00-DOE-00079

RF/RMRS-99-347

Sampling and Analysis Plan for Groundwater Investigations Involving Actinide Drilling-Artifact Contamination, the Industrial Area VOC Plume East Boundary, and Solar Ponds Plume Well Installations

Final

July 1999
Revision 0

1/108

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Revision 0

July 30, 1999

This Sampling and Analysis Plan has been reviewed and approved by:

S. H. Singer — 7/29/99

S. H. Singer, RMRS Project Manager — Date

FOR — 7/29/99

G. D. DiGregorio, RMRS Quality Assurance — Date

Prepared by:
Rocky Mountain Remediation Services, L.L.C.
Rocky Flats Environmental Technology Site
Golden, Colorado

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ACRONYMS

Am	Americium
APO	Analytical Project Office
AR	Administrative Records
ASD	Analytical Services Division
ASI	Advanced Sciences, Inc.
°C	Celsius, degrees
CDPHE	Colorado Department of Public Health and the Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	Decontamination and Demolition
DER	Duplicate Error Ratio
DOE	U. S. Department of Energy
DQO	Data Quality Objective
EDD	Electronic Disc Deliverable
EMD	Environmental Management Department
EMSL	Environmental Monitoring Support Laboratory
EPA	U. S. Environmental Protection Agency
ER	Environmental Restoration
FID	Flame Ionization Detector
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FO	Field Operations
GC/MS	Gas Chromatography/Mass Spectrometry
GPS	Global Positioning System
H_2SO_4	Sulfuric Acid
HNO_3	Nitric Acid
HRR	Historical Release Report
HSS	Health and Safety Specialist
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
IMP	Integrated Monitoring Plan
ITS	Interceptor Trench System
K-H	Kaiser-Hill
mg/L	milligrams per liter
ml	milliliter
µg/L	micrograms per liter
µm	micrometer
NEPA	National Environmental Policy Act
OPWL	Original Process Waste Line
OU	Operable Unit
PA	Protected Area
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCE	Tetrachloroethene
pCi/L	picocuries per liter
PID	Photoionization detector

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ACRONYMS (cont'd)

PPE	Personal protective equipment
Pu	Plutonium
QA/QC	Quality Assurance/Quality Control
QAPD	Quality Assurance Program Description
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RMRS	Rocky Mountain Remediation Services, L.L.C.
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SEP	Solar Evaporation Ponds
SOPs	Standard Operating Procedures
SPP	Solar Ponds Plume
SWD	Soil and Water Database
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TSS	Total Suspended Solids
U	Uranium
UHSU	Upper Hydrostratigraphic Unit
VOC	Volatile Organic Compound

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LIST OF APPLICABLE STANDARD OPERATING PROCEDURES (SOPs)

Identification Number	Procedure Title
1-PRO-079-WGI-001	*Waste Characterization, Generation, and Packaging*
2-S47-ER-ADM-05.15	*Use of Field Logbooks and Forms*
5-21000-OPS-FO.03	*General Equipment Decontamination* or successor (RMRS/OPS-PRO.127)
4-H66- ER-OPS-FO.05	*Handling Purge and Development Water* or successor (RMRS/OPS-PRO.128)
5-21000-OPS-FO.06	*Handling of Personal Protective Equipment*
4-K56-ENV-OPS-FO.08	*Monitoring and Containerizing Drilling Fluids and Cuttings* or successor (RMRS/OPS-PRO.115)
5-21000-OPS-FO.15	*Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs)*
5-21000-OPS-FO.16	*Field Radiological Measurements*
5-21000-OPS-GT.06	*Monitoring Wells and Piezometer Installation* or successor (RMRS/OPS-PRO.118)
4-E42-ER-OPS-GT.08	*Surface Soil Sampling*
5-21000-OPS-GT.17	*Land Surveying* or successor (RMRS/OPS-PRO.123)
4-S64-ER-OPS-GT.39	*Push Subsurface Soil Sampling* or successor (RMRS/OPS-PRO.124)
RMRS/OPS-PRO.069	*Containing, Preserving, Handling and Shipping of Soil and Water Samples*
RMRS/OPS-PRO.070	*Equipment Decontamination at Decontamination Facilities*
RMRS/OPS-PRO.101	*Logging Alluvial and Bedrock Material*
RMRS/OPS-PRO.102	*Borehole Clearing*
RMRS/OPS-PRO.105	*Water Level Measurements in Wells and Piezometers*

LIST OF APPLICABLE STANDARD OPERATING PROCEDURES (SOPs) - Continued

RMRS/OPS-PRO.106	*Well Development*
RMRS/OPS-PRO.108	*Measurement of Groundwater Field Parameters*
RMRS/OPS-PRO.112	*Handling of Field Decontamination Water and Field Wash Water*
RMRS/OPS-PRO.113	*Groundwater Sampling*
RMRS/OPS-PRO.114	*Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques*
RMRS/OPS-PRO.117	*Plugging and Abandonment of Boreholes*
PADC-96-00003	*WSRIC for OU Operations, Version 6.0, Section 1*
RF/RMRS-98-200	*Evaluation of Data for Usability in Final Reports*
RM-06.02	*Records Identification, Generation and Transmittal*
RM-06.04	*Administrative Record Document Identification and Transmittal*

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1.0 INTRODUCTION

1.1 Purpose

This Sampling and Analysis Plan (SAP) provides for monitoring well installation and groundwater sampling activities at three independent project areas at the Rocky Flats Environmental Technology Site (RFETS) in support of hydrogeologic Site evaluation activities being conducted to refine plume extent and dynamics, and evaluate the potential for long-term contaminant migration to surface water. The scope of this SAP includes the following projects:

Project	Purpose
1) Actinide Drilling-Artifact Contamination	Investigate drilling-artifact contamination as a potential source of plutonium-239/240 and americium-241 to groundwater from actinide-contaminated surface soil areas recommended in *Evaluation of Plutonium and Americium in Groundwater at the Rocky Flats Environmental Technology Site, RF/RMRS-98-229.UN, Draft Final* (DOE, 1998).
2) Industrial Area VOC Plume East Boundary	Delineate eastern Industrial Area (IA) plume boundary to evaluate potential groundwater pathways to surface water and improve groundwater monitoring coverage in critical, unmonitored areas, as required by the *RFETS Integrated Monitoring Plan* (DOE, 1997b).
3) Solar Ponds Plume Well Installations	Investigate the extent of Solar Ponds nitrate and uranium plumes beyond the western end of the proposed Solar Ponds Plume Reactive Barrier Treatment System, as proposed in the *Draft Solar Ponds Plume Decision Document, RF/RMRS-98-286.UN* (RMRS, 1999).

The objective of this SAP is to define specific data needs, sampling and analysis requirements, data handling procedures, and associated Quality Assurance/Quality Control (QA/QC) requirements for these projects. All work will be performed in accordance with the Rocky Mountain Remediation Services (RMRS) Quality Assurance Program Description (QAPD) (RMRS, 1997). Field activities planned under this SAP are limited to well installation, well development, and initial groundwater

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sampling activities. Additional groundwater sampling for long-term monitoring will be accomplished by the Groundwater Monitoring Program as specified in the Integrated Monitoring Plan (IMP) (DOE, 1997b).

This SAP incorporates information and data interpretations from previous investigations conducted at the three project areas as a basis for designing and implementing each proposed field activity. Implementation of this project will be performed in accordance with applicable Federal, State, and local regulations, as well as U. S. Department of Energy (DOE) Orders, Rocky Flats Environmental Technology Site (RFETS) policies and procedures, and RMRS Operating Procedures.

1.2 Background

1.2.1 Actinide Drilling-Artifact Contamination

The potential migration of plutonium-239/240 (Pu-239/240) and americium-241 (Am-241) from surface soils to groundwater at RFETS is being considered as part of the long-term remedial strategy currently under evaluation for Site closure implementation by DOE, the Kaiser-Hill (K-H) Team, and the Actinide Migration Evaluation Group. Existing data on actinide migration at RFETS was summarized by DOE (1997a) for the development of a conceptual model designed to gain an understanding of actinide transport pathways active at the Site. Over 30 monitoring wells at RFETS were found to contain mean groundwater Pu-239/240 and Am-241 activity-concentrations that exceeded Rocky Flats Cleanup Agreement (RFCA) Tier II action levels (0.15 picocuries per liter (pCi/L) and 0.145 pCi/L, respectively) for these contaminants (DOE, 1996). Groundwater interactions with surface water are inevitable as virtually all shallow groundwater on Site flows toward the major stream drainages and is eventually discharged to surface water via streams or reservoirs. Consequently, groundwater was characterized as representing a potential long-term threat to surface water based on a preliminary review of the available data.

The presence of Pu-239/240 and Am-241 in groundwater samples at RFETS has been the subject of much speculation and study (DOE, 1997a; EG&G, 1995a; CDPHE, 1996; Harnish et. al., 1994 and 1996; and Litaor, et. al., 1996). These contaminants are usually considered to be relatively immobile

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in the soil and groundwater environment due to their low aqueous solubility and tendency to strongly sorb on soil media (Cleveland et. al., 1976 and Honeyman and Santschi, 1997). Most wells with exceedances are located near potential source areas, such as the 903 Pad, but some are located at great distances from sources, including monitoring wells located at the east Site boundary along Walnut Creek. Colloid facilitated-transport of radionuclides in groundwater has been reported in the literature as being a potentially important mechanism for increased radionuclide mobility in the subsurface. Alternatively, it has been speculated that well completion zones may have been cross-contaminated when drilling through radionuclide-bearing surface soils or sediments found near source areas.

Because a significant disparity exists between observed versus expected Pu-239/240 and Am-241 groundwater contaminant distributions, further evaluation of historical groundwater Pu-239/240 and Am-241 data and potential transport pathways was undertaken in 1998 to assess the significance of groundwater action level exceedances reported for RFETS monitoring wells. This analysis, presented in the draft report *Evaluation of Plutonium and Americium in Groundwater at the Rocky Flats Environmental Technology Site* (DOE, 1998), concluded that much of the Pu-239/240 and Am-241 contamination detected in groundwater probably occurs from residual surface soil contamination introduced to the borehole during drilling and well installation operations (drilling-artifact contamination). Groundwater samples collected from these wells using historical RFETS sampling techniques (i.e., bailing) have the unavoidable effect of suspending contaminated drilling-artifact soil materials, thus creating artificially high contaminant levels. Under these circumstances, existing groundwater sampling results are unreliable indicators of groundwater contaminant concentration and transport.

Well drilling and installation using special surface-casing techniques offer a means to minimize or eliminate drilling-artifact contamination as a source for Pu-239/240 and Am-241 detections in groundwater samples. When paired with existing monitoring wells containing Pu-239/240 and Am-241 contamination, monitoring wells installed with special surface-casing techniques can 1) provide a basis for assessing the effects, if any, of drilling-artifact contamination on groundwater sample quality, and 2) allow for the collection of groundwater samples that more accurately represent contaminant concentrations and transport conditions. Non-paired, specially-cased monitoring wells were installed in 1994 to evaluate elevated Pu-239/240 and Am-241 activity-concentrations in the lower Walnut Creek drainage and to upgrade boundary monitoring well integrity in other RFETS drainages (EG&E, 1995a). No Pu-239/240 and Am-241 contamination above Tier II groundwater action levels was detected in any of the wells installed under this program. To date, monitoring wells installed with special surface-casing techniques have not been paired with existing monitoring wells to validate or invalidate radionuclide detections found in the original well.

Four wells with persistent Pu-239/240 activity-concentrations that exceed the RFCA action level of 0.151 pCi/L have been selected for pairing under this program based on a preliminary evaluation of Pu-239/240 and Am-241 in groundwater conducted by DOE (1998). These wells include 1587, 06991, 11791, and P313489, all of which are known to occur in the surface soil plutonium contamination areas shown on Figure 1-1. It is expected that paired well comparisons of Pu-239/240 and Am-241 activity-concentrations will help resolve some lingering issues involving groundwater plutonium and americium contamination at RFETS, particularly with regard to vertical transport through soil materials.

1.2.2 Industrial Area VOC Plume East Boundary

A broad area of chlorinated hydrocarbon groundwater contamination associated with the central IA has been identified and consolidated into a single composite "plume" known as the IA Volatile Organic Contaminant (VOC) Plume. As currently depicted in Figure 1-2, this plume extends approximately south to the Woman Creek drainage; north to the Protected Area (PA) perimeter fence; west to Buildings 444 and 334; and east to the Solar Evaporation Ponds (SEP), Building 707, and Eighth Street south of Central Avenue. Organic compounds selected to delineate the IA VOC plume boundary include trichloroethene (TCE), tetrachloroethene (PCE), carbon tetrachloride, and vinyl chloride. The variable distribution and concentration of individual VOC contaminants (see RMRS, 1998, Plates 8, 9, 10, and 12) suggest that multiple sources make up this plume, the best known being the Individual Hazardous Substance Site (IHSS) 118.1 carbon tetrachloride plume north of Buildings 776/777 (currently being addressed under a separate technical memorandum). The IA VOC plume contains elevated concentrations of TCE thought to emanate from IHSSs 117.1, 117.2, 157.1, 158, and 171; PCE thought to emanate from IHSSs 117.1, 117.2, 157.1, 158, 160, and 171; and carbon tetrachloride thought to emanate from IHSSs 117.1, 117.2, and 158. Additional sources, such as process waste

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lines, may also have contributed to the plume. The center of this composite plume is southwest of Building 559, outside of the fenced portion of the PA.

