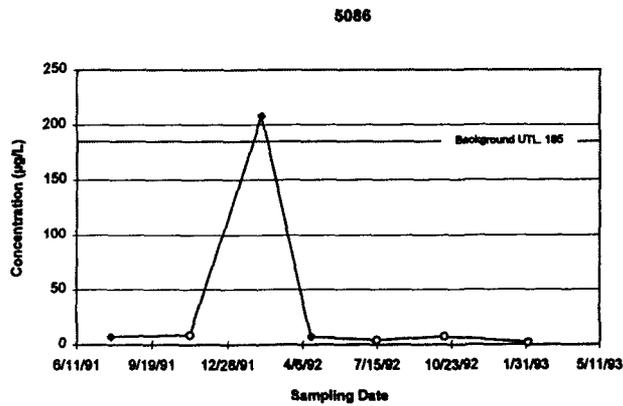
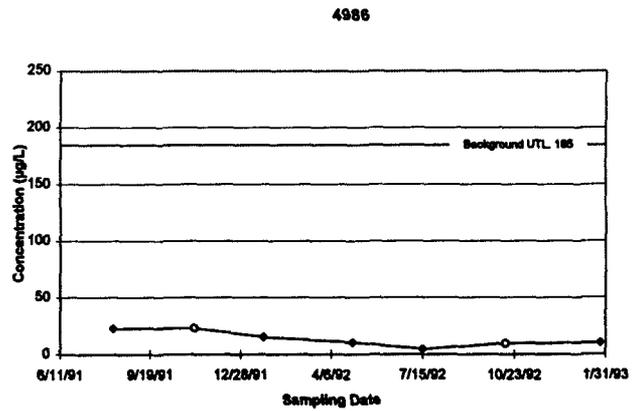
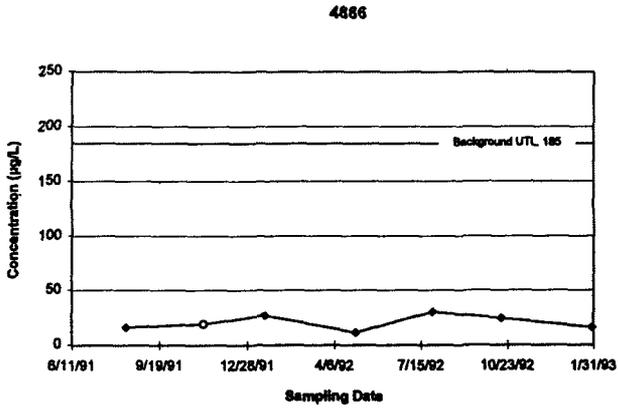


U S Department of Energy  
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 Golden, Colorado

OU 11--West Spray Field  
 CHROMIUM  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-19

**Figure D-20**  
**Time Series Plots - Total Chromium**

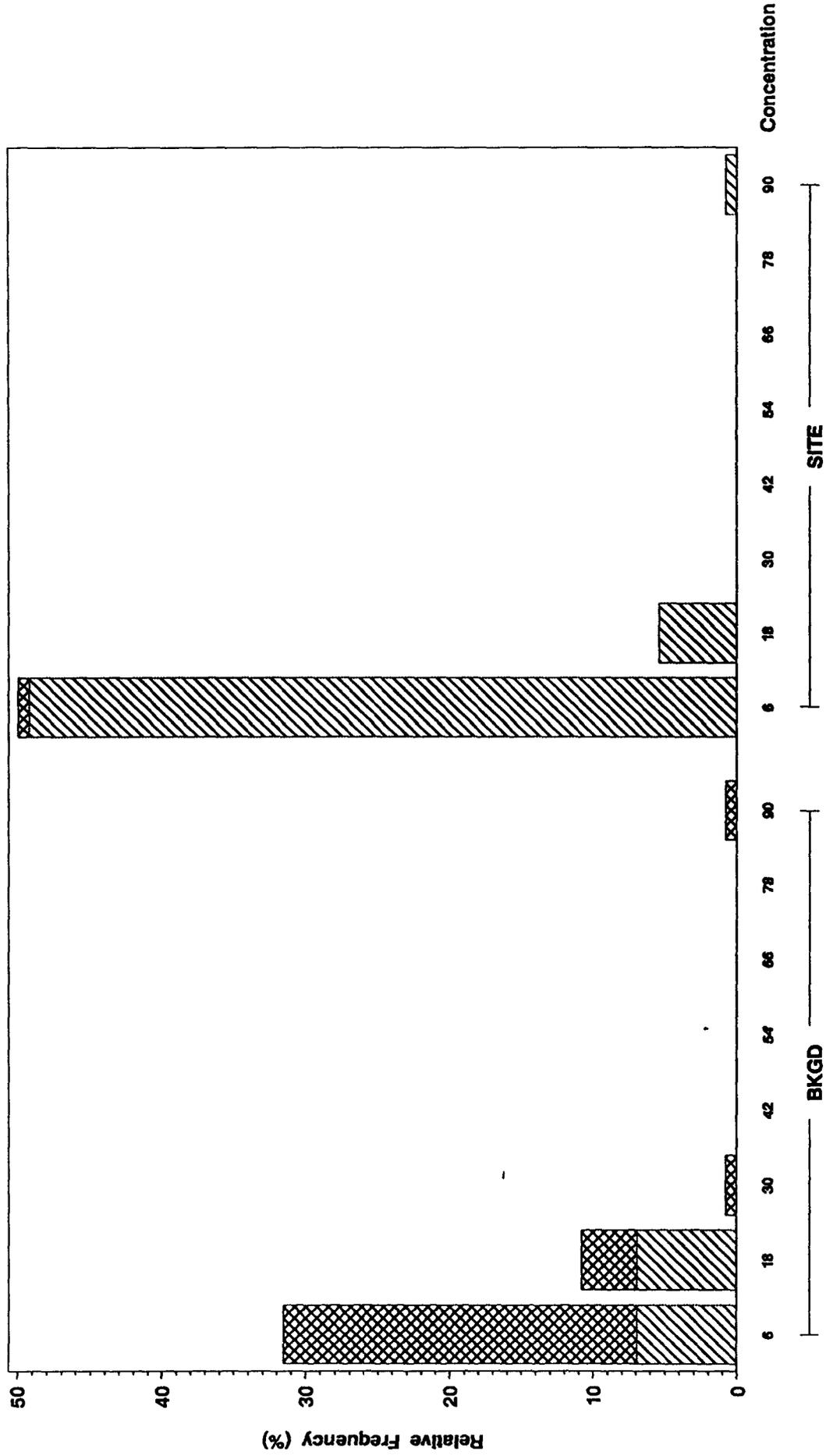


◆ Hit - Y  
○ Hit - N



**Figure 22**  
**Background (subsurface geologic material) Qrf vs OU11 Qrf (0 - 12 feet)**

**Frequency Histogram**  
**COBALT (mg/kg) in Qrf**



SITE = Borehole samples within and downgradient of IHSS 168

Figure D-23  
Background vs OU11 Subsurface Geologic Materials (0' - 12')

Cobalt in Qrf

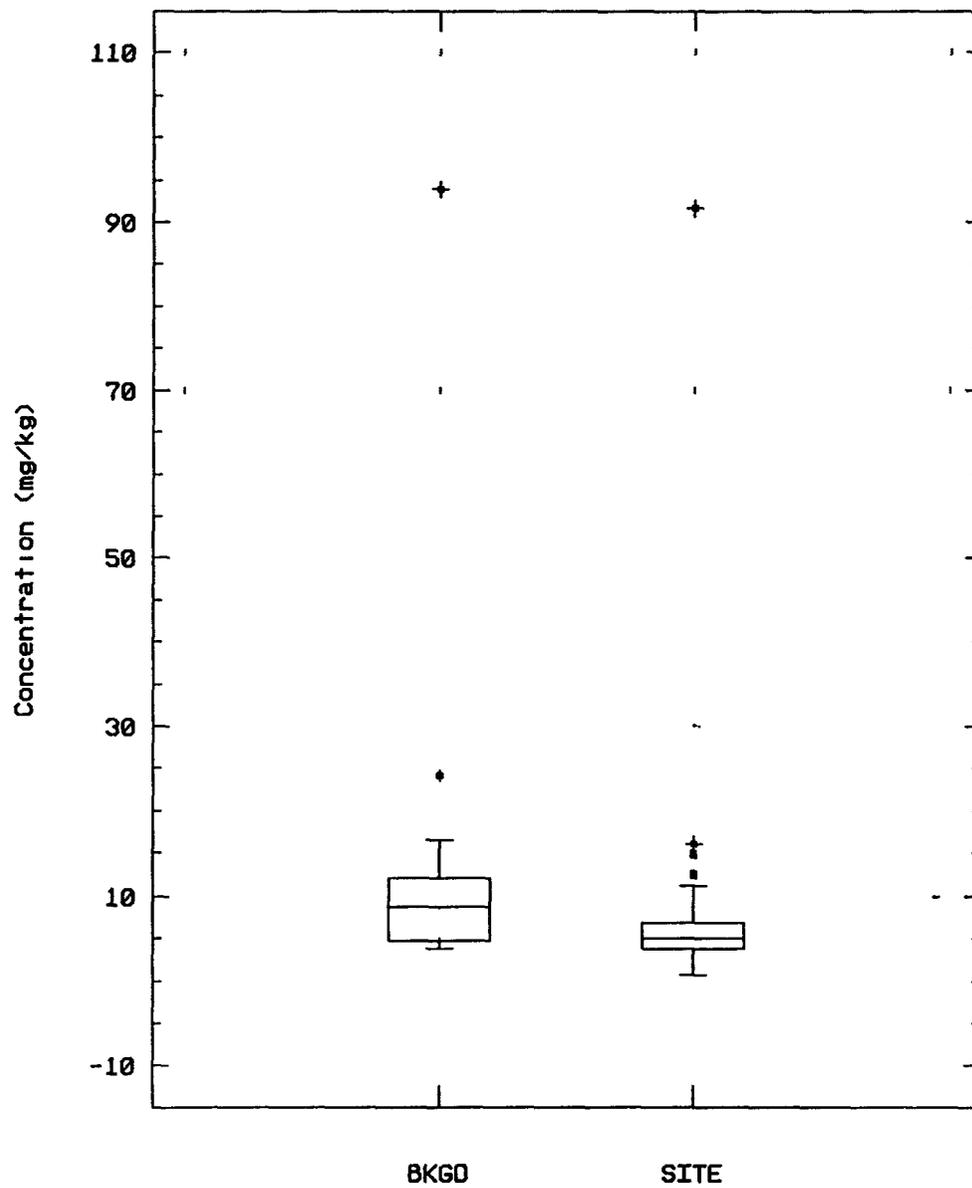


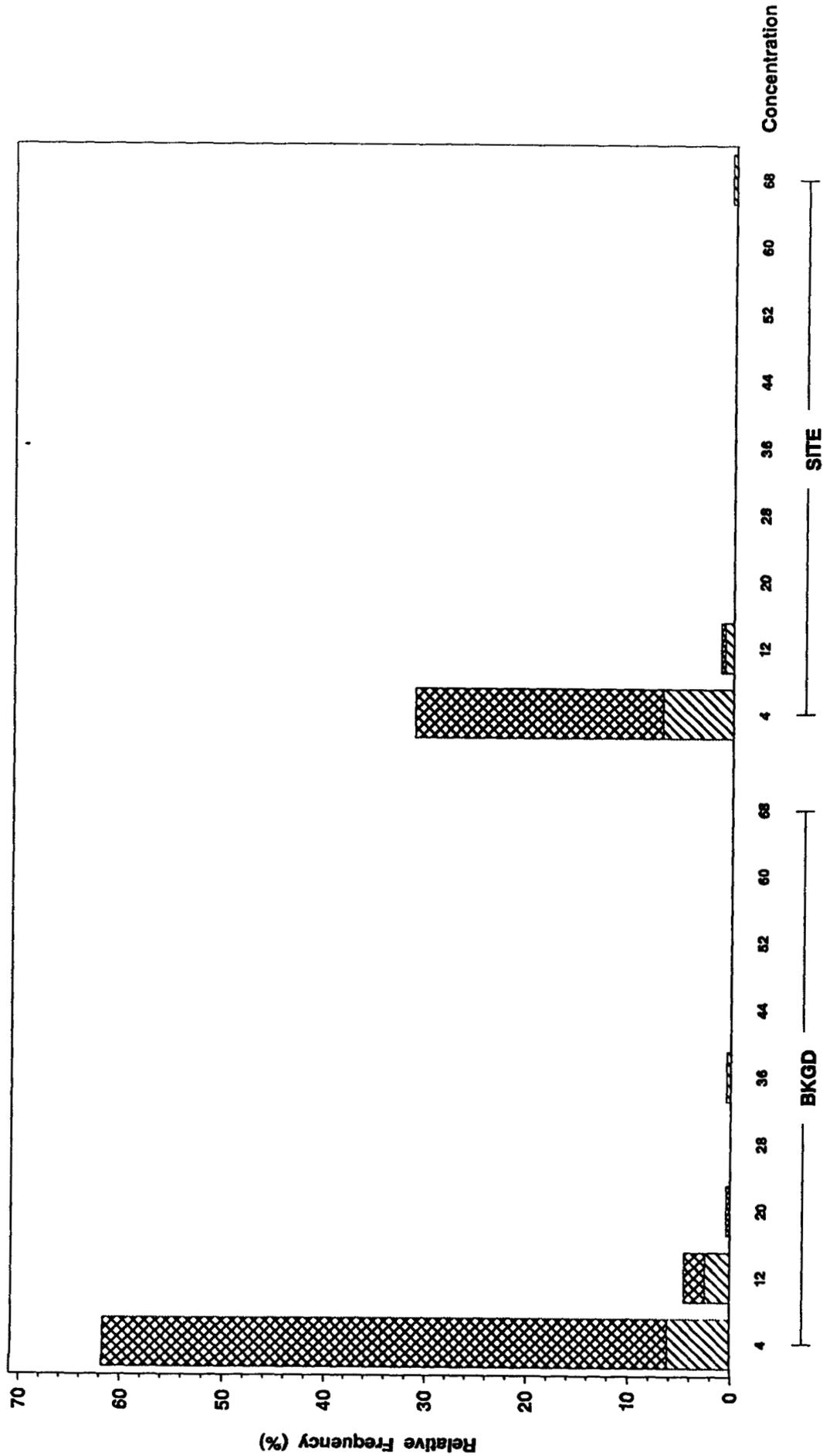


Figure 25

# Background vs OU11 UHSU Groundwater

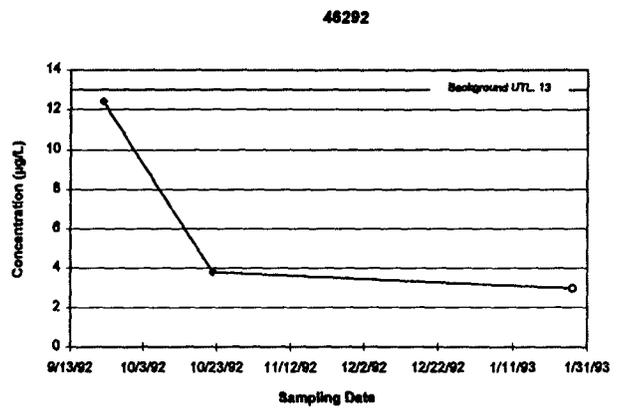
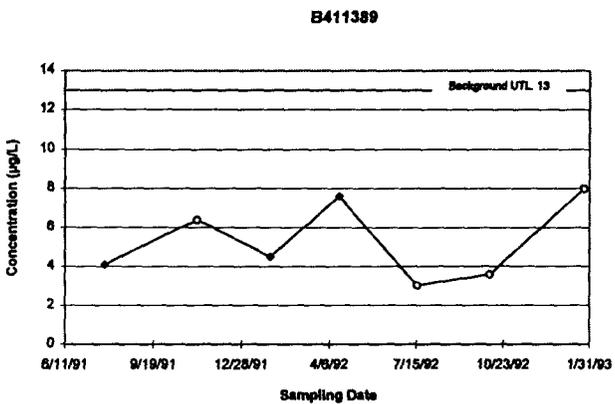
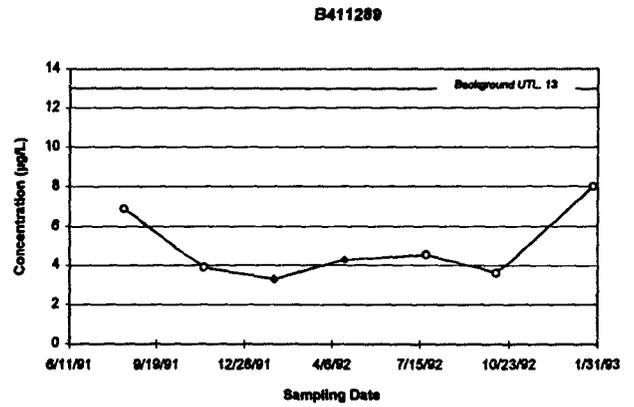
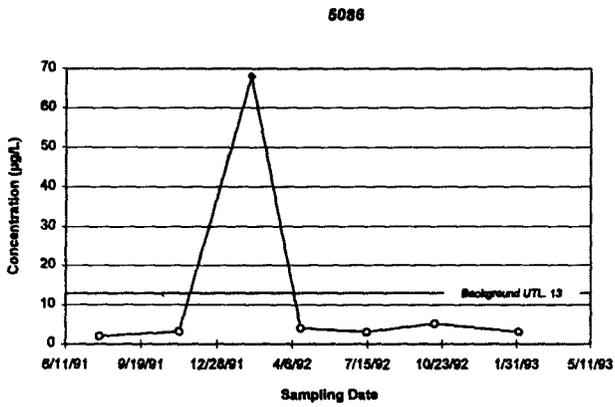
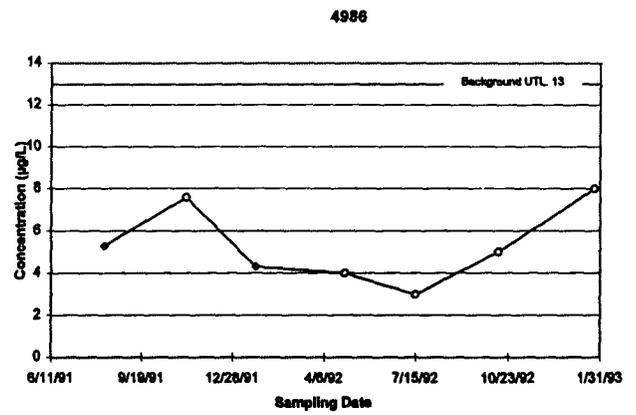
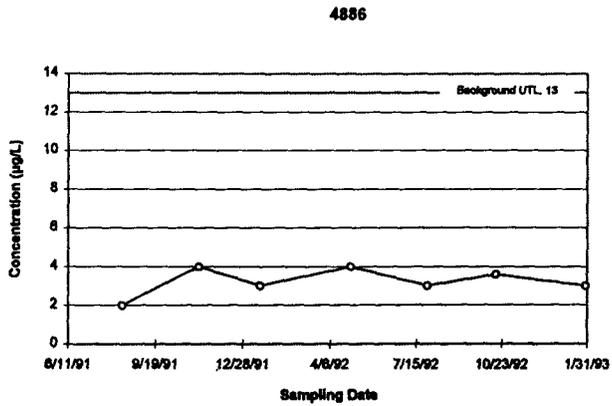
## Frequency Histogram

COBALT (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

**Figure D-26**  
**Time Series Plots - Total Cobalt**

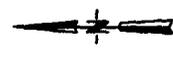


◆ Hit - Y  
○ Hit - N

# EXPLANATION

- △ Sample Location
- ▲ Values above the background mean +2 standard deviations (BM+2SD)
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- - - OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Concentrations are in mg/kg  
BM+2SD = 22



Scale = 1 7200  
1 inch = 600 feet



State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

Surficial Soil (0 to 2 inches)  
COPPER  
Concentrations\*  
at the  
OU 11--West Spray Field

March 1995  
Figure D-27

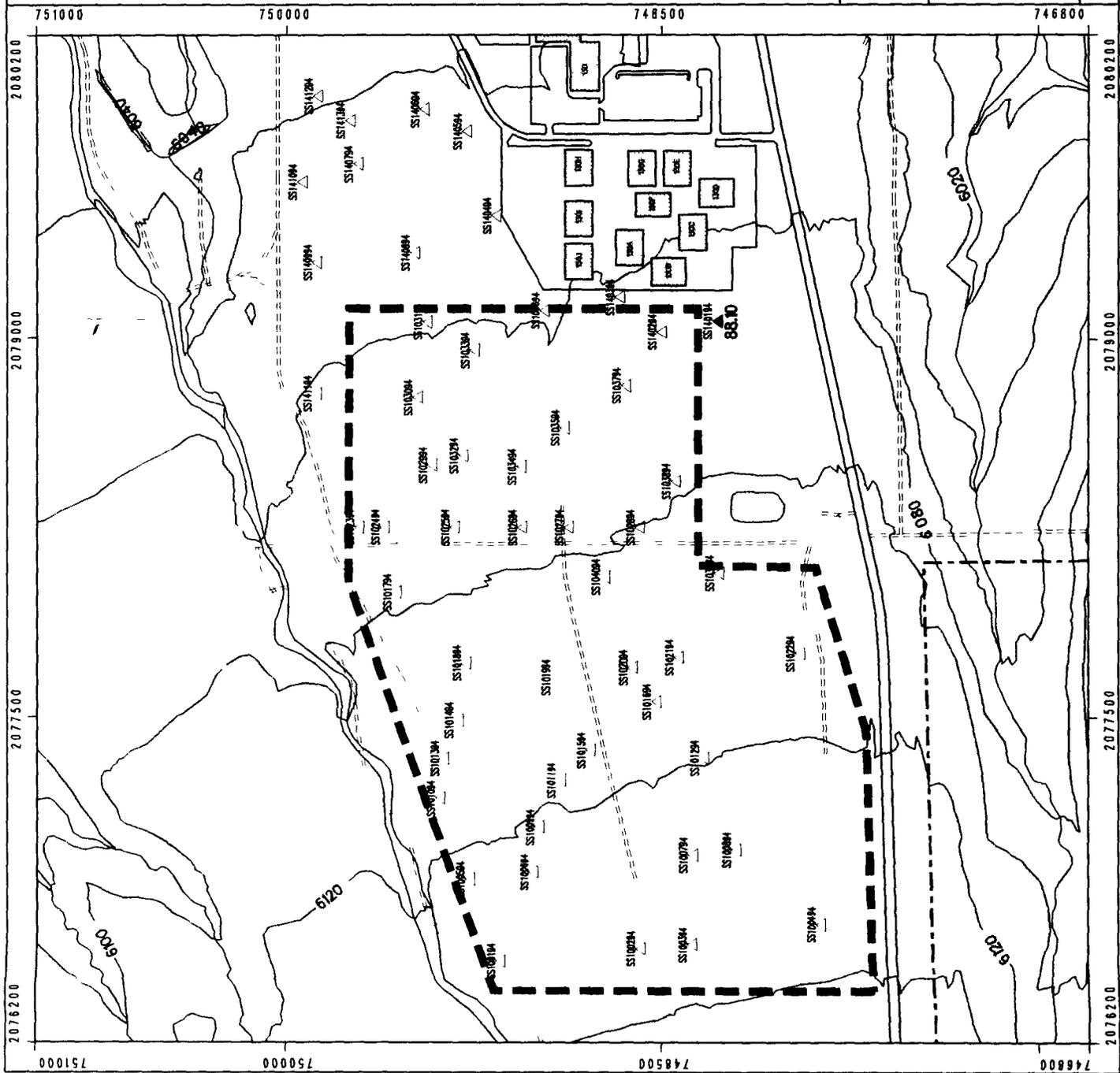
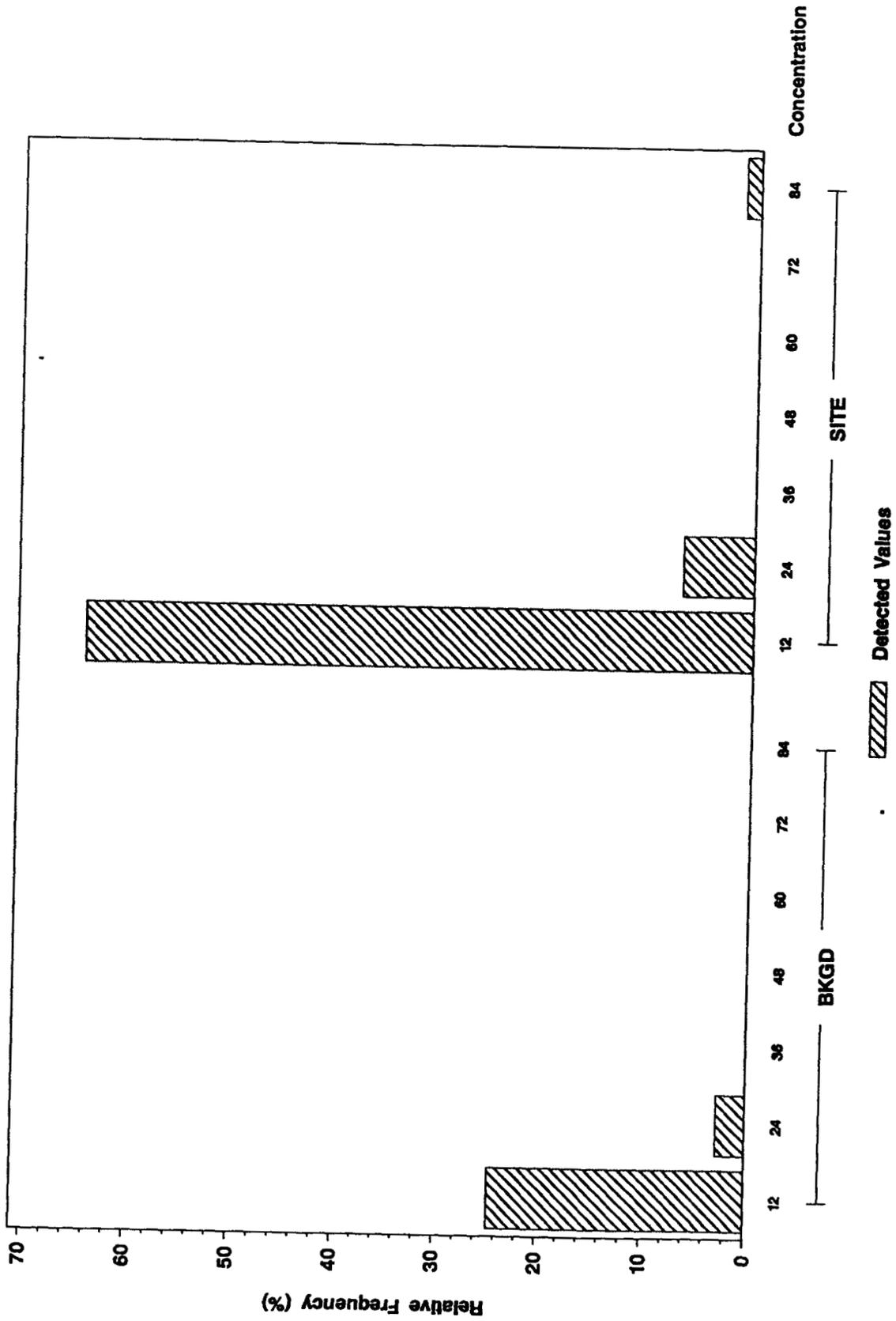


Figure D-28

# Background vs OU11 Surface Soil Frequency Histogram COPPER (mg/kg) in Surface Soil (0-2 inches)



SITE = All areas sampled within OU11

Figure D-29  
Background vs OU11 Surface Soil  
Copper in Surface Soil (0 to 2 inches)

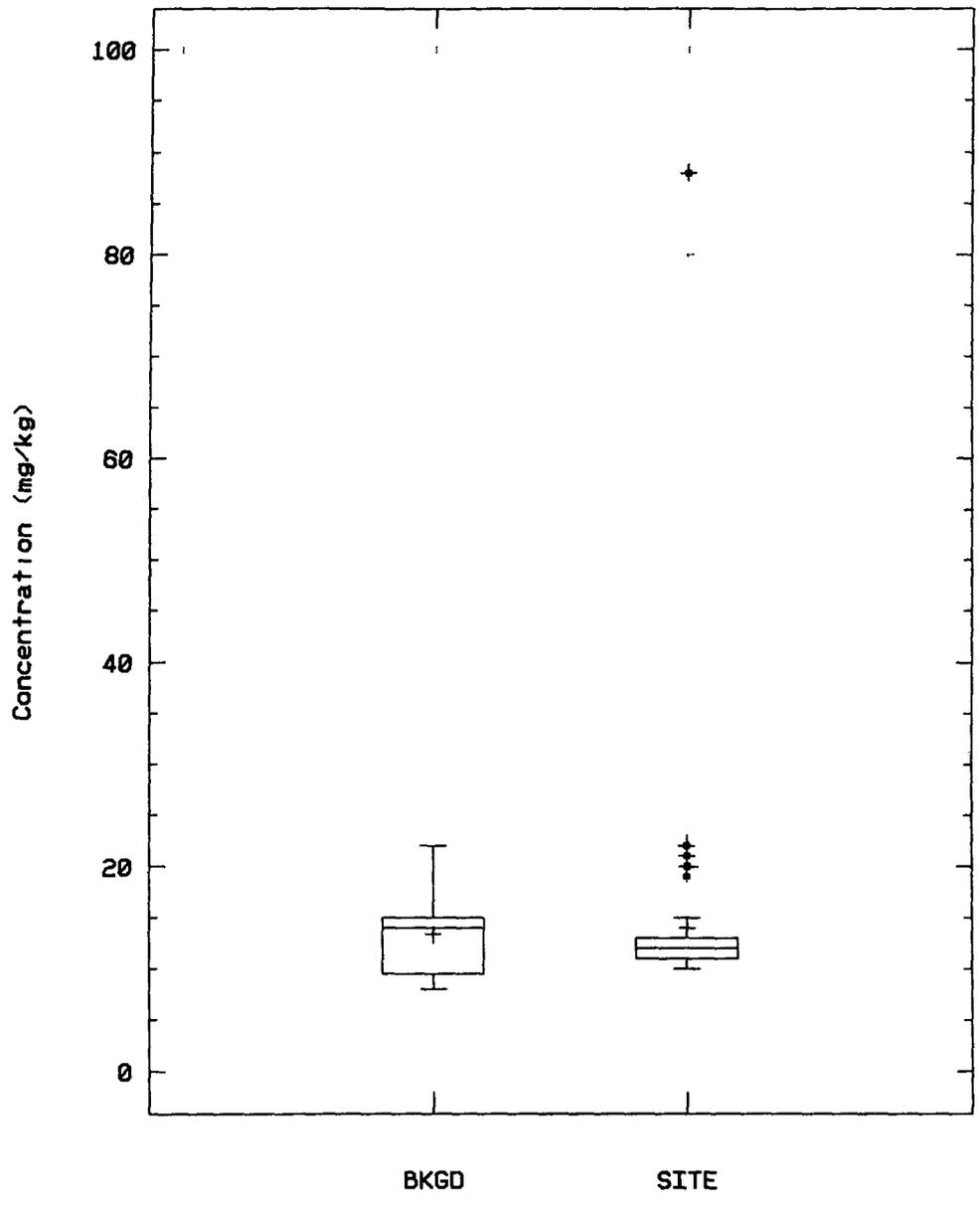
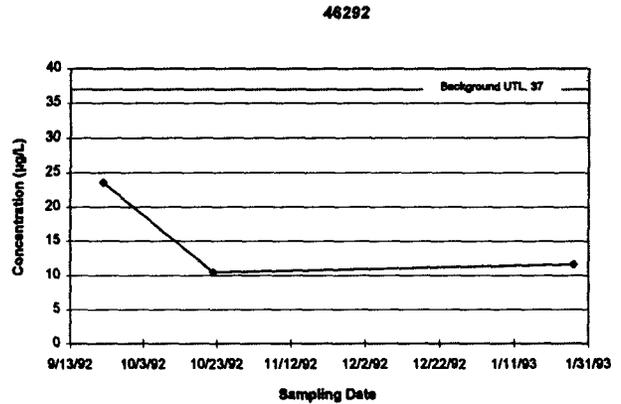
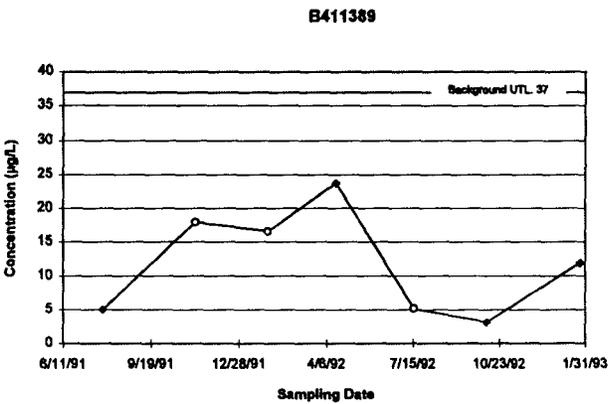
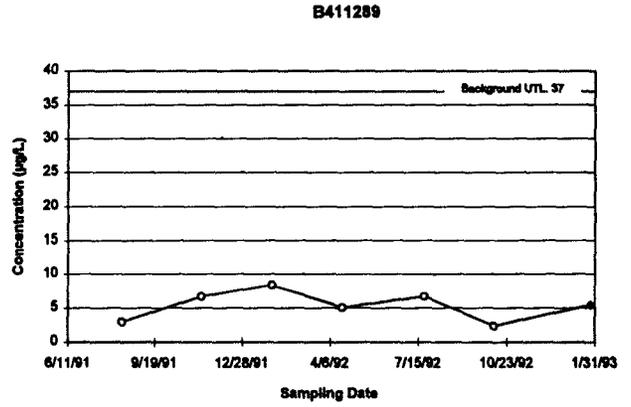
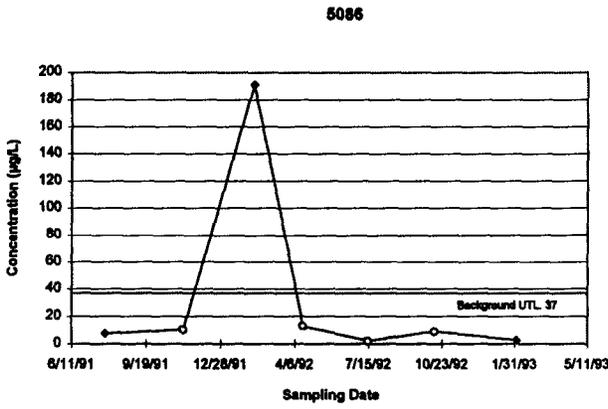
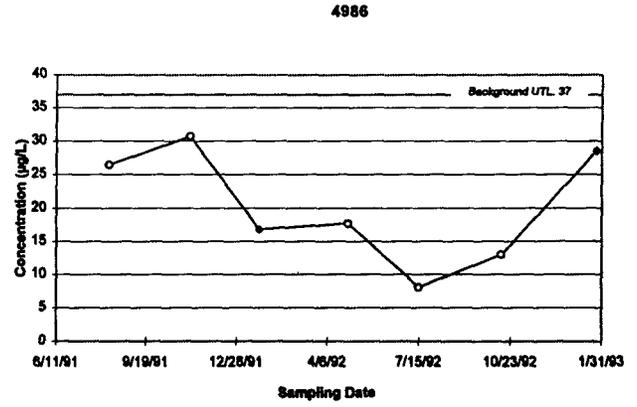
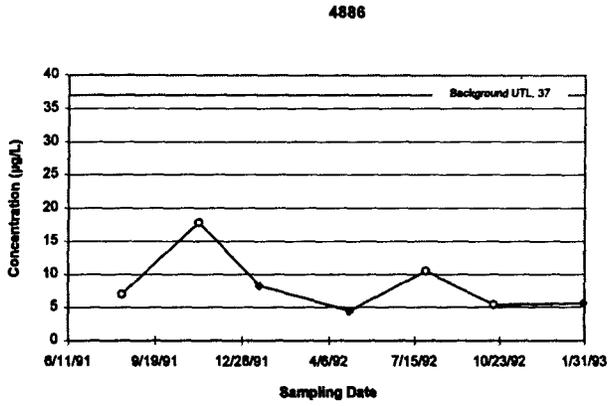


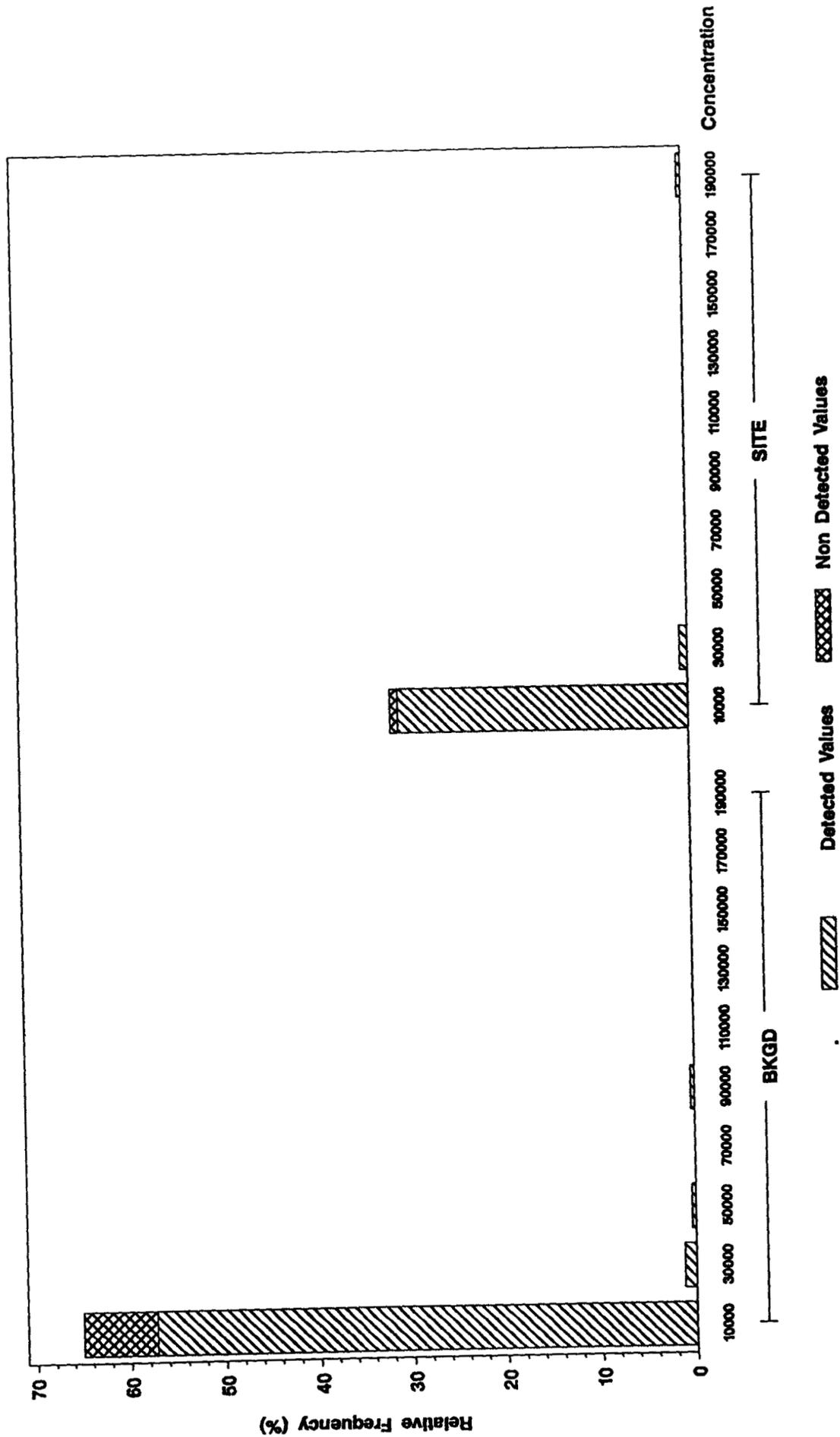


Figure D-31  
Time Series Plots - Total Copper



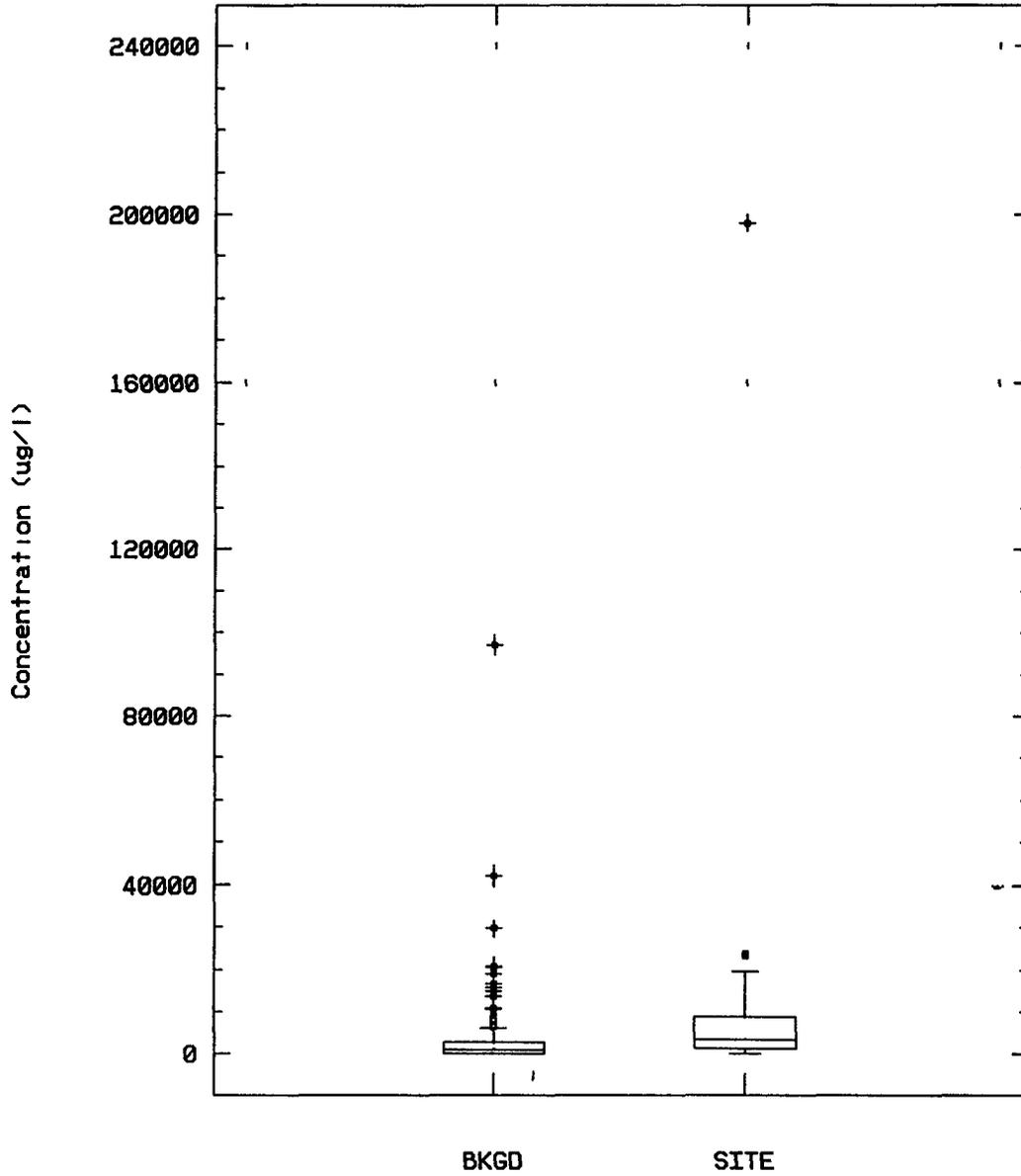
◆ Hit - Y  
○ Hit - N

Figure D-32  
**Background vs OU11 UHSU Groundwater**  
**Frequency Histogram**  
**IRON (ug/l) in Groundwater (Total)**