Previous interpretations of IA VOC plume boundaries and groundwater flow patterns have concluded that plume movement is relatively slow or stagnant, particularly along the east boundary. To date, the south and north plume boundaries have either been or are currently being evaluated to assess the potential for contaminant migration to surface water, specifically Woman and North Walnut Creeks. At the leading edge of each boundary, a line of Geoprobe® well point piezometers spaced at 100 foot intervals was installed and sampled to identify primary plume pathways (Figure 1-2). The current project focuses on the east boundary extending from the northwest corner of Building 881 in the south-central IA to the northwest corner of Building 776 in the north-central IA. Areas downgradient of this boundary have not been adequately characterized due to incomplete well coverage in key locations, especially near major buildings (i.e., 883, 707, and 776), and a buried headcut portion of South Walnut Creek, a former seepage area, located between the south end of Building 707 and the south PA perimeter fence.

1.2.3 Solar Ponds Plume Well Installations

RFETS is preparing to install a collection trench/reactive barrier treatment system for the remediation of Solar Ponds Plume (SPP) nitrate and uranium contaminated groundwater associated with the Solar Evaporation Ponds (SEP). The SEPs were used to store and evaporate radioactive process wastes and neutralize acidic process wastes containing high concentrations of nitrate and aluminum hydroxide from 1953 to 1986. Leakage from the SEPs has contaminated shallow groundwater in the area, which is migrating northward from the SEPs and entering North Walnut Creek. Additional information about SEP history and previous investigations is presented in the *Solar Ponds Plume Decision Document* (RMRS, 1999) currently in preparation.

RMRS (1999) conducted an evaluation of remedial alternatives which determined that a reactive barrier treatment system was the most effective means for remediating SPP groundwater. Figure 1-3 illustrates the proposed location of this system. Concerns about the extent of plume contaminants, specifically at the west end of the reactive barrier, have prompted the need for additional well

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installations. The complex vertical distribution of SPP contaminants observed in wells completed elsewhere in the Solar Ponds area indicate that a cluster of alluvial and bedrock wells will be required to adequately delineate the vertical extent of contamination. In addition to delineating SPP extent, these wells will be used for monitoring the performance of the treatment system.

1.3 Hydrogeologic Setting

1.3.1 Geology

RFETS is situated at the margin of a gently eastward-sloping topographic and bedrock pediment surface mantled by unconsolidated Pleistocene Rocky Flats Alluvium and underlain mainly by claystones, siltstones, and sandstones of the Cretaceous Arapahoe and Laramie Formations (EG&G, 1995b). East of this margin, colluvium-covered hillslopes dominate the landscape, except along valley bottoms where valley-fill alluvial deposits occupy the major stream courses. The Actinide Drilling-Artifact Contamination, IA VOC Plume East Boundary, and SPP project areas are situated primarily on Rocky Flats Alluvium and colluvium, and will involve borehole drilling and well installation in these deposits and, to a lesser extent, the underlying weathered bedrock.

The Rocky Flats Alluvium is comprised chiefly of poorly sorted, clayey gravels and sands with abundant cobble and boulder-sized material and discontinuous lenses of clay, silt, and sand. Hillside colluvial deposits are markedly finer-grained in texture, being comprised of clay, clayey gravels, and lesser amounts of sand and silt. These deposits were derived from geologic material exposed on the steep slopes and topographic highs, and were formed by slope wash, downslope creep, and landslide action. Valley-fill deposits were fluvially derived from upstream materials, and consist of clay, silt, and sand with lenses of gravel. These deposits occur along the drainage bottoms in and adjacent to stream beds, and are most common in the eastern portions of RFETS.

The Arapahoe Formation ranges from 0 to 50 feet thick at RFETS and consists mainly of a discontinuous but mappable, fine- to medium-grained, moderately- to poorly- sorted sandstone unit that forms the uppermost sandstone of significant lateral extent. This unit has been designated the Arapahoe Formation (or Number 1) sandstone (EG&G, 1995b) and is known to locally subcrop beneath the Rocky Flats

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Alluvium and colluvium in the 903 Pad, East Trench and other areas of the eastern Industrial Area. It has been shown to be an important pathway for the lateral transport of contaminated groundwater to surface water in other areas of the Site (i.e., South Walnut Creek) (RMRS, 1998).

The Laramie Formation conformably underlies the Arapahoe Formation and consists primarily of massive claystone and siltstone with discontinuous clayey sandstone units (EG&G, 1995b). Unlike the Arapahoe Formation sandstone, these sandstone units exhibit lithologic and hydrologic characteristics (i.e., high matrix clay content and low permeability) that are not indicative of contaminant pathways. These lenticular Laramie Formation sandstones are texturally distinct from the Arapahoe Formation sandstone by virtue of their high silt and clay content (EG&G, 1995b).

1.3.2 Actinide Drilling-Artifact Contamination

1.3.2.1 Groundwater Occurrence and Distribution

Monitoring well locations for the Actinide Drilling-Artifact Contamination Investigation were selected on the basis of elevated and persistent Pu-239/240 and Am-241 contamination levels reported in previous groundwater sampling events; groundwater contamination that is consistent with mapped surface soil plutonium concentrations; well drilling and construction practices that indicate the potential for drilling-artifact contamination from surface and shallow subsurface soils; and site access considerations, including radiological work permit restrictions and support requirements. This section describes the specific hydrogeologic conditions that affect well design at each of the four proposed monitoring well locations.

Figure 1-4 illustrates the location of the four proposed monitoring well locations in relationship to groundwater flow patterns developed from 2nd quarter 1997 water level data. Wells 1587, 06991, and P313489 are completed in the Rocky Flats Alluvium and well 11791 is completed in weathered bedrock. The depth to bedrock, average depth to groundwater, saturated thickness, and water table fluctuation ranges for the four well locations are presented in Table 1-1. Each new well will be offset 10 feet from the existing paired well to minimize disturbances to the well and associated groundwater. Well logs and hydrographs for each of the existing wells are provided in Appendix A.

Table 1-1 Hydrogeologic Conditions at Selected Actinide Drilling-Artifact Contamination Monitoring Well Sites

Well Number	Completion Zone	Surface Elevation (ft amsl)	Depth to Bedrock (ft)	Average Depth to Water (ft)	Average Saturated Thickness (ft)	Water Table Fluctuation Range (ft bgs)	
						High	Low
1587	Q_{rf}	5971.3	21.9	19.3	2.6	6.3	22.1
06991	Q_{rf}	5972.9	28.6	16.9	11.7	6.9	19.9
11791	K_{wbr}	5923.3	6.9	6.3	6.8	0.3	7.5
P313489	Q_{rf}	6011.7	20.6	11.7	8.9	7.5	13.9

Data compiled from individual well hydrographs (EG&G, 1995c)
Q_{rf} = Rocky Flats Alluvium; K_{wbr} = weathered bedrock; amsl = above mean sea level; bgs = below ground surface

1.3.2.2 Type and Extent of Contamination

Soils

Actinide transport to groundwater from contaminated surficial soils is a primary concern at RFETS. As shown in Figure 1-1, widespread areas of the buffer zone and localized areas in the IA have received windblown Pu-239/240 surface soil contamination. Vertical soil profiles of Pu-239/240 activity-concentrations for the uppermost 96 centimeters (cm) (3 feet) of RFETS soils presented in DOE (1998) and Litaor et. al. (1994) indicate that plutonium movement is mainly restricted to the top 20 to 25 cm of soil. Pu-239/240 activity-concentrations exponentially decline below a depth of about 12 cm (Litaor et. al., 1994) to less than 1 pCi/g at 72 cm. Elevated plutonium activity-concentrations were detected in soil macropores (i.e., root channels) compared to the surrounding soil matrix, but extensive macropore development was not observed below a depth of 120 cm (3.9 feet) (Litaor et. al., 1994). This depth roughly corresponds with the average depth of most RFETS grass and forb root systems as compiled by Jody Nelson, RFETS Ecology group, from Weaver (1920). According to Weaver (1920), many grassland plants have root systems that can exceed a depth of 5 feet and some can attain maximum depths in excess of 10 feet. This information suggests that deep soil macropores may be present at RFETS, but these macropores should be relatively unimportant as a source medium for drilling-artifact contamination.

Groundwater

Figure 1-1 illustrates that wells containing unfiltered Pu-239/240 contamination (colored dots) are generally associated with surface soil contamination areas (color-shaded contours). The highest groundwater unfiltered Pu-239/240 activity-concentrations are found in alluvial wells at and east of the 903 Pad. Elevated unfiltered Pu-239/240 activity-concentrations are also found in certain bedrock wells in this area, including well 11791, as described in DOE (1998).

Activity-concentration plots of unfiltered Pu-239/240 and Am-241 for wells 1587, 06991, 11791, and P313489 presented in Appendix B and DOE (1998) indicate that, with the exception of well 1587, Pu-239/240 and Am-241 activity-concentrations have generally declined with time. The reason for this decline is thought to result from the flushing of contaminants in the borehole disturbed zone caused by routine sampling activities.

1.3.3 Industrial Area VOC Plume East Boundary

1.3.3.1 Groundwater Occurrence and Distribution

The IA VOC Plume east boundary, as currently drawn, occurs in the central IA area along a transition zone between a body of relatively thick and continuously saturated alluvium west of Eighth Street and a body of largely discontinuous and thinly saturated alluvium to the east (see EG&G, 1995c, Plates 4 and 5). This abrupt change in hydrologic conditions corresponds with a general thinning of alluvium in the 700 and 800 areas of the IA and a concentration of north-south aligned utility corridors and buildings containing foundation drains (B771, B707, B865, B883, B881, and possibly B776). In addition, pre-Site aerial photographs (1937 and 1951) indicate the presence of a prominent seep complex (Rocky Flats Alluvium groundwater discharge area) in the former headcut area of South Walnut Creek located in the vicinity of Buildings 708 and 709 situated to the south of Building 707. The combination of these factors suggest that plume migration pathways along the east boundary might deviate from

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groundwater flow patterns depicted by the RFETS monitoring well network and be controlled by a complex interaction of subsurface anthropogenic and natural features. This concept has been presented in previous RFETS documents dealing with building foundation drains (EG&G, 1994), infiltration/inflow and exfiltration (ASI, 1991), and incidental water evaluations associated with utility manholes and pits (EG&G, 1993; Woodward-Clyde, 1990), although the actual effects of these structures on IA groundwater flowpaths and contaminant transport have not been directly investigated.

Groundwater in the vicinity of the IA VOC Plume east boundary generally occurs at depths ranging from 3 to 15 feet with saturated thicknesses of 0 to 6 feet. Depth to bedrock varies from about 8 to 15 feet, with the deepest section found near the southwest corner of Building 883. Seasonal water levels in alluvial wells near the east boundary (i.e., 6186, P313589, P213689, P314089, and P218089) typically fluctuate within a 1 to 3 foot range. Many of these wells exhibit erratic or flattened responses that are uncharacteristic of seasonal fluctuations normally recorded in non-IA wells. It is believed that the water level behavior in these IA wells is moderated by such factors as reduced infiltration (and increased surface runoff) created by widespread IA impermeable areas (i.e., buildings, parking lots, roads, etc.), water losses from leaky pipes and ditches, and inflows to utility corridors that criss-cross much of the IA. Figure 1-5 illustrates the location of existing monitoring wells, foundation drains, and main utility corridors found in the IA VOC Plume east boundary area.

As shown in Figure 1-5, groundwater flows predominantly to the east or northeast across the 300, 500, and 700 building complexes toward the South Walnut Creek and North Walnut Creek drainages, and to the east and southeast across the 400, 600, and 800 complexes toward the South Walnut Creek and Woman Creek drainages. Local groundwater flow patterns are significantly altered by building foundation drains at Buildings 881 and 883, but appears less affected at Buildings 865, 707, and 559. The Site-wide effects of the IA utility corridor network on groundwater flow patterns are not discernable from natural patterns in this figure, but the network is expected to have potentially significant impacts on groundwater flow in the IA, as suggested by annual well hydrograph responses. Local perturbations in flow patterns are expected for certain individual corridors, such as found along Central, Sage, and Cottonwood Avenues, and Eighth Street, particularly during periods of high water table conditions. However, these perturbations are too complex to represent individually with the available potentiometric data set.

The effect of utility corridors on contaminant transport may be especially significant anywhere in the IA that is underlain by a shallow water table (< 10 feet), but is expected to be greatest in areas where utility line excavations (typically sanitary sewer or process waste lines) have cut into bedrock and form narrow, high permeability drains for groundwater flow. Groundwater flowing laterally along the bedrock surface could be intercepted by these corridors and diverted in a direction away from natural flow paths. Sanitary sewer, process waste, and domestic water lines have the greatest potential to impact flow and contaminant transport because these lines were installed deep (> 6 feet) for freeze protection. Shallower utility systems, such as electrical lines, are also known to periodically intercept and collect groundwater (Woodward-Clyde, 1990). In general, the depth of underground line installation varies depending on the type of line and local circumstances. Areas with the greatest potential for being impacted by utility corridors (i.e., shallow average depths to groundwater or underlain by 10 feet or less of alluvial material) are illustrated in Figure 1-5.

Groundwater discharge along the east boundary of the IA VOC plume area occurs as subsurface flow to colluvial materials at the edge of the Rocky Flats Alluvium, inflow to the sanitary sewer and storm drain systems, inflow to building foundation drains, and utility pit pumping. Natural discharge areas, such as the buried upper reach of South Walnut Creek, if still active, probably create a greater degree of localized flow convergence south of Building 707 than depicted in Figure 1-5, and could represent an additional plume migration pathway for contamination in the Building 569 area. Monitoring and analysis of sanitary sewer flows and water table elevations by Advanced Sciences, Inc. (ASI, 1991) and EG&G (1994) determined that infiltration to sewer lines near the eastern boundary of the plume should be occuring. The importance of utility pit pumping as a mechanism for groundwater discharge is unknown, although Woodward-Clyde (1990) found few pits with operational sump pumps during their 1990 field survey.

1.3.3.2 Type and Extent of Contamination

The current IA VOC groundwater plume boundary shown in Figure 1-5 is based on available well control and does not account for anthropogenic impacts on groundwater flow patterns and plume spreading or containment. Well control along the east boundary is sparsest near Buildings 883, 707,

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and 776, and the Central Avenue utility corridor. Along the east boundary, the plume appears to abruptly end along the Eighth Street (south side) and 76 Drive (PA) utility corridors. The continuity of IA VOC plume contamination in the PA, specifically in the Building 707, 708, 776, 777, and 779 areas, is somewhat speculative owing to a lack of well control on the west side of 76 Drive and among the buildings. These buildings are located in an area of thinly saturated alluvium and shallow bedrock where utility corridors could control plume migration. Of special interest are the east-west corridors situated north and south of Building 778 that connect with the 76 Drive corridor northeast of Building 559. The Central Avenue and Patrol Road utility corridors also represent potential eastward migration pathways given their proximity to the RFCA Tier I groundwater action level plume boundary.

Individual VOC plume maps for average TCE, PCE, and carbon tetrachloride concentrations prepared by RMRS (1998) reveal that regions of the IA VOC composite plume are dominated by different proportions of these VOC constituents. The highest concentrations of TCE occur in two areas: the Building 559/569 area extending from wells P215798 to 22896 along 76 Drive, and a smaller region between Building 779 and the westernmost Solar Pond indicated by wells 2286 and P210189 (RMRS, 1998, Plate 8). PCE contamination is widespread in the west central IA, but exceeds Tier I action levels (500 micrograms per liter [μg/L]) at well P320089 located west of Building 883 and appears to be closely associated with TCE only in the Building 334/551 area (RMRS, 1998, Plate 9). Carbon tetrachloride concentrations exceed Tier I action levels (500 μg/L) in three limited areas; specifically an area northeast of Building 551 at well P114689, wells 2286 and P210189, and IHSS 118.1 (currently being investigated for monitored natural attenuation) (RMRS, 1998, Plate 10). The dominance of individual VOC constituents in different regions of the composite plume, such as TCE along 76 Drive, suggest that these constituents might be used to trace plume migration, although multiple localized sources of these contaminants from intervening buildings and IHSSs could compromise this approach.

Other than well data, a limited amount of groundwater VOC data is available from samples collected from foundation drains, manholes, utility pits, and miscellaneous incidental water sampling locations. VOC detections in foundation drain waters for Buildings 707, 883, and 865, located along the east boundary are presented in Appendix C. The only plume-related VOC detected in these foundation drain waters was PCE at Building 883 (BS-883-1 and FD-883-1). PCE detections were reported in three of six samples collected at Building 883 ranging from 5 to 6 μg/L, with all detections occurring during the spring months. These detections are possibly related to an area of above-Tier I PCE concentrations reported at well P320089, which is located 450 feet due west of Building 883. TCE detections ranging from 87 to 460 μg/L were reported for incidental water samples obtained from two utility pits, precursor excavations associated with a steam line located north and south of the PA perimeter fence near Building 569, and well P215798 (known to contain above-Tier I concentrations of TCE). TCE (222 μg/L), carbon tetrachloride (232 μg/L), 1,1-dichloroethene (35 μg/L), and PCE (12 μg/L) have been detected in a utility pit that receives groundwater from a tunnel sump (FD-559-561) connecting Buildings 559 and 561. Appendix C contains a listing of all incidental water sample analyses with VOC detections.

It is evident from this information that, with the exception of Building 883, all east boundary foundation drain and incidental water sampling sites with VOC detections are located within the IA VOC plume boundary shown in Figure 1-5. Therefore, the current plume boundary forms the basis for the proposed monitoring well system design described in Section 3.3.

1.3.4 Solar Ponds Plume Well Installations

1.3.4.1 Groundwater Occurrence and Distribution

The SPP treatment system will be constructed entirely within upper hydrostratigraphic unit (UHSU) materials comprised of colluvium and weathered bedrock. Geologic information compiled by RMRS (1999) indicates that bedrock at the west end of the system is located at depths ranging from 10 to 20 feet, as shown in Figure 1-6. The thickness of weathered bedrock is estimated to range from 20 to 30 feet. Examination of well completion records indicate that most SEP weathered bedrock wells are completed in the upper to middle portions of this unit. The closest SEP weathered bedrock well to the west end, P210089, has a 9.3 foot screened zone that monitors the middle portion of the weathered zone. Colluvial wells in the vicinity of the proposed collection trench are typically dry because the Interceptor Trench System (ITS) drains much of the shallow subsurface flow associated with the area. Depth to UHSU groundwater at the proposed collection trench is estimated to occur 10 to 20 feet below grade based on water levels recorded at nearby wells P210089, 45093, 45393, and 26995.

1.3.4.2 Type and Extent of Contamination

Figure 1-7 illustrates nitrate concentrations for UHSU groundwater in the SPP area. The SPP occurs in both colluvium and weathered bedrock units of the UHSU, with the highest concentrations of nitrate typically found in the weathered bedrock. Nitrate concentrations in excess of 200 mg/L (as N) occur in wells 30595 and P210089 located south of the northeast access road near the west end of the proposed treatment system. The presence of nitrate concentrations above the interim surface water standard (100 mg/L, as N) in these wells indicate that the distal section of the SPP that intersects North Walnut Creek may be wider than currently depicted in Figure 1-7. Uranium contamination is also present in SPP groundwater, but is less widespread than nitrate contamination (see RMRS, 1999).

2.0 DATA QUALITY OBJECTIVES

The data quality objective (DQO) process consists of seven steps and is designed to be iterative; the outputs of one step may influence prior steps and cause them to be refined. Each of the seven steps are described below for the investigative areas shown in Figures 3-1, 3-2, and 3-3. Data requirements to support these projects were developed and are implemented in the projects using criteria established in *Guidance for the Data Quality Objective Process*, QA/G-4 (EPA 1994).

2.1 State the Problem

2.1.1 Actinide Drilling-Artifact Contamination

Low levels of Pu-239/240 (mean values ranging from 0.15 to 94.6 pCi/L) and Am-241 (mean values ranging from 0.15 to 11.17 pCi/L) contamination have been detected in groundwater samples from wells located in the 903 Pad and other areas of the Site (DOE, 1998). The presence of these contaminants in groundwater is unexpected considering the highly conservative behavior usually attributed to Pu-239/240 and Am-241 migration in the subsurface aqueous environment. Confirmation of these data is required to assess the long-term significance of actinide transport in groundwater to surface water currently under consideration by the Actinide Migration Evaluation Group.

Investigation into the cause of these detections has raised concerns that adequate precautions for protecting well intake zones from surface soil contamination were not taken during the drilling and well installation process (DOE, 1998). This investigation is designed to ascertain the importance of drilling and well installation methods as transport mechanisms for introducing Pu-239/240 and Am-241 to groundwater samples.

2.1.2 Industrial Area VOC Plume East Boundary

Previous groundwater investigations at the Site have identified a large area of VOC-contaminated groundwater associated with various historical solvent releases in the central IA. The resulting plume has migrated away from source areas and now threatens surface water streams. The north and south boundaries of this plume have been investigated over the last two years to identify plume pathways and monitor contaminant migration. The current investigation will better delineate potential flow pathways associated with the east boundary of the IA VOC plume and provide locations for plume monitoring under the IMP.

2.1.3 Solar Ponds Plume Well Installations

SPP nitrate data from wells P210089 and 30595, located beyond the west end of the proposed collection trench, indicate that contamination may be more widespread to the west than shown on Figure 1-7. The proposed well installations will remedy this deficiency and provide locations for monitoring the performance of the proposed collection trench and treatment system.

2.2 Identify the Decision

2.2.1 Actinide Drilling-Artifact Contamination

Groundwater

Decisions required to be made using groundwater field and analytical data collected from groundwater wells include:

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- Do groundwater sample results from new and existing paired wells indicate that actinide contamination has been transported to well intake zones via natural or artificial (i.e., drilling-artifact contamination) means?

- Do actinide activity-concentrations measured in newly installed wells exceed the RFCA Tier II actions levels for groundwater?

Soils

Decisions required to be made using soil analytical data collected from boreholes include:

- Do soil samples collected at the ground surface and base of the surface isolation casing indicate a potential for actinide contamination to deeper zones?

- Do borehole soil samples contain chemical concentrations or radionuclide activity-concentrations that will require special waste handling and disposition of drill cuttings?

2.2.2 Industrial Area VOC Plume East Boundary

Groundwater

Decisions required to be made using groundwater field and analytical data collected from groundwater wells include:

- Do groundwater VOC sample results from new Geoprobe® wells installed along the IA VOC plume east boundary indicate the presence of unmonitored eastward migration pathways toward South and North Walnut Creeks?

- Do VOC results suggest that additional monitoring wells should be installed in other locations east of the investigation area?

2.2.3 Solar Ponds Plume Well Installations

Groundwater

Decisions required to be made using groundwater field and analytical data collected from groundwater wells include:

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- Do groundwater sample results from new wells completed in colluvial and weathered bedrock indicate that SPP extends further to the west?

Soils

Decisions required to be made using soil analytical data collected from groundwater wells include:

- Do borehole soil samples contain chemical concentrations or radionuclide activity-concentrations that will require special waste handling and disposition of drill cuttings?

2.3 Identify Inputs to the Decision

2.3.1 Actinide Drilling-Artifact Contamination

Inputs to the decision include field observations and well installation records of existing and new wells; Pu-239/240 and Am-241 analytical results for groundwater samples collected from new and existing paired wells; soil analytical results; and the RFCA groundwater action levels for Pu-239/240 and Am-241. The parameters of interest include:

- Geologist logbooks, daily drilling and borehole logs, and well completion logs;
- Groundwater Pu-239/240 and Am-241 activity-concentrations;
- Groundwater total suspended solids (TSS) concentrations; and
- Surface and subsurface soil VOC and metals concentrations, and radionuclide activity-concentrations.

A listing of the analytes of interest, including sample quantities and analytical methodology, are outlined in Table 3-3.

2.3.2 Industrial Area VOC Plume East Boundary

Inputs to the decision include hydrogeologic information and VOC analytical results for groundwater samples collected from new Geoprobe® and existing conventional monitoring wells. The parameters of

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interest include:

- Depth to bedrock;
- Depth to groundwater;
- Alluvial saturated thickness; and
- Groundwater VOC concentrations.

A listing of the analytes of interest, including sample quantities and analytical methodology, are outlined in Table 3-6.

Further inputs to the decision include water level measurements from new and existing monitoring wells, which will be used to delineate groundwater flow directions for interpretation of groundwater analytical data.

2.3.3 Solar Ponds Plume Well Installations

Inputs to the decision include hydrogeologic information and analytical results for groundwater samples collected from new monitoring wells. The parameters of interest include:

- Depth to bedrock and unweathered bedrock;
- Depth to groundwater;
- Colluvial saturated thickness; and
- Groundwater nitrate and uranium concentrations.

A listing of the analytes of interest, including sample quantities and analytical methodology, are outlined in Table 3-9.

2.4 Define the Boundaries

The investigative boundaries and rationale for each project are detailed in Sections 3.2 through 3.4 of this SAP.

2.5 Develop a Decision Rule

2.5.1 Actinide Drilling-Artifact Contamination

The decision rule for determining whether actinide contamination in groundwater samples results mainly from drilling artifacts associated with well installation in surface soil contamination areas or natural mechanisms, such as transport through macropores, will be based on a comparison of groundwater analytical results from twinned monitoring wells at multiple locations. New wells installed using special surface-casing isolation techniques will be installed next to existing wells that contain evidence of persistent groundwater actinide contamination. These well pairs will then be sampled concurrently. The presence of similar concentrations of actinides in both wells will indicate that the contamination probably reached the water table by natural means. On the other hand, if actinide contamination is found to be consistently low or absent in the new wells compared to the existing wells, then drilling-artifact contamination will be assumed to be primarily responsible for the elevated concentrations in the existing wells. Additional sampling and analyses may be required to interpret initial values from new monitoring wells that are found to contain actinides because of declining concentrations observed in some trend plots (see Appendix B). In addition, groundwater sample analyses from each new well location will be compared to the RFCA groundwater action levels to determine if activity-concentrations exceed current RFETS regulatory guidelines.