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

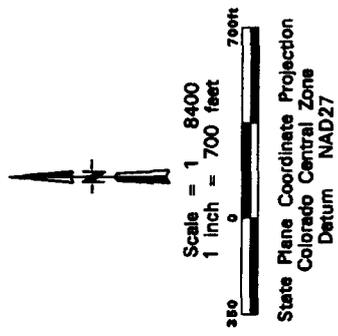
Figure D-33  
Background vs OU11 UHSU Groundwater  
Iron in Groundwater (Total)



# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 22061



U S Department of Energy  
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OU 11--West Spray Field  
 IRON  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-34

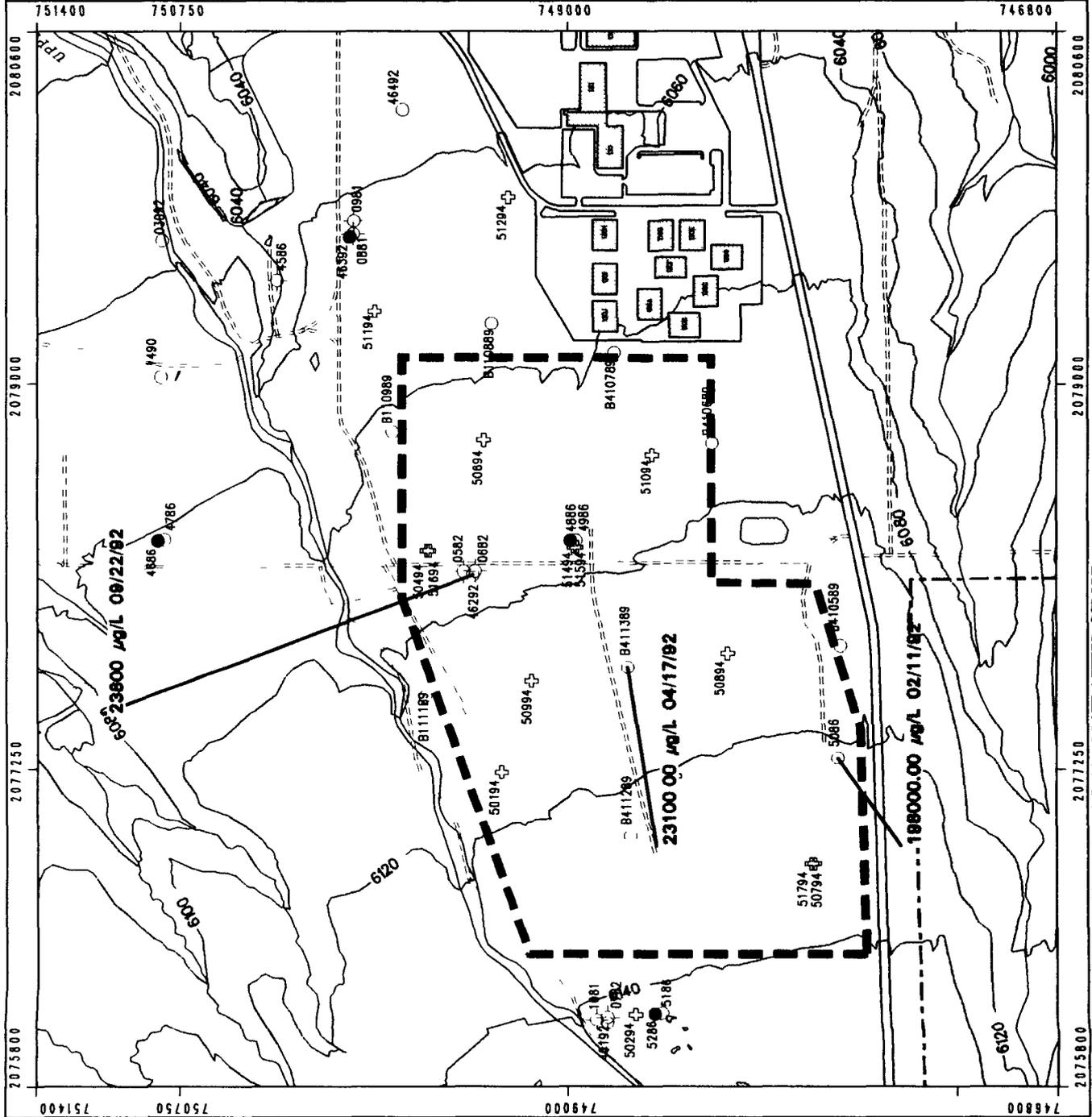
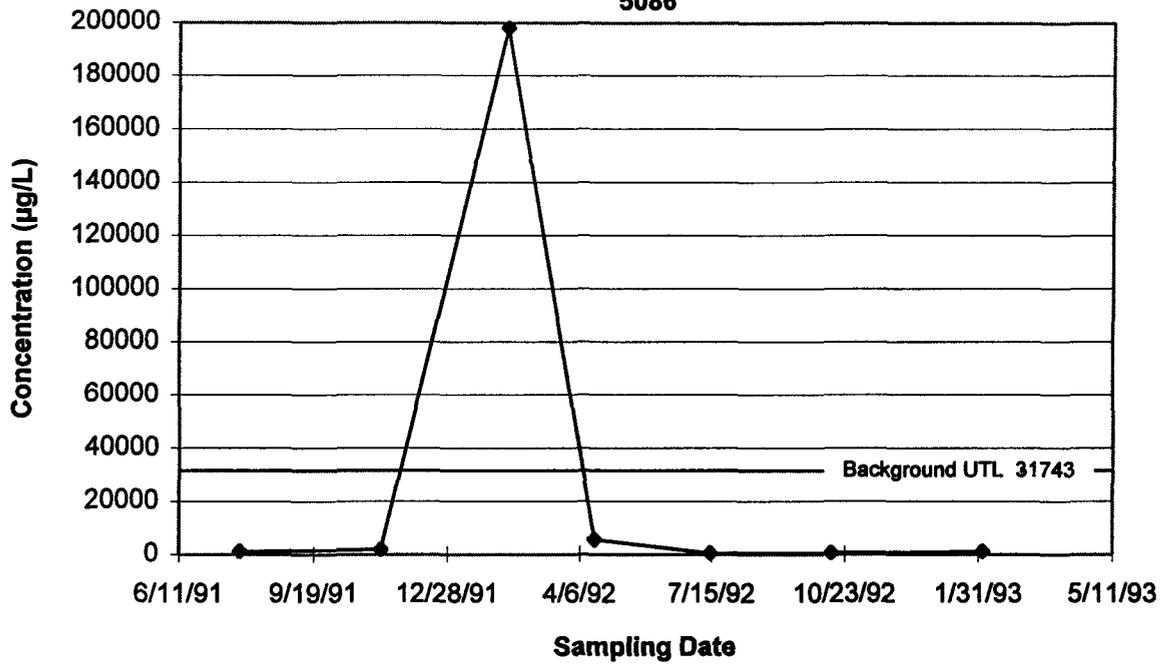


Figure D-35  
Time Series Plot - Total Iron  
5086

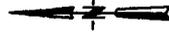


◆ Hit - Y  
○ Hit - N

# EXPLANATION

- △ Sample Location
- ▲ Values above the background mean +2 standard deviations (BM+2SD)
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- ==== Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Concentrations are in mg/kg  
BM+2SD = 50



Scale = 1 / 7200  
1 inch = 600 feet



State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

Surficial Soil (0 to 2 inches)

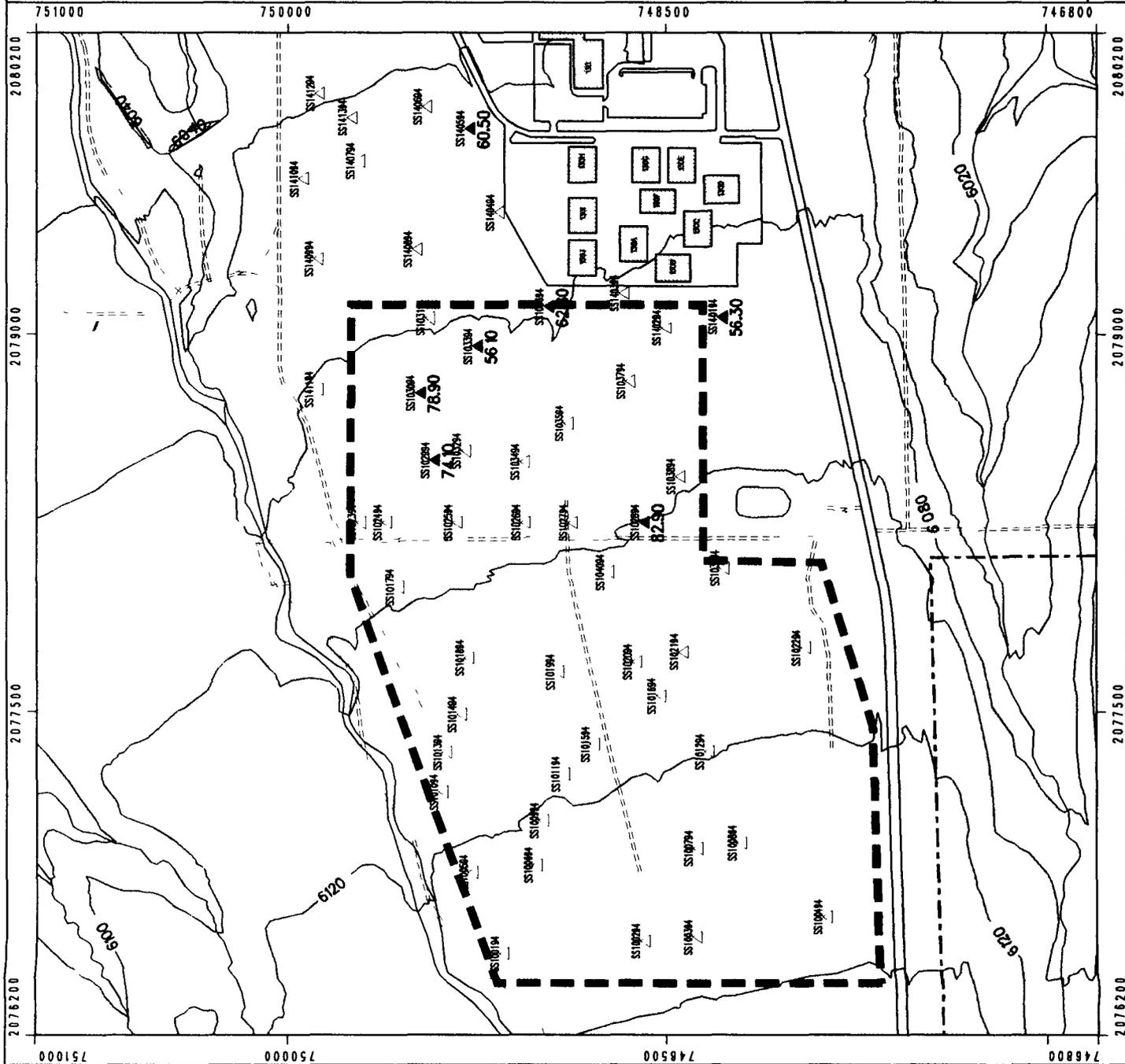
LEAD

Concentrations\*  
at the

OU 11--West Spray Field

March 1995

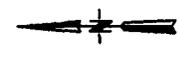
Figure D-36



# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊕ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- == Paved Roads
- == Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- - - OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 14



Scale = 1/8400  
 1 inch = 700 feet



State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 LEAD  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-37

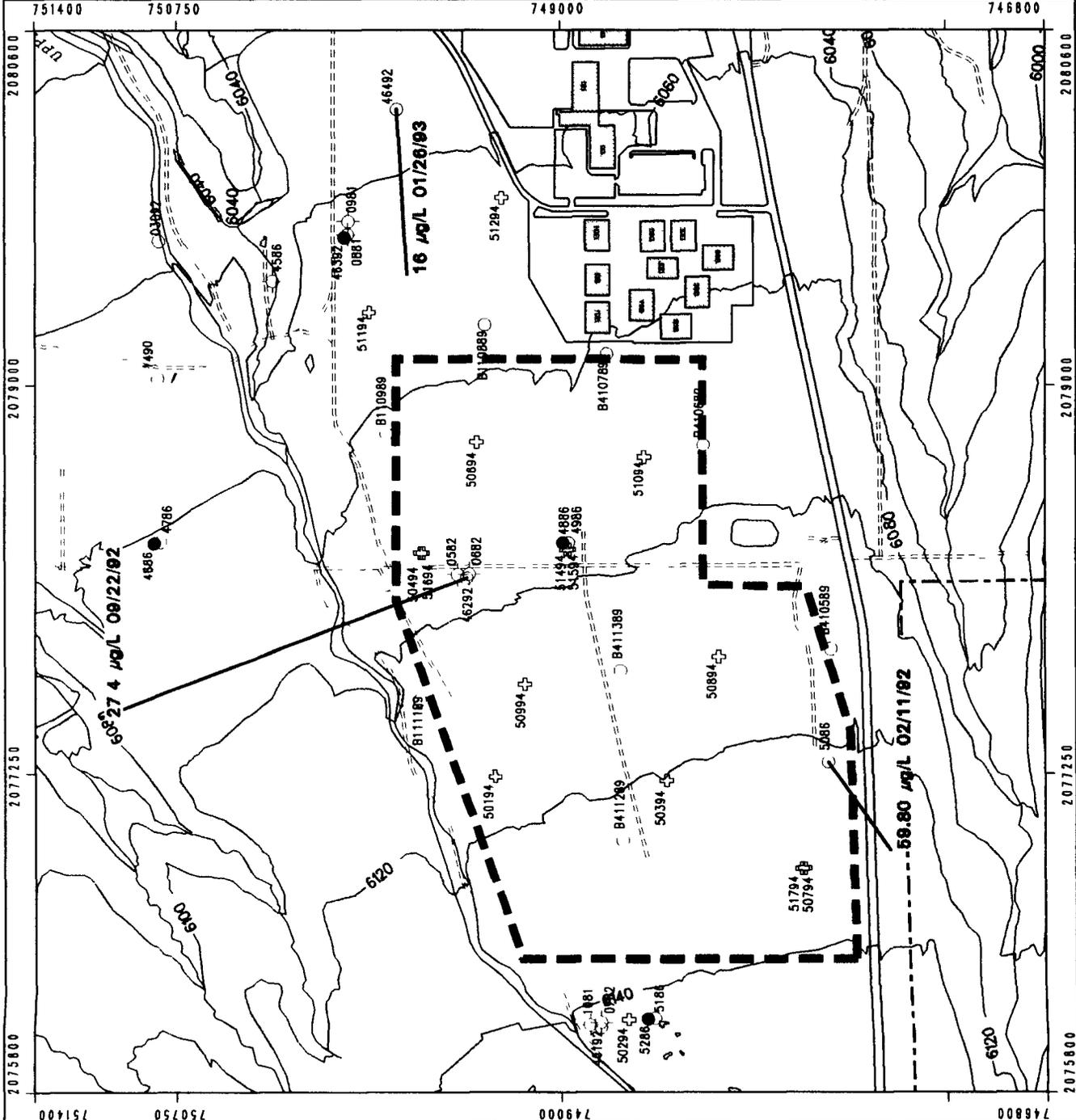
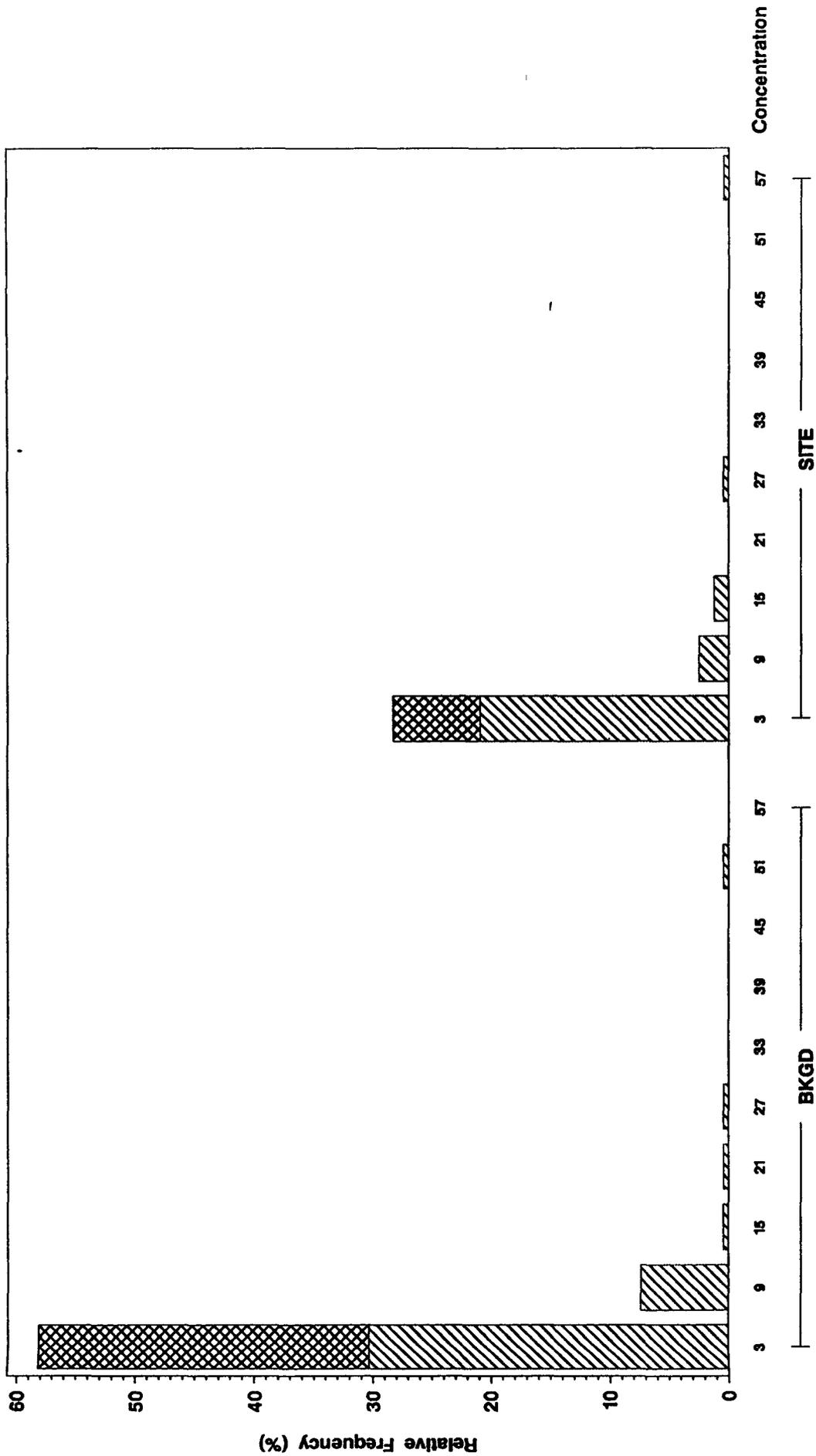


Figure D-38

# Background vs OU11 UHSU Groundwater

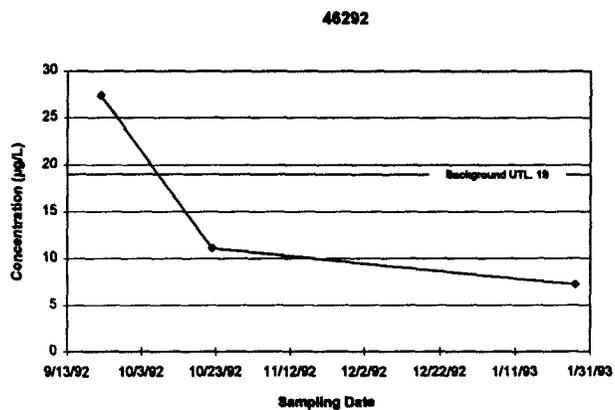
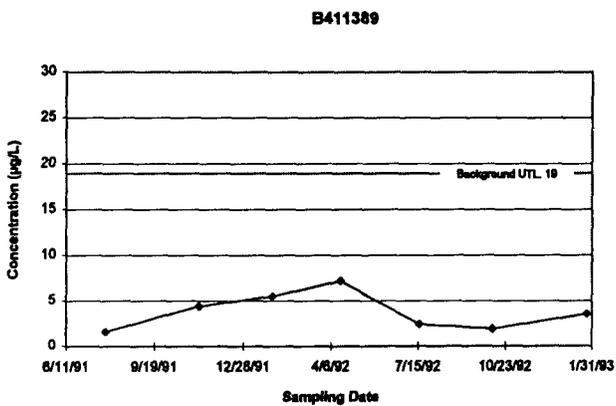
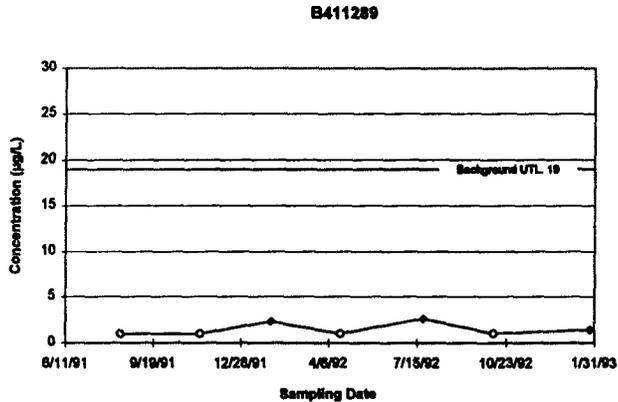
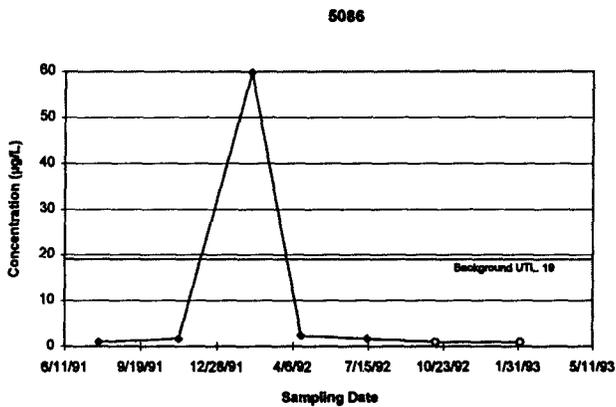
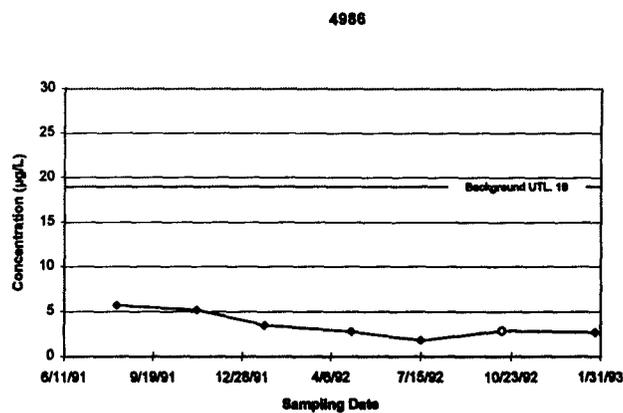
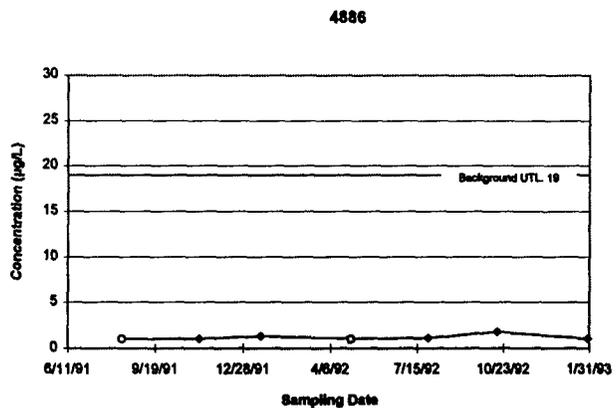
## Frequency Histogram

### LEAD (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

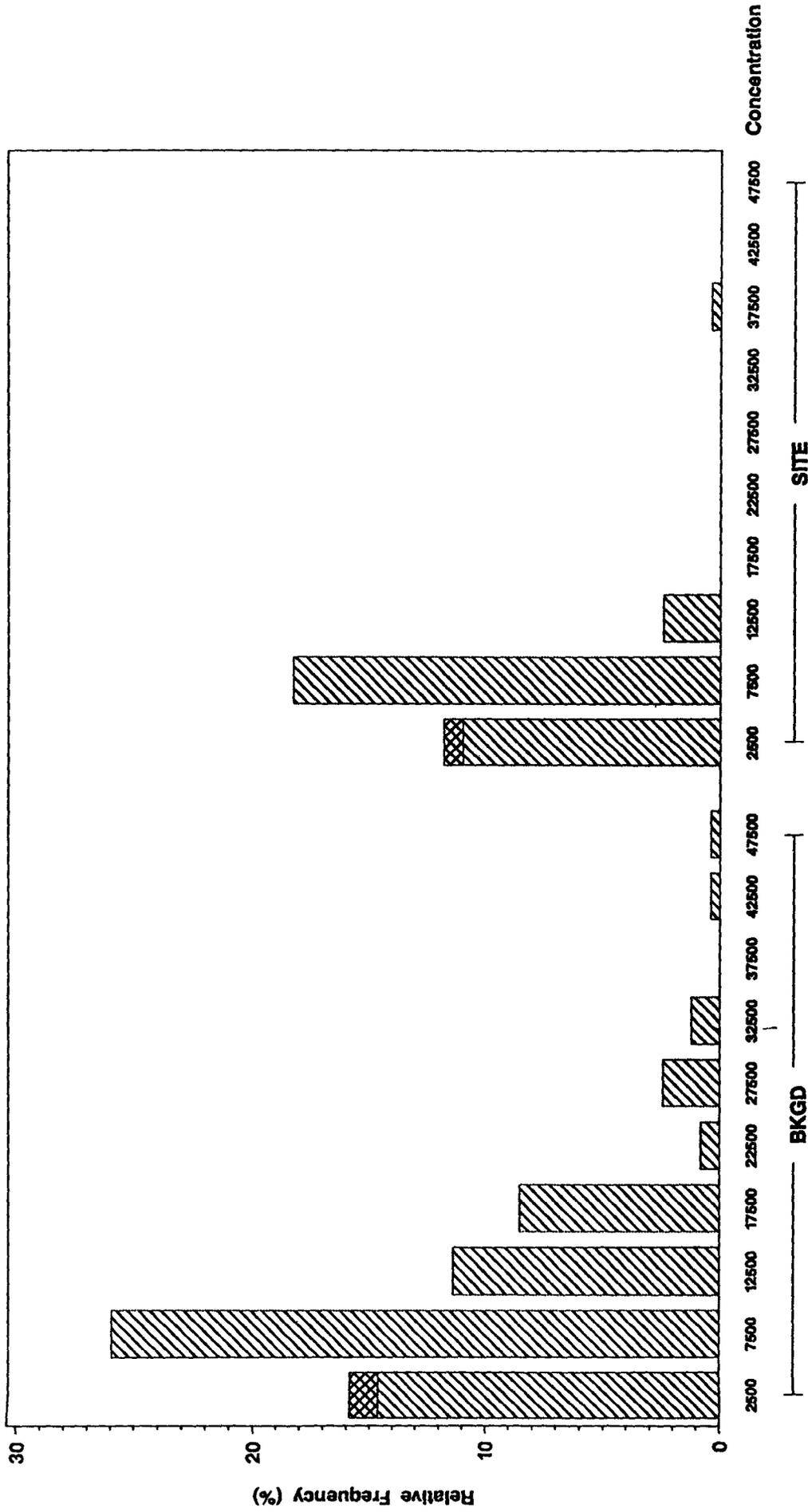
**Figure D-39**  
**Time Series Plots - Total Lead**



◆ Hit - Y  
○ Hit - N

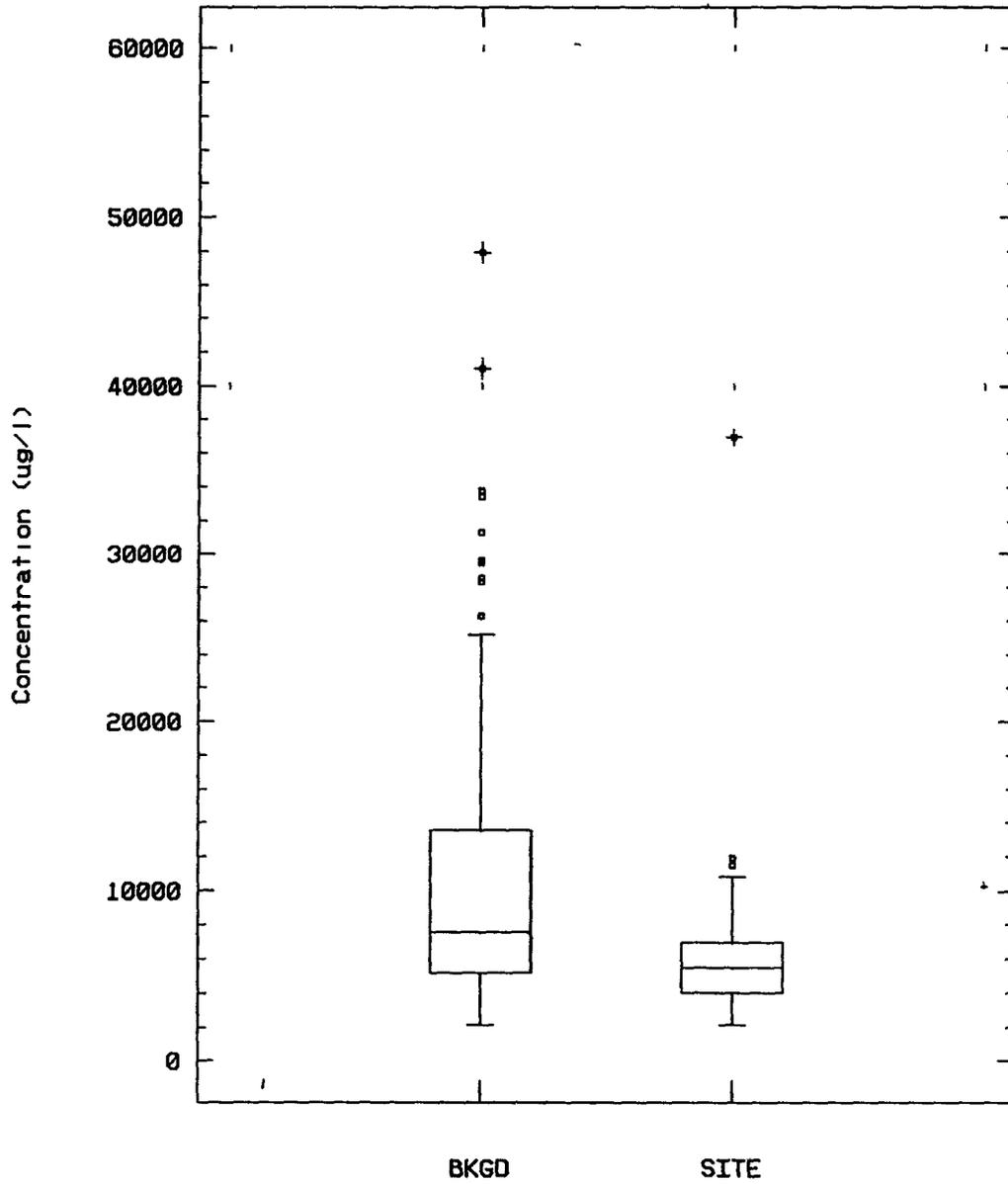
# Figure 00 Background vs OU11 UHSU Groundwater Frequency Histogram

MAGNESIUM (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

Figure D-41  
Background vs OU11 UHSU Groundwater  
Magnesium in Groundwater (Total)

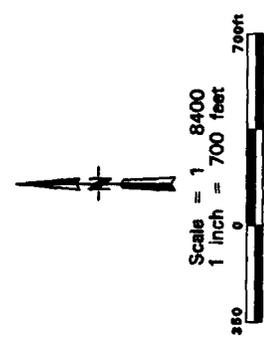


Groundwater samples within and downgradient of IHSS 168

# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (HSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 25479



State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 MAGNESIUM  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-42

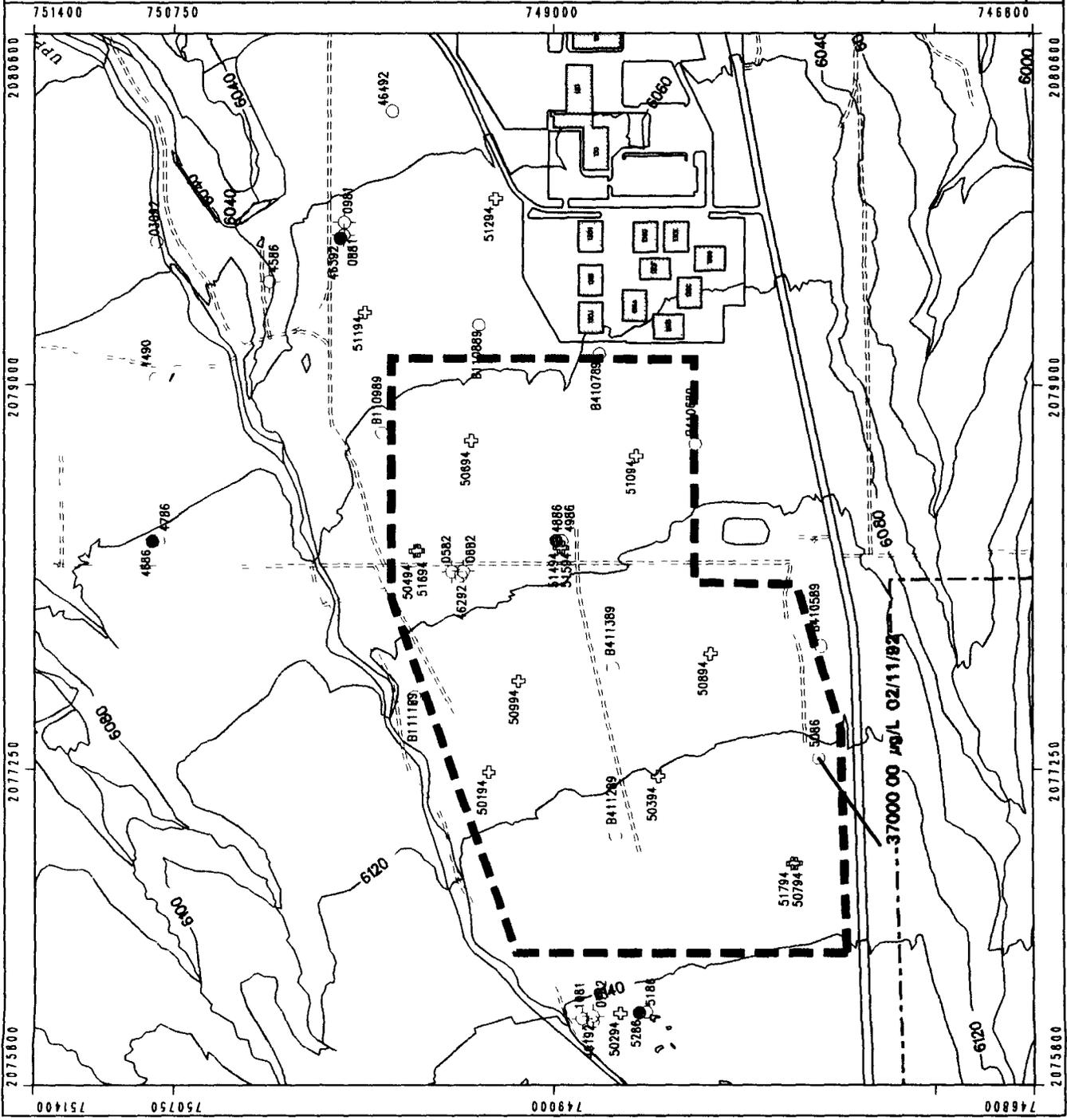
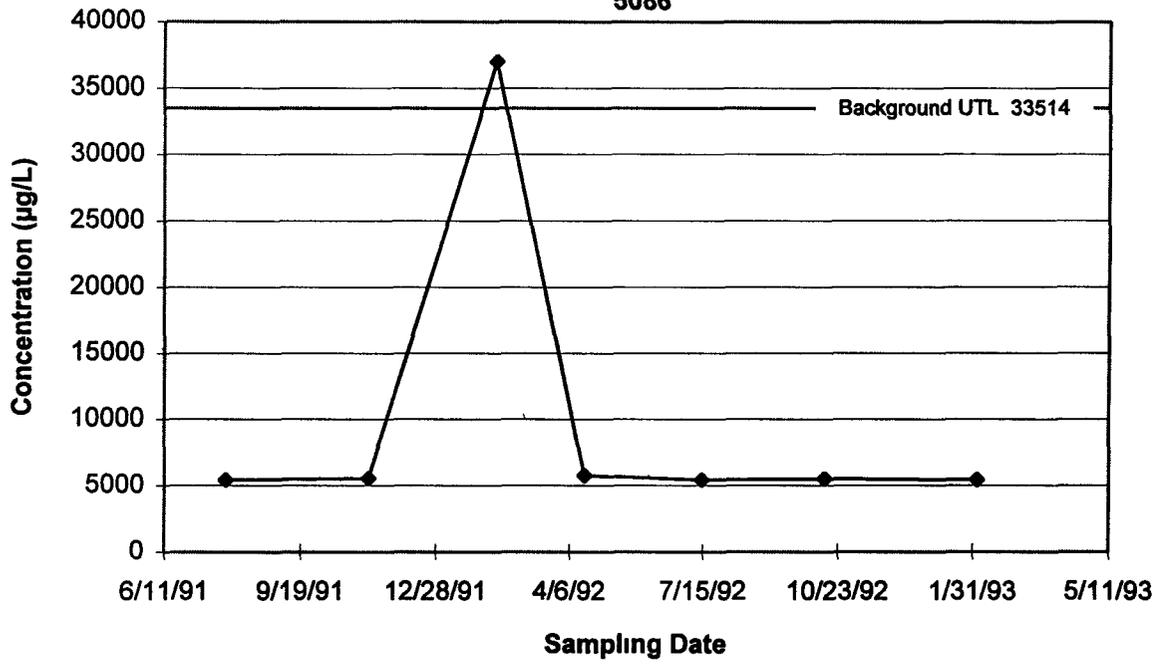


Figure D-43  
Time Series Plot - Total Magnesium  
5086



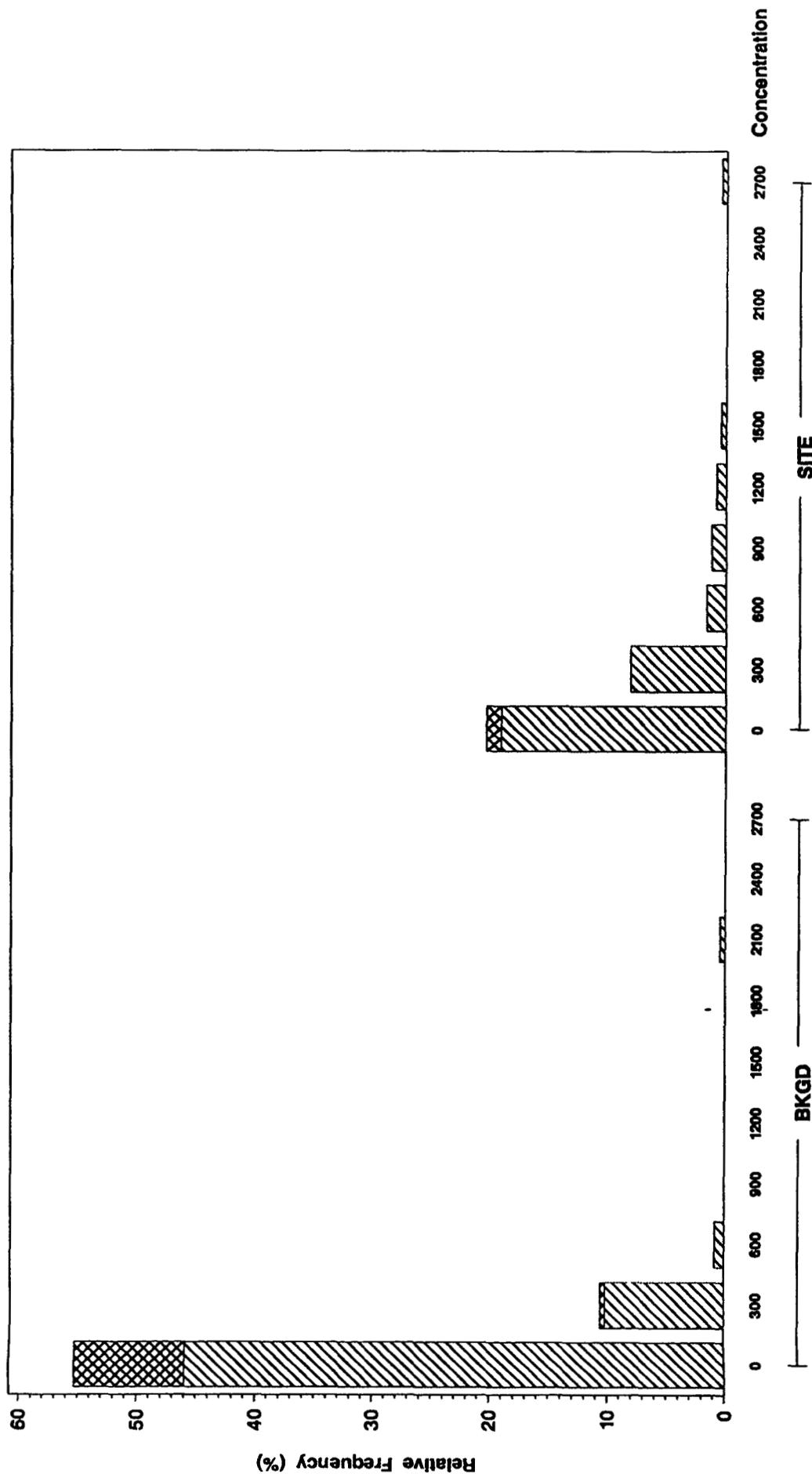
◆ Hit - Y  
○ Hit - N

Figure 44

# Background vs OU11 UHSU Groundwater

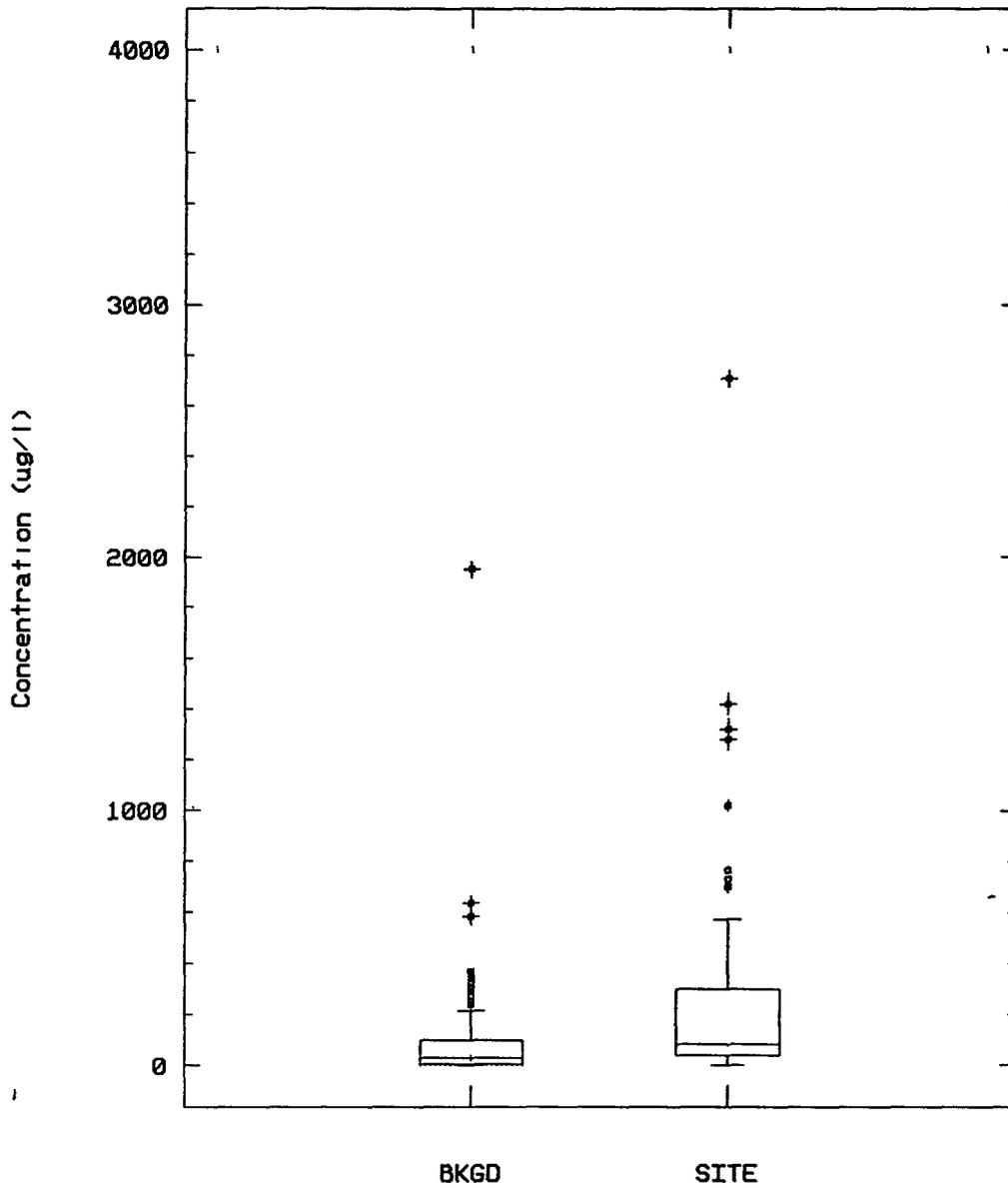
## Frequency Histogram

### MANGANESE (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

Figure D-45  
Background vs OU11 UHSU Groundwater  
Manganese in Groundwater (Total)

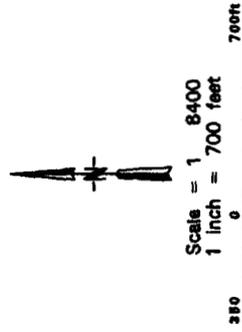


Groundwater samples within and downgradient of IHSS 168

# EXPLANATION

- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊖ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
BM+2SD = 446

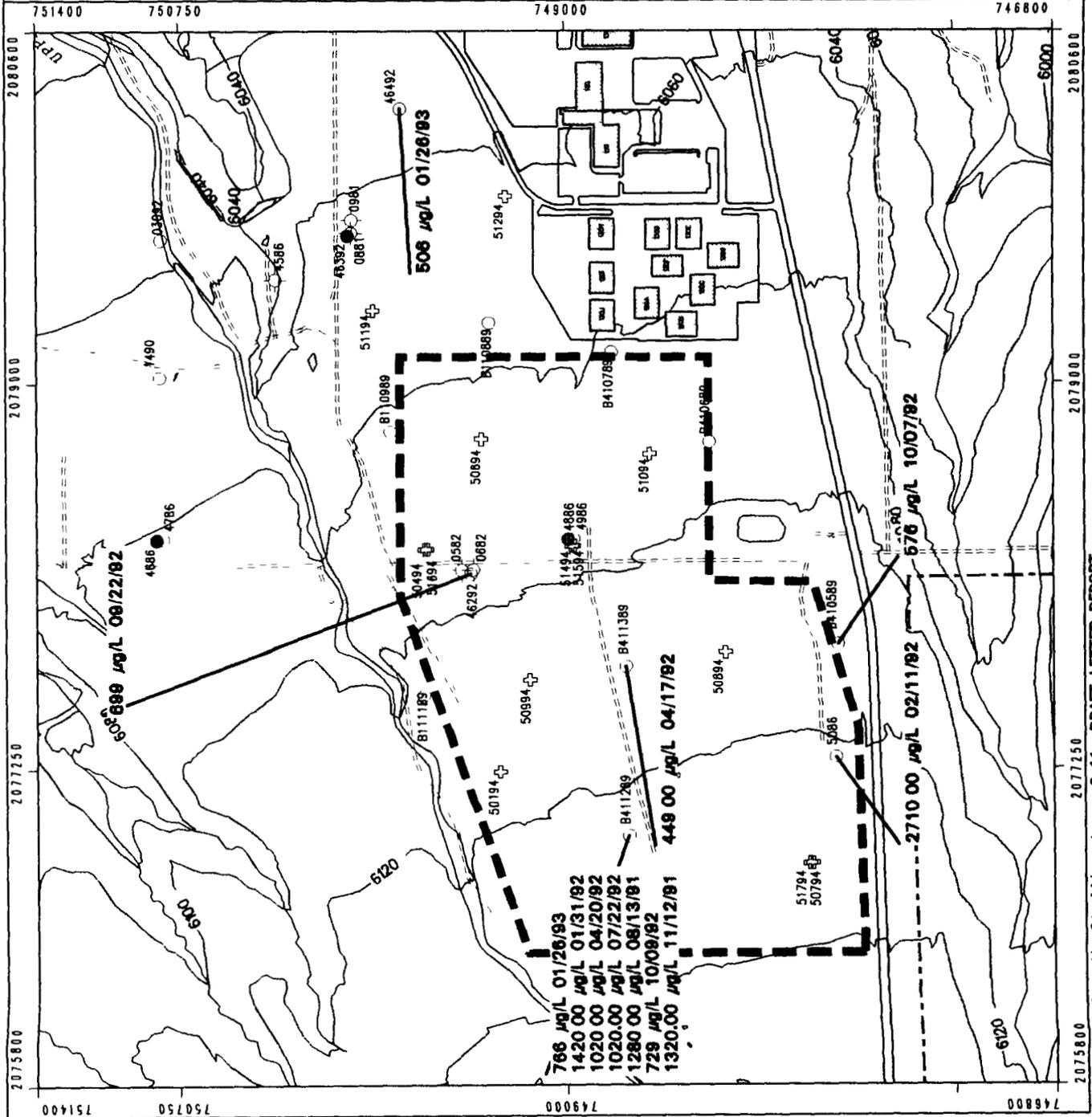


State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
MANGANESE  
Concentrations\*  
(and Sample Dates) in  
UHSU Ground Water

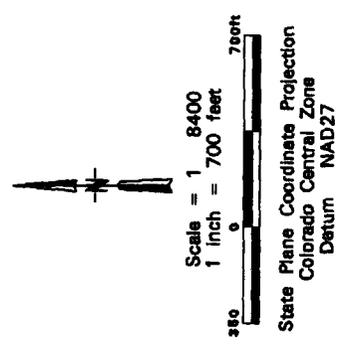
March 1995 Figure D-46



# EXPLANATION

- 1984 Borehole
- 1984 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 0.600



U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 MERCURY  
 Concentrations\*  
 (and Sample Depths) in Subsurface  
 Geologic Materials (0 to 12 Feet)

March 1995 Figure D-47

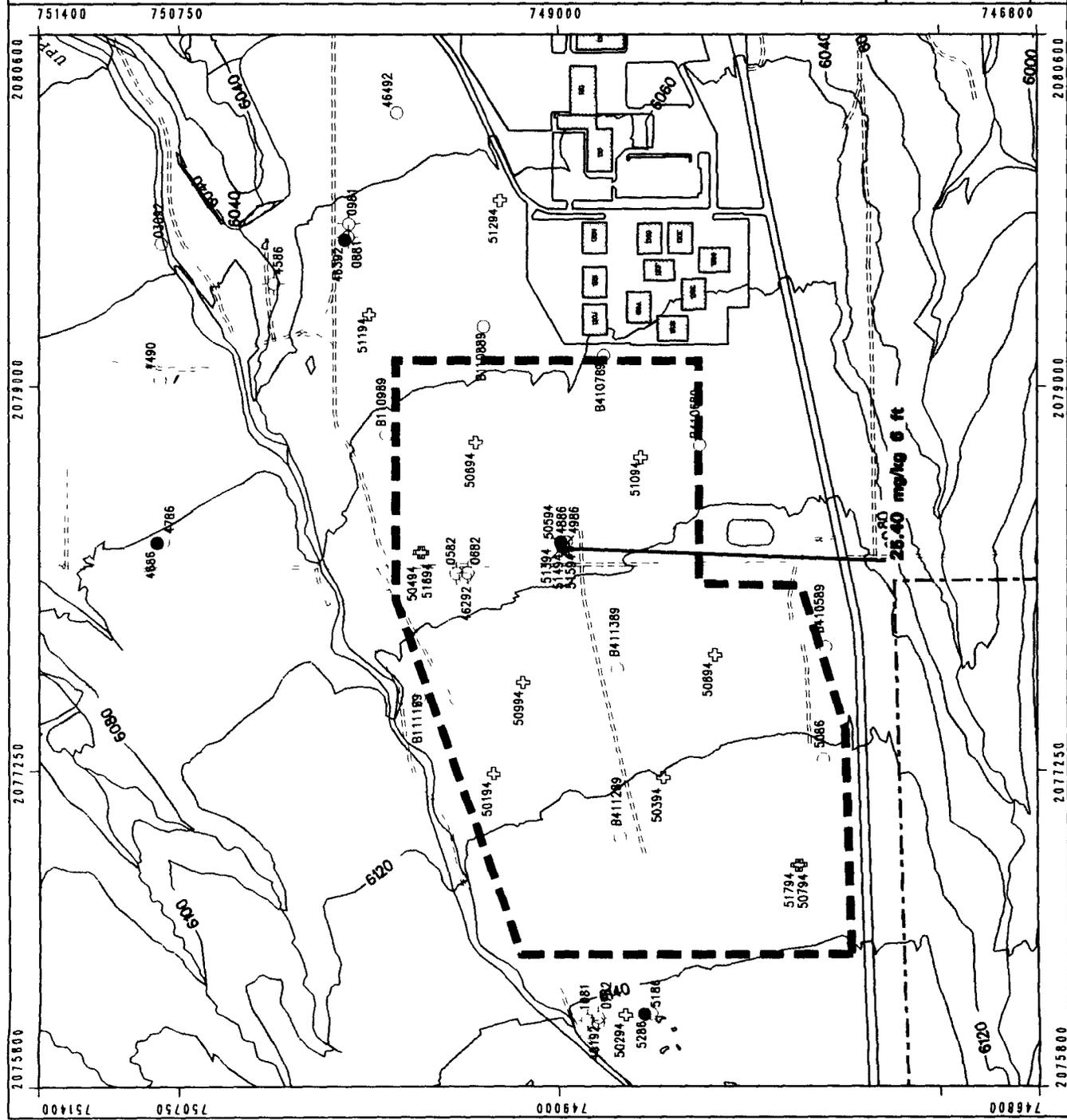
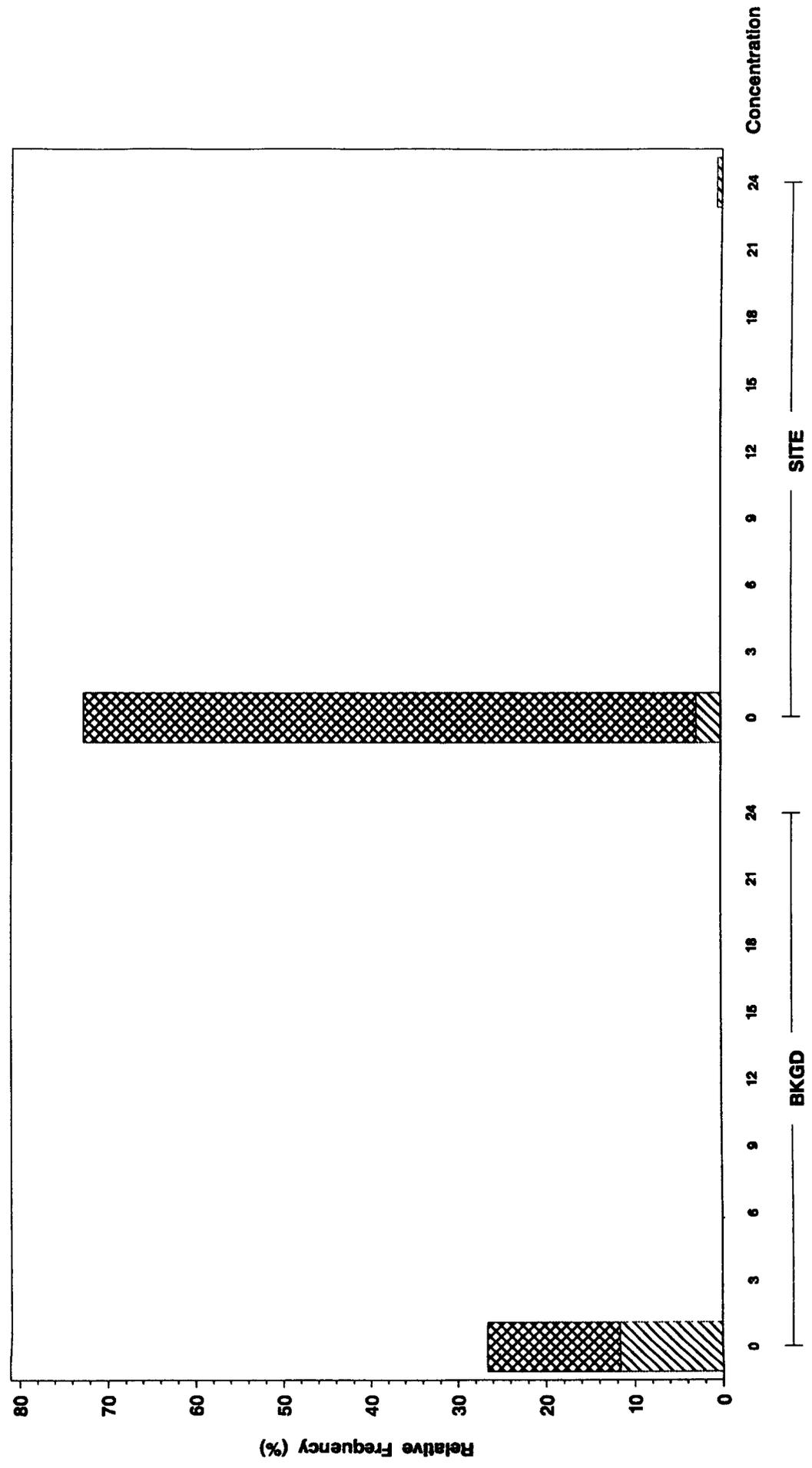


Figure 18

# Background (subsurface geologic material) Qrf vs OU11 Qrf

## Frequency Histogram MERCURY (mg/kg) in Qrf (0 to 12 feet)

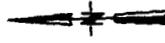


SITE = Boreholes within IHSS 168

# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 0.100



Scale = 1" = 8400'  
 1 inch = 700 feet



State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 MERCURY  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-49

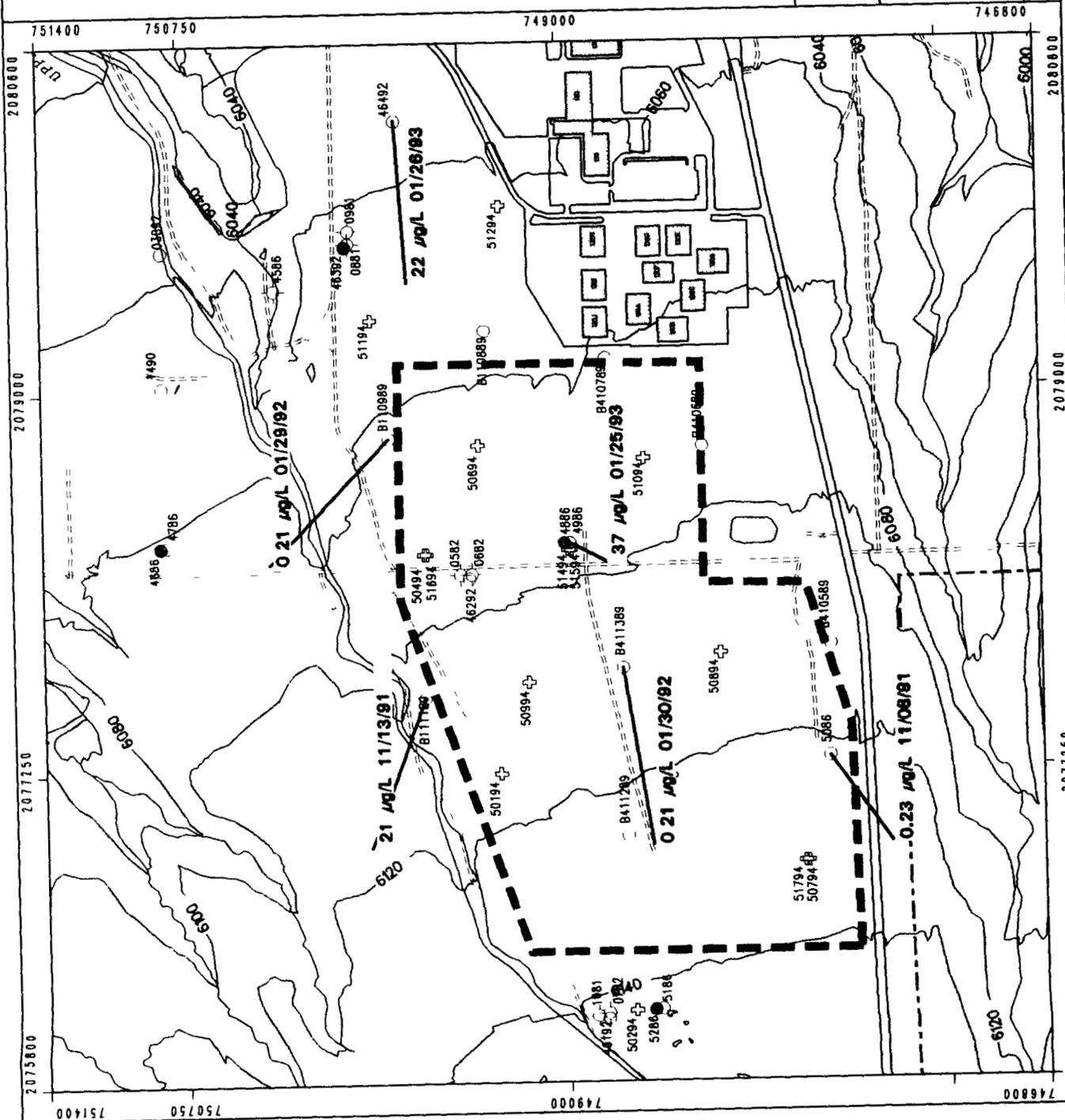
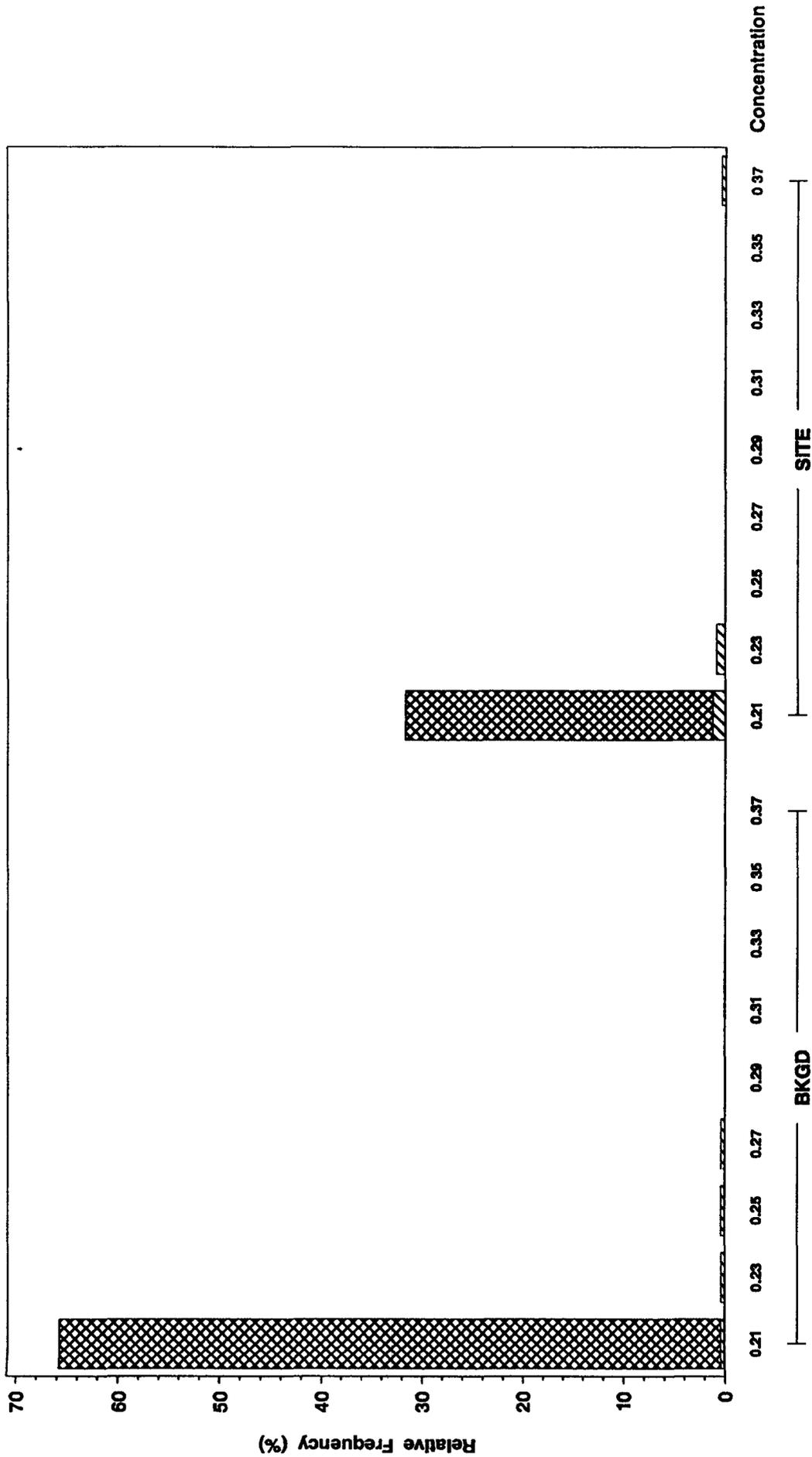


Figure D

# Background vs OU11 UHSU Groundwater

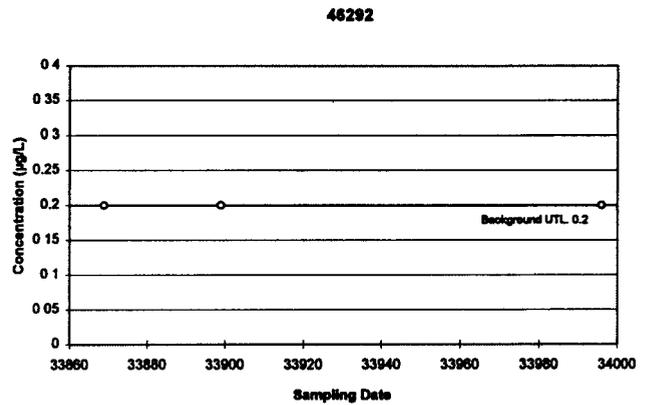
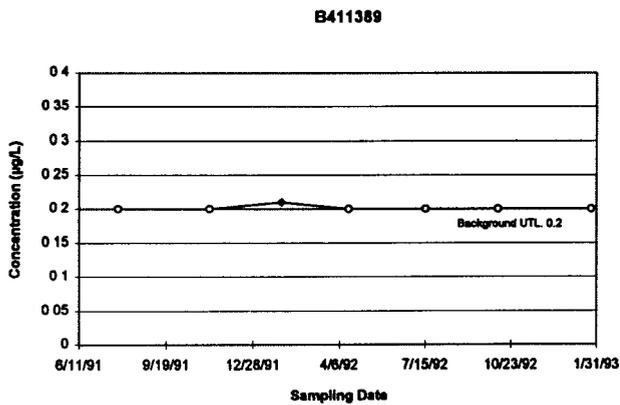
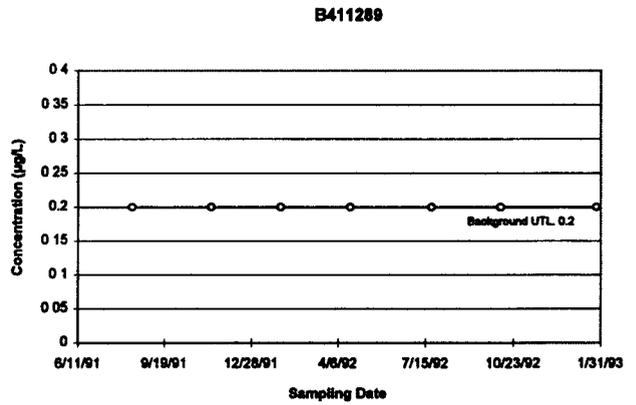
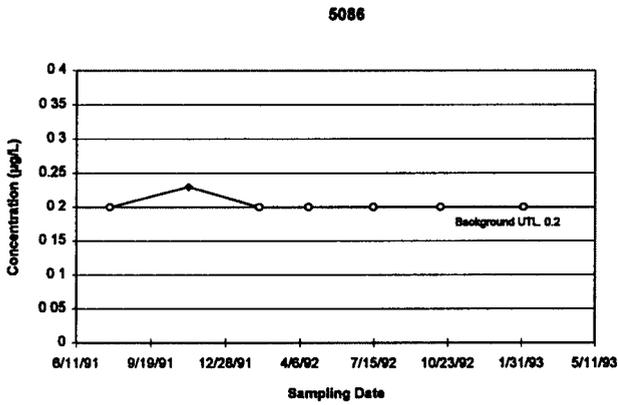
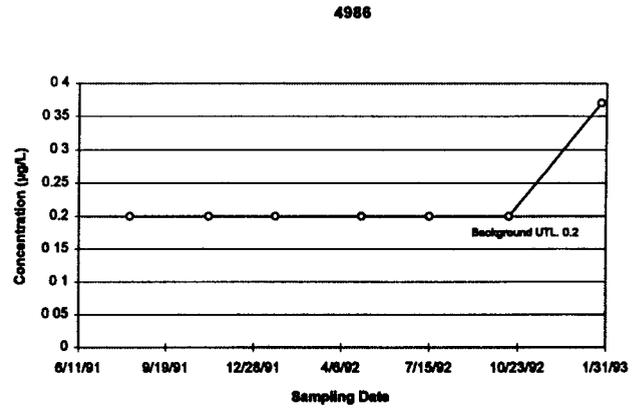
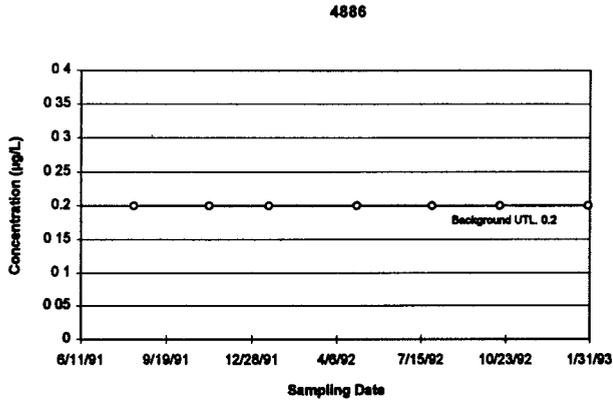
## Frequency Histogram

### MERCURY (ug/l) in Groundwater (Total)



SITE=UHSU samples from saturated media within and downgradient of IHSS 168

**Figure D-51**  
**Time Series Plots - Total Mercury**



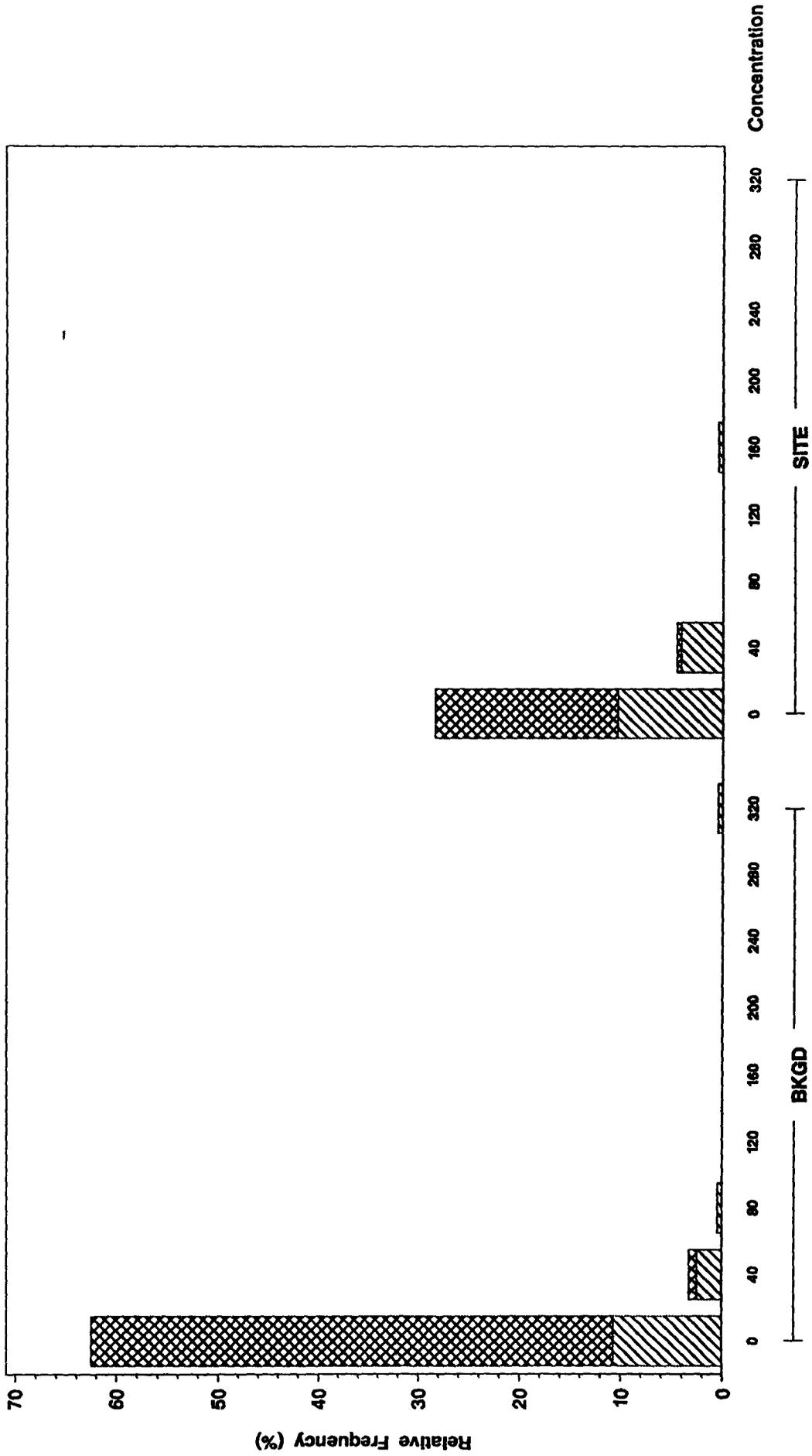
◆ Hit - Y  
○ Hit - N

Figure D-52

# Background vs OU11 UHSU Groundwater

## Frequency Histogram

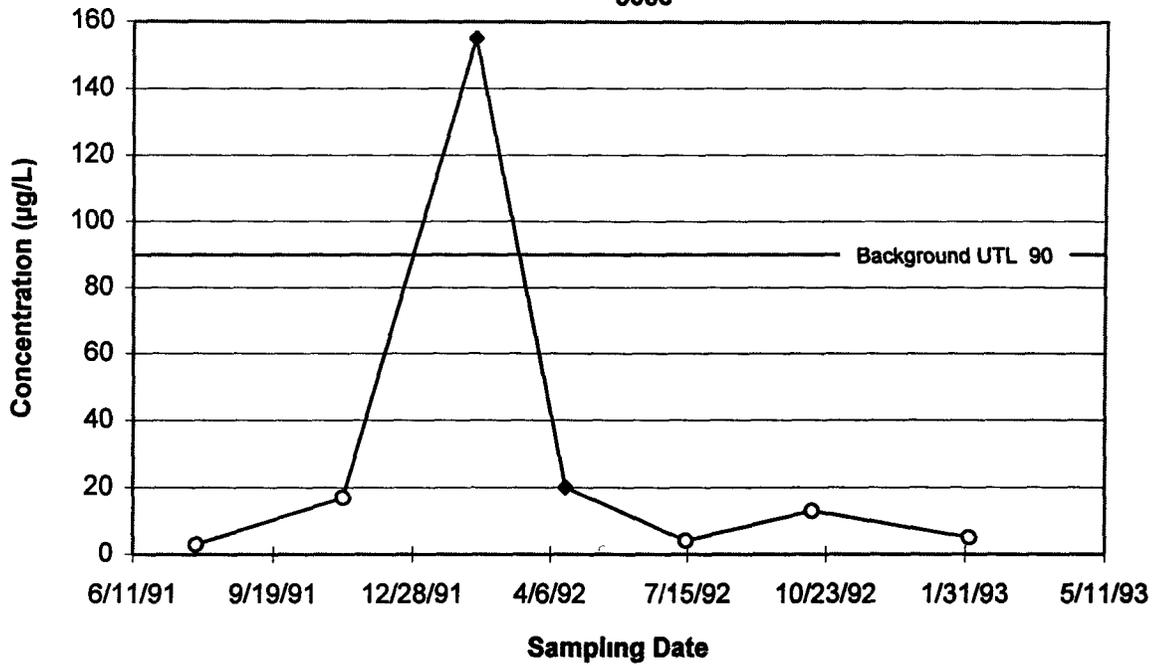
NICKEL (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168



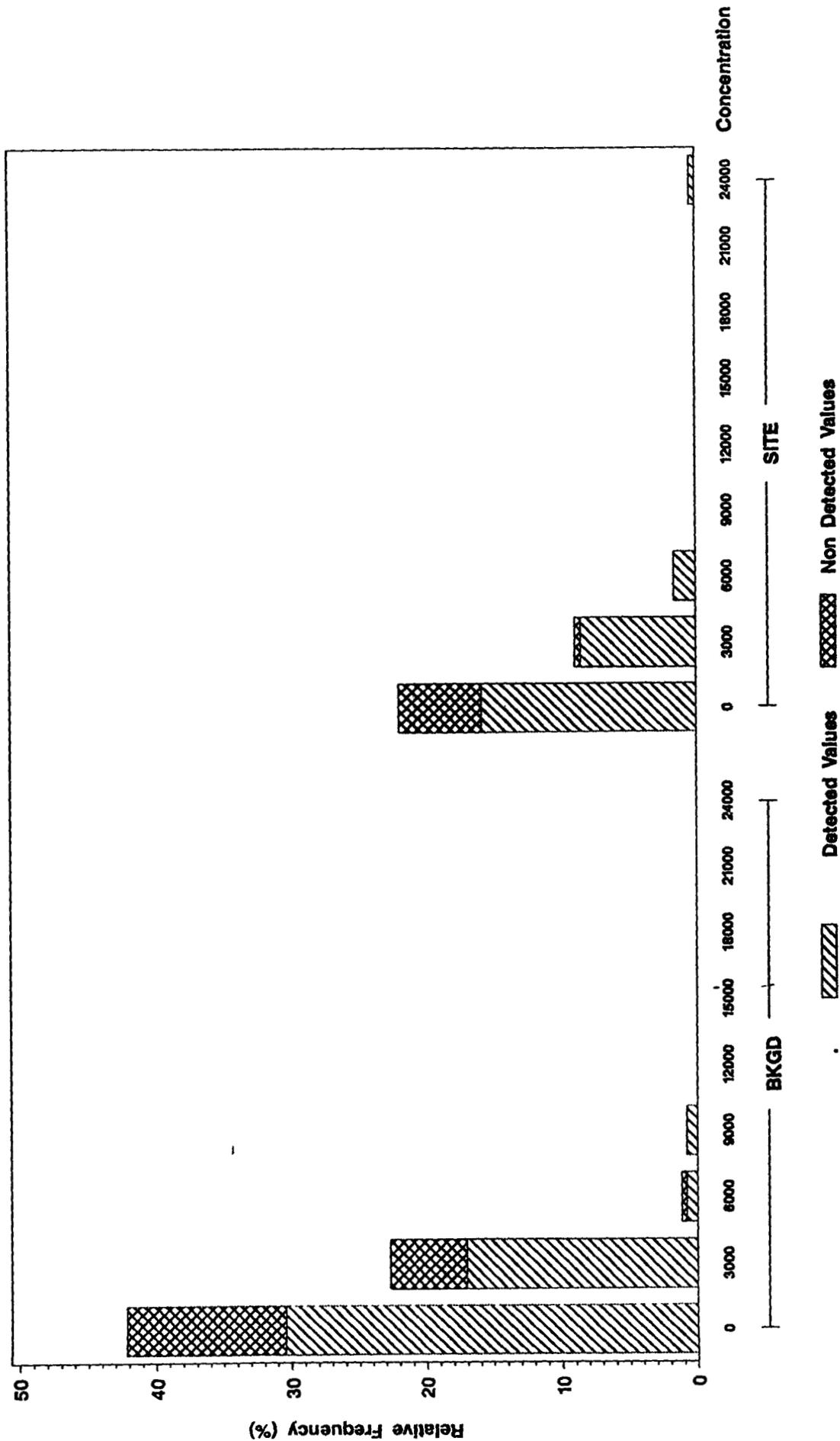
Figure D-54  
Time Series Plot - Total Nickel  
5086



◆ Hit - Y  
○ Hit - N

Figure D-55

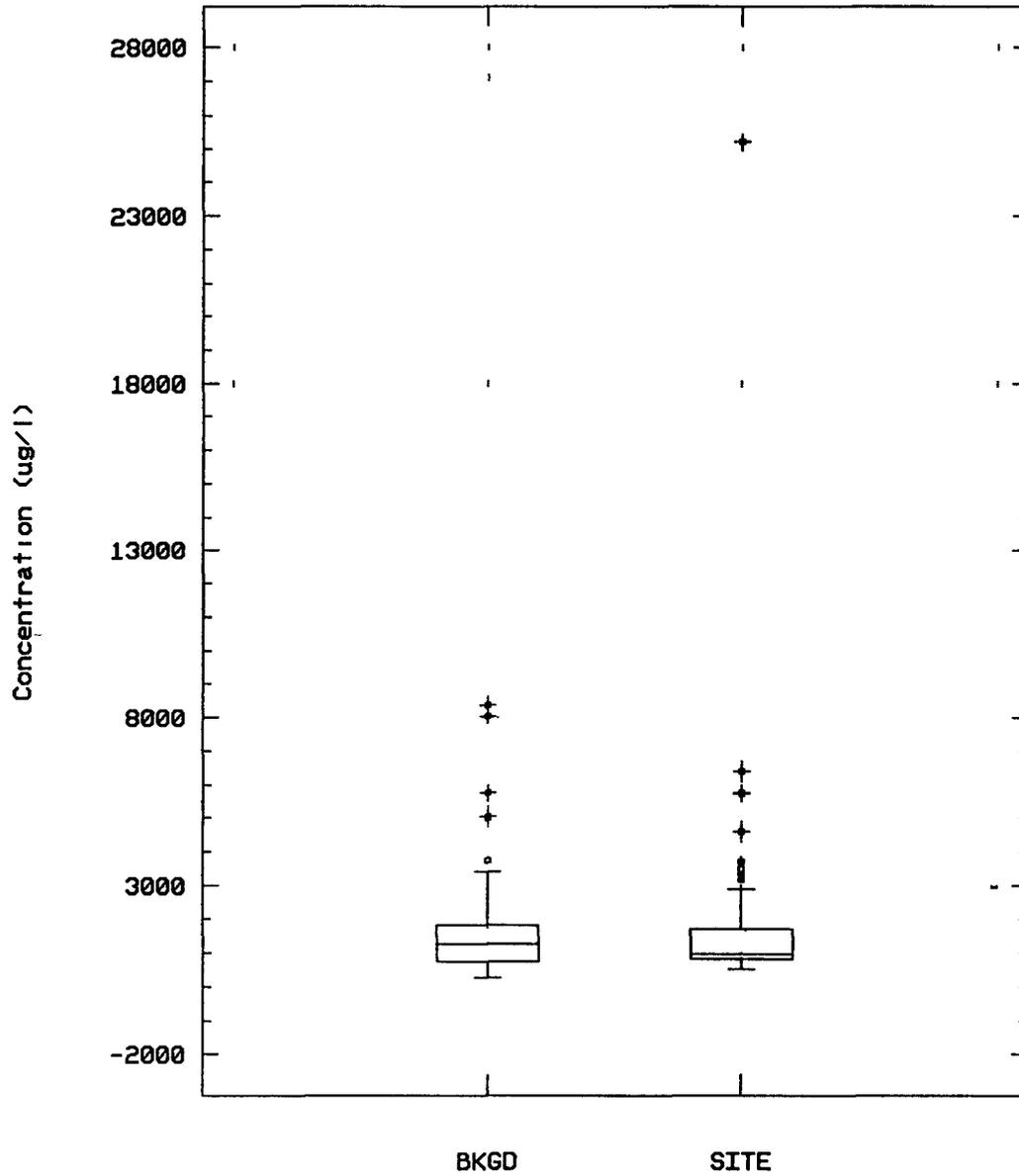
# Background vs OU1 UHSU Groundwater Frequency Histogram POTASSIUM (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

Figure D-56  
Background vs OU11 UHSU Groundwater

Potassium in Groundwater (Total)



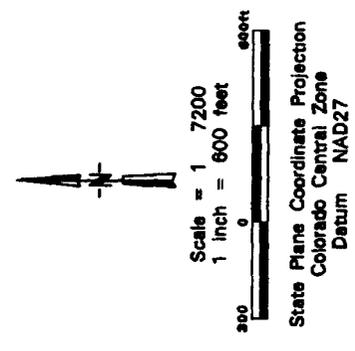
Groundwater samples within and downgradient of IHSS 168



# EXPLANATION

- △ Sample Location
- ▲ Values above the reporting limits
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- - - OU 11 (IHSS 186) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Concentrations are in mg/kg



U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

Surficial Soil (0 to 2 Inches)  
 SILVER  
 Concentrations\*  
 at the  
 OU 11--West Spray Field