It is expected that soil Pu-239/240 activity-concentrations should fall below 1 pCi/g at depths greater than 2 feet below ground level based on vertical Pu-239/240 distributions reported for 903 Pad area soil test pits (Litaor et. al., 1994). Discrete samples of surface soils and subsurface soils at the base of the isolation casing will be collected to document contaminant conditions prior to drilling deeper into the well intake zones. Additional subsurface soil samples will be collected from disturbed materials (slough) deposited above the top of the well intake zone and undisturbed materials in the top one foot of the intake zone. These additional samples will be saved for subsequent analysis pending the outcome of the groundwater and shallow soil results. The presence of appreciable contamination at a 2 foot depth in the new boreholes may indicate that clean conditions were not maintained during or after drilling, casing installation, and pre-drilling casing clean-out. If so, the integrity of the well and resulting groundwater samples will be suspect, potentially compromising any conclusion pertaining to drilling-artifact contamination for that well pair. This condition will be further investigated by submitting archived subsurface soil samples collected from borehole slough and undisturbed materials for analysis. Soil sample analyses of drill cuttings from each new well location will be compared to the waste characterization criteria for disposition of all excess soils and drill cuttings, and will also be used to further document the contaminant conditions in the borehole.

Decision rule summary for Actinide Drilling-Artifact Contamination project:

- If Pu-239/240 and Am-241 activity-concentrations of groundwater samples collected from specially-cased (new) wells are comparable or higher than groundwater samples collected from the existing well, then an evaluation of subsurface soil results will be undertaken to assess the potential for drilling-artifact contamination at the new well, including the submittal of any archived subsurface soils samples for Pu-239/240 and Am-241 analysis. If the Pu-239/240 or Am-241 activity-concentration of disturbed (slough) samples collected at the top of the well intake zone exceed both 1 pCi/g and the activity-concentration of underlying undisturbed soils collected from within the well intake zone, then drilling-artifact contamination will be implicated as a probable mechanism for actinide transport to groundwater in the new well; otherwise, it will be assumed that the new well is unaffected by drilling-artifact contamination.

- If Pu-239/240 and Am-241 in groundwater samples collected from specially-cased monitoring wells have activity-concentrations that are comparable or higher than groundwater samples collected from an existing paired well, then natural transport mechanisms, such as macropore flow, will be implicated as the most likely means for actinide migration through subsurface soils to groundwater; otherwise, drilling-artifact contamination will be assumed to be primarily responsible for the presence of actinides in groundwater (i.e., the activity-concentration of these actinides being markedly lower in the new well compared to the existing well). This rule applies to the final groundwater sample sets collected at each well pair provided that 1) the new wells are adequately developed prior to sampling, as verified by a second round of groundwater sampling, and 2) soil sampling results substantiate the absence of drilling artifact-contamination in the new wells.

- If contaminant concentrations of core or drill cuttings samples exceed soil action levels, then the cuttings will be treated as hazardous, low-level, or low-level mixed waste, whichever is appropriate, and processed for disposal; otherwise, the cuttings will be considered non-hazardous/radioactive and dispositioned in accordance with Site procedures.

2.5.2 Industrial Area VOC Plume East Boundary

The decision rule for determining the presence of an east plume pathway(s) is based on consideration of the existing plume boundary; groundwater sampling results; hydrologic conditions, especially saturated thickness; and subsurface factors, such as utility corridors, foundation drains, and natural discharge areas. All wells will be installed east of the Eight Avenue and 76 Drive utility corridor in locations along suspected pathways or areas that lack adequate well coverage. Similarities in VOC contaminant type, such as TCE in the PA, will also aid in redefining existing plume boundaries eastward to the new well locations.

Decision rule summary for IA VOC Plume East Boundary project:

- If groundwater samples collected from new monitoring wells indicate the presence of IA VOC Plume contaminants, then redraw the plume east boundary to show potential migration pathways, with consideration given to the probable hydrologic effects of utility corridors, building foundation drains, and buried seepage areas, and initiate plume extent monitoring as specified under the IMP.

2.5.3 Solar Ponds Plume Well Installations

The decision rule for defining of the western boundary of the SPP near the proposed collection trench will be based on consideration of SPP contaminant concentrations detected in a cluster of three new monitoring wells. Groundwater sampling results from these wells will help define the extent of nitrate and uranium contamination in this area of the plume. It is expected that these wells will also be utilized for treatment system performance monitoring purposes.

Decision rule summary for the Solar Ponds Plume Well Installation project:

- If either nitrate/nitrite or uranium concentrations exceed groundwater clean-up levels in samples collected from the proposed well cluster located at the west end of the proposed treatment trench, then redefine plume boundaries, assess probable collection system effectiveness with respect to plume, and initiate performance monitoring; otherwise initiate performance monitoring.
- If contaminant concentrations of core or drill cuttings samples exceed soil action levels, then the cuttings will be treated as hazardous, low-level, or low-level mixed waste, whichever is appropriate, and processed for disposal; otherwise, the cuttings will be considered non-hazardous/radioactive and dispositioned in accordance with Site procedures.

2.6 Specify Limits on Decision Errors

To minimize decision errors, all field work will be performed in accordance with approved RMRS standard operating procedures. These procedures specify methods and equipment for ensuring the accuracy and integrity of well installations, field parameter measurements, sampling, and other related field data collection activities. A listing of applicable SOPs is provided at the beginning of this document.

2.6.1 Actinide Drilling-Artifact Contamination

Confidence in differentiating actinide drilling-artifact contamination from natural contamination of groundwater is dependent on monitoring well installation success, collection of representative samples using consistent techniques, and quality control. Well installation is a key aspect of the monitoring program because surface contamination can easily be introduced deeper into the borehole unless adequate precautions are taken to exclude surface materials. The success of the twinned well approach is clearly dependent upon the development a contaminant-free monitoring well design that can be implemented by field personnel to minimize or eliminate surface contamination during well construction. Telescoped casing, borehole and casing clean-outs, annular grout seals, and thorough decontamination of downhole equipment at each stage of well construction are the primary steps that will be taken to ensure well intake zone integrity. Decision errors related to well installation success will be minimized by collecting soil samples for Pu-239/240 and Am-241 analysis at the base of the isolation casing to verify that measures taken to exclude surface soil contamination were successful.

Project success is also dependent on factors such as well development and sampling techniques. Decision errors can result from interpretation of erroneous groundwater analytical data caused by inadequate well development and inconsistent sampling techniques between well pairs. Unless adequate well development is undertaken, the activity-concentrations of initial Pu-239/240 and Am-241 samples can be significantly elevated above baseline levels, as indicated by sharp declines in early contaminant trends observed for many wells (DOE, 1998). Additional development activity beyond the minimum requirements of PRO.106, *Well Development*, with emphasis on turbidity reduction, will serve to minimize well development effects on initial groundwater sample quality. Decision errors related to sample collection will further be limited by employing identical sampling methods for each well pair to minimize sampling variability.

Quality control of field measurements and laboratory analytical data collected during the investigation is important because decision errors may result if not based on reliable information. Quality control samples for the project will include a 1 in 20 frequency for duplicate and equipment rinse samples. Relative percent difference (RPD) goals for groundwater and soil analytes will be 30%, as set forth in the K-H ASD subcontract statement of work. A completion goal of 90% of the data analyzed and verified will be of acceptable quality for decision making. Considering the importance that these analytical results will have in helping reach decisions related to actinide migration, one hundred percent of the total analytical data will undergo validation by a third party.

2.6.2 Industrial Area VOC Plume East Boundary

Decision errors associated with the IA VOC Plume East Boundary Investigation primarily involve monitoring well location success and quality control. Well placement is a key aspect of the monitoring program because, given the complexity of the hydrogeologic setting, improper placement could jeopardize the ability of the program to adequately delineate plume migration pathways. Location success will be confounded somewhat by the dense network of utilities in the area. Quality control of field measurements and laboratory analytical data collected during the investigation is important because decision errors may result if not based on reliable information.

Monitoring well placement errors will be minimized through a combination of close well spacings and identification of potential pathways, such as utility corridors and flow convergence areas (i.e., building foundation drains and buried seepage area). It is possible that decision errors may result from wells positioned to monitor east-west utility corridors because it is not possible to drill directly into the utility trenches without incurring a substantial safety risk. In these cases, wells will be positioned as close as feasible to the corridors in consultation with K-H Construction Management personnel.

Quality control samples for the project will include a 1 in 20 frequency for duplicate and equipment rinsate samples. Relative percent difference (RPD) goals for groundwater VOCs will be 30%, as set forth in the K-H ASD subcontract statement of work. A completion goal of 90% of the data analyzed and verified will be of acceptable quality for decision making. Twenty-five percent of the total analytical data will undergo validation by a third party. The remaining 75 percent of the data will be verified.

2.6.3 Solar Ponds Plume Well Installations

Decision errors associated with SEP well installations primarily involve monitoring well location and completion, geologic interpretation, and quality control. Improper well placement and bedrock identification could jeopardize collection trench effectiveness and design. Quality control of field measurements and laboratory analytical data collected during the investigation is important because decision errors may result if not based on reliable information.

Monitoring well placement errors will be minimized by installing a vertically nested well cluster consisting of three wells in colluvium and weathered bedrock at the west end of the proposed collection trench. This well cluster will be located north or northeast of well P210089 along the projected alignment of the trench to investigate nitrate plume extent at the west terminus of the proposed treatment system. Decision errors may result if the well cluster is positioned either too close or too far away from the end of the system. Concerning bedrock identification, decision errors will be

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minimized by conforming with guidance provided in PRO.101, *Logging Alluvial and Bedrock Material*. Decision errors related to waste handling and disposition of drill cuttings will be minimized by adherence to PRO.115, *Monitoring and Containerizing Drilling Fluids and Cuttings*.

Quality control samples for the project will include a 1 in 20 frequency for duplicate and equipment rinsate samples. Relative percent difference (RPD) goals for groundwater and soil analytes will be 30%, as set forth in the K-H ASD subcontract statement of work. A completion goal of 90% of the data analyzed and verified will be of acceptable quality for decision making. Twenty-five percent of the total analytical data will undergo validation by a third party. The remaining 75 percent of the data will be verified.

2.7 Optimize the Design for Obtaining Data

2.7.1 Actinide Drilling-Artifact Contamination

Monitoring program design will be optimized through the implementation of a paired well approach. Four existing wells out of a population of over 30 wells containing Pu-239/240 and Am-241 contaminated-groundwater (DOE, 1998) were selected for pairing and sample comparisons. New wells will be installed using special surface-casing techniques, which have proven reliable at other RFETS well sites. In addition, multiple sampling episodes will be undertaken to verify the initial sampling results. Composite sampling of drill cuttings or core materials will serve to minimize the number of samples required for waste characterization purposes.

2.7.2 Industrial Area VOC Plume East Boundary

Monitoring well network design will be optimized through a combination of hydrogeologic interpretation of existing data and Geoprobe® boring technology. The proposed monitoring well network is aligned along the east boundary of the IA VOC plume in consideration of the current plume boundary, groundwater flow patterns, potential anthropogenic pathways, and existing wells. The Geoprobe® is capable of efficiently obtaining geologic data and installing small diameter monitoring wells while generating little or no waste cuttings. Small diameter wells minimize purge water volumes

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and, despite their small casing storage volume, are capable of providing adequate sample volumes for VOC analyses under normal hydrogeologic circumstances. Small-diameter boreholes are also easier to fit in areas of congested utilities, as may be the case in many instances along the plume boundary.

In the event that further evaluation is required to evaluate contaminant plume migration to surface water, the results of this investigation will be used to design additional field activities, such as selection of additional well locations and refinement of the analytical parameter suite. Additional phases of field activity will be implemented under an amended SAP or the IMP.

2.7.3 Solar Ponds Plume Well Installations

Geochemical and geologic data acquisition will be optimized through the use of conventional drilling methods. The depth and well completion requirements eliminate Geoprobe® technology as a viable option. Groundwater sample collection will be limited to critical analytes only, specifically nitrate and uranium isotopes, for use in plume recontouring. Composite sampling of drill cuttings or core materials will serve to minimize the number of samples required for waste characterization purposes.

3.0 SAMPLING RATIONALE, ACTIVITIES, AND METHODOLOGY

Section 3.0 presents the rationale and methodology for sampling activities proposed for the three projects. To improve continuity, the sampling rationale section usually presented before the Data Quality Objective section has been incorporated into the sampling and activities section. Section 3.1 describes the steps that must be taken prior to mobilization of drilling or Geoprobe® equipment to the work site. Sections 3.2 through 3.4 describe the sampling rationale and proposed sampling activities for each project. Finally, Section 3.5 describes the procedures that will be used for equipment decontamination and waste handling for all projects.

3.1 Pre-Drilling Activities

Before advancing boreholes, all locations will be cleared in accordance with PRO.102, *Borehole Clearing*, and marked in accordance with GT.39, *Push Subsurface Soil Sampling*. A prework

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radiological survey will be conducted in accordance with FO.16, *Field Radiological Measurements*. All necessary Health and Safety protocols will be followed in accordance with addendums prepared for the Well Abandonment and Replacement Program and SPP Health and Safety Plans, as appropriate.

Biological surveys will be conducted at each new well location to comply with RFETS ecological requirements. These requirements include compliance with the National Environmental Policy Act (NEPA), the Endangered Species Act, and the Migratory Bird Treaty Act. The presence or absence of species of concern at each location will be documented by K-H Ecology personnel, who must approve access prior to drilling.