March 1995 Figure D-58

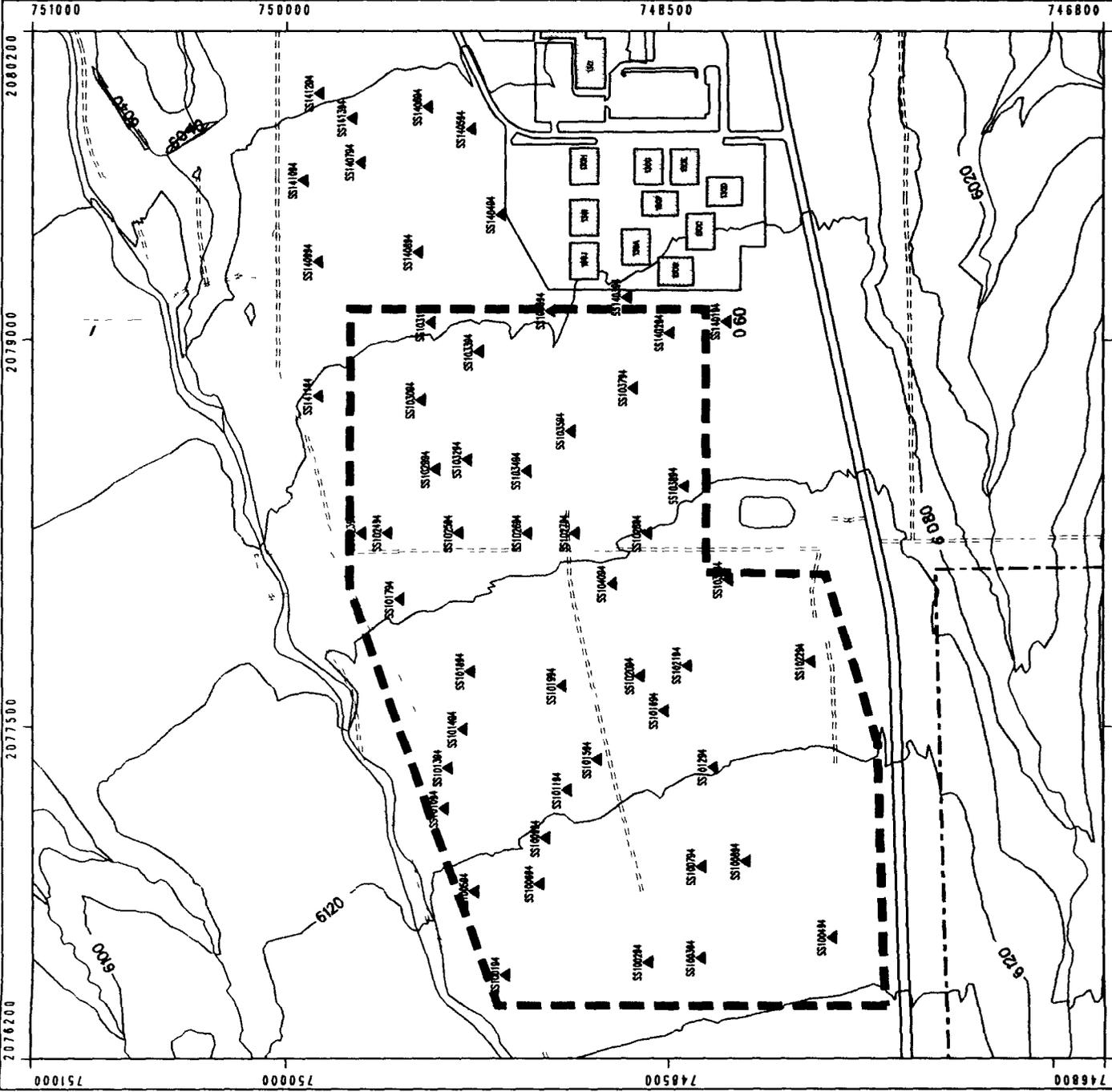
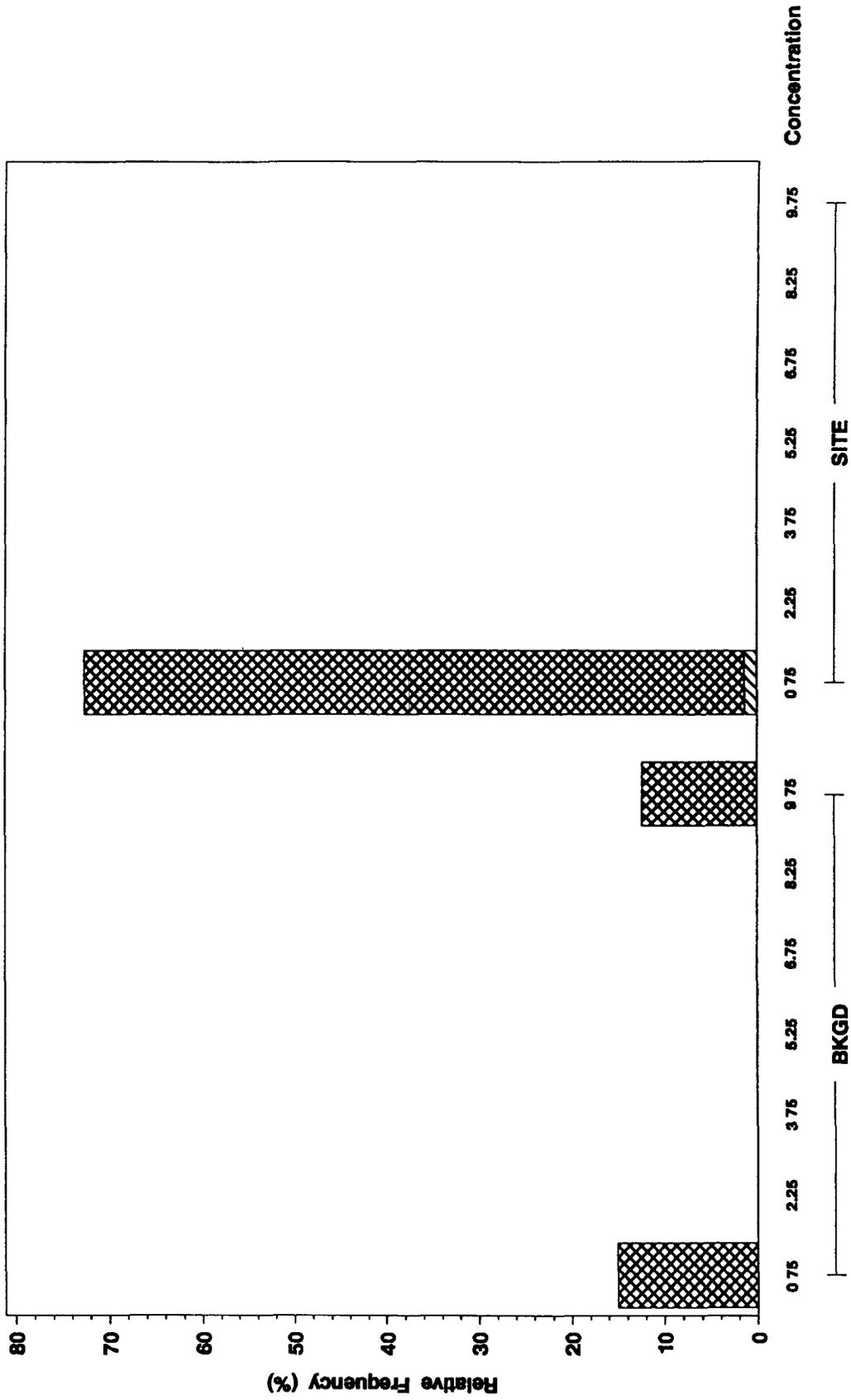


Figure B-39

# Background vs OU11 Surface Soil Frequency Histogram SILVER (mg/kg) in Surface Soil (0 - 2 inches)



SITE = All areas sampled within OU11

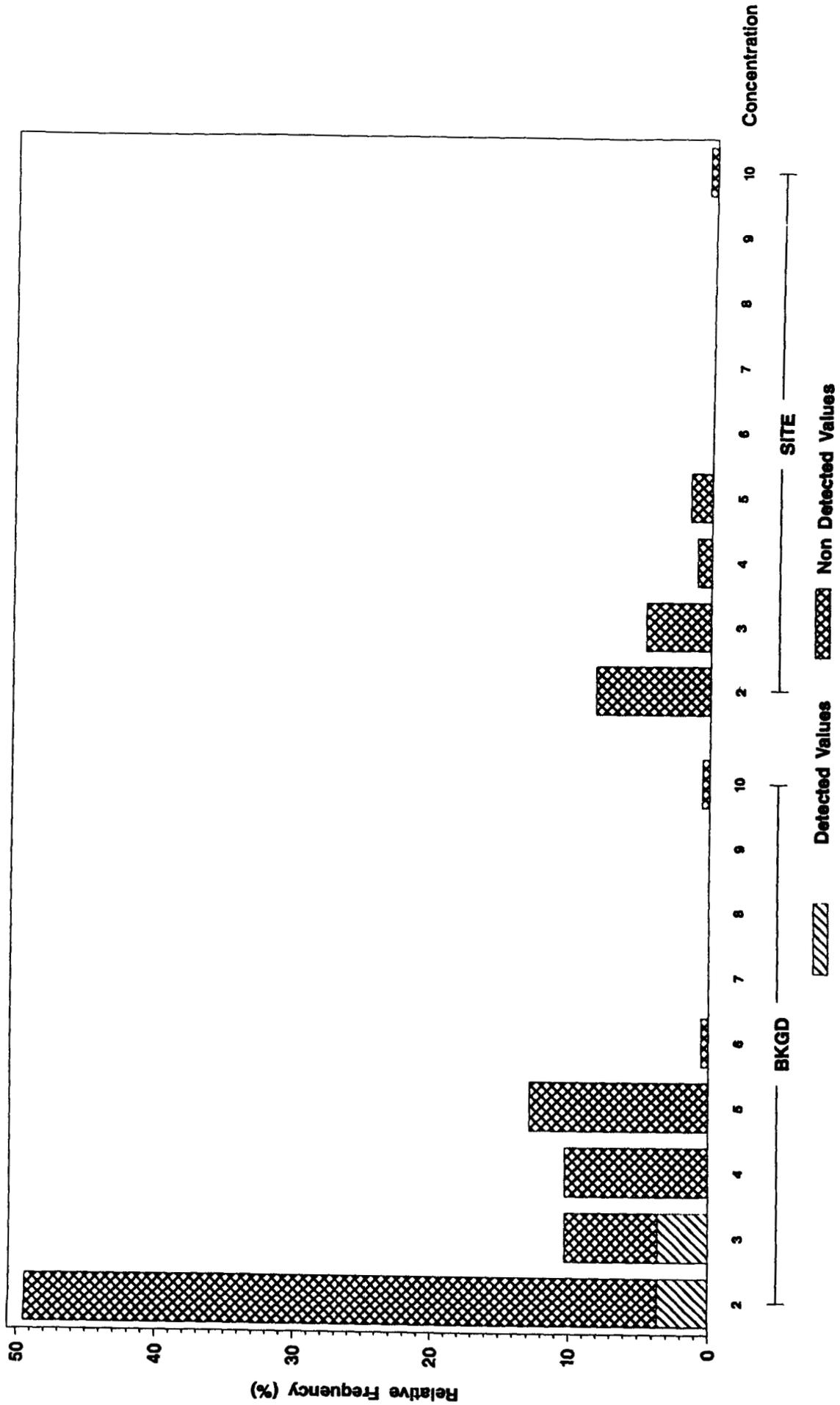


Figure 1

# Background vs OU11 UHSU Groundwater

## Frequency Histogram

### SILVER (ug/l) in Groundwater (Total)



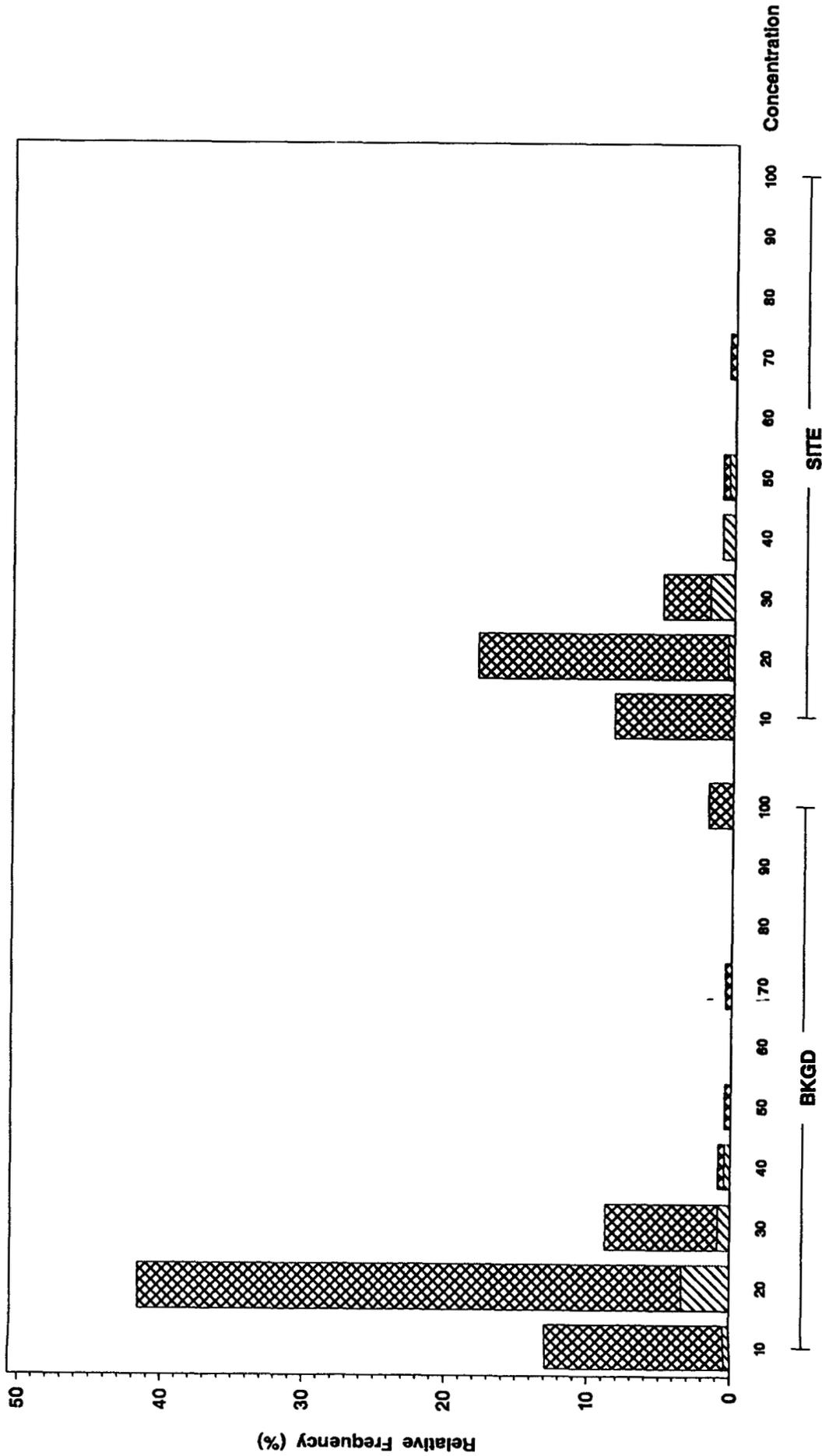
SITE = Wells in IHSS 168

Figure 2

# Background vs OU11 UHSU Groundwater

## Frequency Histogram

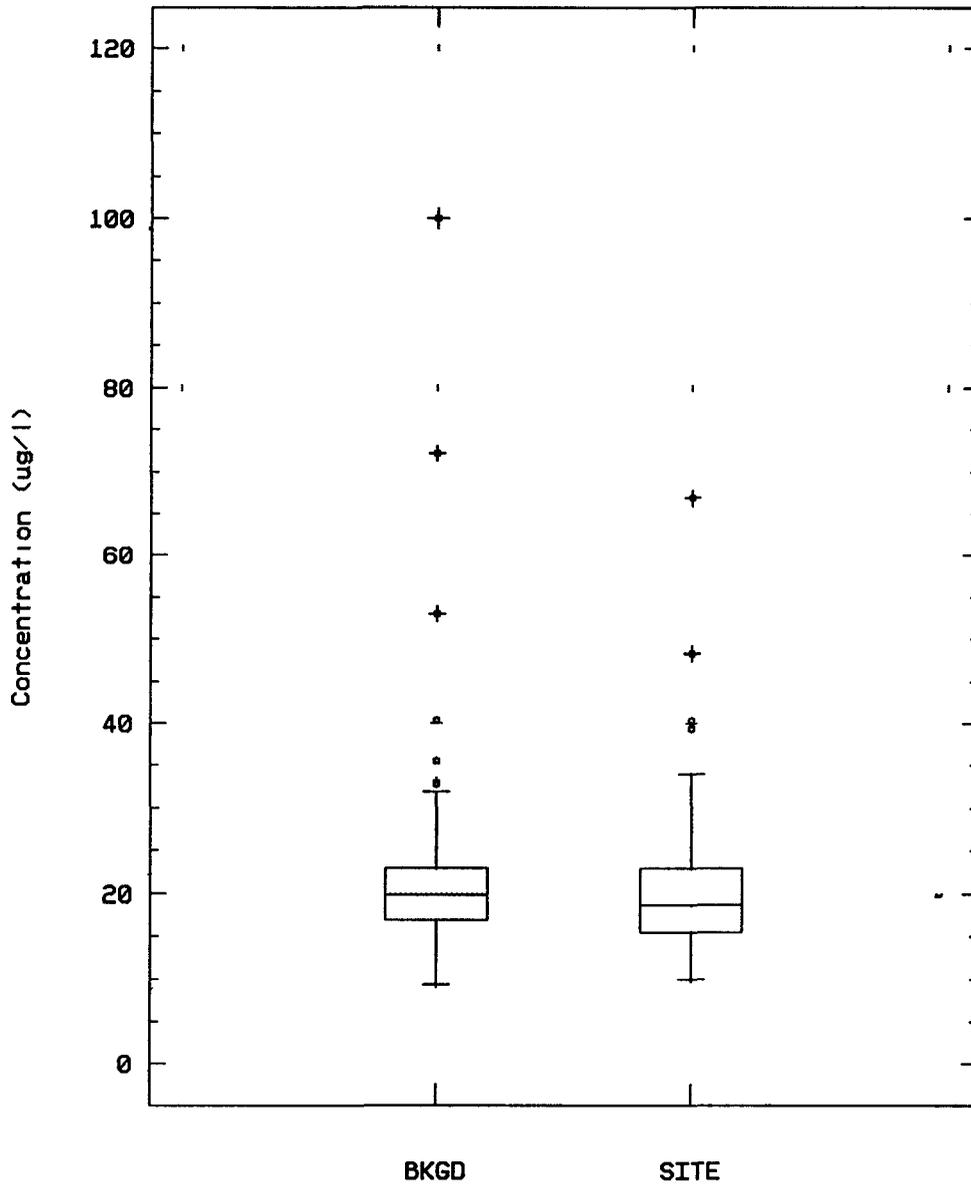
TIN (ug/l) in Groundwater (Total)



SITE = UHSU samples from saturated media within and downgradient of IHSS 168

Figure D-63  
Background vs OU11 UHSU Groundwater

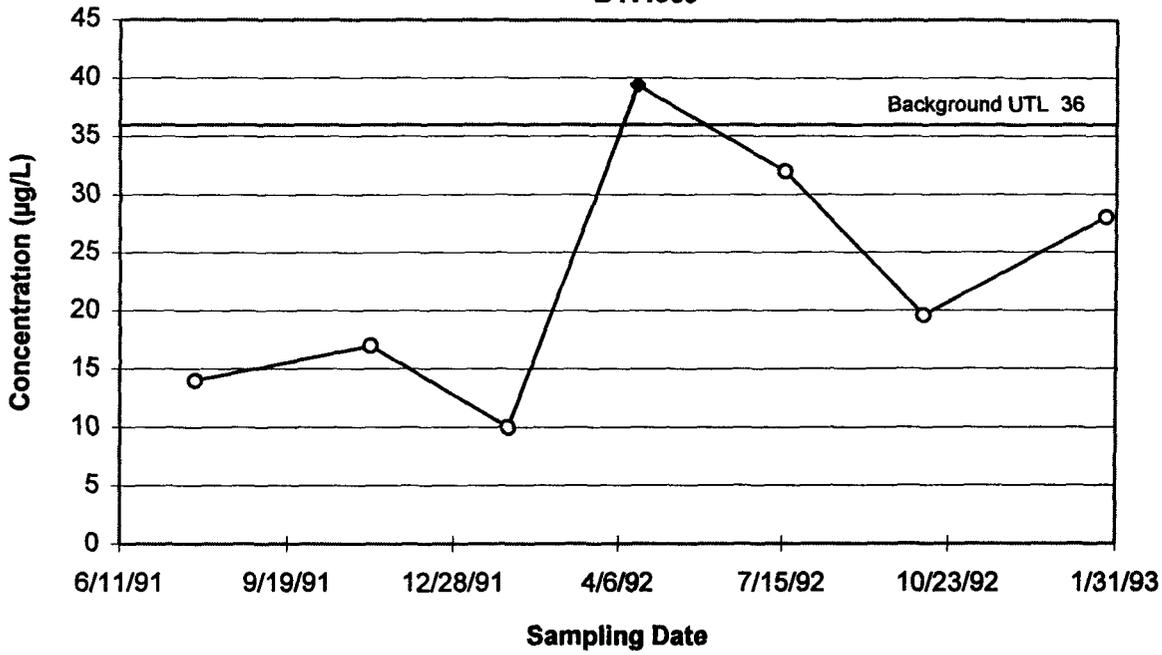
Tin in Groundwater (Total)



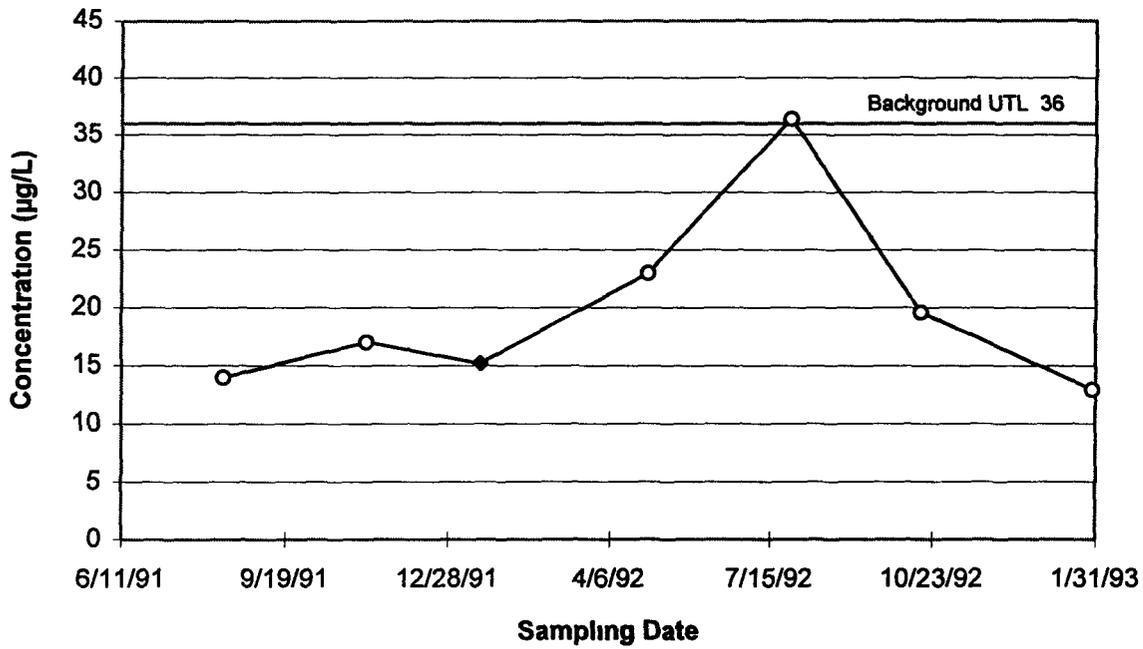
Groundwater samples within and downgradient of IHSS 168



Figure D-65  
 Time Series Plots - Total Tin  
 B411389

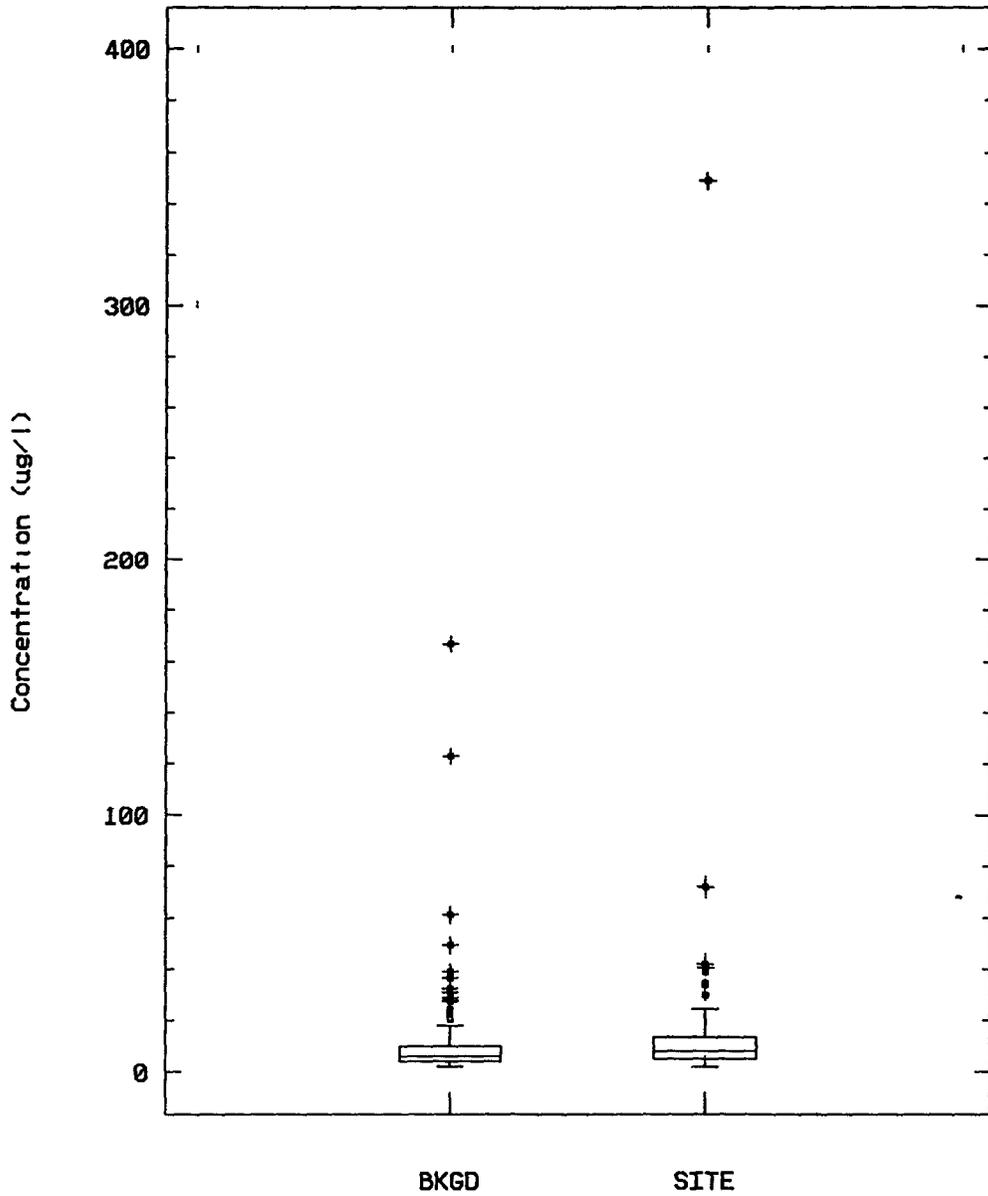


4886



● Hit - Y  
 ○ Hit - N

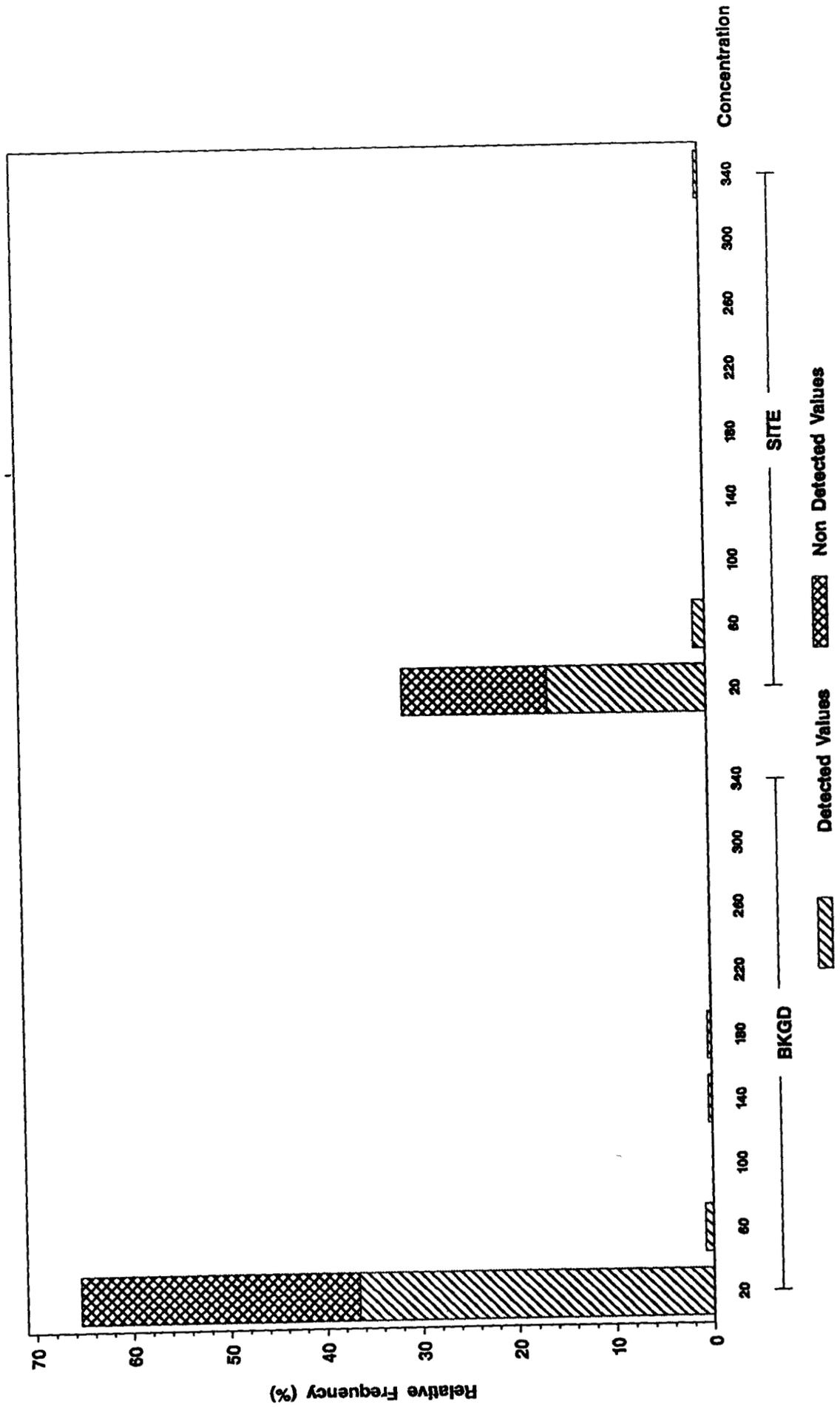
Figure D-66  
Background vs OU11 UHSU Groundwater  
Vanadium in Groundwater (Total)



Groundwater samples within and downgradient of IHSS 168

Figure D-67

# Background vs OU11 UHSU Groundwater Frequency Histogram VANADIUM (ug/l) in Groundwater (Total)

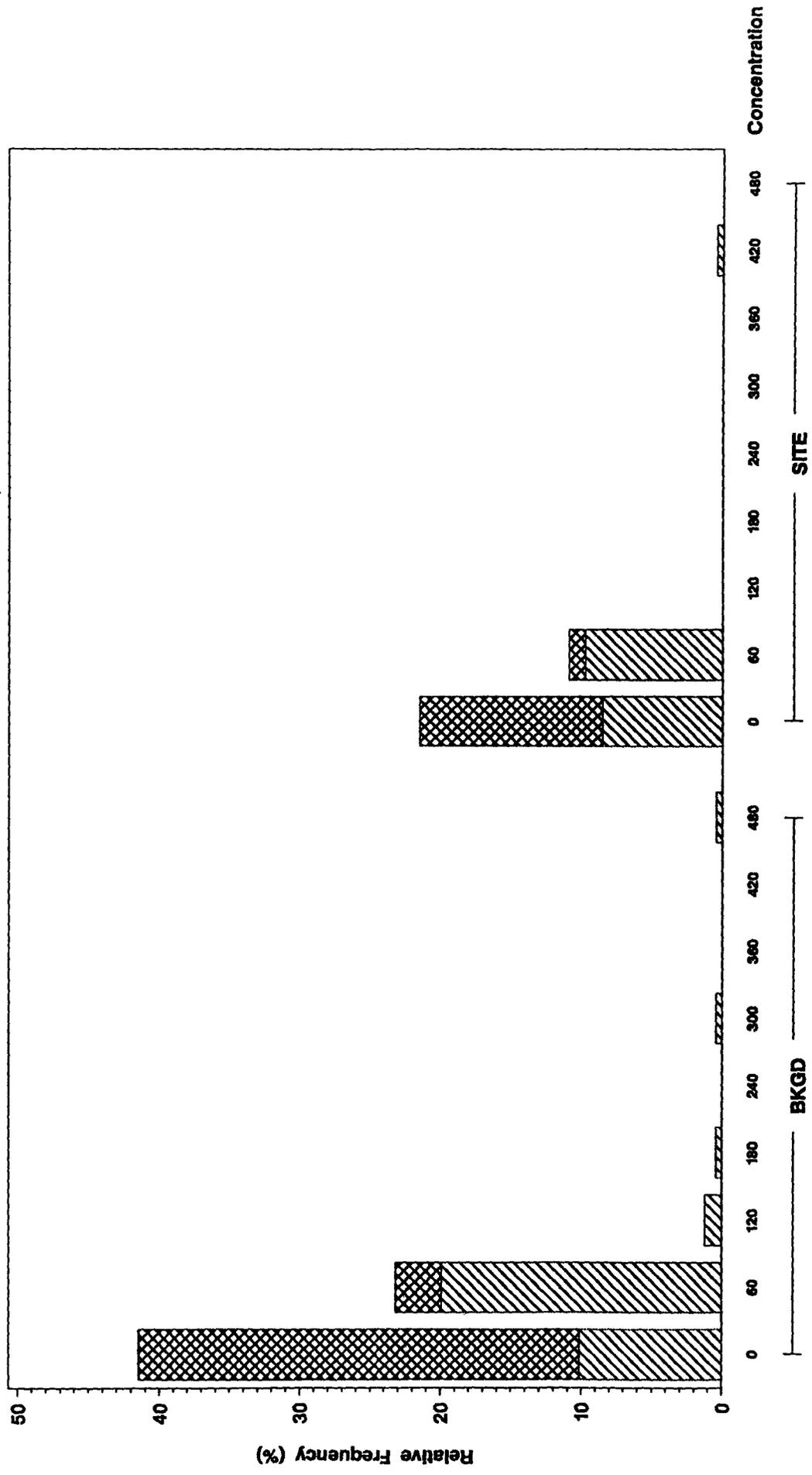


SITE = UHSU samples from saturated media within and downgradient of IHSS 168



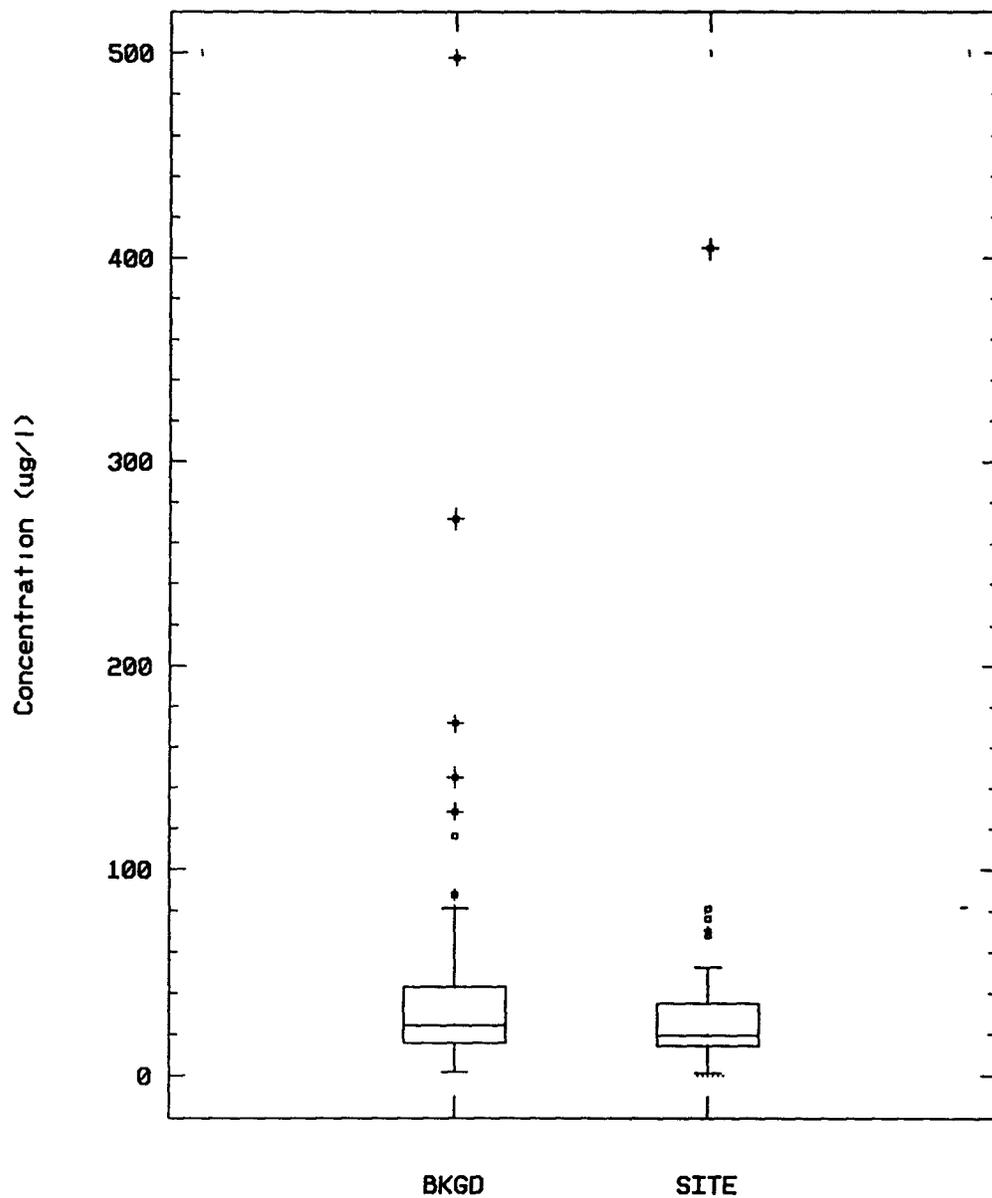
Figure D-69

# Background vs OU11 UHSU Groundwater Frequency Histogram ZINC (ug/l) in Groundwater (Total)



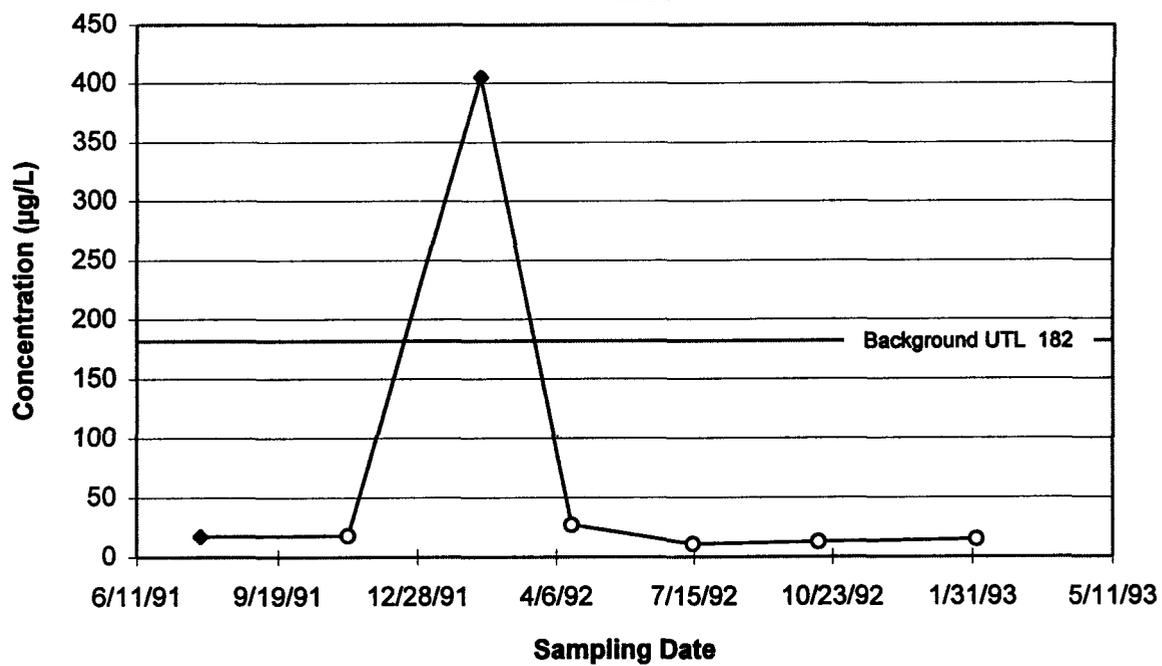
SITE = UHSU samples from saturated media within and downgradient of IHSS 168

Figure D-70  
Background vs OU11 UHSU Groundwater  
Zinc in Groundwater (Total)



Groundwater samples within and downgradient of IHSS 168

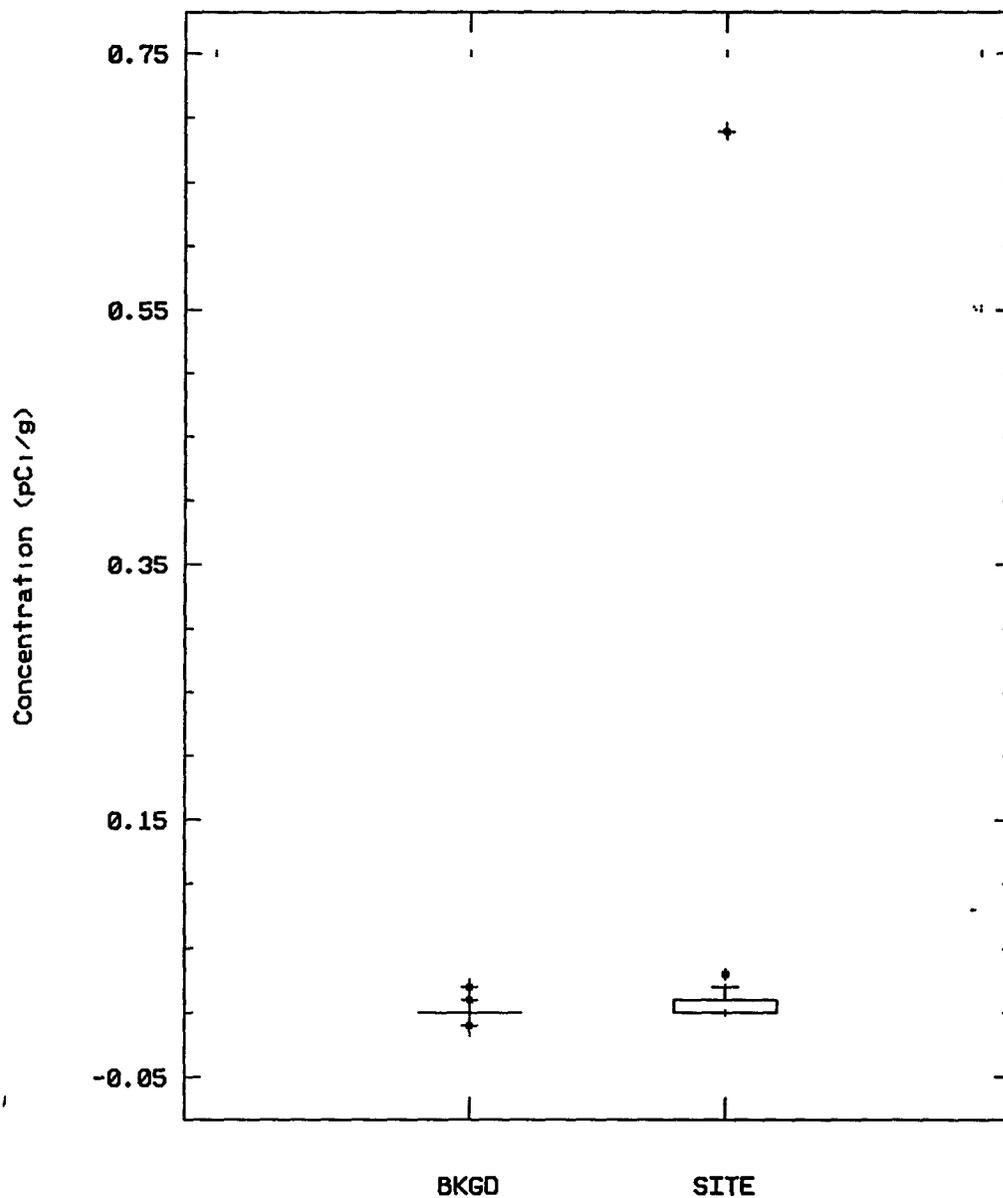
Figure D-71  
Time Series Plot - Total Zinc  
5086