3.2 Actinide Drilling-Artifact Contamination

The following conditions were considered in the development of the sampling strategy for the Actinide Drilling-Artifact Contamination Project:

- The operating history of the former 903 Pad Drum Storage Area and other sites indicate that actinide contaminants, specifically Pu-239 and Am-241, have been released to the environment and transported by wind action to surface soils east and southeast of the pad.
- The physical and chemical properties of the contaminants, vertical soil actinide activity-concentration profiles, and drilling and well installation documentation indicate that cross-contamination from surface soil materials probably accounts for much, if not all, of the actinide contamination found in groundwater samples collected from 903 Pad and surrounding area wells.
- Existing groundwater analytical data indicate that actinide contamination occurs principally in the colloidal and particulate phase.
- Seasonally variable hydrologic conditions can affect well development effectiveness and sampling program success.

3.2.1 Monitoring Well Locations and Rationale

Four monitoring well locations (50099, 50199, 50299, and 50399) have been chosen to evaluate actinide groundwater quality associated with Pu-239/240 surface soil contamination areas. These locations correspond to existing wells 1587, 06991, 11791, and P313489, all of which have a history of elevated groundwater Pu-239/240 and Am-241 activity-concentrations. Three of these wells, 1587, 06991, and 11791, are associated with wind-blown soil contamination from 903 Pad and Lip Area. The fourth well is associated with soil contamination in the IHSS 160 area (Building 444 parking lot). Figure 3-1 illustrates the location of these wells. The rationale for each monitoring well location is summarized in Table 3-1.

Table 3-1 Actinide Drilling-Artifact Contamination Monitoring Well Location Rationale

Well Number	Location	Rationale
50099	10 feet west of paired well 1587	Upgradient location from well 1587 for evaluating historical actinide groundwater contamination per DOE (1998). Groundwater at well 1587 has an apparent increasing Pu-239/240 trend; has a partially saturated screened interval; and was the focus of previous USGS research.
50199	10 feet west of paired well 06991	Upgradient location from well 06991 for evaluating historical actinide groundwater contamination per DOE (1998). Well 06991 has the highest average Pu-239/240 concentration of all wells not located on the 903 Pad and has a partially saturated screened interval.
50299	10 feet north of paired well 11791	Upgradient location from well 11791 for evaluating historical actinide groundwater contamination per DOE (1998). Well 11791 is completed in weathered bedrock materials in an area thought to be a bedrock groundwater discharge area. It has a fully saturated screened interval.
50399	10 feet south of paired well P313489	Cross gradient location from well P313489 for evaluating historical actinide groundwater contamination per DOE (1998). Well P313489 is located in the IA outside of the 903 Pad Soil Contamination Area and has a fully saturated screened interval.

Well names (location codes) were assigned based on a five digit numbering system adopted by the Site in 1992, with the year drilled indicated by the last two digits.

3.2.2 Well Design and Installation

3.2.2.1 Well Design

The type of monitoring wells selected for monitoring actinide contaminants in groundwater are 2-inch inside diameter wells that are suitable for long-term monitoring of shallow water-bearing zones. These wells will be designed with screened intervals that closely approximate the paired well, except that the top of the screened or filter-packed interval for certain wells will be set deeper than the original well to provide additional well intake zone protection. To ensure that these wells exclude drilling-artifact contamination, all wells will be installed using dual ("aseptic") casing construction methods described in PRO.114, *Drilling and Sampling Using Hollow-Stem and Rotary Drilling and Rock Coring Techniques*, and as modified in Section 3.2.2.2. Final well depth determinations will be made in the field based on actual drilling results.

The depth of actinide contamination in surface soils is an important consideration for well design. Surface casing must prevent contaminated soils from entering the borehole and contaminating deeper materials. As most Pu-239/240 is mainly limited to the top 40 to 60 cm of soil, a surface casing depth of 65 cm (2.1 feet) below original grade has been chosen to isolate the majority of contamination while permitting sufficient room for excess soil removal and casing cleaning.

Typical well construction materials will consist of a 2.5 foot section of 16-inch inner diameter (ID) steel surface casing and concrete pad, and 2-inch ID, schedule 40 or 80 polyvinyl chloride (PVC) riser and factory cut (0.010-inch slot width) well screen with a 1 foot long PVC sump. Protective casing consisting of a 6-inch ID or larger steel riser with locking cap and lock will be set in sackrete to a depth of about 2 to 3 feet. Caution will be exercised during each step of the well construction process to prevent surface contaminants from entering the borehole. All downhole equipment, including augers, rods, tools, and casing, will be decontaminated and radiologically surveyed prior to advancing past the base of the isolation casing and into the well intake zone. Table 3-2 lists the preliminary well construction specifications for each proposed monitoring well. These specifications are considered preliminary because conditions encountered during well installation may require them to be adjusted slightly.

Table 3-2 Preliminary Well Construction Specifications for Actinide Drilling-Artifact Contamination Wells

Well Number	Paired Well Number	Surface Isolation Casing Depth (ft)[a]	Estimated Depth to Bedrock (ft)[a]	Top of Well Intake (filter pack) (ft)[b]	Top of Screen (ft bgs)[b]	Bottom of Screen (ft bgs)[b]	Total Depth (ft)[b]
50099	1587	2.1	21.8	10.8	11.8	21.8	22.8
50199	06991	2.1	28.6	13.0	14.0	29.0	30.0
50299	11791	2.1	6.9	8.2	9.2	13.7	14.7
50399	P313489	2.1	20.6	15.7	16.7	22.3	23.3

[a] Below original ground surface
[b] Pending actual depth to bedrock results

3.2.2.2 Borehole Drilling and Logging

Prior to drilling at each site, the uppermost 3 to 4 inches of soil will be removed from a 3 x 3 foot square area surrounding the hole location and the excavated surface securely covered with plastic sheeting to prevent grossly contaminated soils from entering the immediate drill hole area. The work area immediately surrounding the excavation will also be covered with plastic sheeting to suppress dust and minimize potential airborne contamination of the excavation soil surface. Surficial soil sampling and drilling will commence through a pre-cut 16 to 20-inch hole cut in the plastic sheeting at the center of the square excavated area. This square area will later be used for pad construction in conjunction with cementing-in the surface isolation casing.

All borings will be advanced in stages using sequentially smaller diameter boreholes made with a hollow stem auger. Initially, the drill string will proceed to a depth of about 1.8 feet below the excavated soil surface with 12 inch or larger OD augers to prepare for surface isolation casing installation. The borehole will be enlarged, as necessary, with hand tools to a final diameter of 20 inches. All soil cuttings must be carefully removed in preparation for isolation casing installation.

Steel surface casings fitted with welded rebar arms on the outside of the casing will be utilized to create additional surface area for adherence to the concrete pad. The casings will be placed and seated in the boreholes to an approximate depth of 2.1 feet below original ground surface, with a 0.4 foot stick-up, to prevent potentially contaminated surface soil from entering the borehole. The plastic sheeting protecting the excavation surface will then be radially cut and peeled away from the borehole in preparation for cementing and pad construction. After sealing the top of the surface casing with plastic and duct tape, concrete or sakcrete will be placed in the casing annulus, while causing as little disturbance to the borehole wall as possible. Once the annulus is filled, the remainder of the pad will be poured to a finished dimension of 3 x 3 feet wide by 6-inches thick using a wooden frame.

After allowing for a 24 hour or longer cement set-up time, the plastic surface casing cover will be removed for final clean out and sampling (see Section 3.2.5.2). Drilling will commence following sampling pending visual inspection and approval of cement pad hardness and integrity. When the augers reach the top of the well intake zone listed in Table 3-2, the borehole will be cleaned out to the extent possible by rotating the augers to remove excess soil followed by auger removal. A fully decontaminated auger string with an identical outside diameter will then be used to advance the borehole to the total depth. If the surface casing and/or pad become dislodged during drilling or if the augers meet refusal prior to reaching the total depth, the site geologist will consult with the RMRS project manager to determine the appropriate course of action. A new offset well location may be required for problems that could compromise well integrity and program success.

During drilling, soil cores will be recovered continuously in two-foot increments using a split spoon or equivalent core barrel sampler. Following recovery, cores will be monitored with a Flame Ionization Detector (FID) or a Photoionization Detector (PID) in accordance with Site Procedure FO.15, *Photoionization Detectors and Flame Ionization Detectors,* and FO.16, *Field Radiological Measurements*, for health and safety purposes. The core samples will then be boxed and logged in accordance with PRO.101, *Logging Alluvial and Bedrock Material,* except that logging will be conducted more qualitatively than specified in PRO.101 (i.e., sieving, microscope examination, and plasticity testing will not be conducted). All core boxes will be labeled and transferred to an ER core storage conex for archiving following project completion.

3.2.2.3 Well Installation

Groundwater monitoring wells will be installed in accordance with GT.06, *Monitoring Wells and*

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Piezometer Installation. Monitoring wells will be land surveyed in accordance with GT.17, *Land Surveying*, or RFETS global positioning system manuals (Ashtech, 1993).

3.2.3 Well Development

Monitoring wells will be developed prior to sampling using the procedures specified in PRO.106, *Well Development*, except that repeated vigorous surging using a bailer, rather than low energy methods, will be performed to remove borehole disturbed-zone materials to the extent possible. The main objectives of well development are to improve well yields and reduce turbidity levels. This approach will result in the removal of additional well volumes beyond that specified in PRO.106, *Well Development*, and may involve repeated visits to the wells to ensure development effectiveness. Unless otherwise directed by the RMRS project manager, distilled water will not be added to the well to accelerate the well development process. If turbidity levels exceed the instrument range, sample dilutions (*see American Public Health Association, 1989, Standard Methods, 17th Edition, Part 2130, Turbidity, or successor edition*) may be required to provide quantifiable results.

Trend plot data from DOE (1998) indicate that groundwater removal up to the equivalent of five normal sampling episodes, including both purge and sample volumes, will be required to effectively develop the wells to baseline levels. All water produced during well development will be handled as uncharacterized development water in accordance with FO.05, *Handling Purge and Development Water*.

3.2.4 Sample Designation

The Site standard sample numbering system will be implemented in this project. Location codes have been assigned to individual wells as shown in Figure 3-1 and listed in Table 3-1 using the environmental restoration (ER) well numbering convention adopted in 1992. For each groundwater sample or soil sample, dual sample numbers will be assigned: 1) a standard RIN sample number (i.e., 99XXXXX.00X.00X) will be assigned to the project by the Analytical Services Division (ASD), and 2) an RMRS sample number (i.e. GW0XXXXTE, SS0XXXXTE, or BH0XXXXTE) for internal sample tracking. The block of sample numbers will be of sufficient size to include the entire number of possible samples (including QA samples) and location codes. For the final report, the ASD and RMRS sample numbers will be cross-referenced with location codes.

3.2.5 Sample Collection

3.2.5.1 Groundwater Samples

Groundwater sampling will begin after the well fully recovers from well development activities. At each well pair, samples will be collected only if the new well is capable of yielding samples. If the new well is dry or contains an insufficient amount of water, sampling will be delayed until a later date when conditions improve. Two different bailers will be used for sampling: one for sampling the new wells and one for sampling the existing wells. The existing well in each pair will be sampled first followed by the new well. Furthermore, sampling of well pairs will be ordered from least contaminated to worse contaminated, based on historical Pu-239/240 and Am-241 data from the existing wells. The well pairs scheduled for sampling, listed in order of least contaminated to most contaminated, include 11791/50299, P313489/50399, 1587/50099, and 06991/50199.

Prior to sample collection, water levels will be measured according to PRO.105, *Water Level Measurements in Wells and Piezometers*, to determine the purge water requirements of each paired well. Groundwater samples will be collected from each well pair (new and existing well) using the bailer method as specified in PRO.108, *Measurement of Groundwater Field Parameters*, and PRO.113, *Groundwater Sampling*. Variability in operator bailing technique will be minimized by having the same bailer operator collect samples from both wells in a pair. Well purging will focus on turbidity monitoring to a greater degree than routine sampling because plutonium and americium are strongly particle-reactive and excessive turbidity levels may compromise paired comparisons. Ideally, the turbidity levels of groundwater from each well in a pair should stabilize prior to sampling, although realistically, this result cannot be expected from bailed wells. If, at the end of three casing volumes, field parameter stabilization is attained for temperature, pH, and conductivity, well purging should continue until it is evident that turbidity measurements have stopped declining and are approximately stabilized. For low yielding wells where the stabilization criterion is normally waived, this approach does not apply.

Aliquots for TSS samples must be collected directly from the full Pu-239/240 and Am-241 sample aliquot before these samples are acidified; otherwise, subsequent comparisons of these analytical parameters will be compromised. An intermediate sample transfer device, such as a decontaminated stainless steel bucket, should be used for compositing all post-purge groundwater prior to filling the sample bottles. After completion of the initial sampling round, a second round of groundwater sampling from all four well pairs will be conducted within a three month period to confirm the initial analytical results.