◆ Hit - Y  
○ Hit - N

Figure D-72  
Background vs OU11 Subsurface Geologic Materials

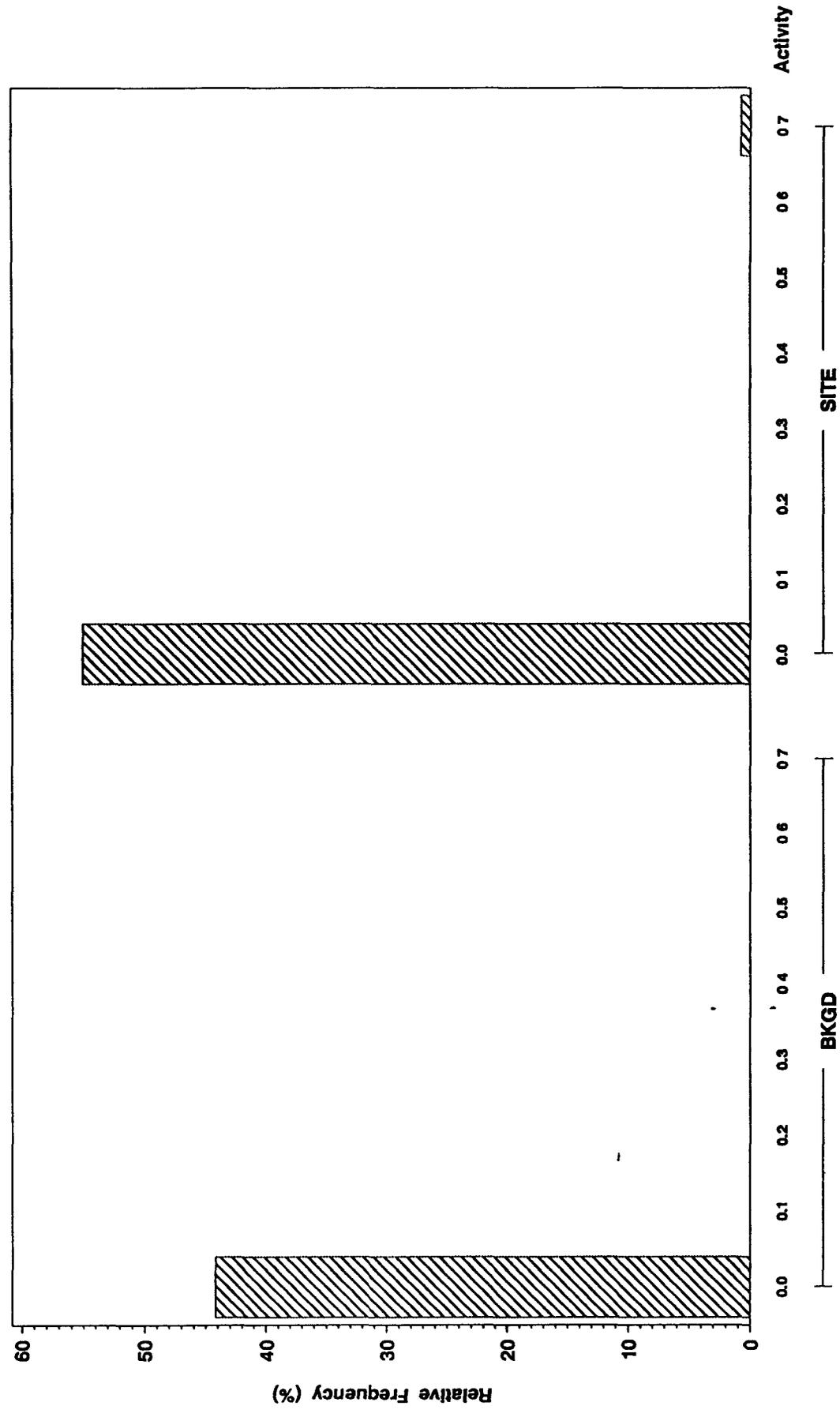
Plutonium-239/240 in Qrf  
(0 to 12 feet)



**Background (subsurface geologic material) Qrf vs OU11 Qrf (0 - 12 feet)**

Fig. D-73

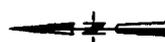
**Frequency Histogram  
PLUTONIUM - 239/240 (pCi/g) in Qrf**

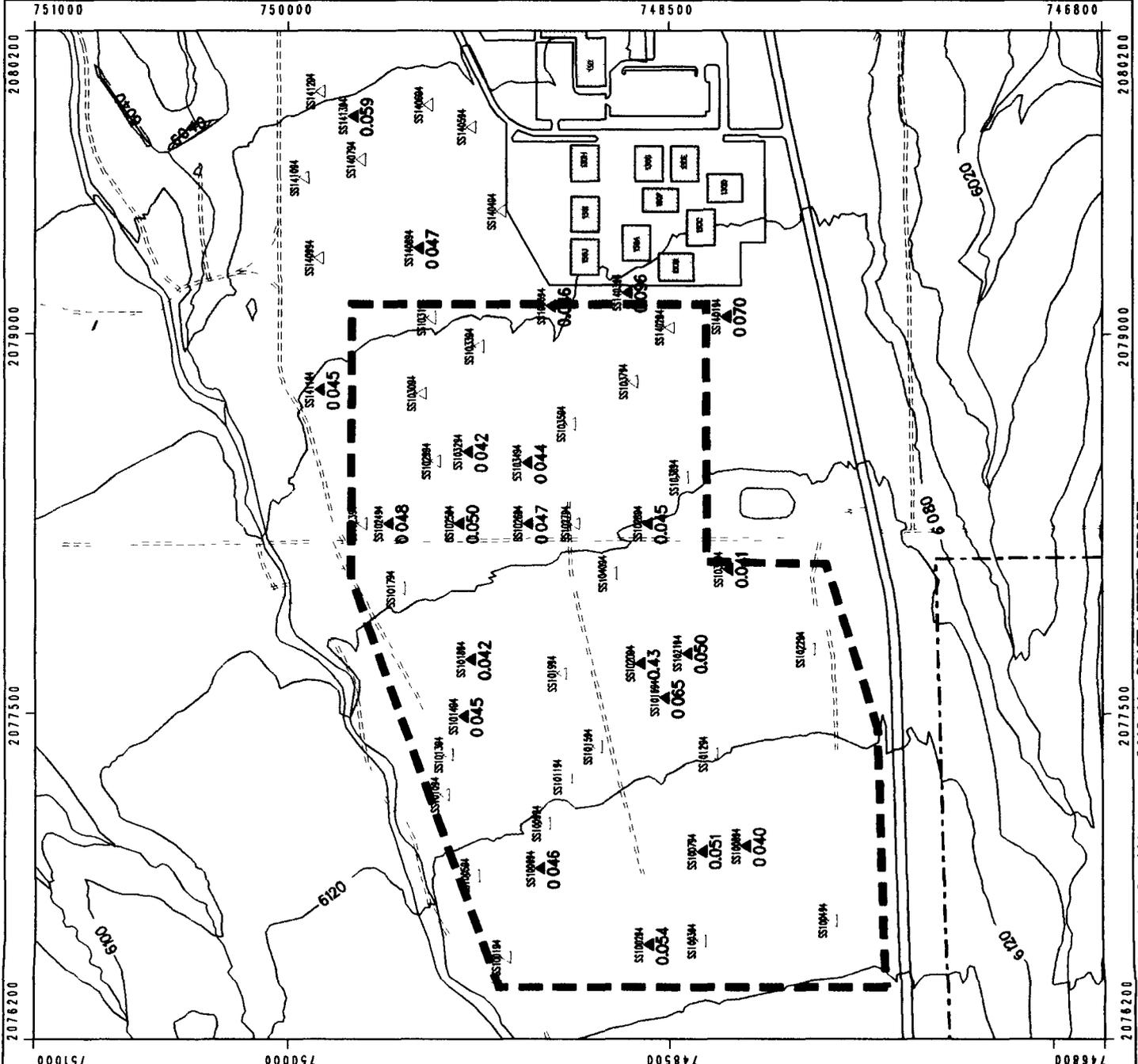


SITE = Borehole samples within and downgradient of IHSS 168



# EXPLANATION

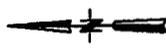
<p>△ Sample Location</p> <p>▲ Values above the background mean +2 standard deviations (BM+2SD)</p> <p>— Streams and Drainages</p> <p>--- Topographic Contours (20' Interval)</p> <p>== Paved Roads</p> <p>--- Dirt Roads</p> <p>--- Security Fences</p> <p>--- Rocky Flats Boundary</p> <p>--- OU 11 (IHSS 168) Boundary</p> <p>▭ Lakes and Ponds</p> <p>▭ Buildings</p>	<p>*Activities are in pCi/g BM+2SD = 0.039</p>	 <p>Scale = 1 7200 1 inch = 600 feet</p>  <p>State Plane Coordinate Projection Colorado Central Zone Datum NAD27</p>
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# EXPLANATION

- 1984 Borehole
- 1984 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 0.010



Scale = 1/8400  
 1 inch = 700 feet

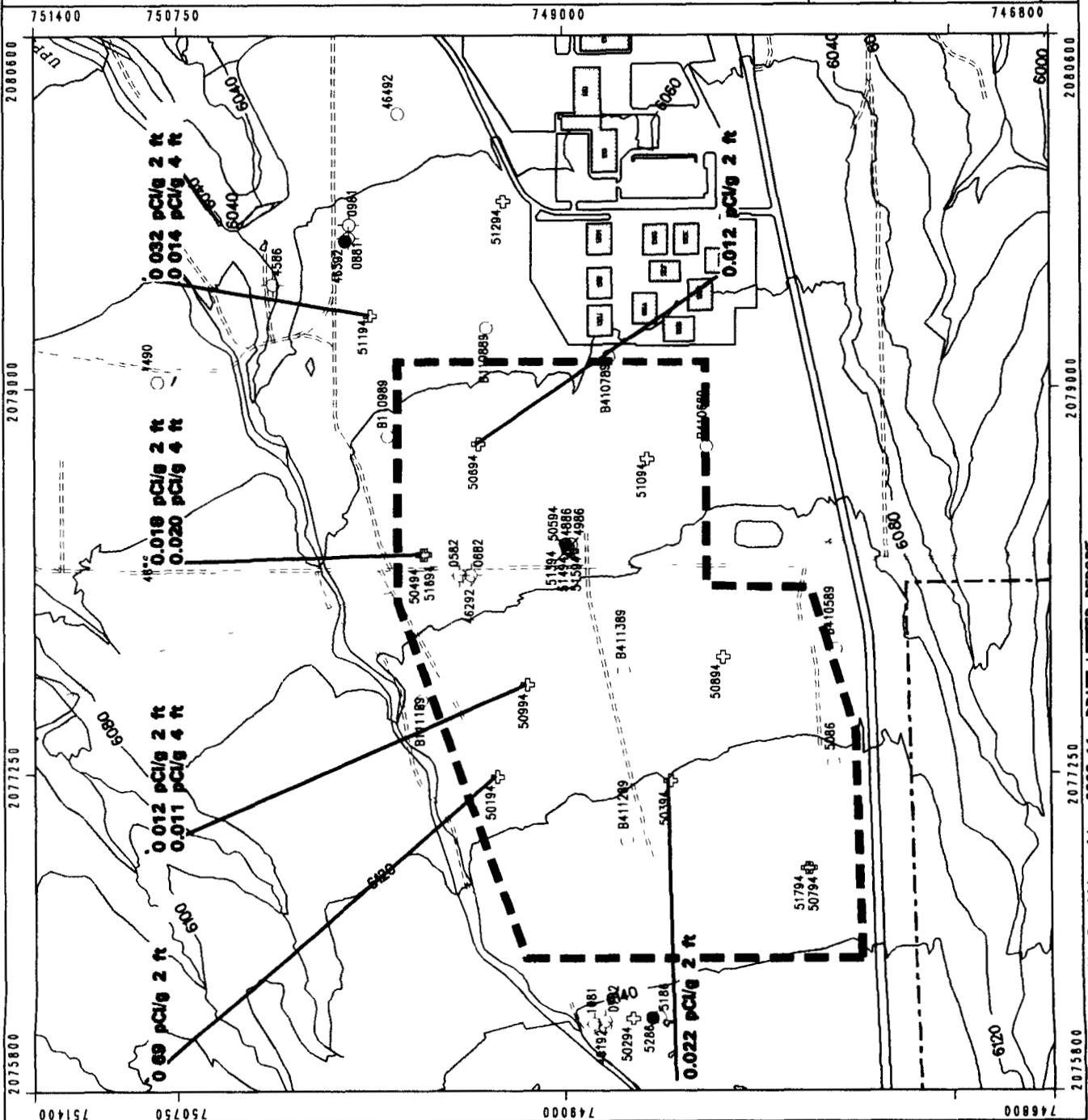
State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 PLUTONIUM-239/240  
 Activities\*

(and Sample Depths) in Subsurface  
 Geologic Materials (0 to 12 Feet)

March 1995 Figure D-76



# EXPLANATION

- 1994 Borehole
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 0.010



Scale = 1 8400  
 1 inch = 700 feet

300 700ft

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 AMERICIUM-241  
 Activities\*

(and Sample Depths) in Subsurface  
 Geologic Materials (0 to 12 Feet)

March 1995 Figure D-76b

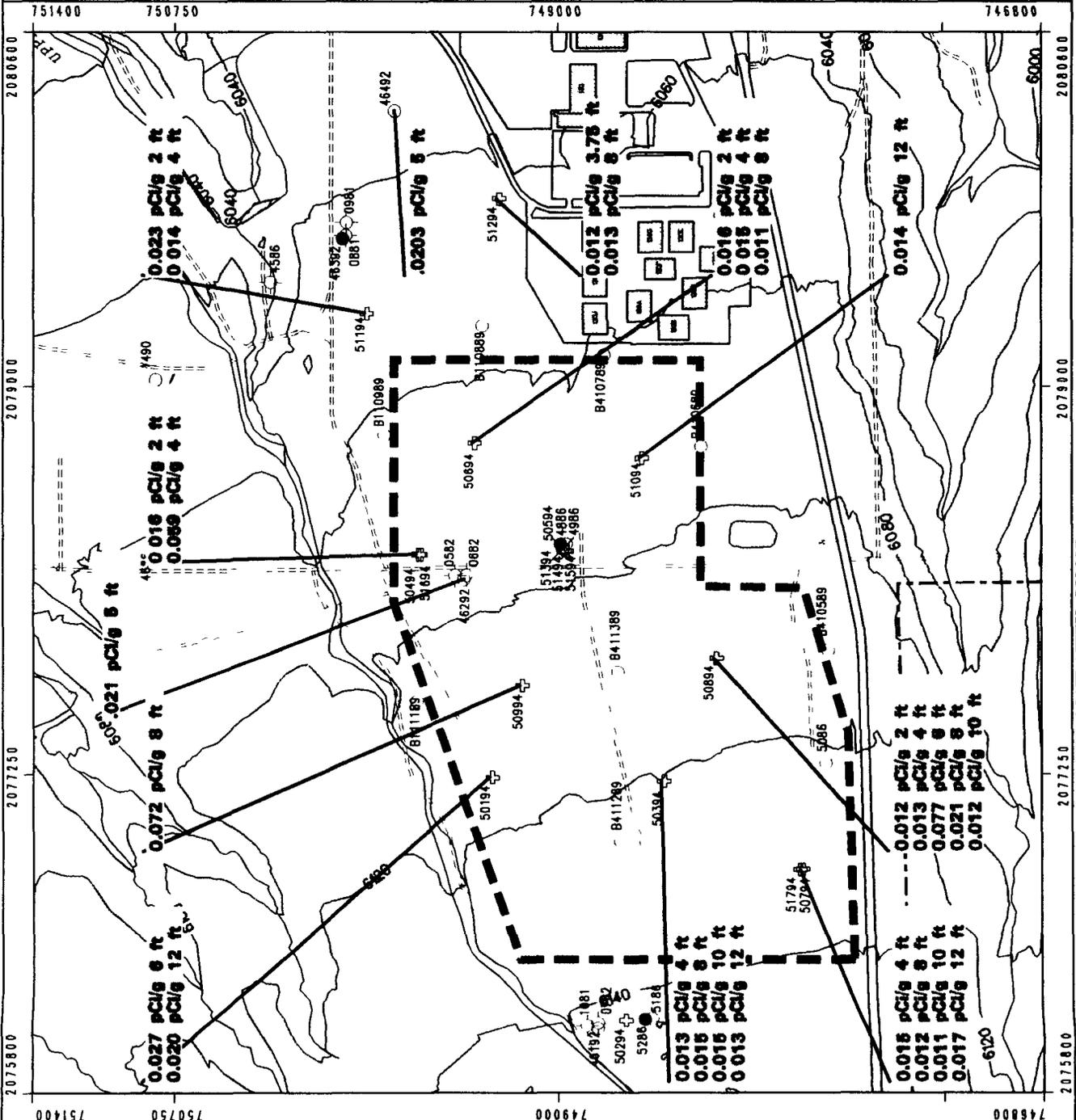
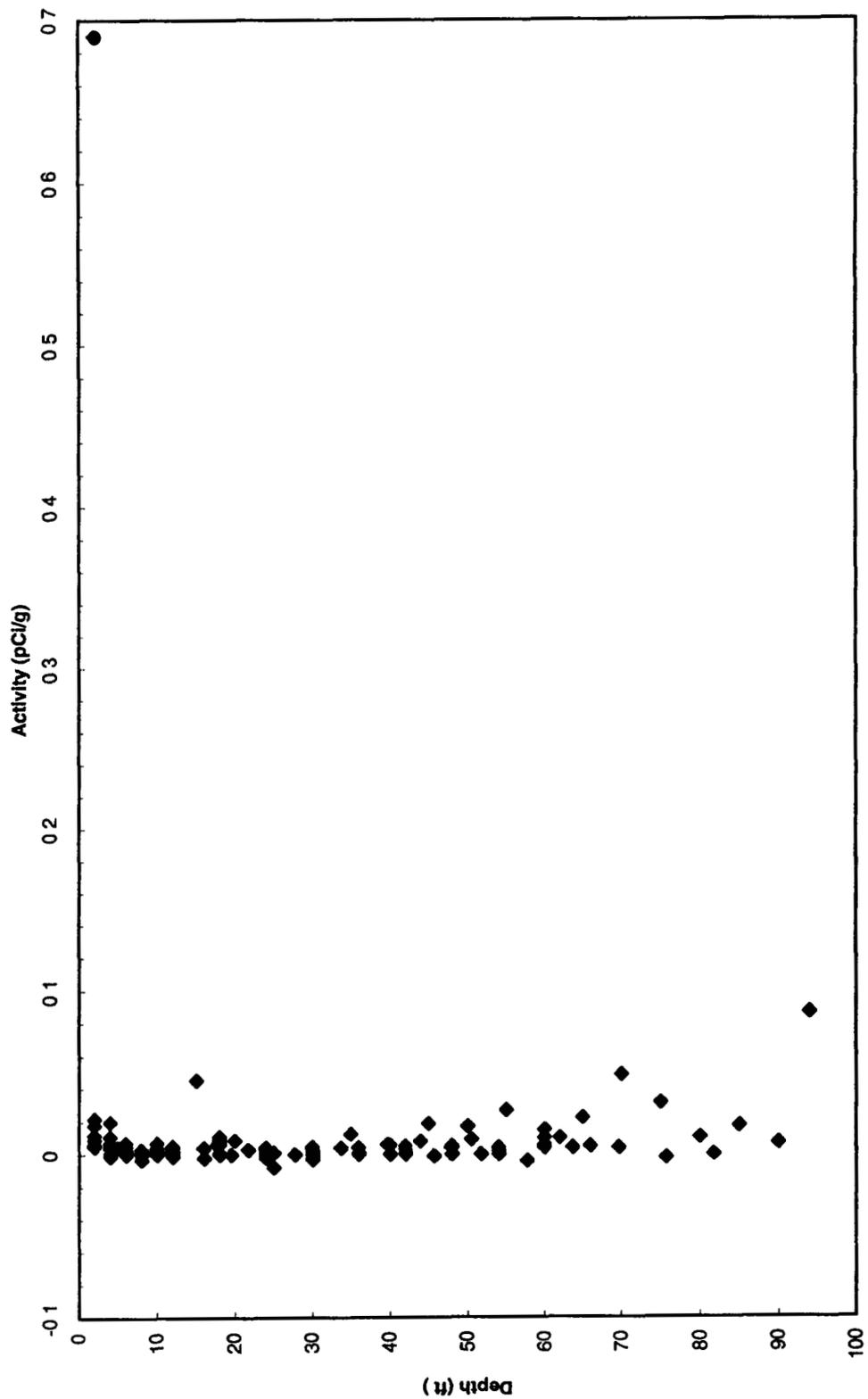


Figure D-77  
Activity versus Depth  
Plutonium-239/240

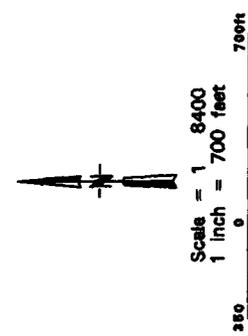




# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 0.030



Scale = 1 8400  
 1 inch = 700 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 AMERICIUM-241  
 Activities\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-79

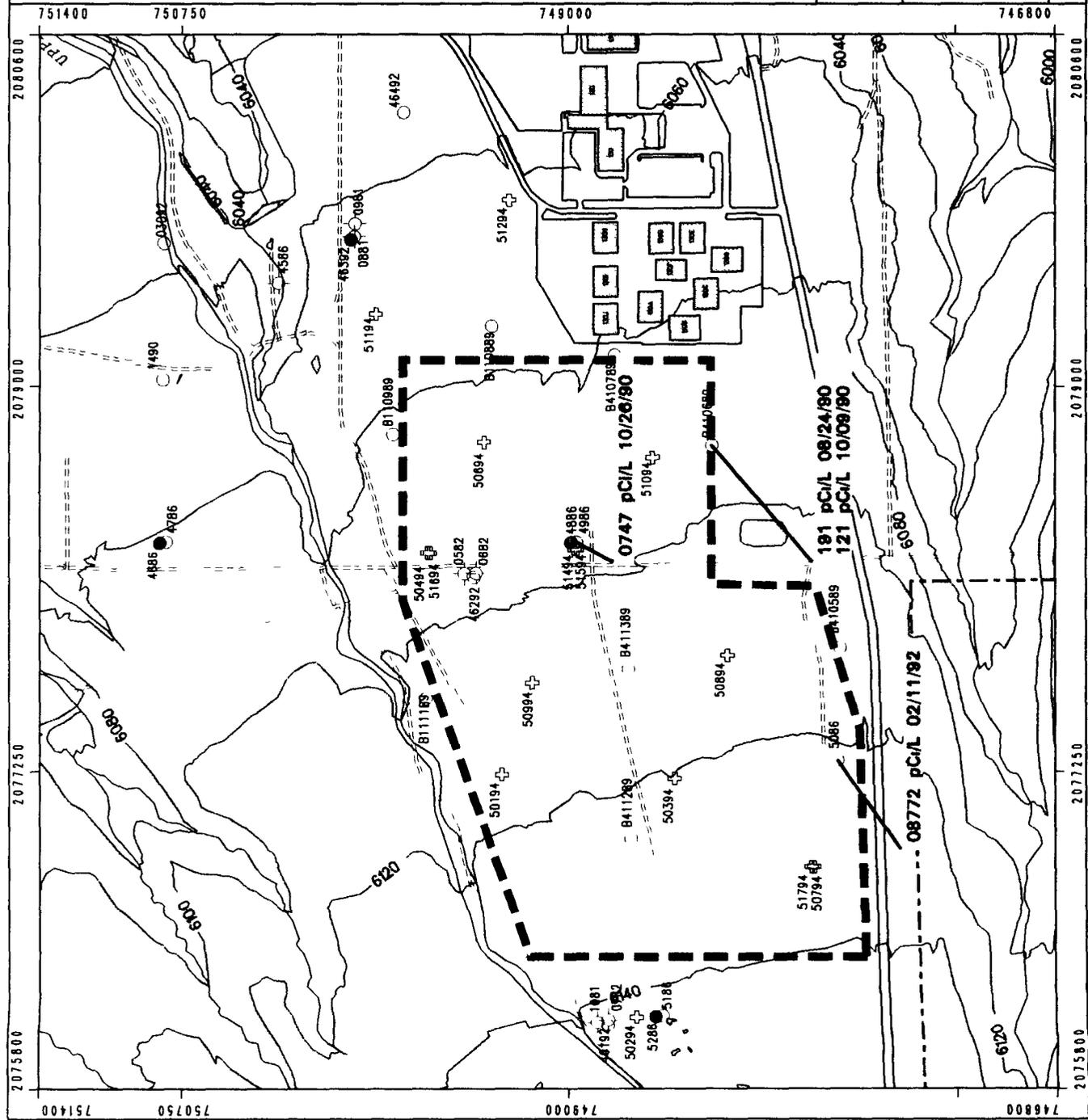
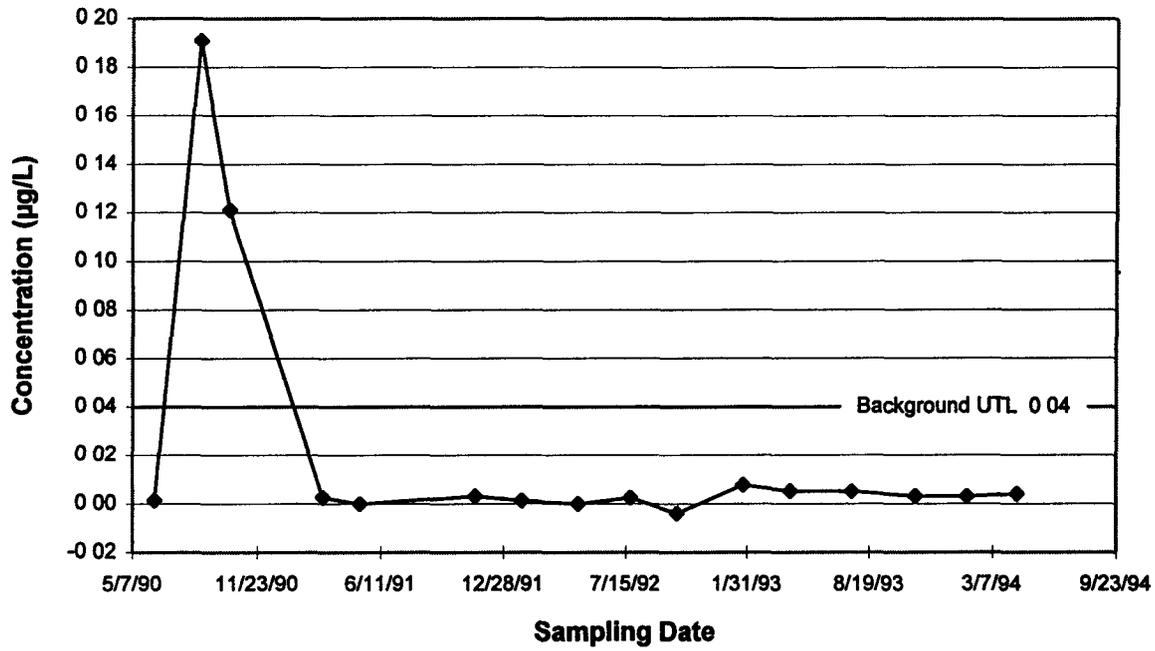
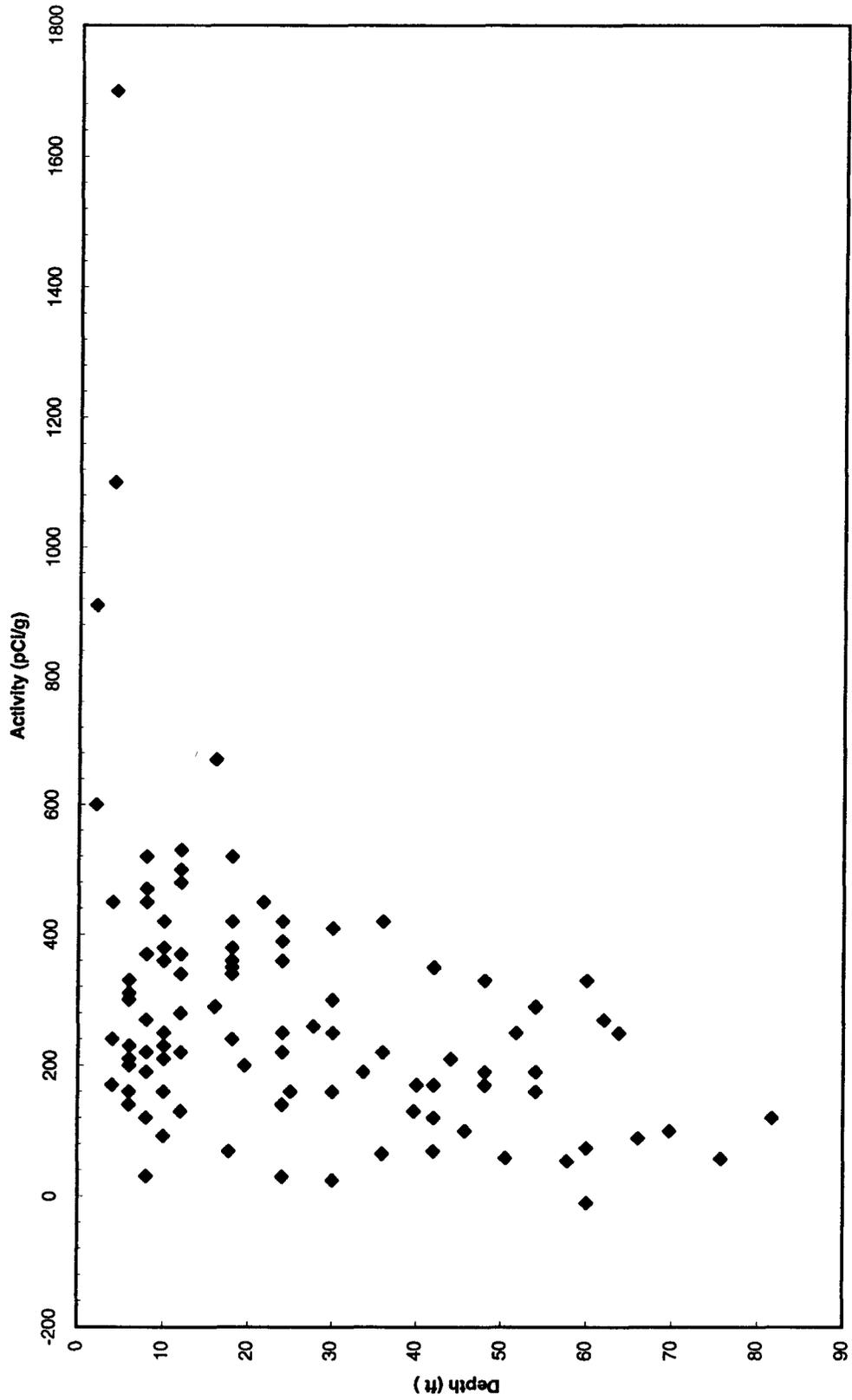


Figure D-80  
Time Series Plot - Total Americium-241  
B410689



◆ Hit - Y  
○ Hit - N

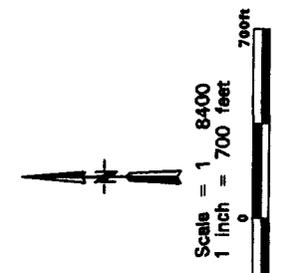
Figure D-81  
Activity versus Depth  
Tritium



# EXPLANATION

- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊙ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 427

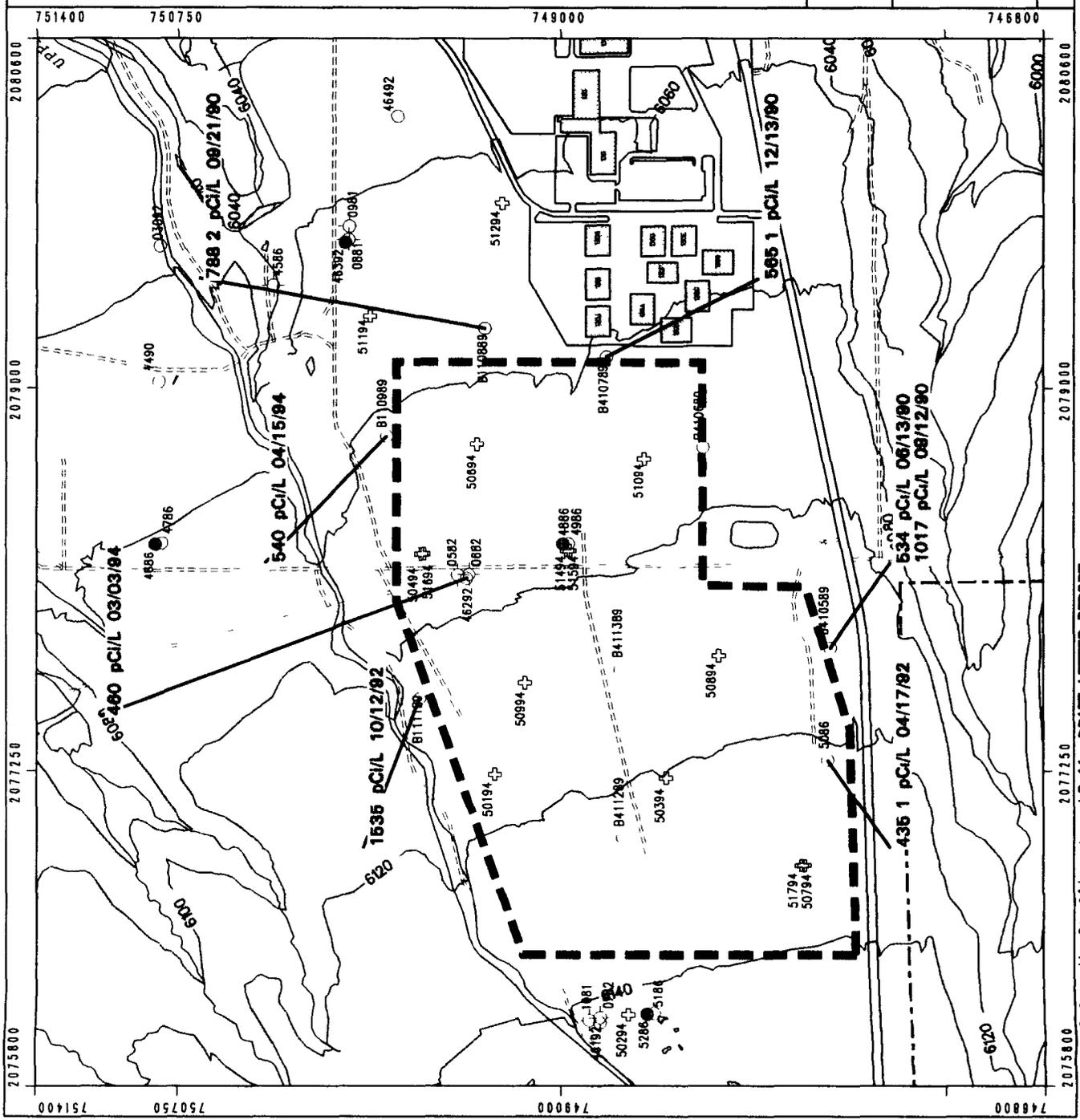


State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U.S. Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

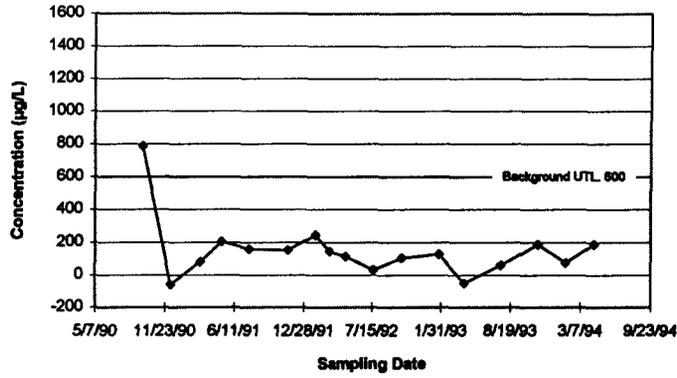
OU 11--West Spray Field  
 TRITIUM  
 Activities\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-82

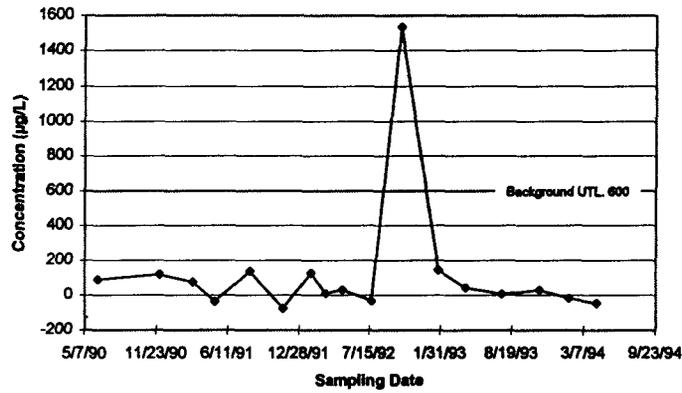


**Figure D-83**  
**Time Series Plots - Total Tritium**

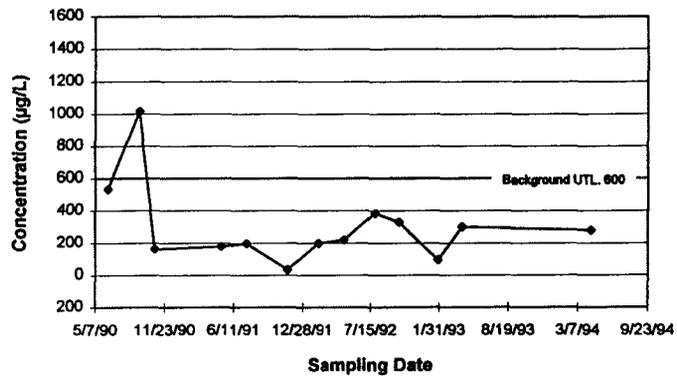
**B110889**



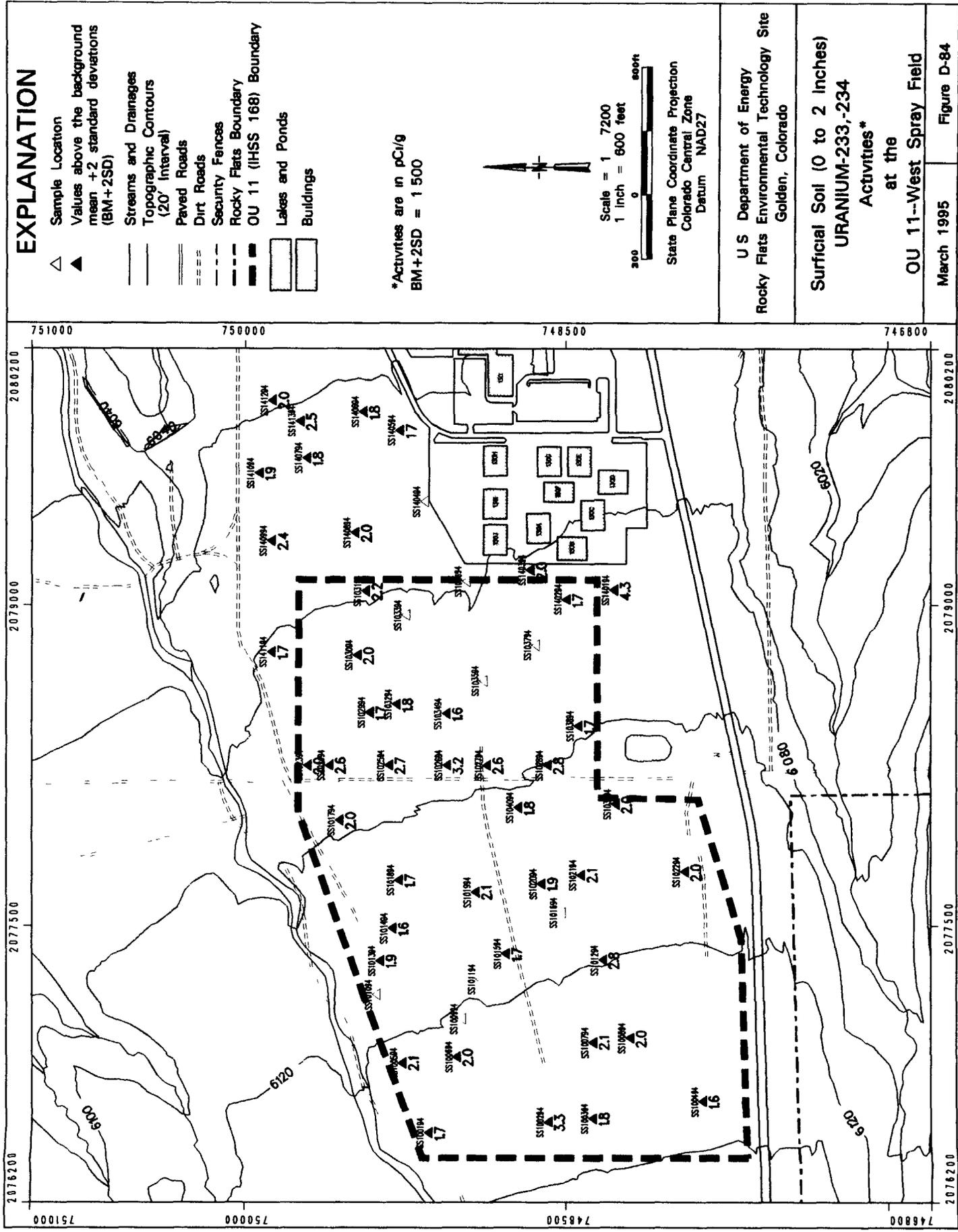
**B111189**



**B410589**



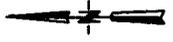
◆ Hit - Y  
○ Hit - N



# EXPLANATION

- △ Sample Location
- ▲ Values above the background mean +2 standard deviations (BM+2SD)
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- - - OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Activities are in pCi/g  
 BM+2SD = 1500



Scale = 1/7200  
 1 inch = 600 feet

0 200 400 600 800 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

Surficial Soil (0 to 2 inches)  
 URANIUM-233,-234  
 Activities\*  
 at the  
 OU 11--West Spray Field

March 1995  
 Figure D-84

# EXPLANATION

△ Sample Location  
 ▲ Values above the background mean +2 standard deviations (BM+2SD)  
 — Streams and Drainages  
 --- Topographic Contours (20' Interval)  
 = Paved Roads  
 - - - Dirt Roads  
 - - - Security Fences  
 - - - Rocky Flats Boundary  
 - - - QU 11 (IHSS 168) Boundary  
 [ ] Lakes and Ponds  
 [ ] Buildings

\*Activities are in pCi/g  
 BM+2SD = 0.115

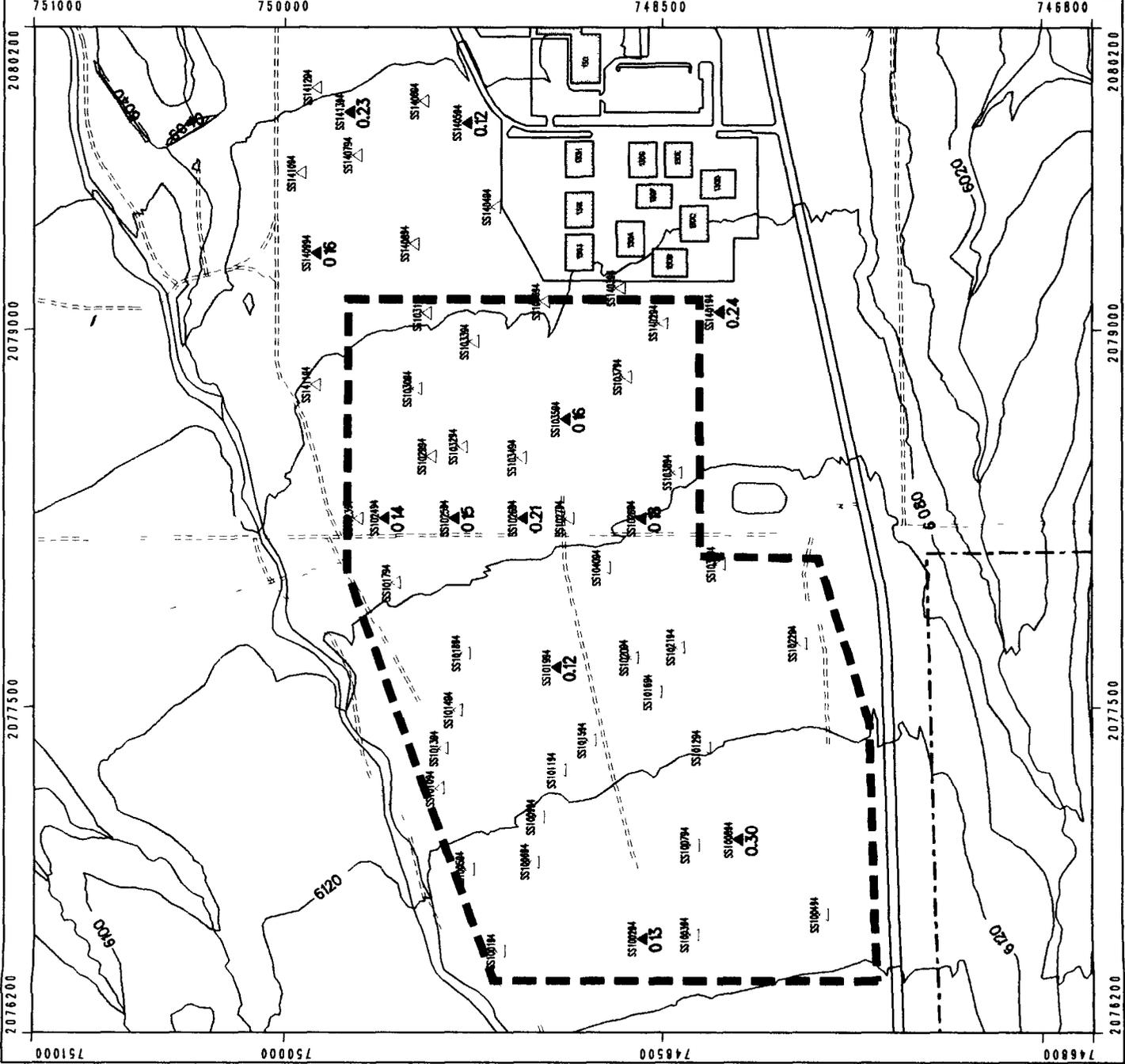
Scale = 1 7200  
 1 inch = 600 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

Surficial Soil (0 to 2 inches)  
 URANIUM-235  
 Activities\*  
 at the  
 OU 11--West Spray Field

March 1995      Figure D-85



# EXPLANATION

- △ Sample Location
- ▲ Values above the background mean +2 standard deviations (BM+2SD)
- Streams and Drainages
- Topographic Contours (20' Interval)
- == Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Activities are in pCi/g  
BM+2SD = 1 600



Scale = 1 7200  
1 inch = 600 feet



State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

Surficial Soil (0 to 2 inches)  
URANIUM-238  
Activities\*  
at the  
OU 11--West Spray Field

March 1995 Figure D-86

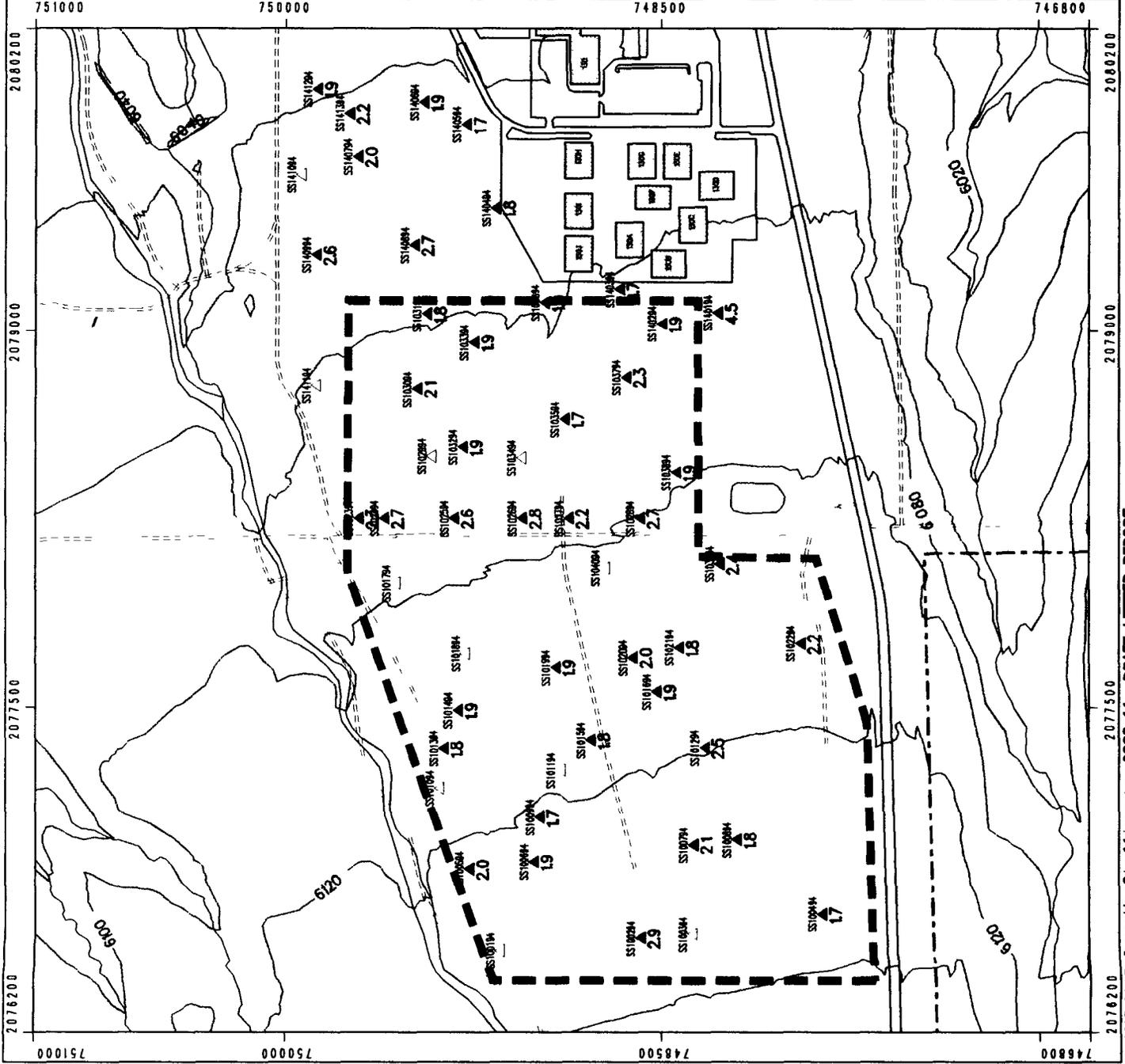
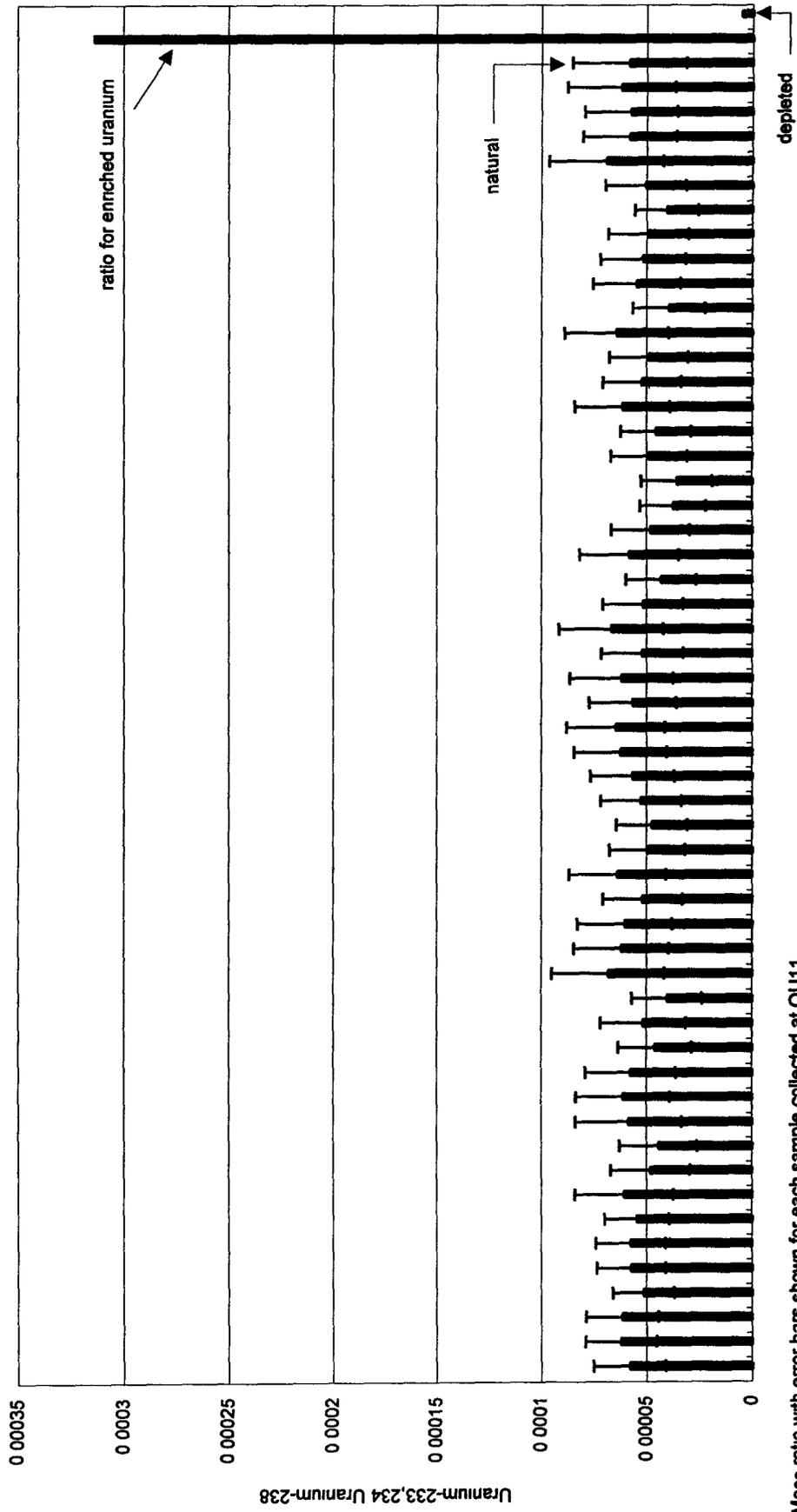
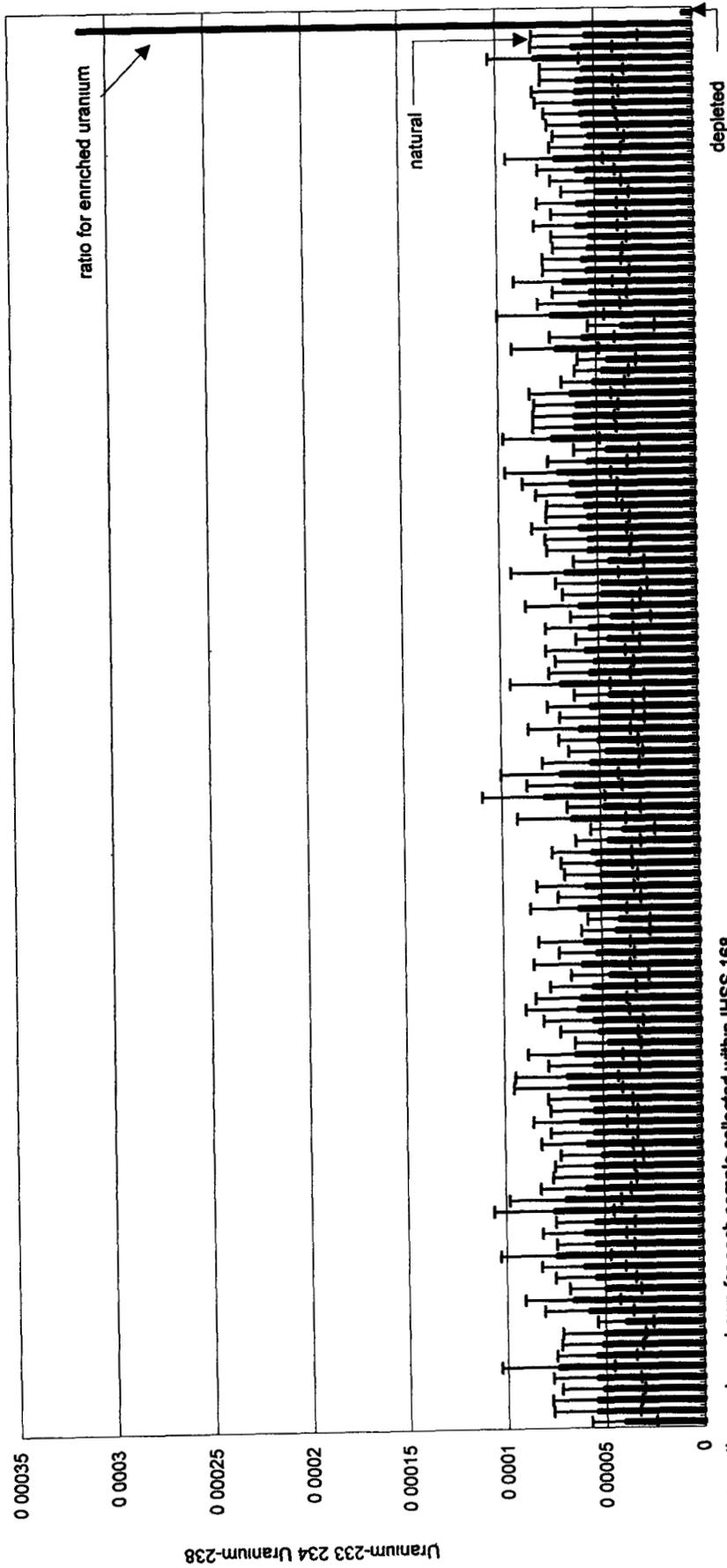


Figure D-87  
Uranium-233,234/Uranium-238 Mass Ratio in Surface Soils



Mass ratio with error bars shown for each sample collected at OU11

Figure D-88  
Uranium-233,234/Uranium-238 Mass Ratio in Geologic Materials



Mass ratio with error bars shown for each sample collected within IHS 168

# EXPLANATION

- 1994 Borehole
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above reporting limits



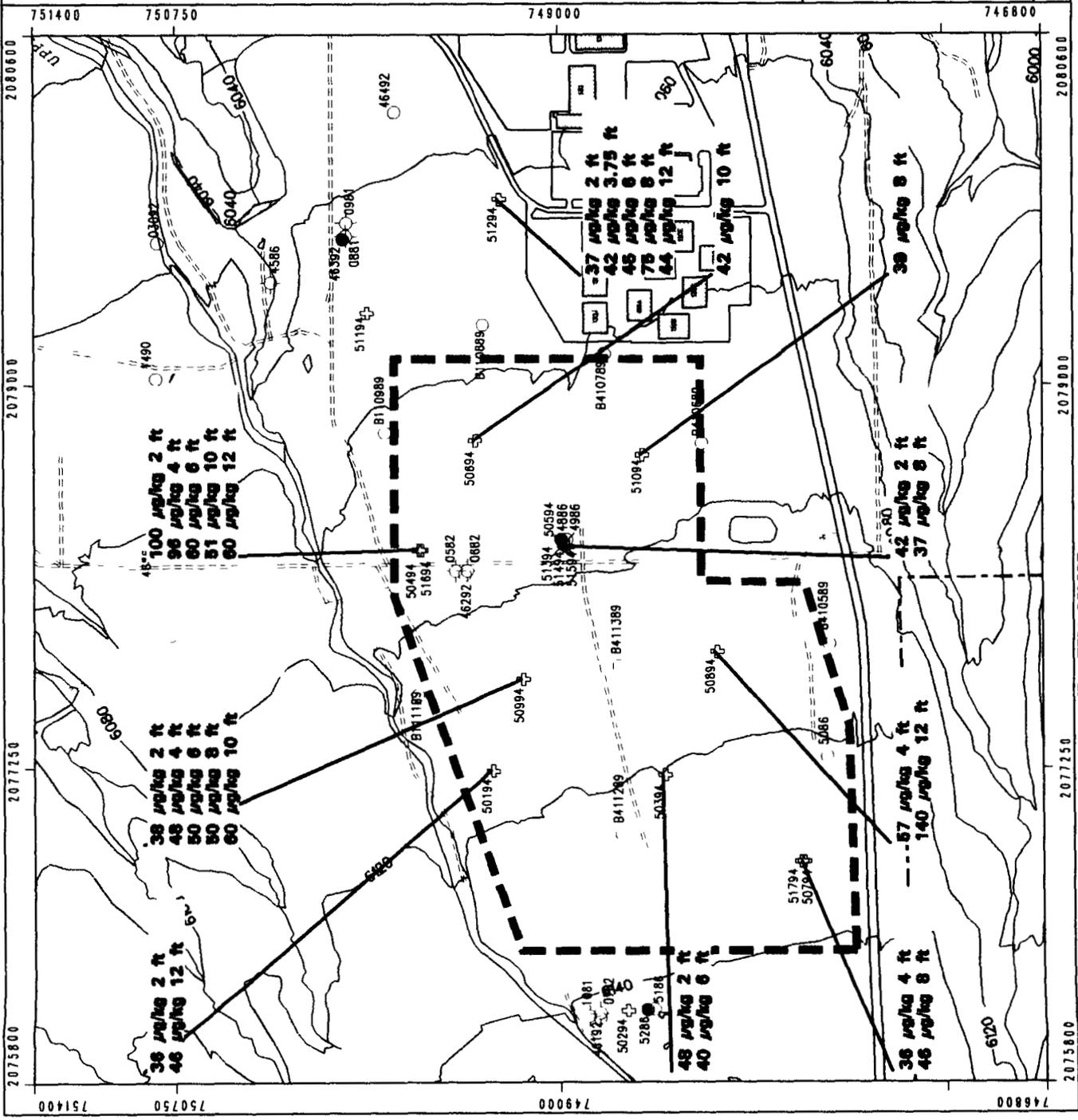
Scale = 1" = 8400'  
1 inch = 700 feet

State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U.S. Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
BIS(2-ETHYLHEXYL)PHTHALATE  
Concentrations\*  
(and Sample Depths) in Subsurface  
Geologic Materials (0 to 12 Feet)

March 1995 Figure D-89

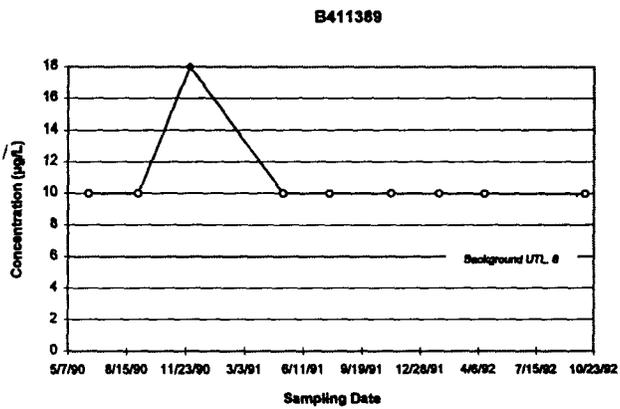
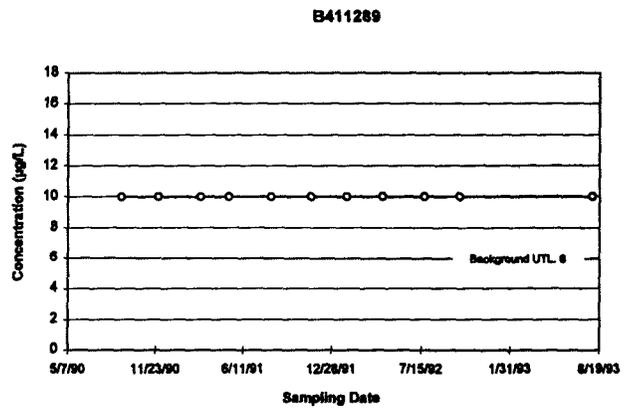
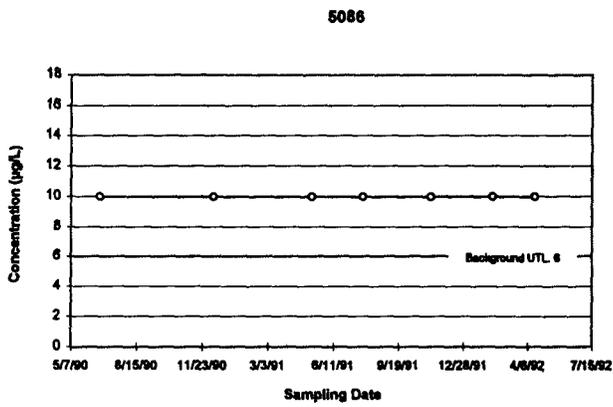
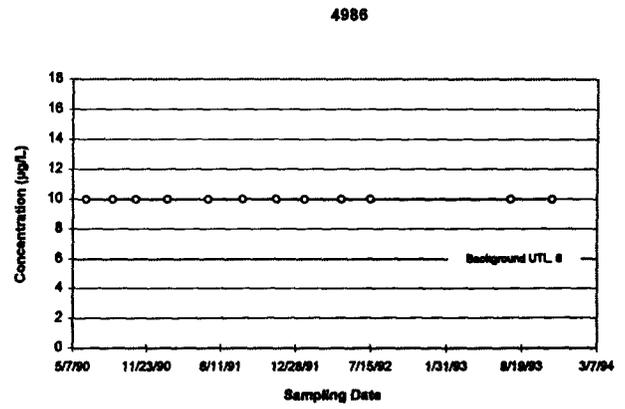
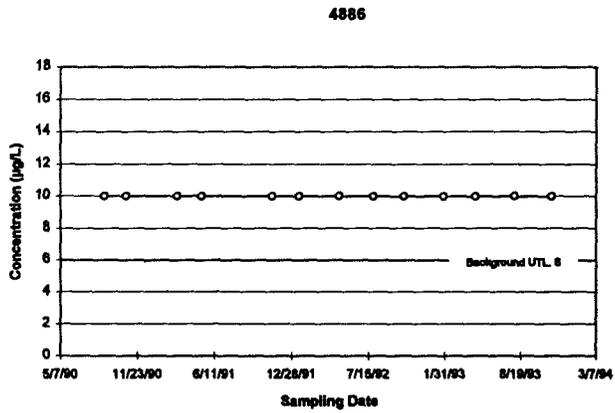








**Figure D-93**  
**Time Series Plots - Total 2-Butanone**



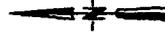
◆ Hit - Y  
○ Hit - N



# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊕ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- == Paved Roads
- Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- - - OU 11 (HSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above reporting limits



Scale = 1/8400  
1 inch = 700 feet

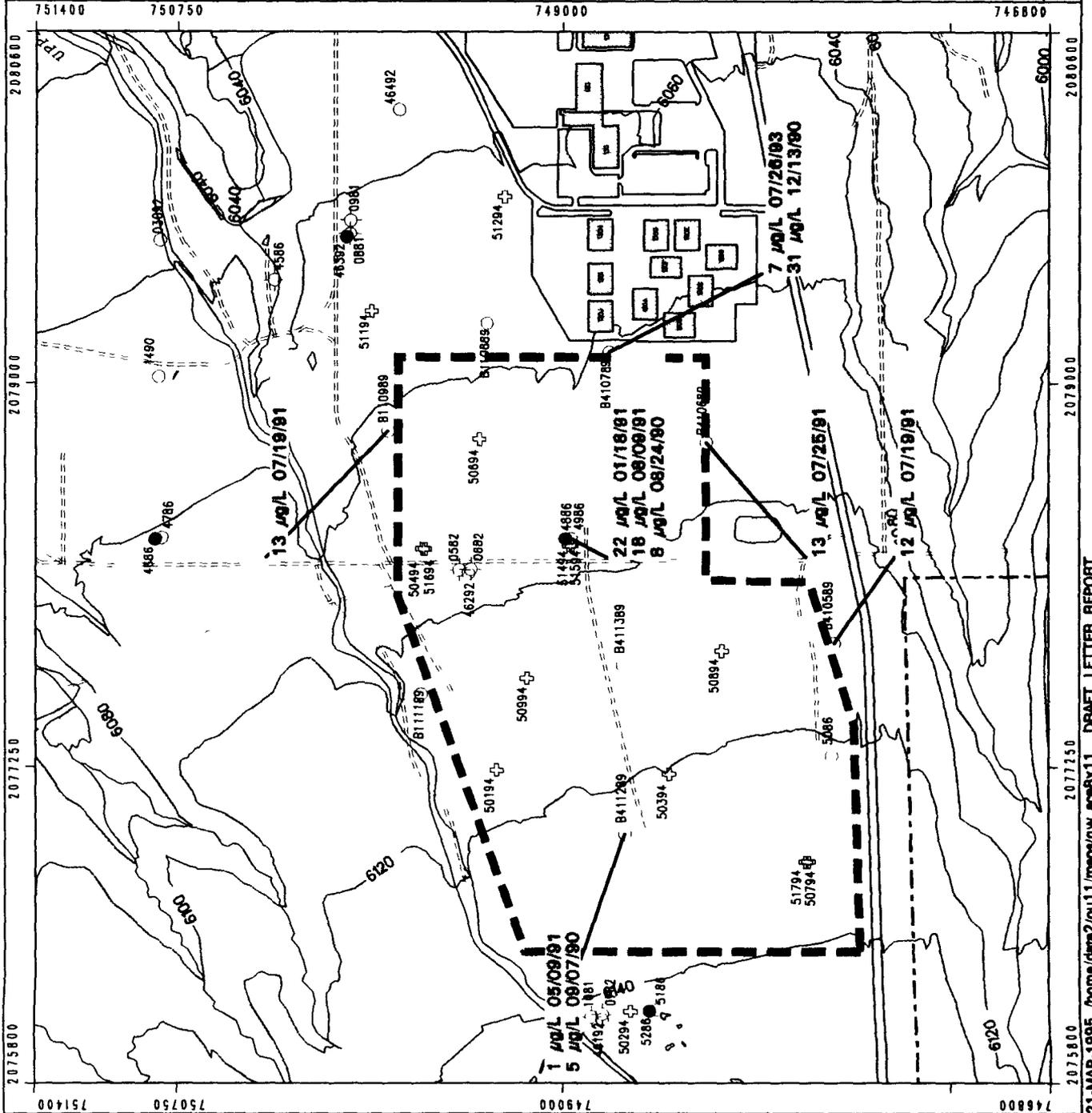


State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

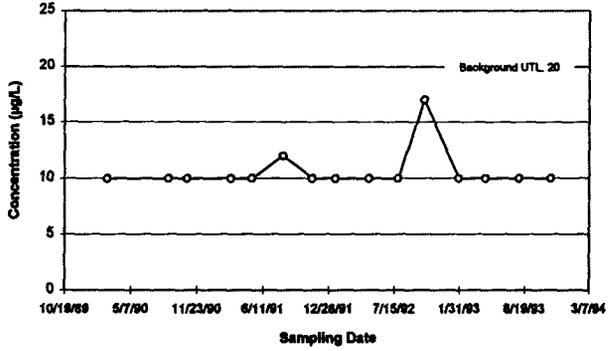
OU 11--West Spray Field  
ACETONE  
Concentrations\*  
(and Sample Dates) in  
UHSU Ground Water

March 1995 Figure D-95

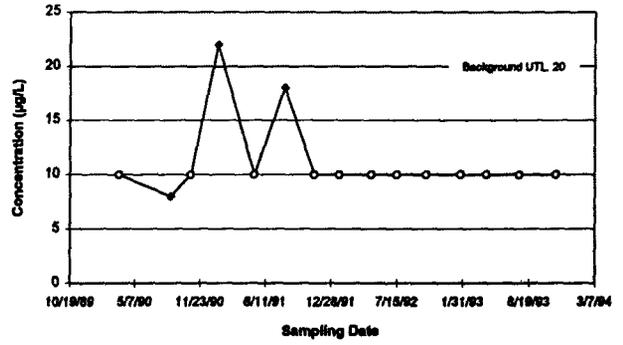


**Figure D-96**  
**Time Series Plots - Total Acetone**

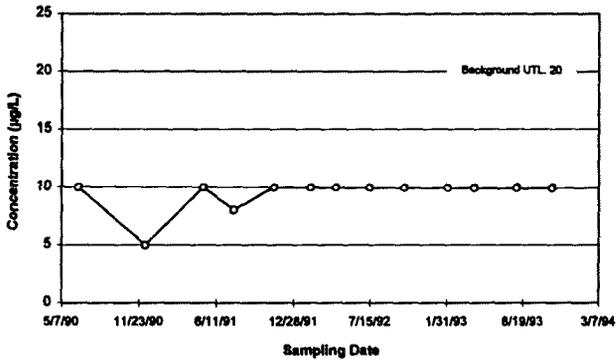
4886



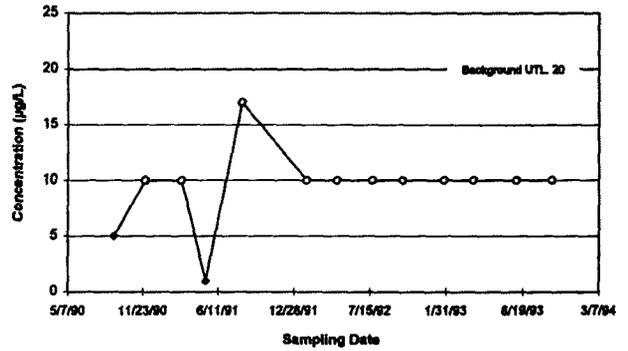
4986



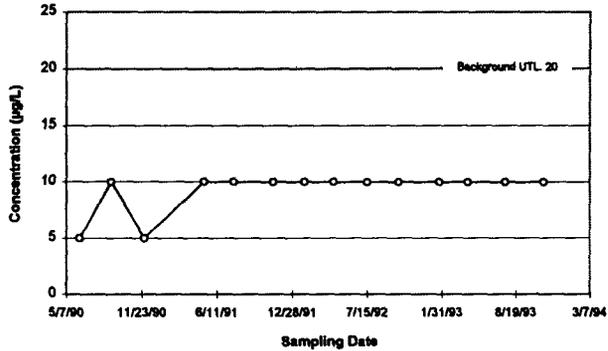
5086



B411289



B411389

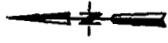


◆ Hit - Y  
○ Hit - N

# EXPLANATION

- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊖ Abandoned Well
- ▬ Streams and Drainages
- ▬ Topographic Contours (20' Interval)
- ▬ Paved Roads
- ▬ Dirt Roads
- ▬ Security Fences
- ▬ Rocky Flats Boundary
- ▬ OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above reporting limits



Scale = 1" = 8400 feet  
 1" = 700 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U.S. Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 BENZENE  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-97

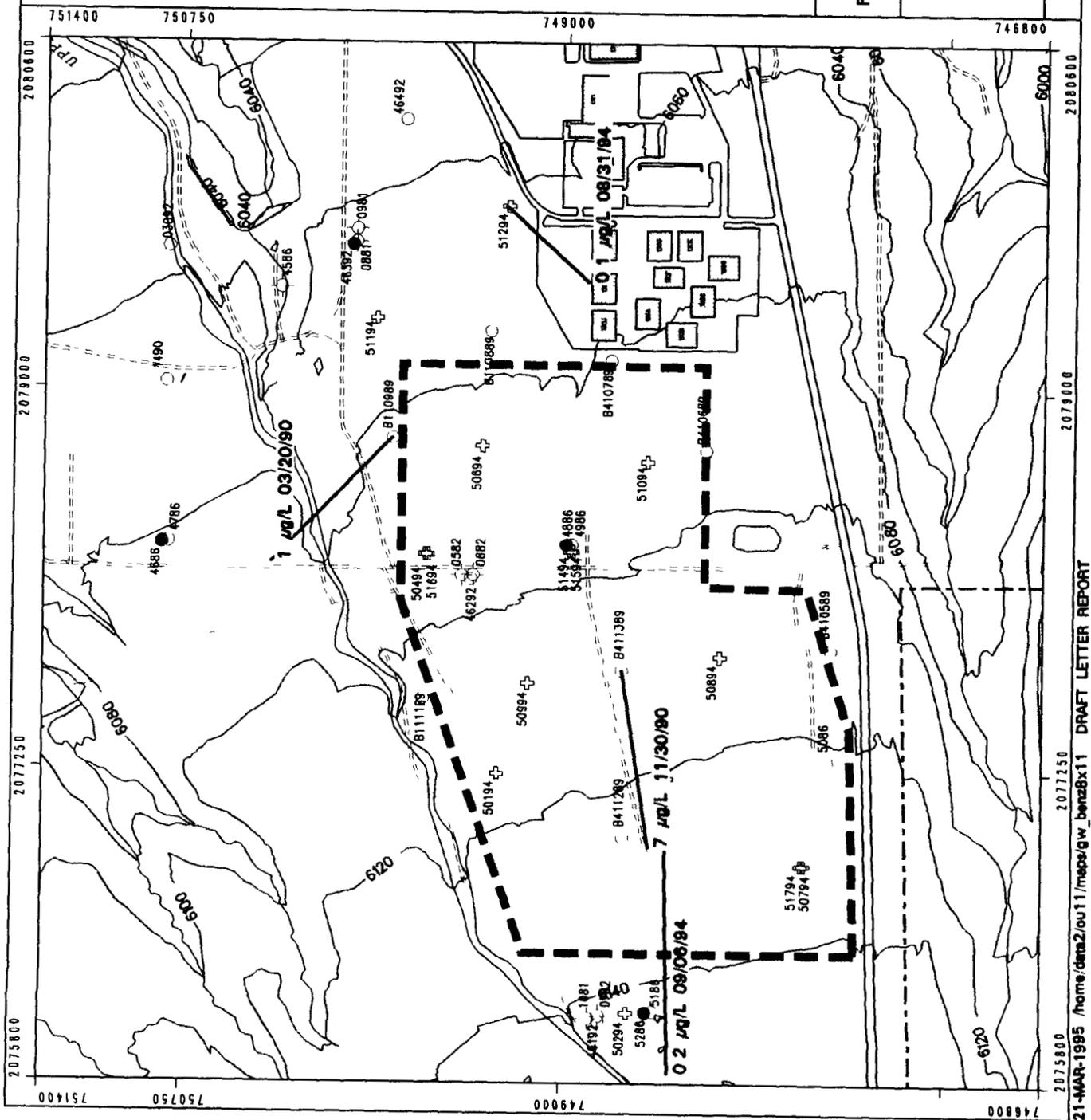
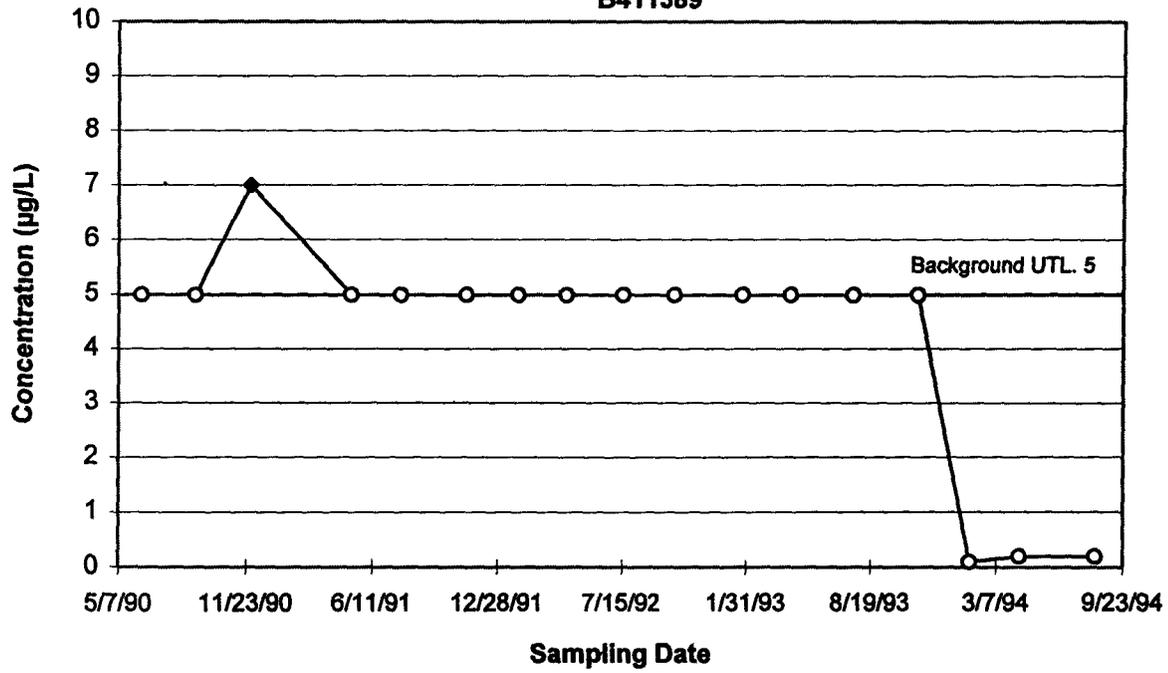
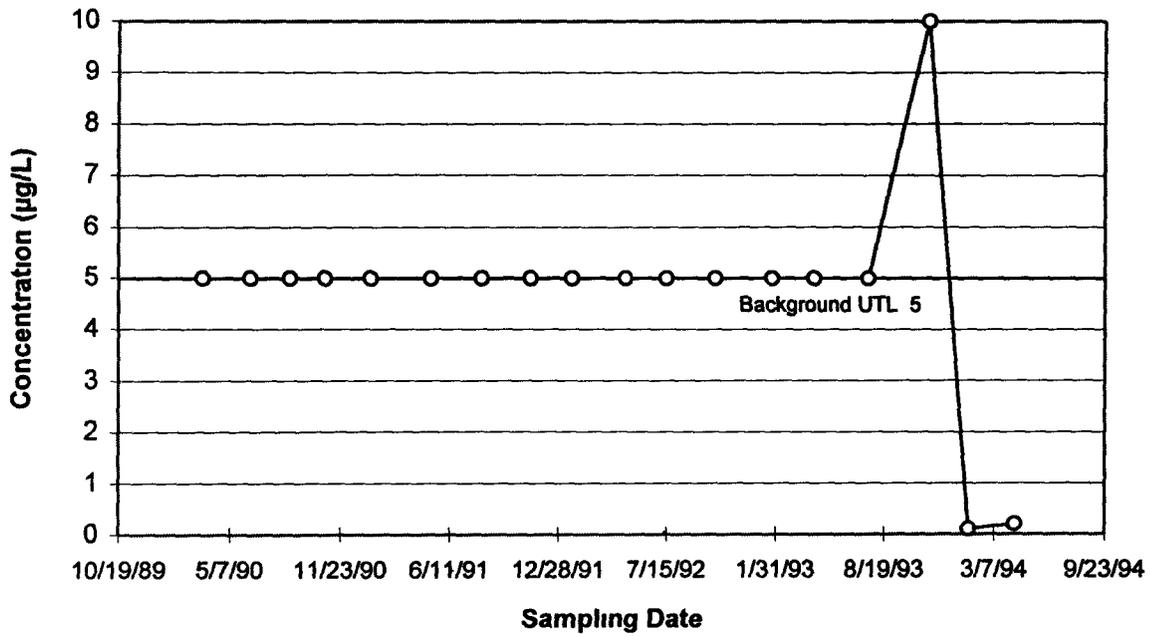