3.2.5.2 Soil Samples

Soils samples collected at new drilling sites will consist of two types: 1) a set of five surface and subsurface samples for documentation of Pu-239/249 and Am-241 contaminant conditions for drilling-artifact contamination evaluation, and 2) one set of samples of drill core or cuttings for waste characterization purposes. Surface soil samples will be collected from each new well location site using the grab sampling method specified in GT.08, *Surface Soil Sampling*. After the uppermost 3 to 4-inch layer of soil has been removed (see Section 3.1.2.2), a soil sample will be collected from the borehole area to a depth of approximately 5 to 6-inches below the excavated soil surface. Following surface isolation casing installation and clean out, a subsurface soil sample will be collected from the base of this casing to a depth approximately 1 to 2-inches below the casing point using hand tools, as specified in GT.08, *Surface Soil Sampling,* or a split spoon sampler, as specified in PRO.114, *Drilling and Sampling using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques*, if hand excavation proves to be infeasible. A second subsurface soil sample from the 4.0 to 5.0 foot depth interval will be collected to characterize shallow subsurface Pu-239/240 and Am-241 concentrations using a split spoon sampler Two additional split-spoon soil samples will be collected from the borehole after borehole clean-out and auger decontamination has been performed (see Section 3.2.2.2). One sample each will be collected from slough deposited at the top of the well intake zone following auger reentry and from undisturbed soils in the upper 1-foot of the well intake zone. Samples for waste characterization will be composited from drill core or cuttings samples in accordance with 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging*.

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3.2.6 Sample Handling and Analysis

Samples will be handled according to PRO.069, *Containing, Preserving, Handling, and Shipping of Soil and Water Samples,* and 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging*. If necessary, a Health and Safety Specialist (HSS) or Radiological Control Technician (RCT) will scan each sample with a Field Instrument for the Detection of Low Energy Radiation (FIDLER). Equipment will also be monitored for radiological contamination during and after sampling activities, if required.

Table 3-3 presents the analytical requirements for each sample. Samples will be submitted to an offsite, EPA-approved laboratory for analysis under normal turnaround time constraints, unless shorter turnaround times are specified by the Project Manager and arranged with ASD. Subsurface soil samples collected from the 4 to 5 foot depth interval and well intake zone will be stored on-site for possible future analyses until after the groundwater Pu-239/240 and Am-241 results are received and interpreted from the laboratory. These samples will be submitted for analysis only if the groundwater sample results from the new well shows evidence of contamination compared to the paired well.

3.3 IA VOC Plume East Boundary Investigation

The following conditions were considered in the development of the sampling strategy for the Industrial Area VOC Plume East Boundary project:

- The number and spacing of monitoring wells located downgradient of the IA VOC plume east boundary is inadequate to monitor eastward plume migration;
- Eastward IA VOC plume migration may be impacted by anthropogenic structures, such as building foundation drains and buried utility lines, which can interact with the groundwater, alter flow patterns, and reroute contaminants away from natural flow paths;
- Depth to bedrock and groundwater is typically less than 15 feet in the east boundary area, and;

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Table 3-3 Analytical Requirements for Actinide Drilling-Artifact Contamination Groundwater and Soil Samples

Analysis	Matrix	No. of Samples	EPA Method	Line Item Code	Utah Certification Required	Container	Preservation	Holding Time
Am-241 Pu-239/240	Water	10[b]	N/A[a]	RC01B007 RC01B012	No	1 (one) 4-liter poly bottle	Unfiltered, HNO_3 to pH<2	180 days
Total suspended solids (TSS)	Water	10[b]	EPA 160.2 or Standard Methods 2540D	SS06B035	No	1 (one) 250 ml glass or poly bottle	Cool, 4° C	7 days
Rad Screen	Water	10[b]	N/A[a]	N/A	No	1 (one) 125 ml poly bottle	Unfiltered	180 days
Metals+Cu, Zn, Sb, Be, Ni, Tl, & V	Soil	4	EPA SW-846 Method 6010A, except Hg, Method 7470	SS05B049	Yes	1 (one) 8-oz Wide-mouth glass jar, teflon-lined closure	Cool, 4° C	180 days
Volatiles	Soil	4	EPA SW-846 Method 8240B/8260A	SS01B006	Yes	1 (one) 120 ml capped core, or 4 or 8 oz. wide-mouth glass jar, teflon-lined closure	Cool, 4° C	14 days
Isotopic analysis (U233/ 244, U235, U-238, Am-241, and Pu-239/240)	Soil	4	N/A[a]	RC01B003	No	1 (one) 500 ml wide mouth glass jar	None	None
Rad Screen	Soil	24[c]	N/A[a]	N/A	No	1 (one) 125-ml wide mouth glass or poly jar	None	6 mos.

[a] No EPA-approved method is currently in place for radionuclide analyses. However, guidance is provided in procedures defined in Environmental Monitoring Support Laboratory (EMSL)-LV 0539-17, *Radiological and Chemical Analytical Procedures for Analysis of Environmental Samples*, March 1979.
[b] Includes two QC samples except for rad screens.
[c] Twelve samples to be stored for possible later analysis pending interpretation of groundwater results (see text)

- Well installation will occur in densely industrialized areas with numerous underground hazards.

3.3.1 Monitoring Well Locations and Rationale

Fifteen monitoring well locations have been chosen to monitor groundwater quality associated with the east boundary of the IA VOC Plume. All wells will be positioned east of the Eighth Street and 76 Drive utility corridor to investigate plume extent across the central IA area. Figure 3-2 illustrates the approximate location of these wells in relationship to existing plume boundaries, building foundation drains, and streams.

The total number and arrangement of wells reflects the complexity of potential plume pathways and spatial limitations imposed by IA buildings and structures. Well names were assigned based on a five digit numbering system adopted by the Site in 1992, with the year drilled indicated by the last two digits. The rationale for each monitoring well location is summarized in Table 3-4.

3.3.2 Well Design and Installation

3.3.2.1 Well Design

Geoprobe® monitoring wells will be installed at all proposed IA VOC Plume east boundary locations because of favorable hydrogeologic conditions (i.e., shallow depth to bedrock and groundwater) and the small sample volume requirements for VOC analyses. These wells will be designed with screened intervals that fully penetrate saturated colluvial materials. Screen lengths of 5 to 7 feet are tentatively selected based on estimated depth to bedrock and groundwater evidence from EG&G (1995b and 1995c). Final well and screen depth determinations will be made in the field based on actual drilling and initial depth to bedrock results. The target depth for each well will be two feet into bedrock.

All wells will be installed using single casing construction methods described in GT.06, *Monitoring Well and Piezometer Installation*. Typical well construction materials will consist of 3/4-inch ID, schedule 40 or 80 PVC riser and factory cut (0.010-inch slot width) well screen with a threaded bottom

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Table 3-4 IA VOC Plume East Boundary Monitoring Well Location Rationale

Well Number	Location	Rationale
60099	NW corner of B776 near intersection of 76 Drive and 79 Drive	Monitor VOC plume extent east of 76 Drive utility corridor
60199	W side of B776	Monitor VOC plume extent east of 76 Drive utility corridor
60299	SW corner of B776 near intersection of 76 Drive and 59 Drive	Monitor VOC plume extent east of 76 Drive utility corridor
60399	NW corner of B707 near intersection of 76 Drive and 59 Drive	Monitor VOC plume extent east of 76 Drive utility corridor
60499	W side of B707	Monitor VOC plume extent east of 76 Drive utility corridor
60599	W side of B707	Monitor VOC plume extent east of 76 Drive utility corridor
60699	NW corner of B708 near steam pits	Monitor VOC plume extent east of Eighth St. utility corridor
60799	SW corner of B708 near Patrol Road	Monitor VOC plume extent east of Eighth St. and along Patrol Drive utility corridors
60899	E of Eighth St. and N of Central Ave. in Parking Lot 50	Monitor VOC plume extent east of Eighth St. and along Central Ave. utility corridors
60999	SE of Central Ave. and Eighth St. intersection NW of B884	Monitor VOC plume extent east of Eighth St. and along Central Ave. utility corridors
61099	E of Eighth St. between B884 and B879	Monitor VOC plume extent east of Eighth St. utility corridor
61199	E of Eighth St. between B879 and B883	Monitor VOC plume extent east of Eighth St. utility corridor
61299	E of Eighth St. near SW corner of B883	Monitor VOC plume extent east of Eighth St. utility corridor
61399	SE corner of B777	Monitor VOC plume extent along utility corridor between B776/777 and B778
61499	NE corner of B707	Monitor VOC plume extent along utility corridor between B778 and B707

cap at the base. Surface protection consisting of a 6-inch ID or larger steel flush mount casing will be set in sackrete to a depth of about 1 feet. Table 3-5 lists the preliminary well construction specifications for each proposed monitoring well.

Table 3-5 Preliminary Well Construction Specifications for IA VOC Plume East Boundary Wells

Well Number	Estimated Depth to Bedrock (ft)[a]	Estimated Depth to Water (ft)[a]	Estimated Alluvial Saturated Thickness (ft)[a]	Top of Screen (ft bgs)[b]	Bottom of Screen (ft bgs)[b]	Total Depth (ft)[b]
60099	10	10	0	7	12	12
60199	12	11	1	9	14	14
60299	11	9	2	8	13	13
60399	8	6	2	5	10	10
60499	9	6	3	6	11	11
60599	8	3	5	3	10	10
60699	8	3	5	3	10	10
60799	10	4	6	5	12	12
60899	10	5	5	5	12	12
60999	8	3	5	3	10	10
61099	9	4	5	4	11	11
61199	12	12	0	9	14	14
61299	15	15	0	12	17	17
61399	9	9	0	6	11	11
61499	9	7	2	6	11	11

[a] Estimated from EG&G (1995b and 1995c)
[b] Pending actual depth to bedrock results

3.3.2.2 Borehole Drilling and Logging

Geoprobe® boreholes will be drilled at proposed well sites using push-type techniques. Detailed drilling and sampling procedures using this methodology are provided in GT.39, *Push Subsurface Soil Sampling*. If probe refusal is encountered before reaching bedrock, the borehole will be abandoned using procedure PRO.117, *Plugging and Abandonment of Boreholes*, and an offset boring will be attempted within 3 feet of the original boring.

Soil cores will be recovered continuously in two to four-foot increments using a 1-inch diameter by 24-inch long lexan-lined California core barrel. Following recovery, cores will be monitored with a FID or a PID in accordance with Site FO.15, *Photoionization Detectors and Flame Ionization Detectors*, for

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health and safety purposes. If necessary, cores will also be monitored for radioactive contamination using FO.16, *Field Radiological Measurements*. The core samples will then be boxed and logged in accordance with PRO.101, *Logging Alluvial and Bedrock Material,* except that logging will be conducted more qualitatively than specified in PRO.101 (i.e., sieving, microscope examination, and plasticity testing will not be conducted). All core boxes will be labeled and transferred to an ER core storage conex for archiving following project completion.

3.3.2.3 Well Installation

Groundwater monitoring wells will be installed in accordance with GT.06, *Monitoring Wells and Piezometer Installation*. Monitoring wells will be land surveyed in accordance with GT.17, *Land Surveying*, or RFETS global positioning system manuals (Ashtech, 1993). Land surveying of new well casing locations (± 1 foot) and elevations (± 0.01 foot) will be conducted to provide control for potentiometric contouring.

3.3.3 Well Development

Monitoring wells will be developed prior to sampling using the procedures specified in PRO.106, *Well Development*. All water produced during well development will be handled as uncharacterized development water in accordance with FO.05, *Handling Purge and Development Water*.

3.3.4 Sample Designation

The Site standard sample numbering system will be implemented in this project. Location codes have been assigned to individual wells as shown in Figure 3-2 and listed in Table 3-4 using the ER well numbering convention adopted in 1992. For each groundwater sample or surface water sample, dual sample numbers will be assigned: 1) a standard RIN sample number (i.e., 98AXXXX.00X.00X) will be assigned to the project by ASD, and 2) an RMRS sample number (i.e., GW0XXXXTE) for internal sample tracking. The block of sample numbers will be of sufficient size to include the entire number of possible samples (including QA samples) and location codes. For the final report, the ASD and RMRS sample numbers will be cross-referenced with location codes.

3.3.5 Sample Collection

Groundwater

Prior to sample collection, the water level will be measured according to PRO.105, *Water Level Measurements in Wells and Piezometers*, to determine purge water requirements.

Groundwater samples will be collected using the methods specified in PRO.108, *Measurement of Groundwater Field Parameters*, and PRO.113, *Groundwater Sampling*. After an initial sampling round is completed for all new wells, future sampling may be conducted in selected wells on an as-needed basis to confirm the initial sampling results, obtain samples from previously dry wells, or monitor selected pathways or building decontamination and demolition (D&D) activities, as specified under the IMP (if modified and required for IA VOC Plume east boundary or D&D groundwater monitoring).

3.3.6 Sample Handling and Analysis

Samples will be handled according to PRO.069, *Containing, Preserving, Handling, and Shipping of Soil and Water Samples,* and 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging*. If necessary, a HSS or RCT will scan each sample with a FIDLER or equivalent instrument. Equipment will also be monitored for radiological contamination during and after sampling activities if required.

Table 3-6 indicates the analytical requirements for each sample. Samples will be submitted to an offsite, EPA-approved laboratory for analysis under normal turnaround time constraints, unless shorter turnaround times are specified by the Project Manager and arranged with ASD.

Table 3-6 Analytical Requirements for IA VOC Plume East Boundary Groundwater Samples

Analysis	Matrix	No. of Samples[a]	EPA Method	Line Item Code	Container	Preservation	Holding Time
Target Compound List (TCL) Volatiles	Water	17	EPA 524.2	SS01B009	3 (three) 40 ml amber glass vials with teflon-lined lids	Unfiltered, cool, 4° C	14 days
Rad Screen	Water	15	N/A[b]	N/A	1 (one) 125 ml poly bottle	Unfiltered	180 days

[a] Includes two QC samples except for rad screens.

[b] No EPA-approved method is currently in place for radionuclide analyses. However, guidance is provided in procedures defined in Environmental Monitoring Support Laboratory (EMSL)-LV 0539-17, *Radiological and Chemical Analytical Procedures for Analysis of Environmental Samples*, March 1979.

3.4 Solar Ponds Plume Well Installations

The following conditions were considered in the development of the sampling strategy for the Solar Ponds Plume Well Installation project:

- A collection trench/reactive barrier treatment system is proposed for capturing and treating SEP nitrate and uranium groundwater contamination prior to intercepting North Walnut Creek;
- Existing wells located beyond the west end of the proposed collection trench indicate that SPP nitrate contamination may be more extensive than previously thought; and
- Depth to bedrock and groundwater is typically less than 20 feet at the west end of the proposed reaction barrier.

3.4.1 Monitoring Well Locations and Rationale

A cluster of three monitoring wells will be drilled at the west end of the SPP groundwater collection

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trench to monitor groundwater quality associated with the SPP. One well will monitor colluvial groundwater, and two wells will monitor upper and lower weathered bedrock groundwater. Figure 3-3 illustrates the approximate location of these wells in relationship to the collection trench and nitrate plume. The rationale for each monitoring well location is summarized in Table 3-7.

Table 3-7 Solar Ponds Plume Monitoring Well Location Rationale

Well Number	Location	Rationale
70099	West end of SPP collection trench NE of well P210089	Refine SPP boundaries and monitor colluvial groundwater quality
70199	West end of SPP collection trench NE of well P210089	Refine SPP boundaries and monitor upper weathered bedrock groundwater quality
70299	West end of SPP collection trench NE of well P210089	Refine SPP boundaries and monitor lower weathered bedrock groundwater quality

3.4.2 Well Design and Installation

Conventional 2-inch inside diameter monitoring wells will be installed for each cluster well. These wells will be designed to monitor vertically discrete intervals associated with the UHSU. Screen lengths of 5 feet for colluvium and 10 feet for weathered bedrock are tentatively selected based on evidence from existing wells which indicate the presence of thinly saturated colluvium and low well yield conditions. Final depth determinations will be made in the field based on actual drilling and initial depth to water results. Table 3-8 presents the preliminary well specifications for SPP wells.

All wells will be installed using single casing construction methods described in GT.06, *Monitoring Well and Piezometer Installation,* unless shallow hole caving problems necessitate the use of isolation casing for the weathered bedrock well completions. Typical well construction materials will consist of 2-inch ID, schedule 40 or 80 PVC riser and factory cut (0.010-inch slot width) well screen. Protective casing consisting of 6-inch ID or larger steel riser with locking cap and lock will be set in sackrete to a depth of about 2 to 3 feet.

Table 3-8 Preliminary Well Construction Specifications for Solar Ponds Plume Monitoring Wells

Well Number	Completion Zone	Estimated Depth to Bedrock (ft)[a]	Top of Well Intake (filter pack) (ft)[b]	Top of Screen (ft bgs)[b]	Bottom of Screen (ft bgs)[b]	Total Depth (ft)[b]
70099	Colluvium	10.0	4.0	5.0	10.0	11.0
70199	Upper Weathered Bedrock	10.0	12.0	13.0	23.0	24.0
70299	Lower Weathered Bedrock	10.0	24.0	25.0	35.0	36.0

[a] Below original ground surface
[b] Pending actual depth to bedrock results

Boreholes for monitoring well installation will be advanced to the target completion zones using hollow stem auger techniques described in PRO.114, *Drilling and Sampling Using Hollow-Stem Auger and Rotary Drilling and Rock Coring Techniques*. Depth to water measurements will be recorded if free groundwater is encountered in the borings.

Soil cores will be recovered continuously in two-foot increments using a 2-inch or larger diameter by 24-inch long split spoon sampler. Following recovery, cores will be monitored with a FID or a PID in accordance with FO.15, *Photoionization Detectors and Flame Ionization Detectors,* for health and safety monitoring purposes. The core samples will then be boxed and logged in accordance with PRO.101, *Logging Alluvial and Bedrock Material,* except that logging will be conducted more qualitatively than specified in PRO.101 (i.e., sieving, microscope examination, and plasticity testing will not be conducted). All core boxes will be labeled and transferred to an ER core storage conex for archiving following project completion.

Groundwater monitoring wells will be installed in accordance with GT.06, *Monitoring Wells and Piezometer Installation* and as described above. Monitoring wells will be land surveyed in accordance with GT.17, *Land Surveying*, or RFETS global positioning system manuals (Ashtech, 1993). Land surveying of new well locations (± 1 foot) and elevations (± 0.01 foot) will be conducted to provide control for potentiometric contouring and bedrock elevations.

3.4.3 Well Development

Monitoring wells will be developed prior to sampling using the procedures specified in PRO.106, *Well Development*. All water produced during well development will be handled as uncharacterized development water in accordance with FO.05, *Handling Purge and Development Water*.

3.4.4 Sample Designation

The Site standard sample numbering system will be implemented in this project. Location codes have been assigned to individual wells as shown in Figure 3-3 and listed in Table 3-7 using the ER well numbering convention adopted in 1992. For each groundwater and soil sample collected from a well, dual sample numbers will be assigned: 1) a standard RIN sample number (i.e., 98A000X.00X.00X) will be assigned to the project by ASD, and 2) an RMRS sample number (i.e. GW0XXXXTE) for internal sample tracking. The block of sample numbers will be of sufficient size to include the entire number of possible samples (including QA samples) and location codes. For the final report, the ASD and RMRS sample numbers will be cross-referenced with location codes.

3.4.5 Sample Collection

3.4.5.1 Groundwater Samples

Prior to sample collection, the water level will be measured according to PRO.105, *Water Level Measurements in Wells and Piezometers*, to determine purge water requirements.

Groundwater samples will be collected using the methods specified in PRO.108, *Measurement of Groundwater Field Parameters*, and PRO.113, *Groundwater Sampling*. After an initial sampling round is completed for all new wells, future sampling will be conducted on a semi-annual basis for plume definition and system performance monitoring, as specified under the IMP (to be modified for SPP groundwater monitoring).

3.4.5.2 Soil Samples

Samples for waste characterization will be composited from drill core or cuttings samples in accordance with 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging*.

3.4.6 Sample Handling and Analysis

Samples will be handled according to PRO.069, *Containing, Preserving, Handling, and Shipping of Soil and Water Samples,* and 1-PRO-079-WGI-001, *Waste Characterization, Generation, and Packaging*. If necessary, a HSS or RCT will scan each sample with a FIDLER. Equipment will also be monitored for radiological contamination during and after sampling activities if required.

Table 3-9 indicates the analytical requirements for each sample. Samples will be submitted to an offsite, EPA-approved laboratory for analysis under a normal 30-day result turnaround time unless otherwise specified by the Project Manager and arranged with ASD.

3.5 Equipment Decontamination and Waste Handling

Reusable sampling equipment will be decontaminated with Liquinox solution, and rinsed with deionized or distilled water, in accordance with procedure FO.03, *General Equipment Decontamination*. Decontamination waters generated during the project will be managed according to procedure PRO.112, *Handling of Field Decontamination Water and Field Wash Water*. Geoprobe® and drilling equipment will be decontaminated following project completion (or earlier, if it becomes excessively dirty, at the discretion of the field crew) using procedure PRO.070, *Equipment Decontamination at Decontamination Facilities*. Personal protective equipment will be disposed of according to FO.06, *Handling of Personal Protective Equipment*. All excess drill cuttings will be handled in accordance with PRO.115, *Monitoring and Containerizing Drilling Fluids and Cuttings*.

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Table 3-9 Analytical Requirements for Solar Ponds Plume Groundwater and Soil Samples

Analysis	Matrix	No. of Samples/ Event	EPA Method	Line Item Code	Utah Certification Required	Container	Preservation	Holding Time
Nitrates	Water	5	EPA 300 Methods	SS06B022	No	1 (one) 250 ml poly bottle	Cool, 4° C, H_2SO_4 pH < 2	28 days
Uranium Isotopes (U233/ 244, U235, and U-238)	Water	5	N/A[a]	RC01B017	No	1 (one) 1-liter poly bottle	Field filtered (0.45 µm membrane), HNO_3 to pH < 2	180 days
Rad Screen	Water	5	N/A[a]	N/A	No	1 (one) 125 ml poly bottle	Unfiltered	180 days
Metals + Cu, Zn, Sb, Be, Ni, Tl, & V	Soil	3	EPA SW-846 Method 6010A, except Hg, Method 7470	SS05B049	Yes	1 (one) 8-oz Wide-mouth glass jar, teflon-lined closure	Cool, 4° C	180 days
Volatiles	Soil	3	EPA SW-846 Method 8240B/8260A	SS01B006	Yes	1 (one) 120 ml capped core or 4 or 8 oz. Wide-mouth glass jar, teflon-lined closure	Cool, 4° C	14 days
Isotopic analysis (U233/244, U235, U-238, Am-241, and Pu-239/240)	Soil	3	N/A[a]	RC01B003	No	1 (one) 500 ml wide mouth glass jar	None	None
Rad Screen	Soil	3	N/A[a]	N/A	No	1 (one) 125-ml wide mouth glass or poly jar	None	6 mos.

[a]No EPA-approved method is currently in place for radionuclide analyses. However, guidance is provided in procedures defined in Environmental Monitoring Support Laboratory (EMSL)-LV 0539-17, *Radiological and Chemical Analytical Procedures for Analysis of Environmental Samples*, March 1979.

[b] Includes two QC samples except for rad screens.

4.0 DATA MANAGEMENT

Project field logbooks will be created and maintained for each project by the project manager or designee in accordance with Site Procedure 2-S47-ER-ADM-05.15, *Use of Field Logbooks and Forms*. The logbook will include time and date of all field activities, sketch maps of sample locations, or any additional information not specifically required by the SAP. The originator will legibly sign and date each completed original hard copy of data. Appropriate field data forms will also be utilized when required by the operating procedures that govern the field activity. A peer reviewer will examine each completed original hard copy of data. Any modifications will be indicated in black ink, and initialed and dated by the reviewer. Logbooks will be controlled through RMRS Document Control.

Analytical data record tracking for this project will be performed by KH-ASD. Sample analytical results will be delivered directly from the laboratory to KH-ASD in an Electronic Disc Deliverable (EDD) format and archived in the Soil and Water Database (SWD). Hard copy records of laboratory results will be obtained from KH-ASD in the event that the analytical data is unavailable in EDD or SWD at the time of report preparation.

5.0 PROJECT ORGANIZATION

Figures 5-1 through 5-3 illustrate the project organization structure for each project. The RMRS Groundwater Operations project manager will be the primary point of responsibility for maintaining data collection and management methods that are consistent with Site operations. Other organizations assisting with the implementation of these projects are: RMRS Health and Safety, RMRS Closure Projects, RMRS Quality Assurance, RMRS Radiological Engineering, and KH-ASD.

Sampling personnel will be responsible for field data collection, documentation, and transfer of samples for analysis. Field data collection will include sampling and obtaining screening results. Documentation will include field logs and completing appropriate forms for data management and chain-of-custody shipment and as required by the appropriate governing SOPs. The sampling crew will coordinate sample shipment for on-site and off-site analyses through the ASD personnel. The

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sampling manager is responsible for verifying that chain-of-custody documents are complete and accurate before the samples are shipped to the analytical laboratories.

6.0 HEALTH AND SAFETY PLAN

All field activities contained within this SAP will be performed in accordance with the health and safety requirements set forth in addendums to *Health and Safety Plan for the 1996 Well Abandonment and Replacement Program, RF/ER-96-0016*, and the SPP Health and Safety Plan. These addendums will be prepared and approved prior to the initiation of field work and will specifically address hazards and preventative measures associated with well and Geoprobe® drilling, and groundwater sampling at the project sites.

7.0 QUALITY ASSURANCE

All components and processes within this project will comply with the RMRS Qualify Assurance Program Description RMRS-QAPD-001 (RMRS, 1997a), which is consistent with the K-H Team QA Program. The RMRS QA Program is consistent with quality requirements and guidelines mandated by the EPA, CDPHE and DOE. In general, the applicable categories of quality control are as follows:

- Quality Program;
- Training;
- Quality Improvement;
- Documents/Records;
- Work Processes;
- Design;
- Procurement;
- Inspection/Acceptance Testing;
- Management Assessments; and
- Independent Assessments.

The project manager will be in direct contact with QA to identify and address issues with the potential to affect project quality. Field sampling quality control will be conducted to ensure that data generated

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from all samples collected in the field for laboratory analysis represent the actual conditions in the field. The confidence levels of the data will be maintained by the collection of QC and duplicate samples and equipment rinsate samples.