Figure D-98  
 Time Series Plots - Total Benzene  
 B411389



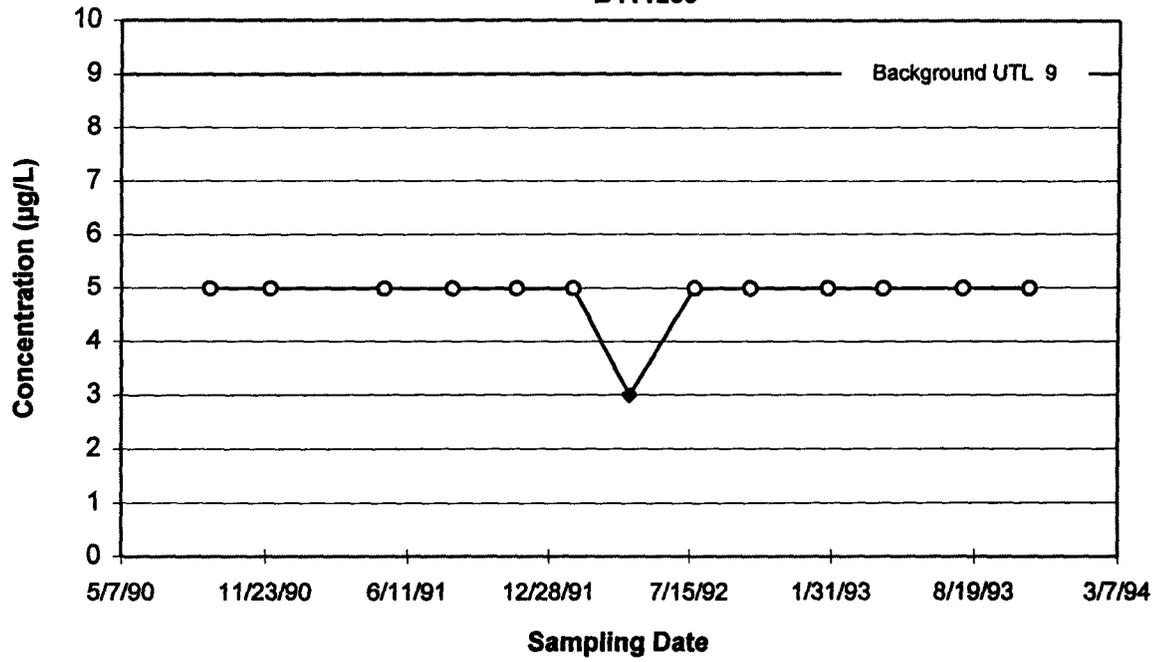
4986



● Hit - Y  
 ○ Hit - N



Figure D-100  
Time Series Plot - Total Carbon Disulfide  
B411289

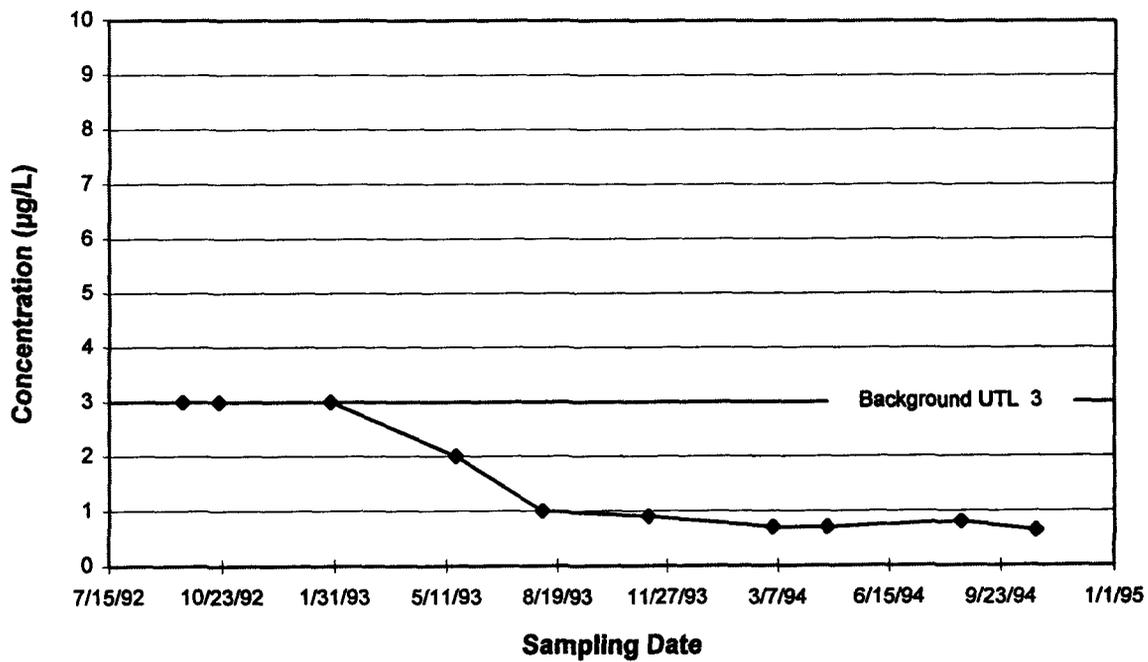


◆ Hit - Y  
○ Hit - N



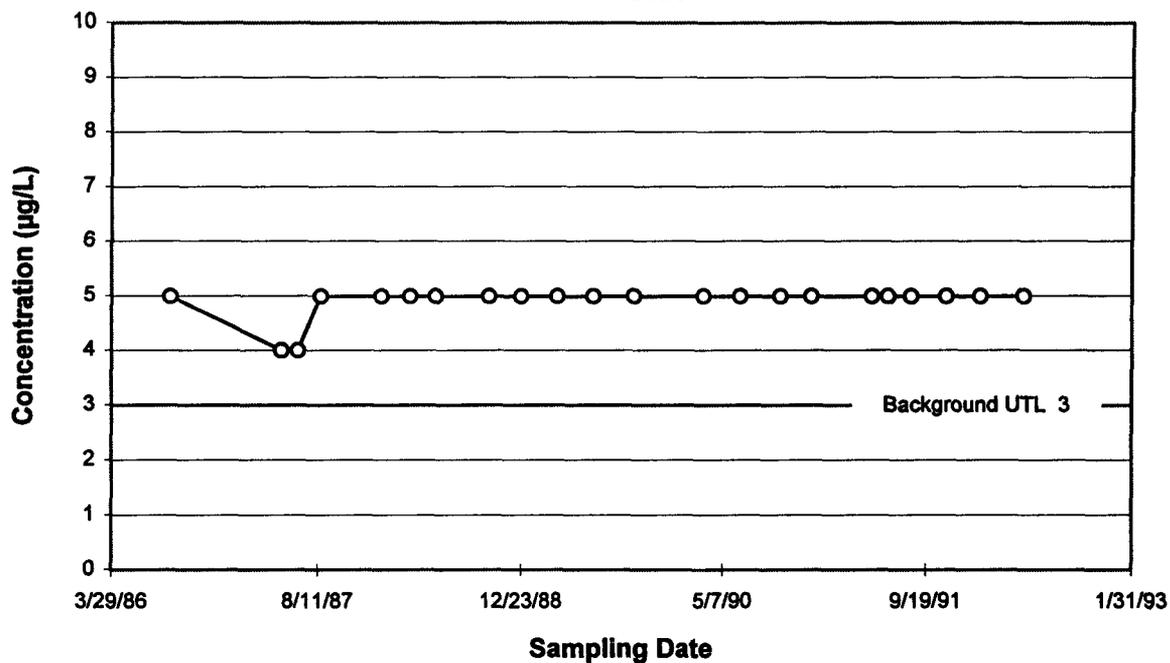


Figure D-103  
Time Series Plot - Total Chloroform  
46392

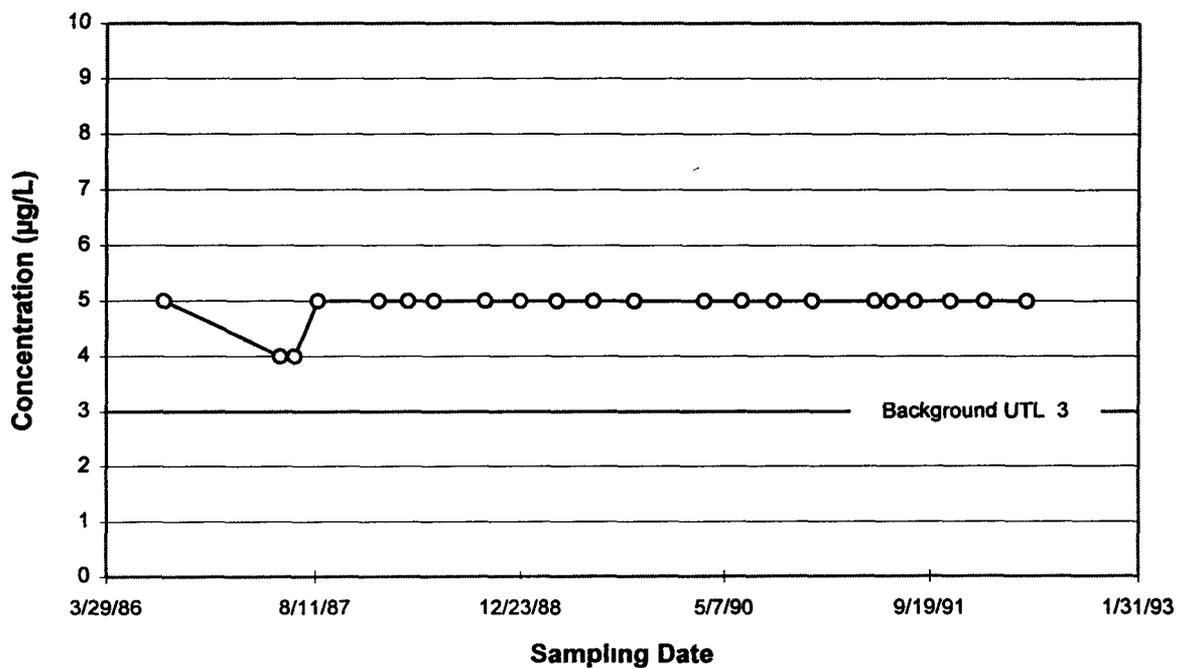


◆ Hit - Y  
○ Hit - N

Figure D-104  
Time Series Plots - Total Chloroform  
0881

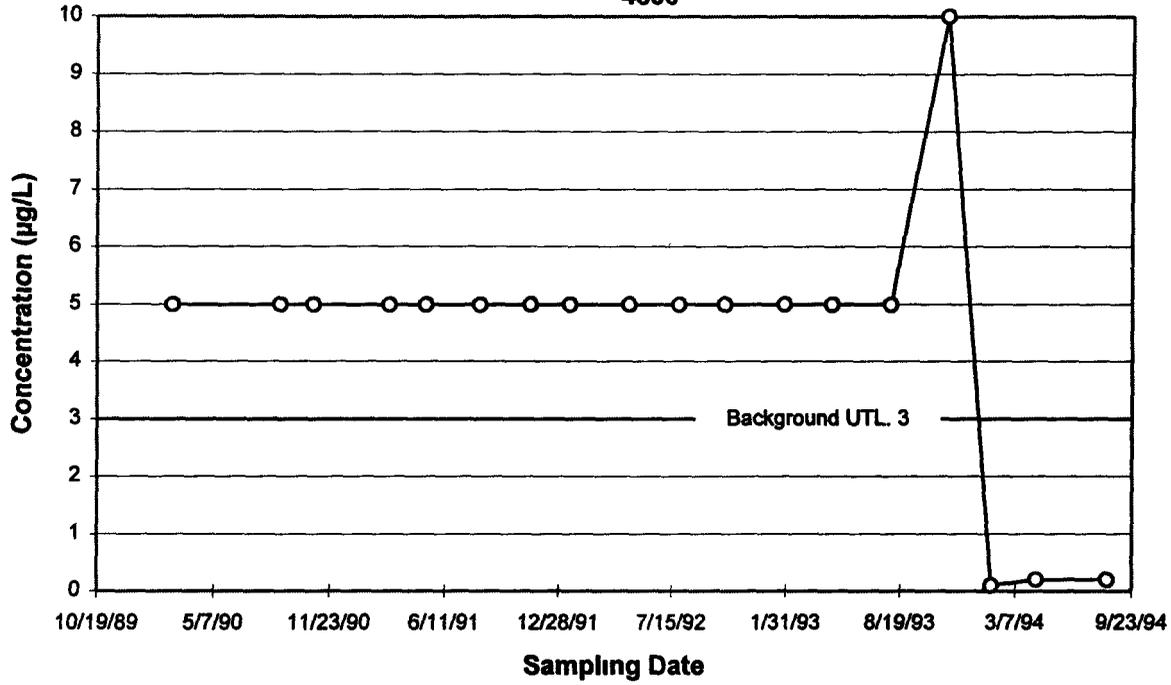


0981

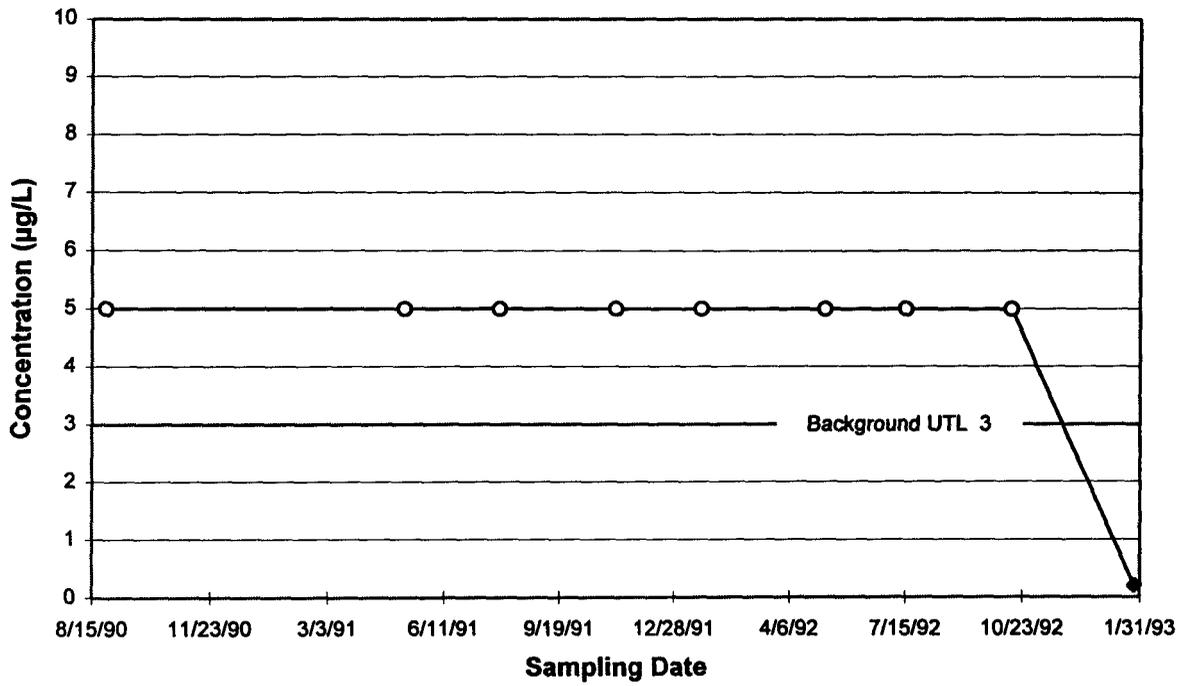


◆ Hit - Y  
○ Hit - N

Figure D-105  
 Time Series Plots - Total Chloroform  
 4886



5286

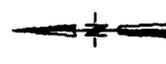


◆ Hit - Y  
 ○ Hit - N

# EXPLANATION

- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊖ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above reporting limits



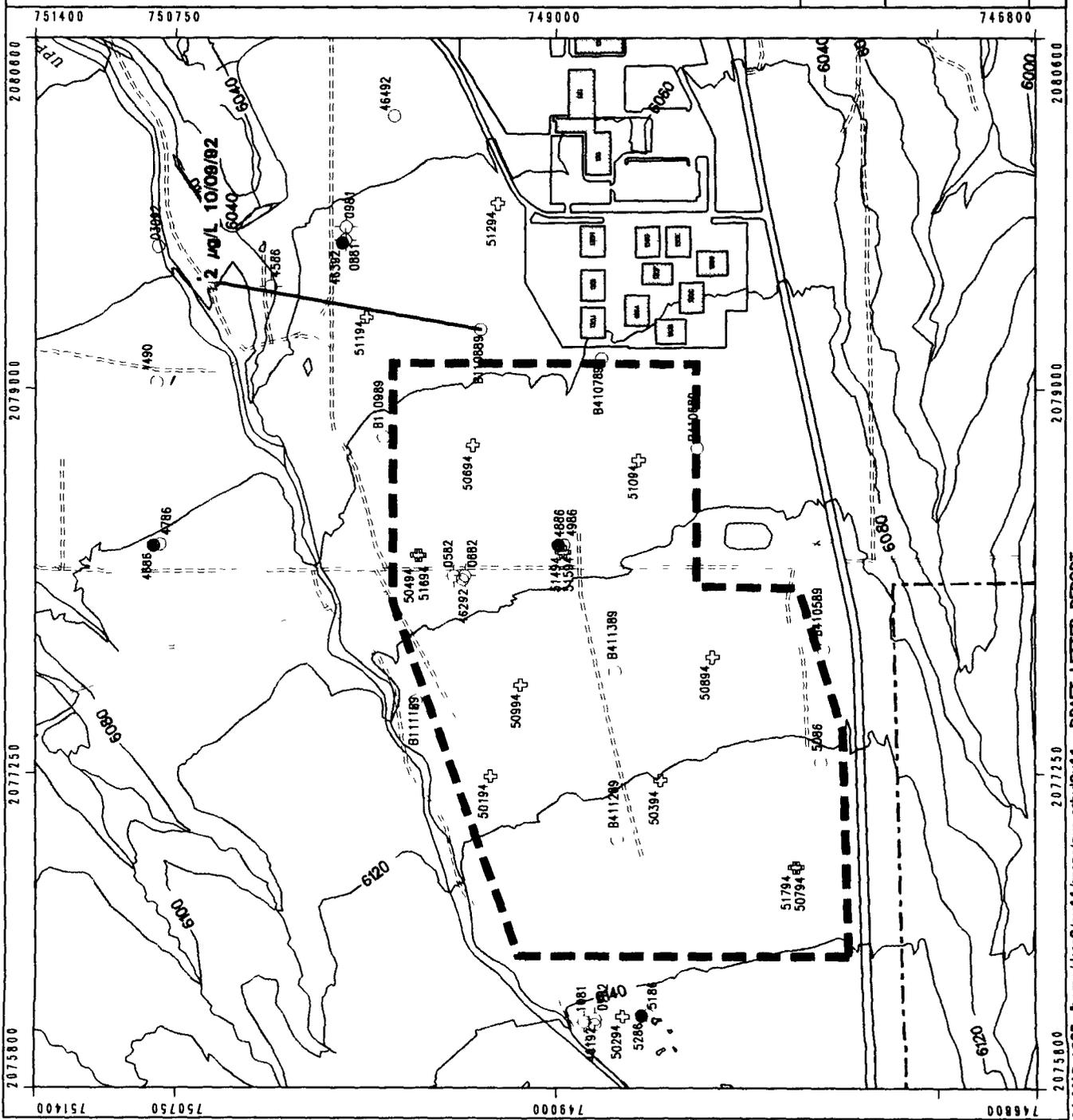
Scale = 1/8400  
 1 inch = 700 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 ETHYLBENZENE  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-108

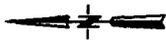




# EXPLANATION

- 1994 Borehole
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above reporting limits



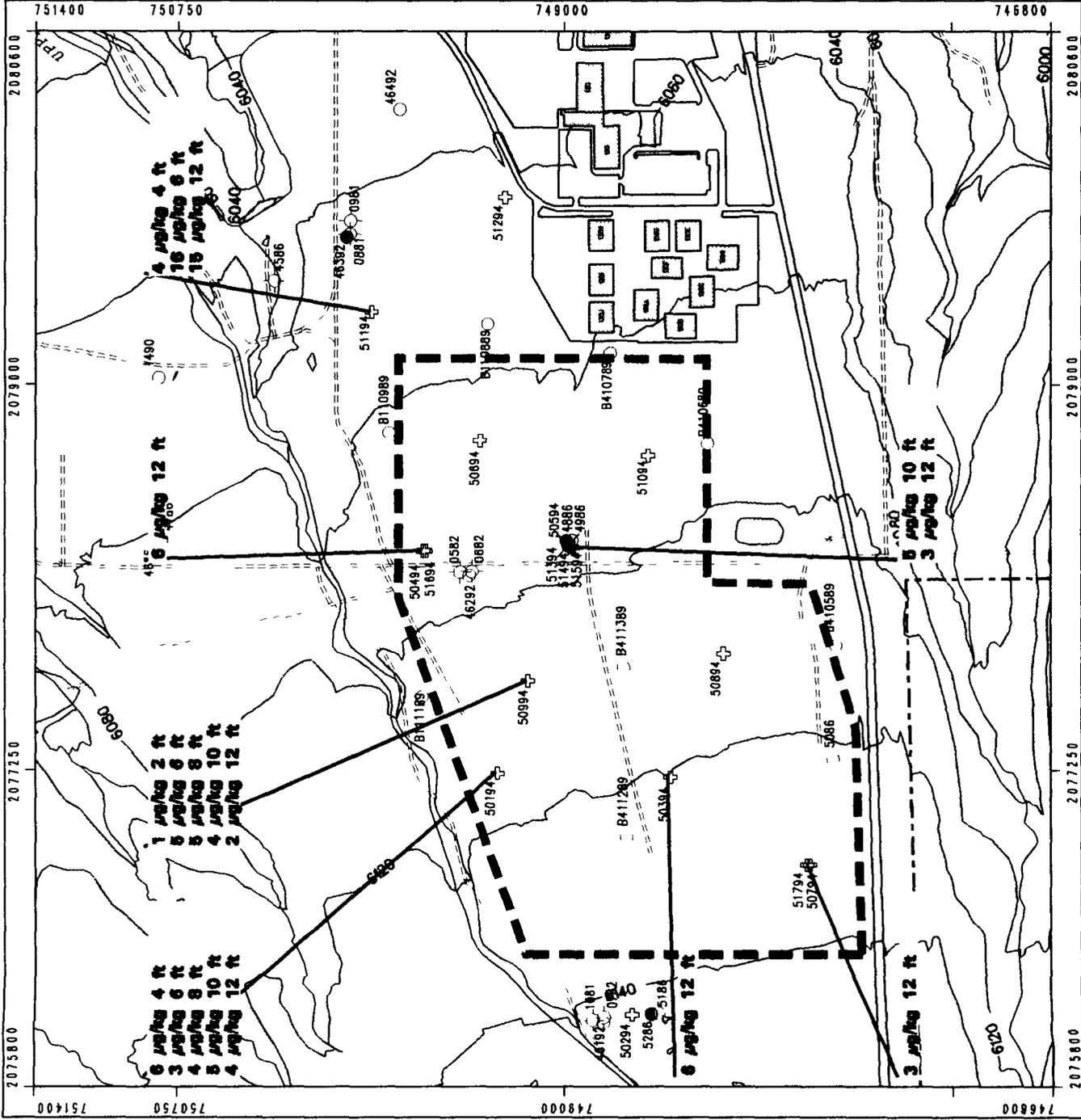
Scale = 1/8400  
1 inch = 700 feet

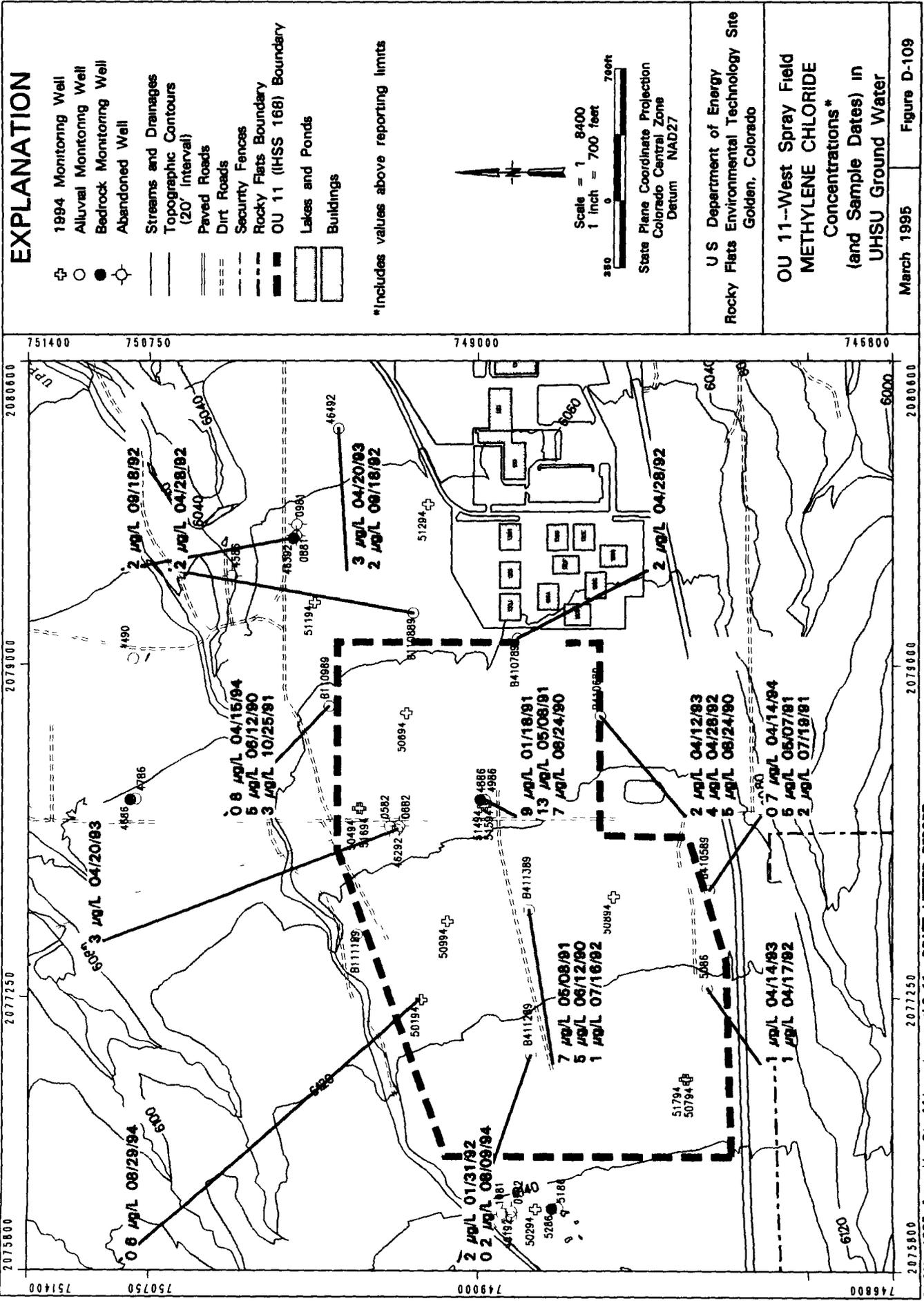
State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
METHYLENE CHLORIDE  
Concentrations\*  
(and Sample Depths) in Subsurface  
Geologic Materials (0 to 12 Feet)

March 1995 Figure D-108

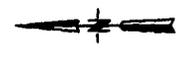




# EXPLANATION

- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊖ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- ==== Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above reporting limits



Scale = 1" = 8400  
 1" = 700 feet

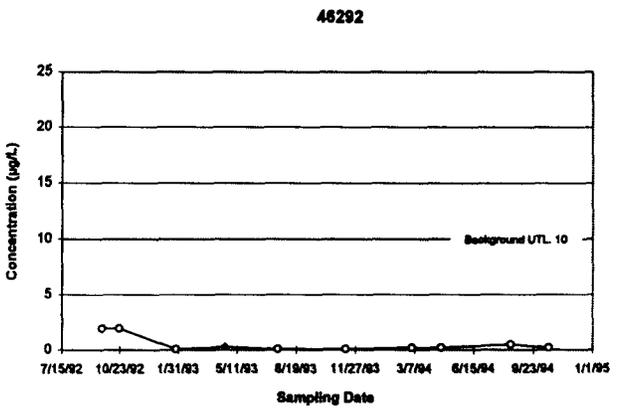
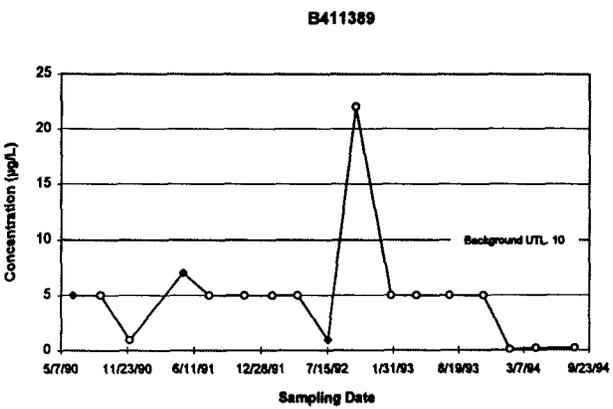
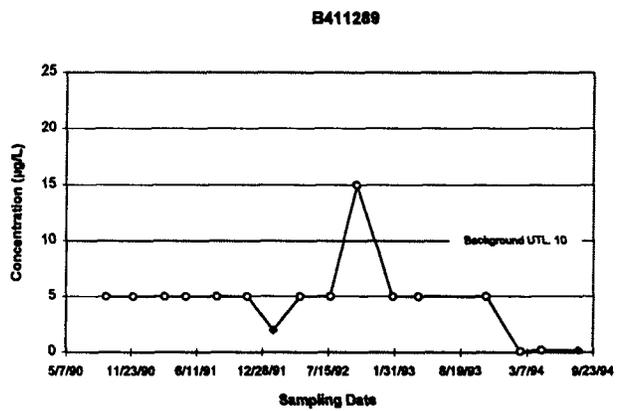
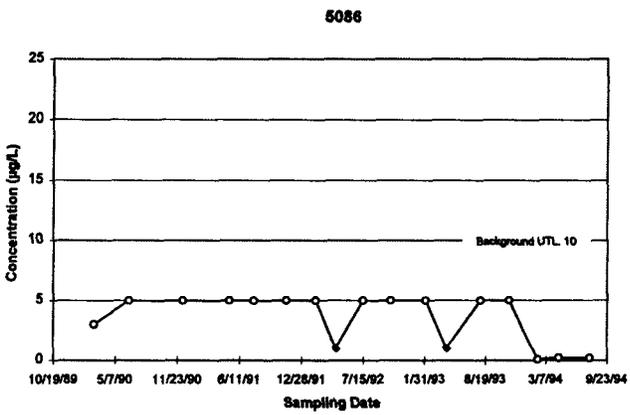
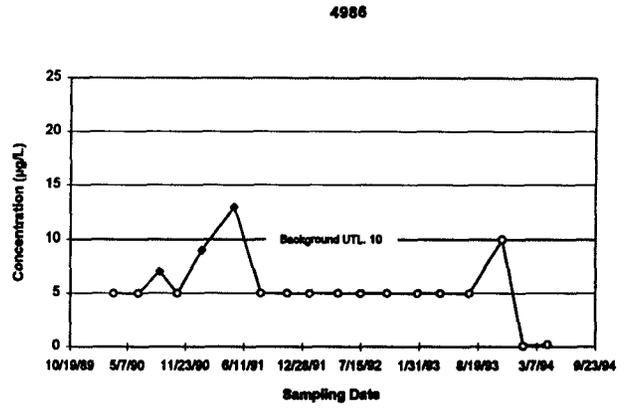
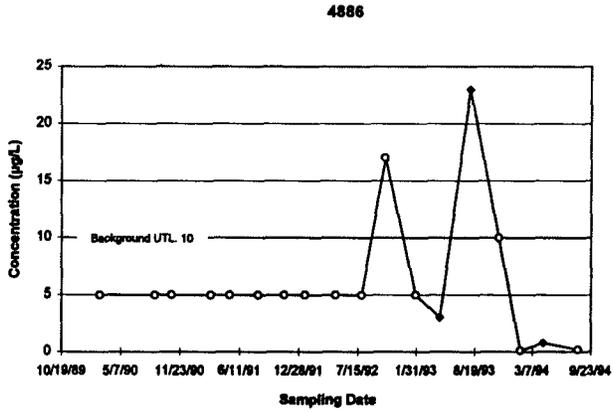
State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U.S. Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 METHYLENE CHLORIDE  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-109

**Figure D-110**  
**Time Series Plots - Total Methylene Chloride**



◆ Hit - Y  
 ○ Hit - N

# EXPLANATION

- ⊕ 1984 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊙ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' interval)
- ==== Paved Roads
- ===== Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- - - OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above reporting limits



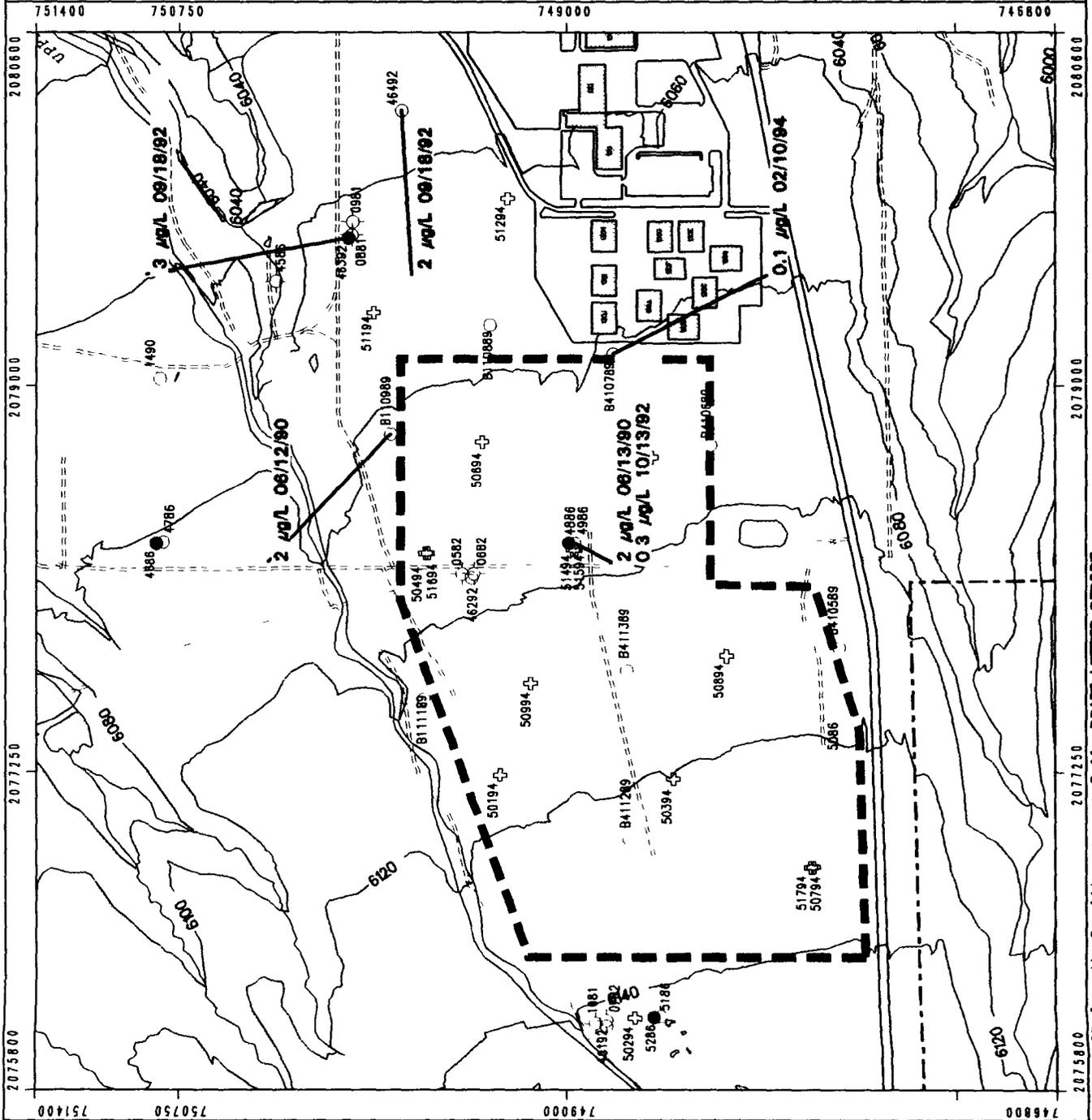
Scale = 1" = 8400'  
1 inch = 700 feet

State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
TETRACHLOROETHENE  
Concentrations\*  
(and Sample Dates) in  
UHSU Ground Water

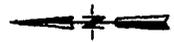
March 1995 Figure D-111



# EXPLANATION

- 1994 Borehole
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above reporting limits



Scale = 1" = 8400'  
 1" = 700 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U.S. Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 TOLUENE  
 Concentrations\*  
 (and Sample Depths) in Subsurface  
 Geologic Materials (0 to 12 Feet)

March 1995 Figure D-112

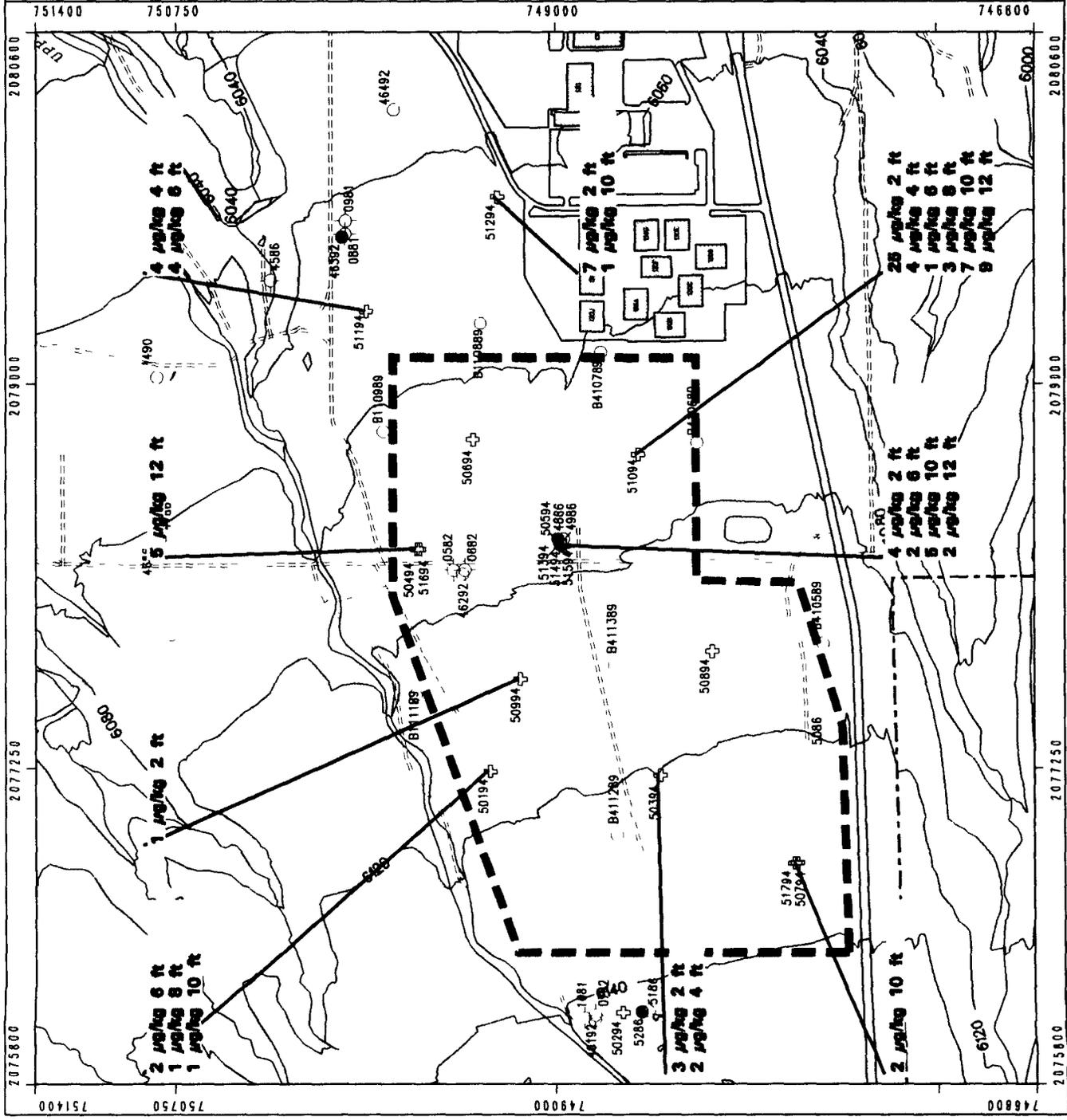
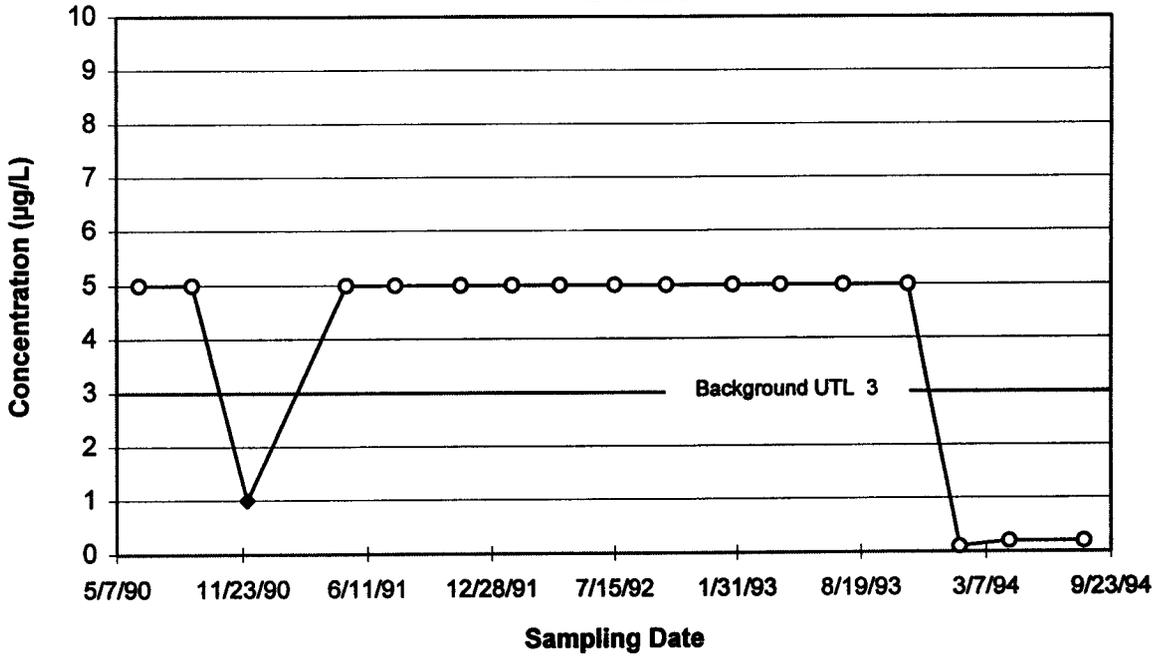




Figure D-114  
Time Series Plot - Toluene  
B411389

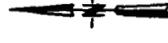


◆ Hit - Y  
○ Hit - N

# EXPLANATION

- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊙ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- ▬ OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above reporting limits



Scale = 1/8400  
1 inch = 700 feet



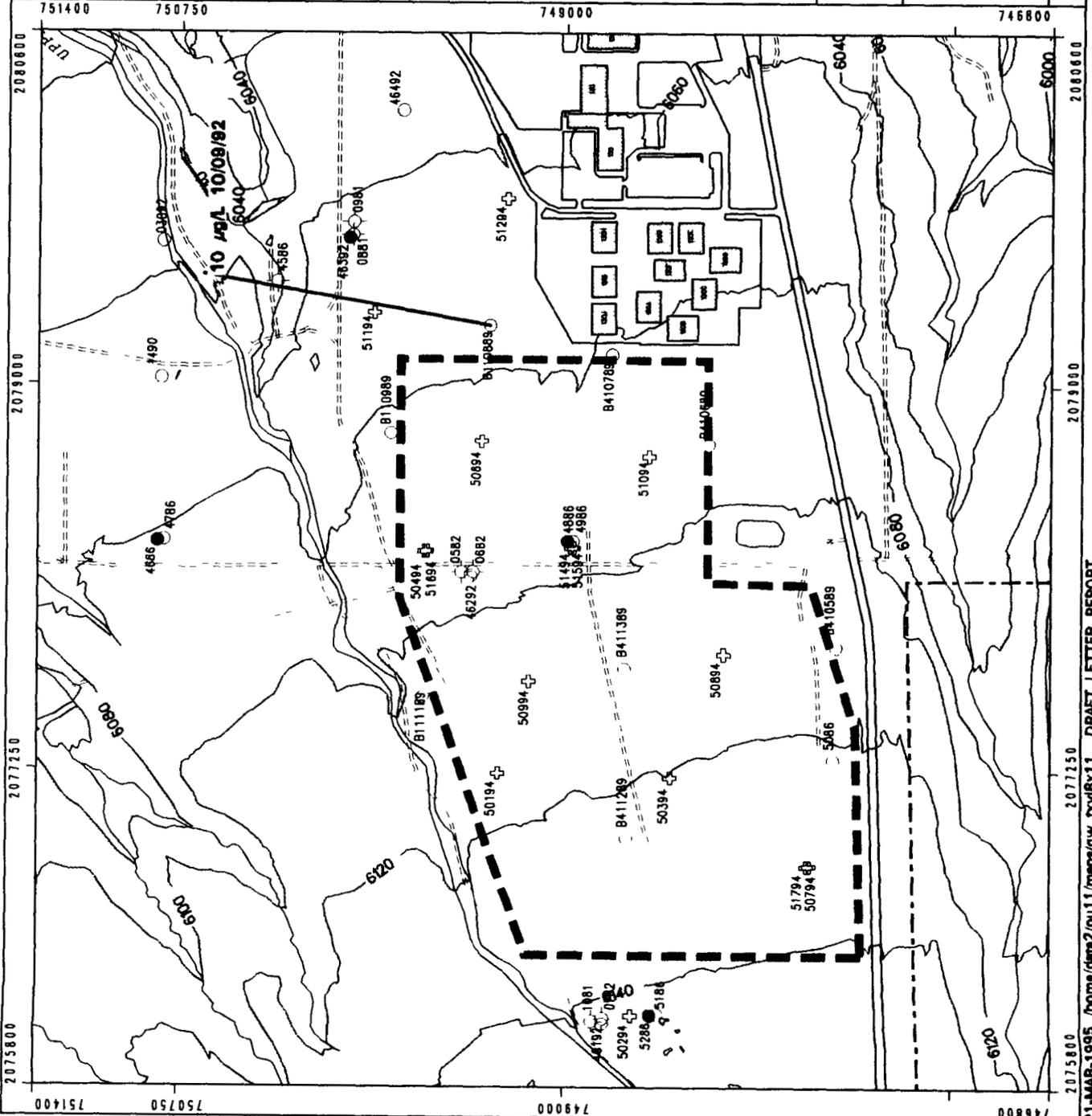
State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
TOTAL XYLENES  
Concentrations\*  
(and Sample Dates) in  
UHSU Ground Water

March 1995

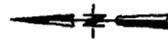
Figure D-115



# EXPLANATION

- ⊕ 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊙ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- ==== Paved Roads
- Dirt Roads
- - - Security Fences
- - - Rocky Flats Boundary
- - - OU 11 (IHSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above reporting limits



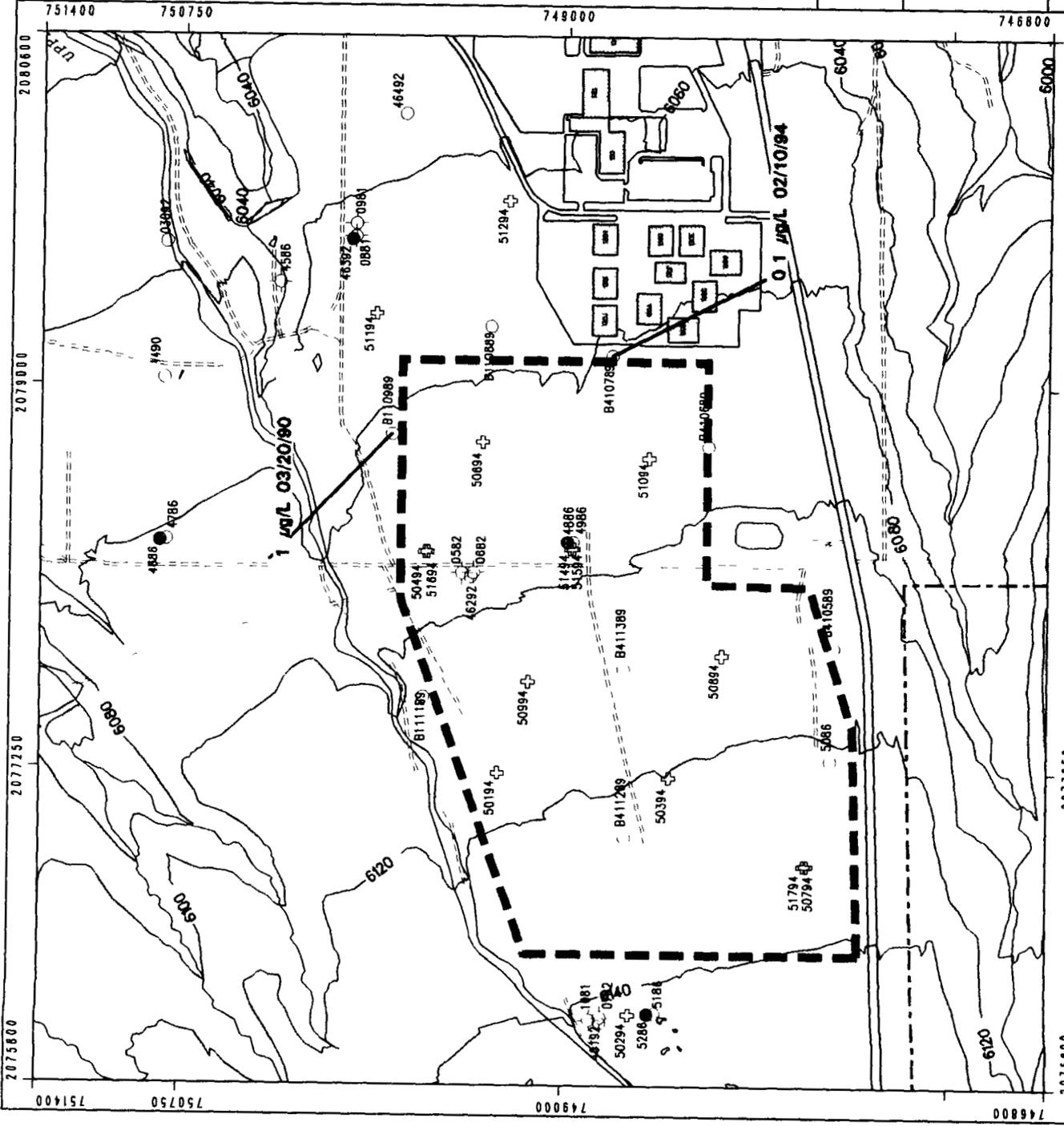
Scale = 1/8400  
1 inch = 700 feet

State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U S Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
TRICHLOROETHENE  
Concentrations\*  
(and Sample Dates) in  
UHSU Ground Water

March 1995 Figure D-116



# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- ⊕ Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (HSS 168) Boundary
- ▭ Lakes and Ponds
- ▭ Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD) BM+2SD = 1069



Scale = 1" = 8400 feet  
1 inch = 700 feet

State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U.S. Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
CYANIDE  
Concentrations\*  
(and Sample Dates) in  
UHSU Ground Water

March 1995 Figure D-117

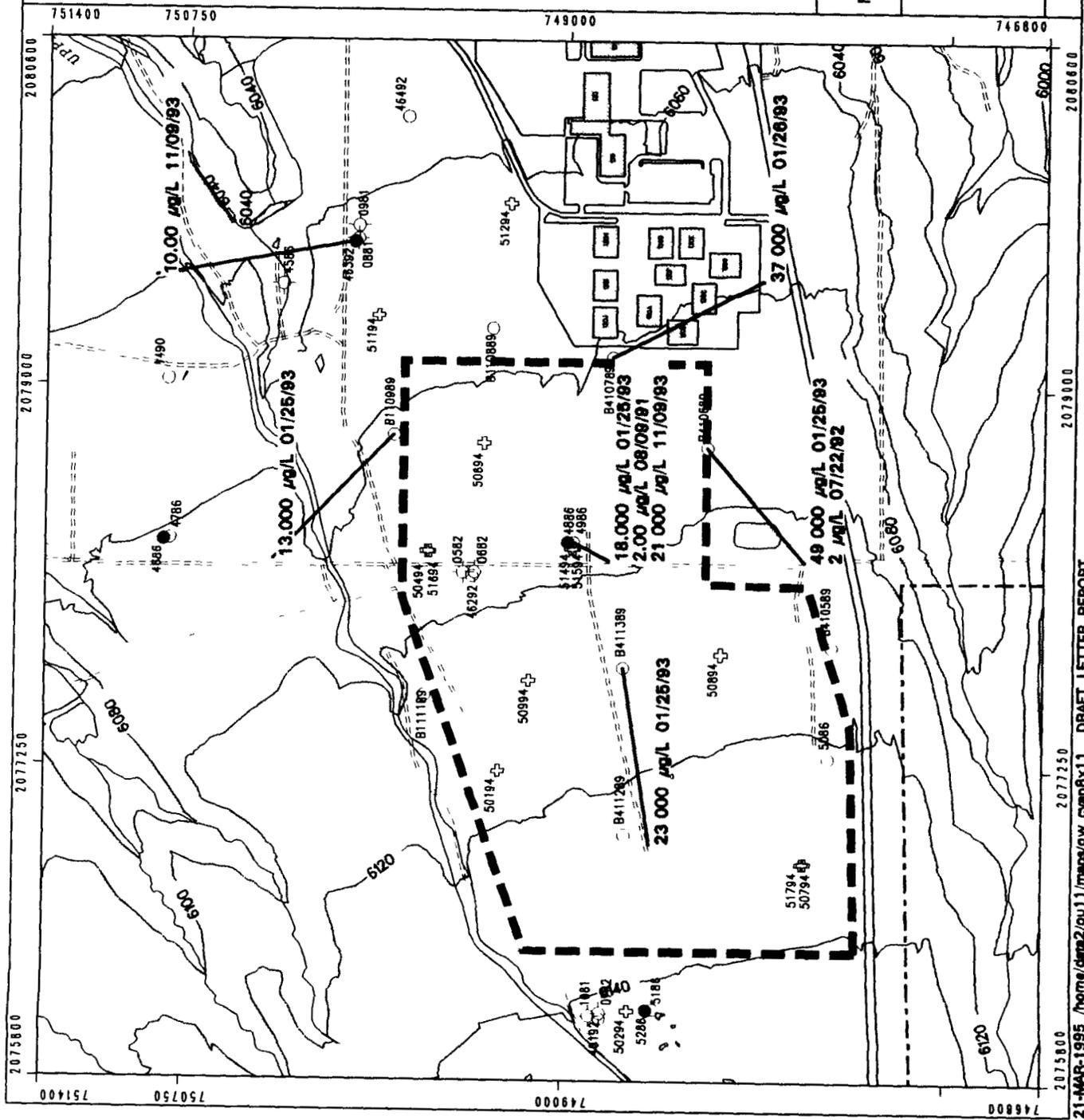
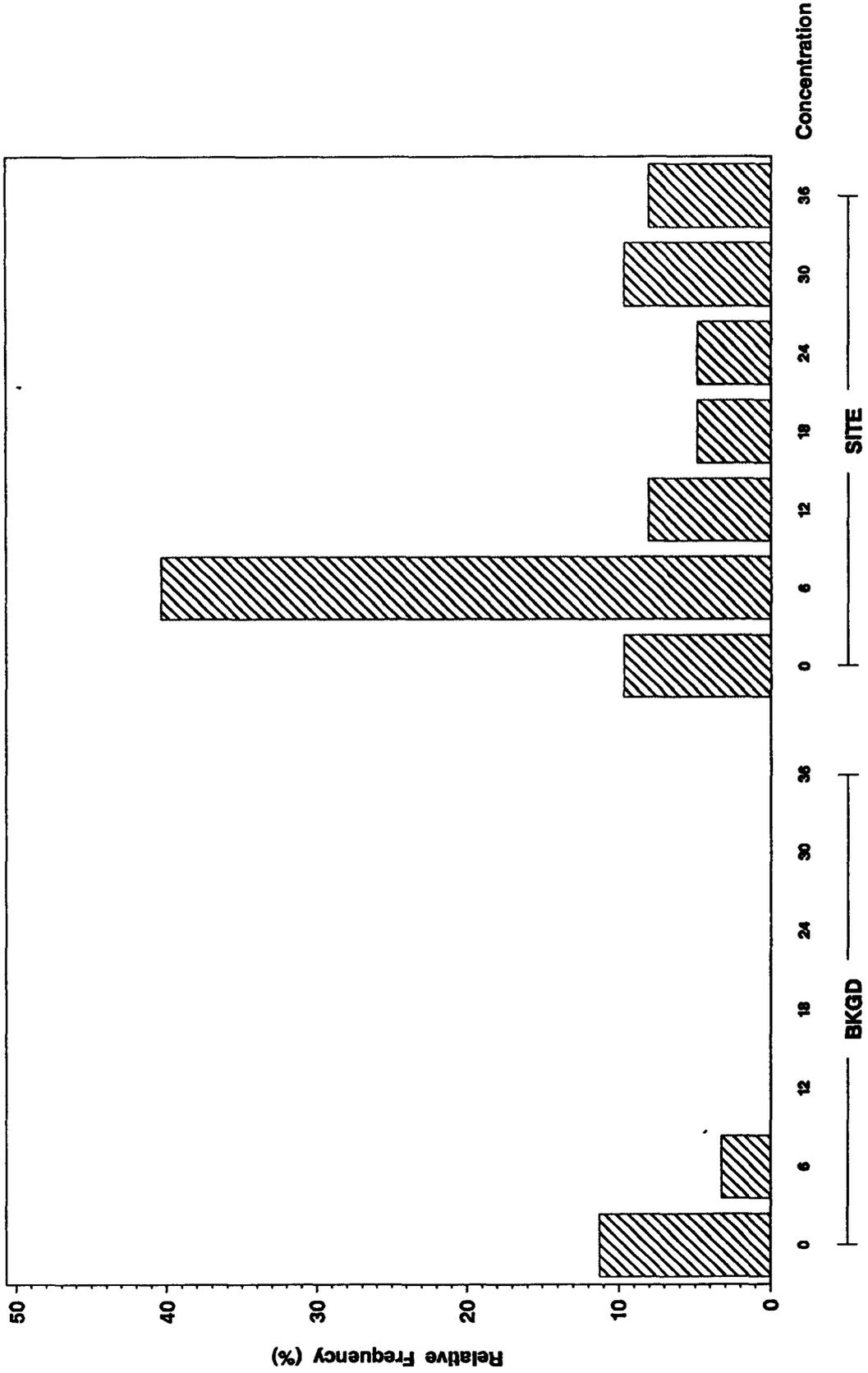


Figure B-118

# Background vs OU11 Surface Soil

## Frequency Histogram

NITRATE/NITRITE (mg/kg) in Surface Soil (0-2 inches)

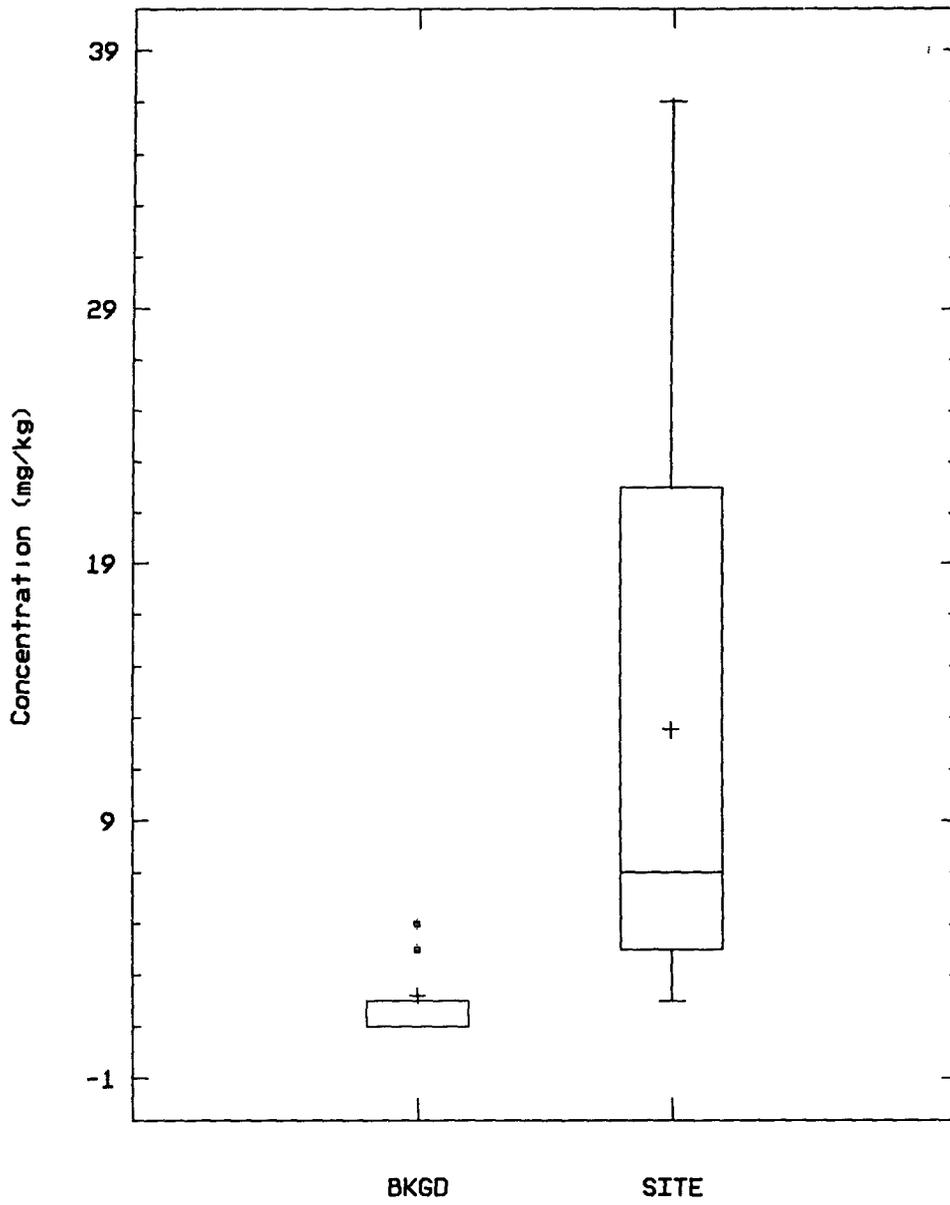


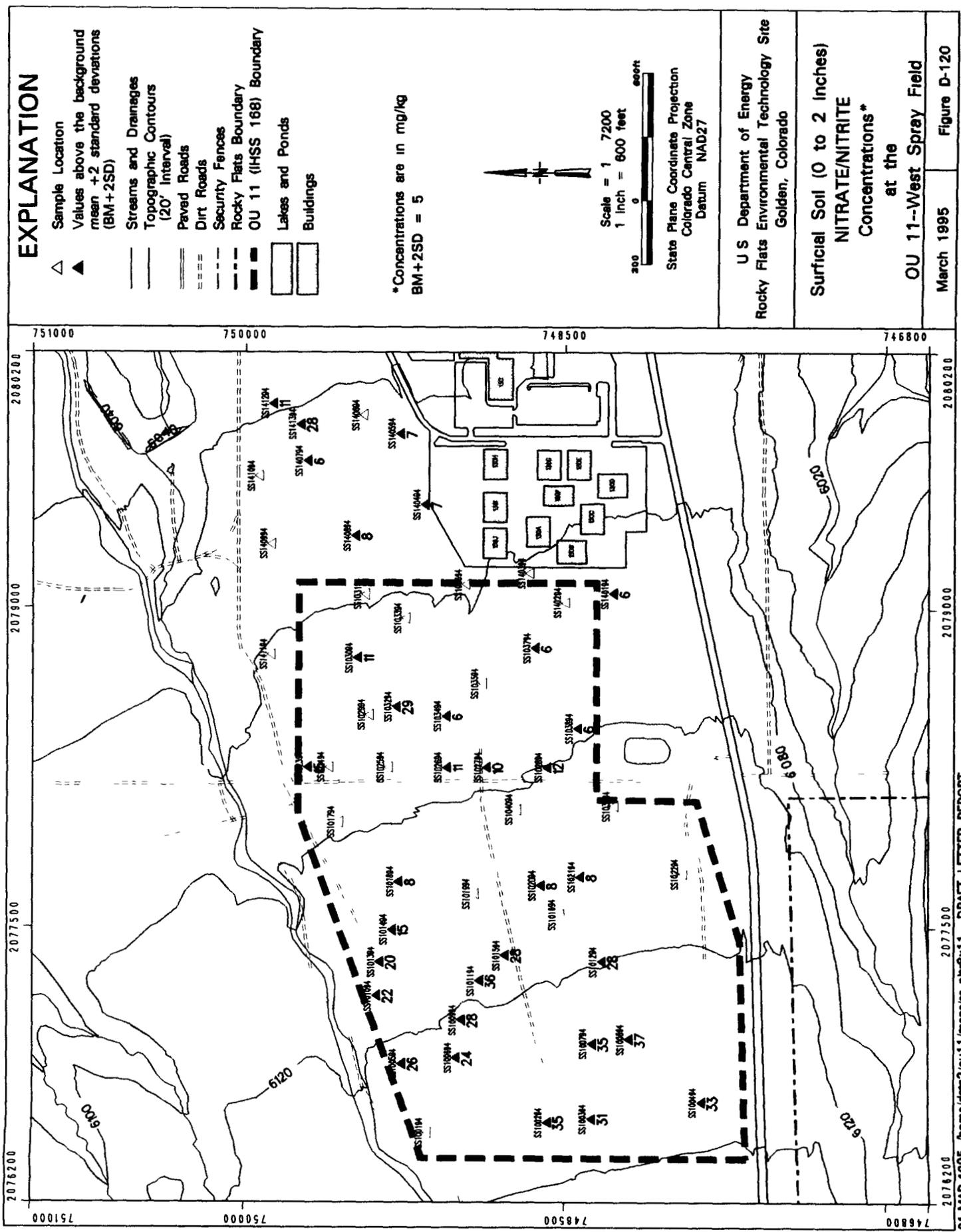
• Detected Values

SITE = All areas sampled within OU11

Figure D-119  
Background vs OU11 Surface Soil

Nitrate/Nitrite in Surface Soil (0 to 2 inches)

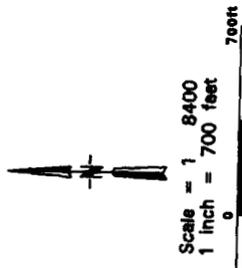




# EXPLANATION

- 1984 Borehole
- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Values above reporting limits



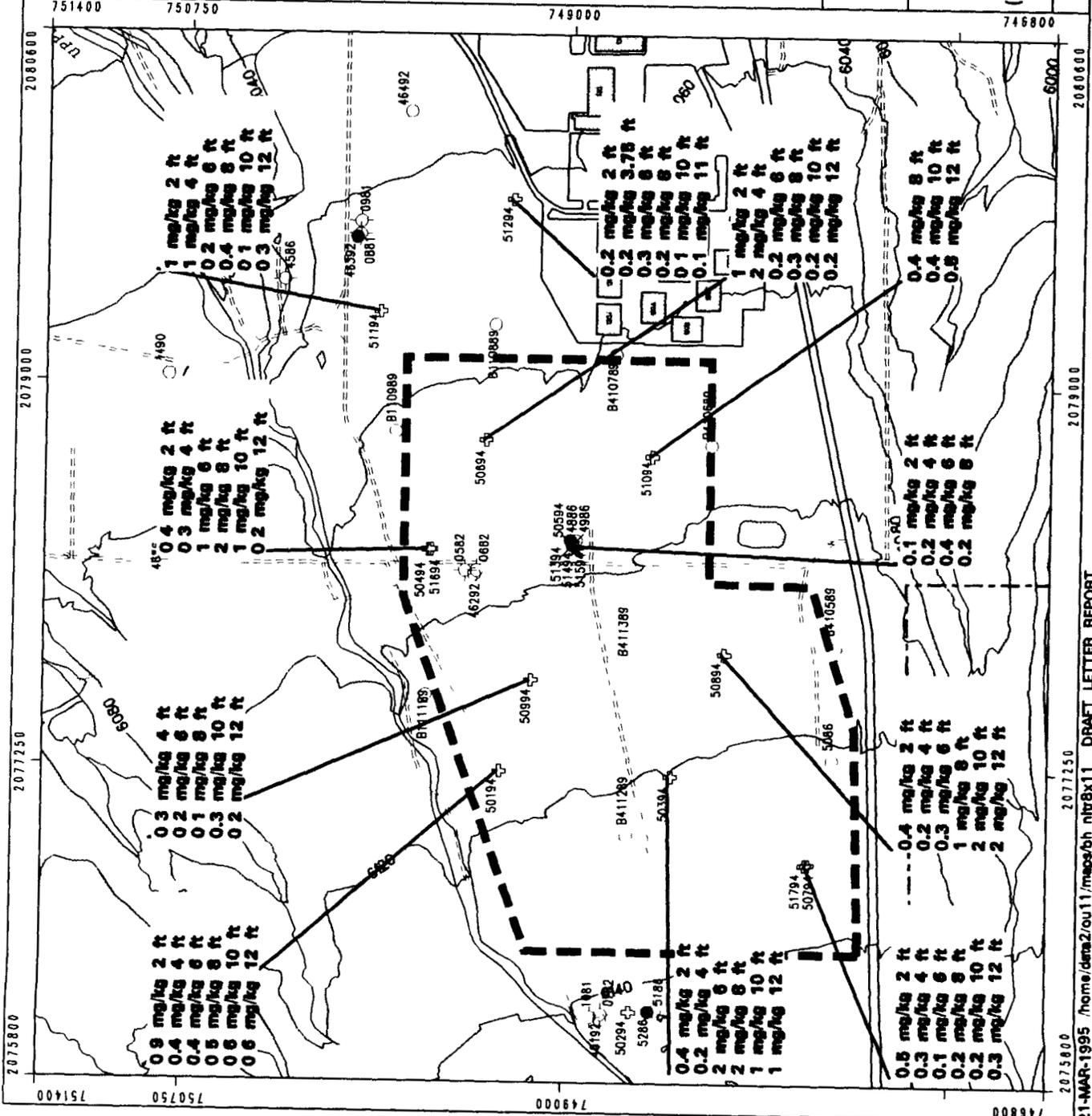
State Plane Coordinate Projection  
Colorado Central Zone  
Datum NAD27

U.S. Department of Energy  
Rocky Flats Environmental Technology Site  
Golden, Colorado

OU 11--West Spray Field  
NITRATE/NITRITE  
Concentrations\*  
(and Sample Depths) in Subsurface  
Geologic Materials (0 to 12 Feet)

March 1995

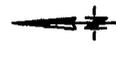
Figure D-121



# EXPLANATION

- 1994 Monitoring Well
- Alluvial Monitoring Well
- Bedrock Monitoring Well
- Abandoned Well
- Streams and Drainages
- Topographic Contours (20' Interval)
- Paved Roads
- Dirt Roads
- Security Fences
- Rocky Flats Boundary
- OU 11 (IHSS 168) Boundary
- Lakes and Ponds
- Buildings

\*Includes values above the background mean +2 standard deviations (BM+2SD)  
 BM+2SD = 4551



Scale = 1/8400  
 1 inch = 700 feet

State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum NAD27

U S Department of Energy  
 Rocky Flats Environmental Technology Site  
 Golden, Colorado

OU 11--West Spray Field  
 NITRATE/NITRITE  
 Concentrations\*  
 (and Sample Dates) in  
 UHSU Ground Water

March 1995 Figure D-122

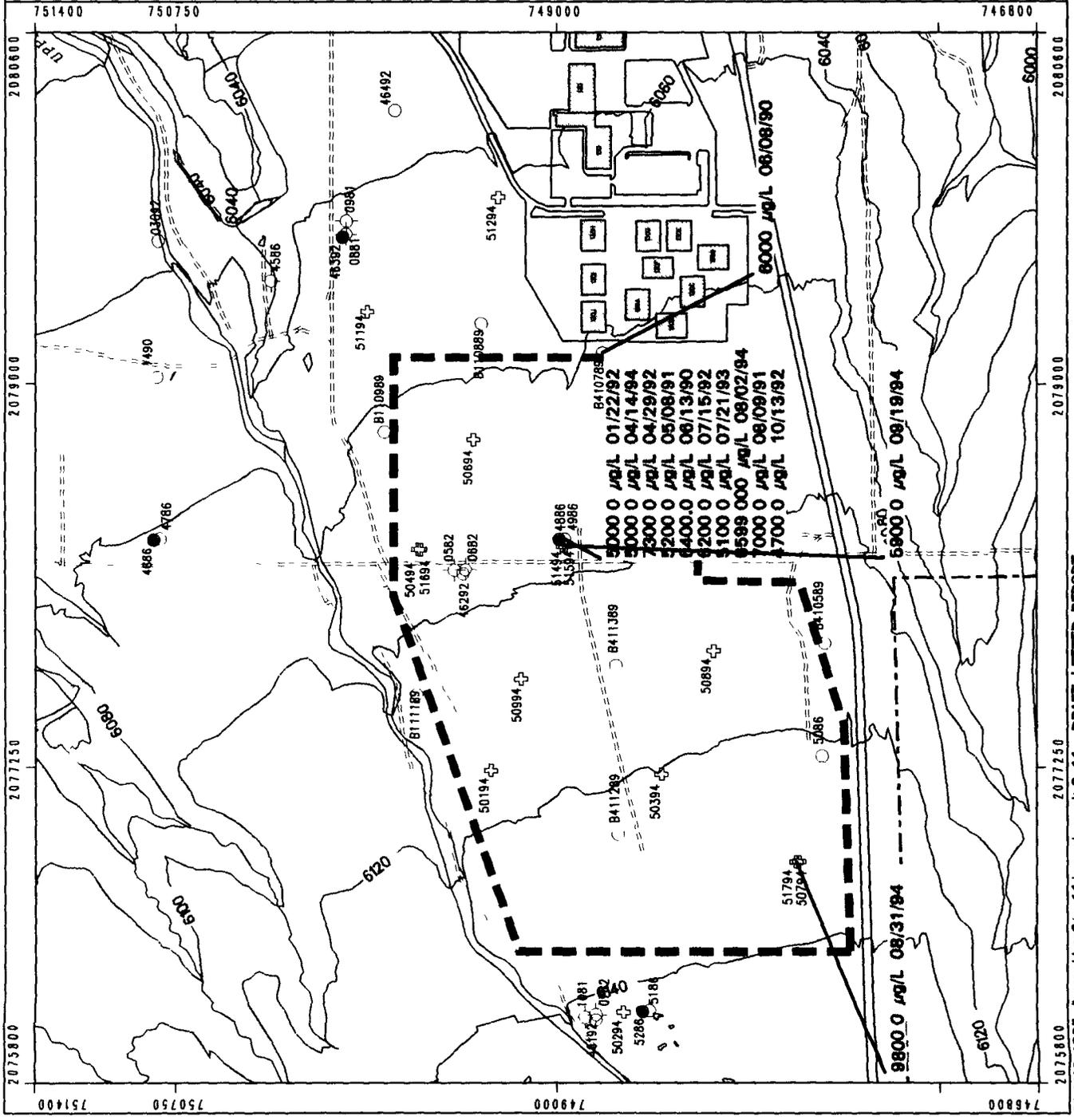
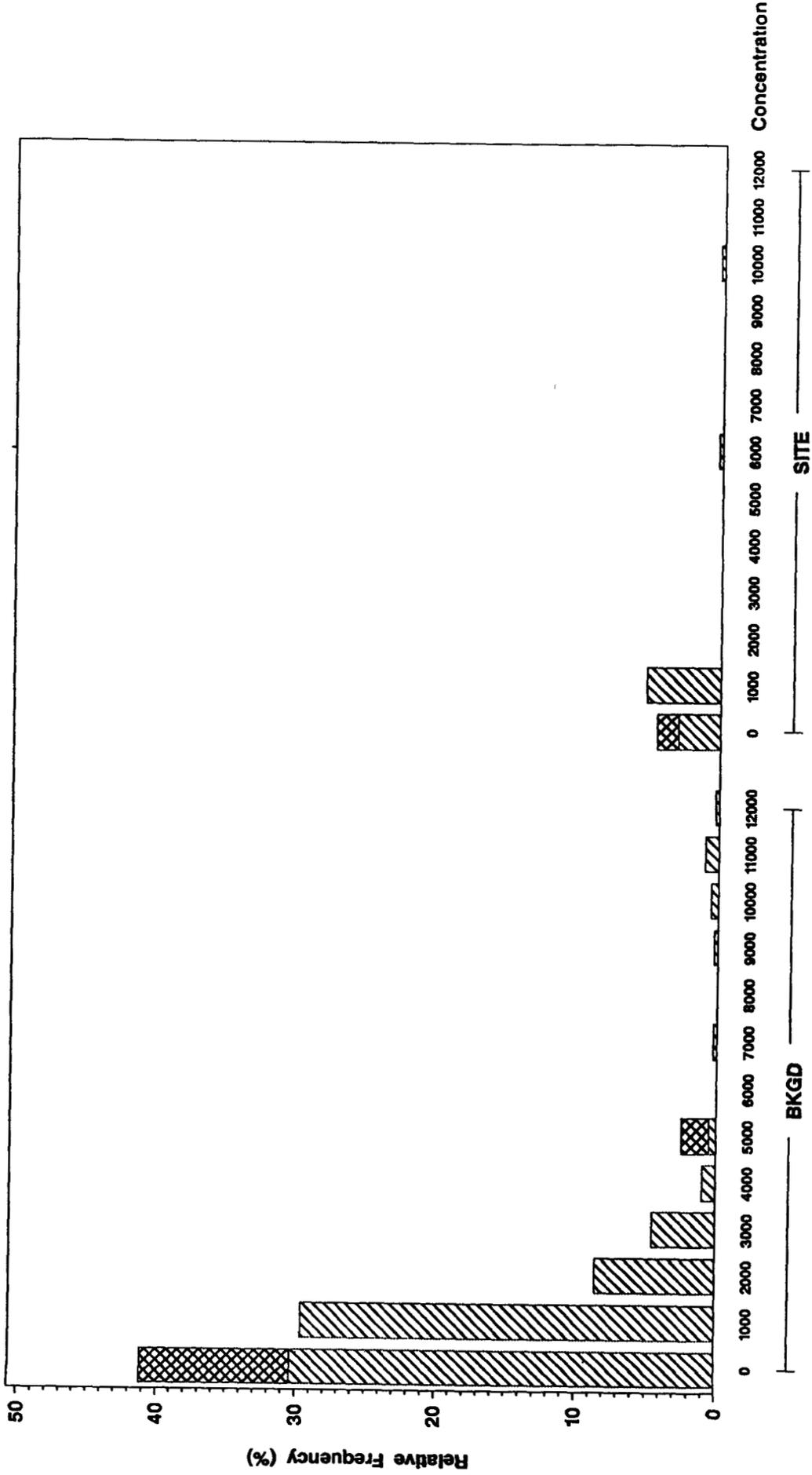


Figure D-123

# Background vs OU11 UHSU Groundwater

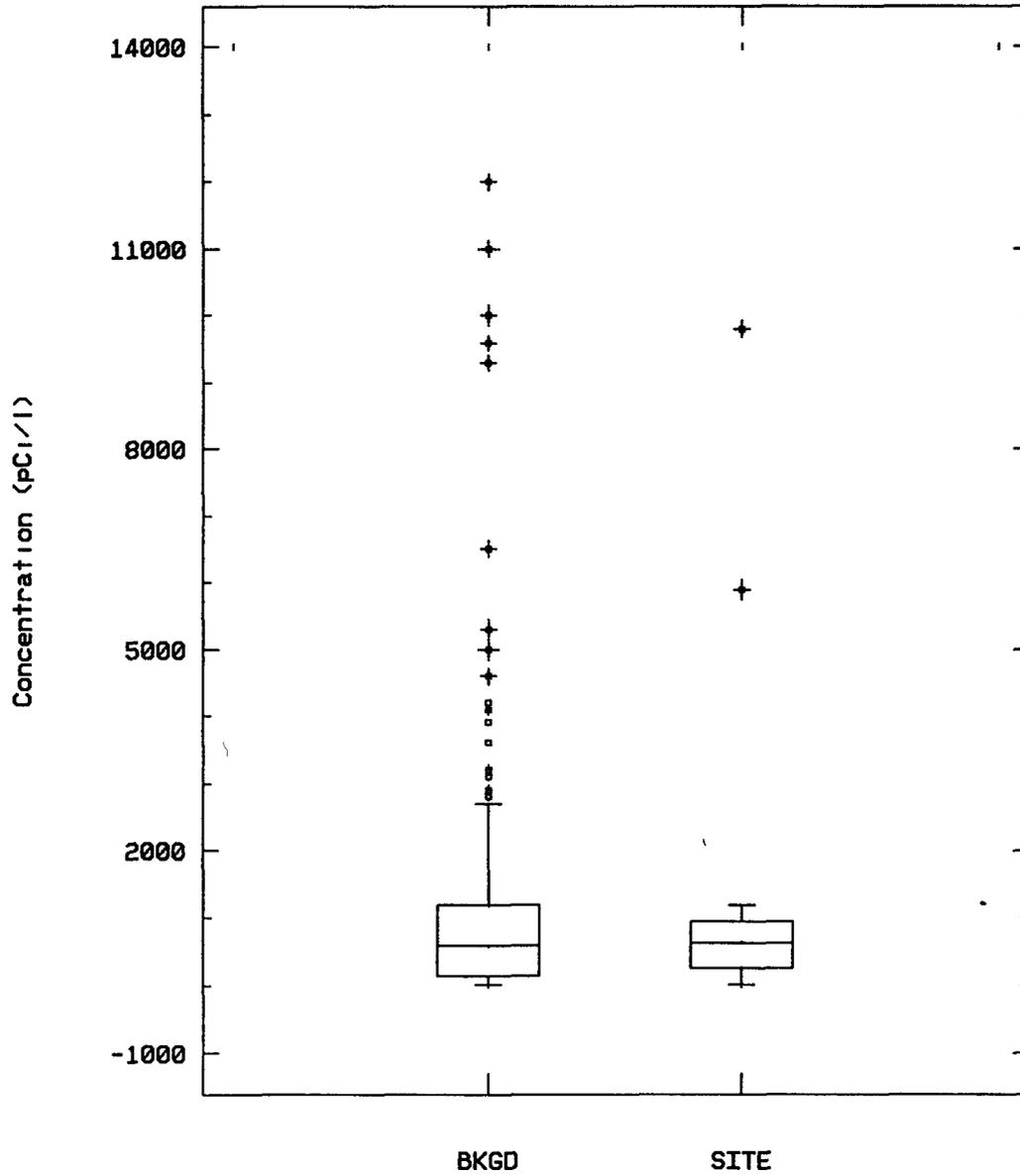
## Frequency Histogram

NITRATE/NITRITE (ug/l) in Groundwater (Total)



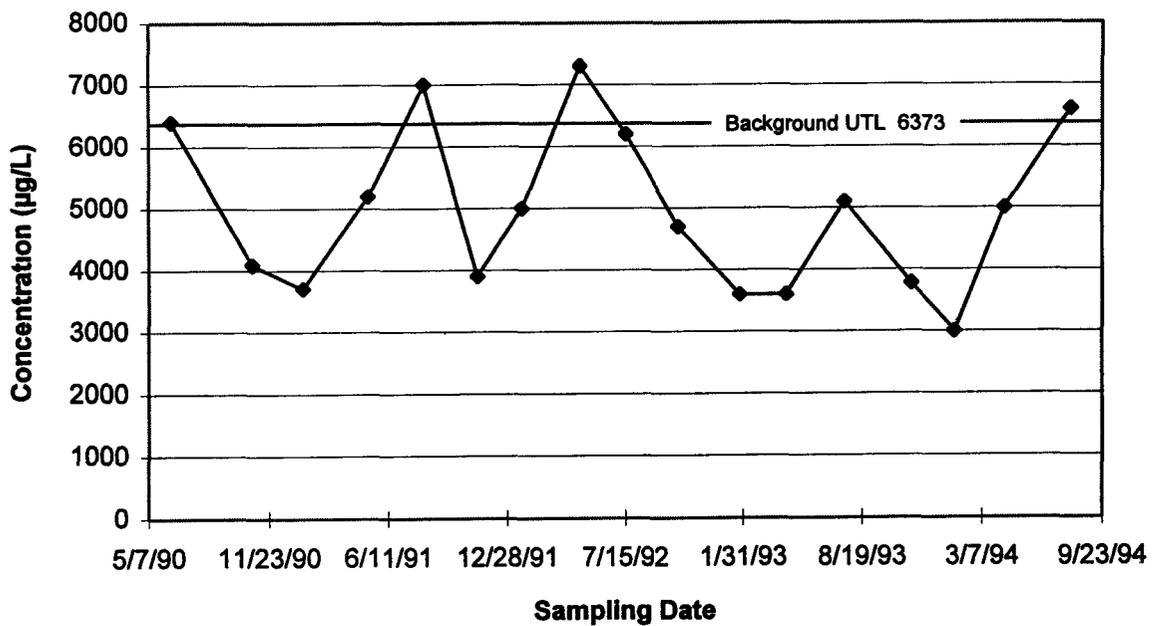
SITE = UHSU samples from saturated media within and downgradient of IHSS 168

Figure D-124  
Background vs OU11 UHSU Groundwater  
Nitrate/Nitrite in Groundwater (Total)



Groundwater samples within and downgradient of IHSS 168

Figure D-125  
Time Series Plot - Total Nitrate/Nitrite  
4986



● Hit - Y  
○ Hit - N

**APPENDIX E**

**Evaluation of Dermal Contact**

## APPENDIX E—EVALUATION OF DERMAL CONTACT

This document presents results of the dermal contact evaluation for residential exposure to surface soil in the OU 11 source area. As discussed in Section 6.0 of the OU 11 CDPHE Letter Report, Comparison of Ratio Sums to CDPHE Conservative Screen Decision Criteria, any source area that has a ratio sum less than or equal to 1 warrants no further action by DOE, pending results of a dermal contact evaluation.

To conduct the dermal contact evaluation for OU 11, maximum values for potential contaminants of concern (PCOCs) in surface soil (0 to 12 feet) in the OU 11 source area (all had a maximum PPRG ratio less than or equal to 1) were compared to risk-based concentrations (RBCs) based on dermal contact [dermal RBCs]. Carcinogenic and noncarcinogenic dermal RBCs were calculated using the following equations:

$$RBC-C \text{ (pCi/g)} = \frac{TR}{ED \times SF_r \times EF \times SA \times ABF_r \times ADF \times CF_r}$$

$$RBC-C \text{ (mg/kg)} = \frac{TR \times ATC \times BW}{ED \times SF_r \times EF \times SA \times ABF_r \times ADF \times CF_r}$$

$$RBC-NC \text{ (mg/kg)} = \frac{THI \times ATN \times BW}{ED \times \frac{1}{RfD} \times EF \times SA \times ABF_r \times ADF \times CF_r}$$

Exposure parameters for dermal contact with surface soil in a residential exposure scenario were provided by EG&G (DOE 1995) and are defined and presented in Table E-1. Dermal RBCs for each PCOC in OU 11 source area surface soil (0 to 12 feet) are presented in Table E-2.

All maximum concentrations or activities for PCOCs in surface soil in the OU 11 source area were below the dermal RBCs (Table E-3). Results of the comparison of concentrations and activities of PCOCs in OU 11 source area surface soil to dermal RBCs confirm that dermal exposure is not a significant exposure pathway for OU 11 and that OU 11 is a candidate for no action in accordance with the CDPHE/EPA/DOE Risk Assessment Agreement (CDPHE/EPA/DOE 1994) (Figure 1-2 of the OU 11 CDPHE Letter Report).

DOE 1995 Programmatic Risk-Based Preliminary Remediation Goals, Final, Revision 2 Rocky Flats Environmental Technology Site, Golden, Colorado U.S. Department of Energy February

EPA 1989 Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) EPA/540/1-89/002 U.S. Environmental Protection Agency Office of Emergency and Remedial Response Washington, D.C. December

**Table E-1. Exposure Parameters for Dermal Contact with Surface Soil (Residential Exposure Scenario)**

Exposure Parameter	Abbreviation	Value	Units
Target Risk	TR	1 0E-06	--
Target Hazard Index	THI	1	--
Averaging Time - carcinogens	ATC	25550	days
Averaging Time - noncarcinogens	ATN	10950	days
Body Weight	BW	70	kg
Exposure Duration	ED	30	yr
Oral Slope Factor - radionuclides	SF <sub>r</sub>	chemical specific	risk/pCi
Oral Reference Dose	RfD	chemical specific	mg/kg-day
Exposure Frequency	EF	350	events/yr
Surface Area	SA	5300	cm <sup>2</sup> /event
Absorption Factor - inorganics	ABF <sub>i</sub>	0 001	--
Soil-to-Skin Adherence Factor	ADF	1 0	mg/cm <sup>2</sup>
Unit Conversion Factor - radionuclides	CF <sub>r</sub>	1 0E-03	g/mg
Unit Conversion Factor - inorganics	CF	1 0E-06	kg/mg

\* According to EPA, "dermal uptake is generally not an important route of uptake for radionuclides, which have small dermal permeability constants" (EPA, 1989) however, dermal exposure to radionuclides has been quantified

**Table E-2 Dermal RBCs for PCOCs in OU 11 Source Area Surface Soil (0 to 12 Feet) (Residential Exposure Scenario)**

Potential Contaminant of Concern	Carcinogenic Dermal RBC		Noncarcinogenic Dermal RBC	
	Slope Factor (risk/pCi)	RBC-C (pCi/g)	Reference Dose (mg/kg-day)	RBC-NC (mg/kg)
AMERICIUM-241	2 4E-10	7 5E+01	--	--
NITRATE/NITRITE	--	--	1 6E+00	2 2E+07
PLUTONIUM-239/240	2 3E-10	7 8E+01	--	--
TRITIUM	5 4E-14	3 3E+05	--	--

RfD is for nitrate because nitrate is the dominant species present

**Table E-3 Comparison of Maximum Concentrations/Activities of PCOCs in OU 11 Source Area Surface Soil (0 to 12 Feet) to Carcinogenic and Noncarcinogenic Dermal RBCs**

Potential Contaminant of Concern	Maximum Concentration or Activity (Max) (mg/kg or pCi/g)	Dermal RBC		Ratio of Max to Dermal RBC
		Carcinogen (pCi/g)	Noncarcinogen (mg/kg)	
AMERICIUM-241	0 43	7 5E+01	--	0 0057
NITRATE/NITRITE	37	--	2 2E+07	--
PLUTONIUM-239/240	2 2	7 8E+01	--	0 028
TRITIUM	3 4	3 3E+05	--	0 000010