Duplicate samples will be collected on a frequency of one duplicate sample for every 20 real samples per project, except for the Actinide Drilling-Artifact Drilling project, where the frequency will be one duplicate sample for every ten real samples. Rinsate samples will be generated at a frequency of one rinsate sample for every 20 real samples collected. Data validation will be performed on 25% of the laboratory data according to the Rocky Flats ASD, Performance Assurance Group procedures, except for actinide drilling-artifact contamination project data, which will undergo a 100% validation. Samples from the remaining two projects will be randomly selected from adequate surface and subsurface sample sets (RINS) by ASD personnel to fulfill data validation of 25% of the total number of VOC and radioisotopic analyses. Table 7-1 provides the QA/QC samples and frequency requirements of QA sample generation.

Table 7-1 QA/QC Sample Type, Frequency, and Quantity

Sample Type	Project	Frequency	Comments	Quantity[a] (estimated)
Duplicate	Actinide Drilling-Artifact Contamination	One duplicate for each twenty real samples		1 water/1 soil
	IA VOC Plume East Boundary	One duplicate for each twenty real samples		1 water
	Solar Ponds Plume Well Installations	One duplicate for each twenty real samples		1 water/1 soil
Rinse Blank	Actinide Drilling-Artifact Contamination	One rinse blank for each twenty real samples	To be performed with reusable sampling equipment following decontamination procedures	1 water/1 soil
	IA VOC Plume East Boundary	One rinse blank for each twenty real samples	To be performed with reusable sampling equipment following decontamination procedures	1 water/1 soil
	Solar Ponds Plume Well Installations	One rinse blank for each twenty real samples	To be performed with reusable sampling equipment following decontamination procedures	1 water/1 soil

Analytical data that is collected in support of the three projects will be evaluated using the guidance developed by the RMRS Administrative Procedure RF/RMRS-98-200, *Evaluation of Data for Usability* *in Final Reports*. This procedure establishes the guidelines for evaluating analytical data with respect to precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters.

A definition of PARCC parameters and the specific applications to these investigations are as follows:

Precision. A quantitative measure of data quality that refers to the reproducibility or degree of agreement among replicate or duplicate measurements of a parameter. The closer the numerical values of the measurements are to each other, the lower the relative percent difference and the greater the precision. The relative percent difference (RPD) for results of duplicate and replicate samples will be tabulated according to matrix and analytical suites to compare for compliance with established precision DQOs. Specifications on repeatability are provided in Table 7-2.. Deficiencies will be noted and qualified, if required.

Accuracy. A quantitative measure of data quality that refers to the degree of difference between measured or calculated values and the true value of a parameter. The closer the measurement to the true value, the more accurate the measurement. The actual analytical method and detection limits will be compared with the required analytical method and detection limits for VOCs and radionuclides to assess the DQO compliance for accuracy.

Representativeness. A qualitative characteristic of data quality defined by the degree to which the data absolutely and exactly represent the characteristics of a population. Representativeness is accomplished by obtaining an adequate number of samples from appropriate spatial locations within the medium of interest. The actual sample types and quantities will be compared with those stated in the SAP or other related documents and organized by media type and analytical suite. Deviation from the required and actual parameters will be justified.

Completeness. A quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from a measurement system. A completeness goal of 90% has been set for this SAP. Real samples and QC samples will be reviewed for the data usability and achievement of internal DQO usability goals. If sample data cannot be used, the non-compliance will be justified, as required.

Comparability. A qualitative measure defined by the confidence with which one data set can be compared to another. Comparability will be attained through consistent use of industry standards (e.g., SW-846) and standard operating procedures, both in the field and in laboratories. Statistical tests may be used for quantitative comparison between sample sets (populations). Deficiencies will be qualified, as required. Quantitative values for PARCC parameters for the project are provide in Table 7-2.

Laboratory validation shall be performed on 25% of the characterization data collected in support of the IA VOC Plume East Boundary and Solar Pond Plume projects and 100% for the Actinide Drilling-Artifact Contamination project. Laboratory verification shall be performed on the remaining 75% of the data. Data usability shall be performed on laboratory validated data according to procedure RF/RMRS-98-200, *Evaluation of Data for Usability in Final Reports*.

Table 7-2 PARCC Parameter Summary

PARCC	Radionuclides	Non-Radionuclides
Precision	Duplicate Error Ratio ≤ 1.42	RPD ≤ 30% for VOCs
Accuracy	Detection Limits per method and ASD Laboratory SOW	Comparison of Laboratory Control Sample Results with Real Sample Results
Representativeness	Based on SOPs and SAP	Based on SOPs and SAP
Comparability	Based on SOPs and SAP	Based on SOPs and SAP
Completeness	90% Useable	90% Useable

Data validation will be performed according to KH-ASD procedures, but will be done after the data is used for its intended purpose. Analytical laboratories supporting this task have all passed regular laboratory audits by KH-ASD.

8.0 SCHEDULE

Field activities for the actinide and SPP projects are scheduled to begin in late June 1999. Field activities for the IA VOC Plume project will be started in July 1999, depending on Geoprobe® and field crew availability. Well development and groundwater sampling will commence as soon as feasible following well installation. It is anticipated that field work for all projects will be completed by September 30, 1999, unless funding issues delay completion past the end of the fiscal year.

9.0 REFERENCES

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FIGURES

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Figure 5-1
Actinide Drilling-Artifact Contamination Organization Chart

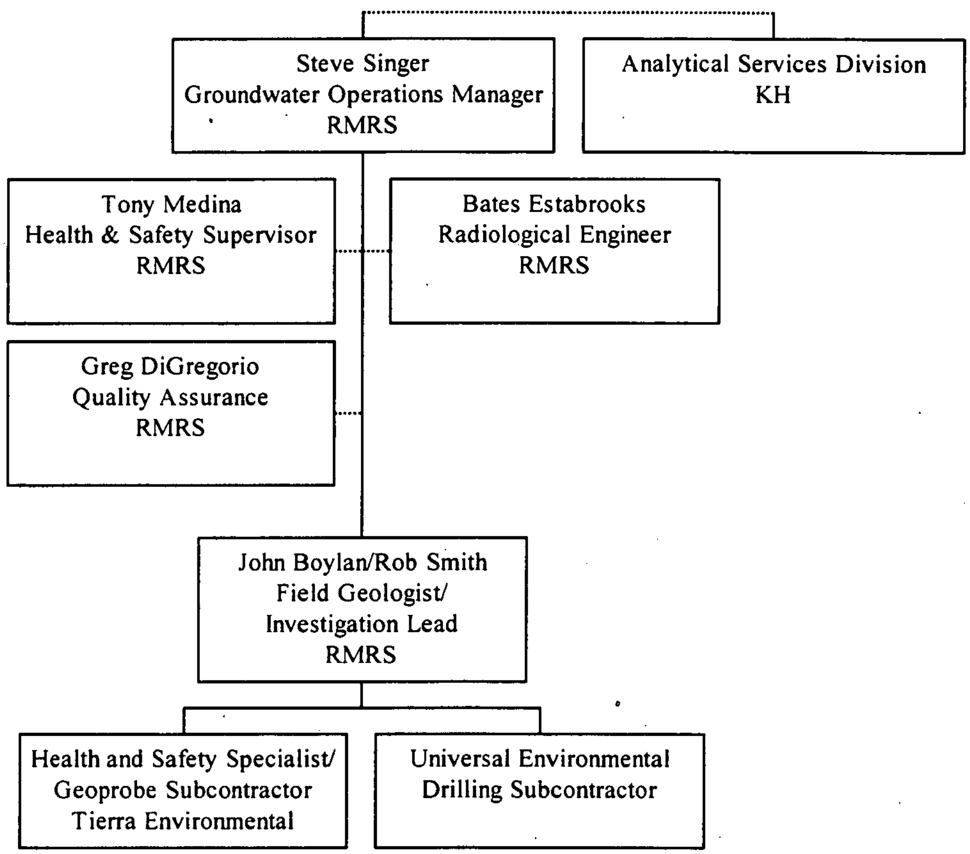

Figure 5-2
Industrial Area VOC Plume East Boundary Organization Chart

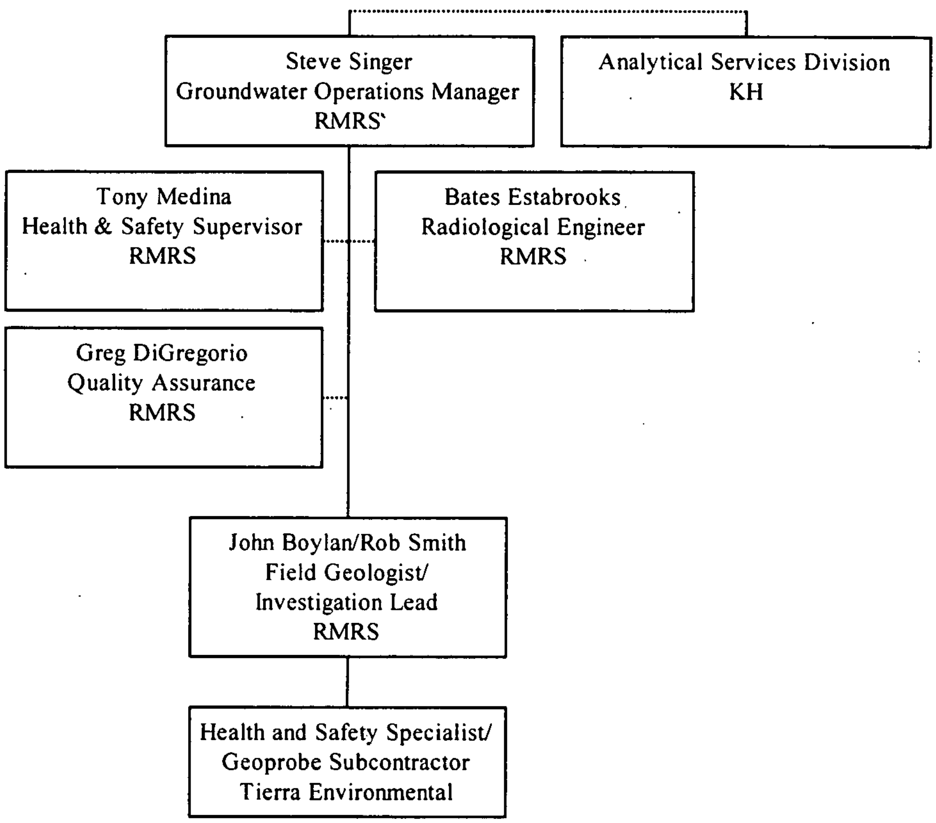

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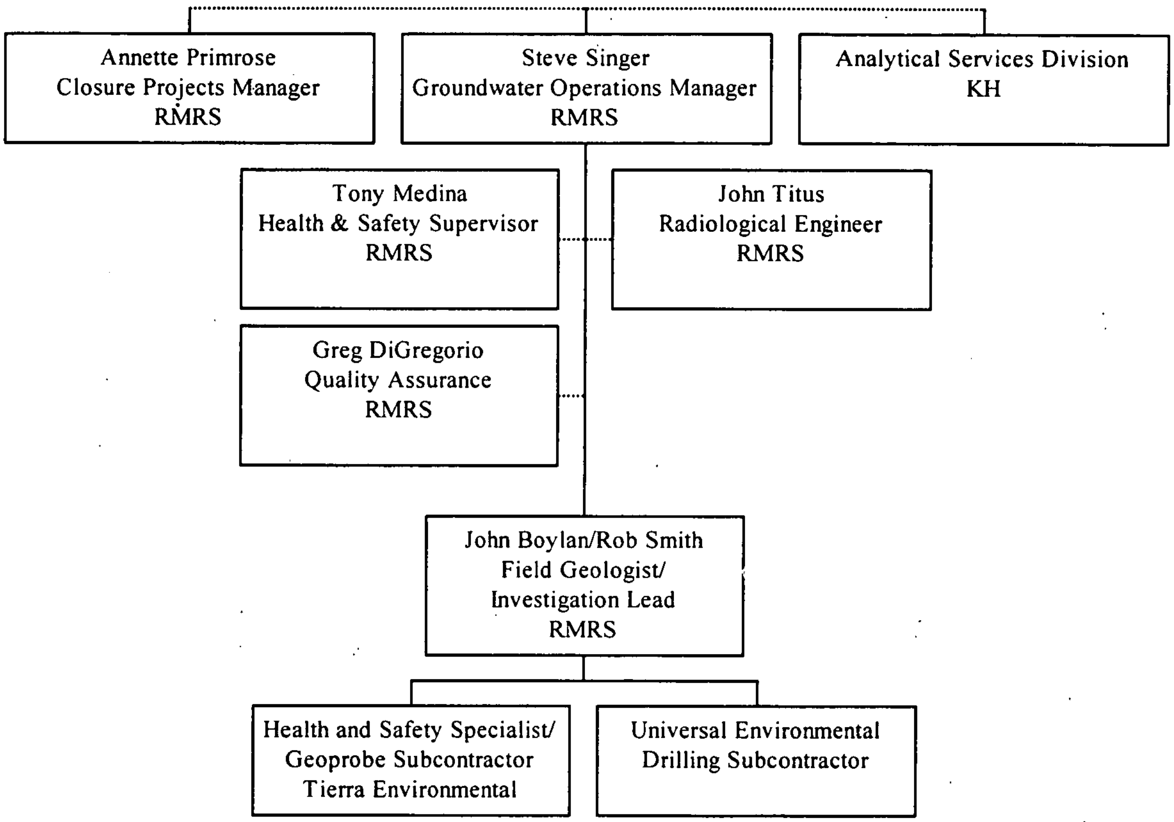
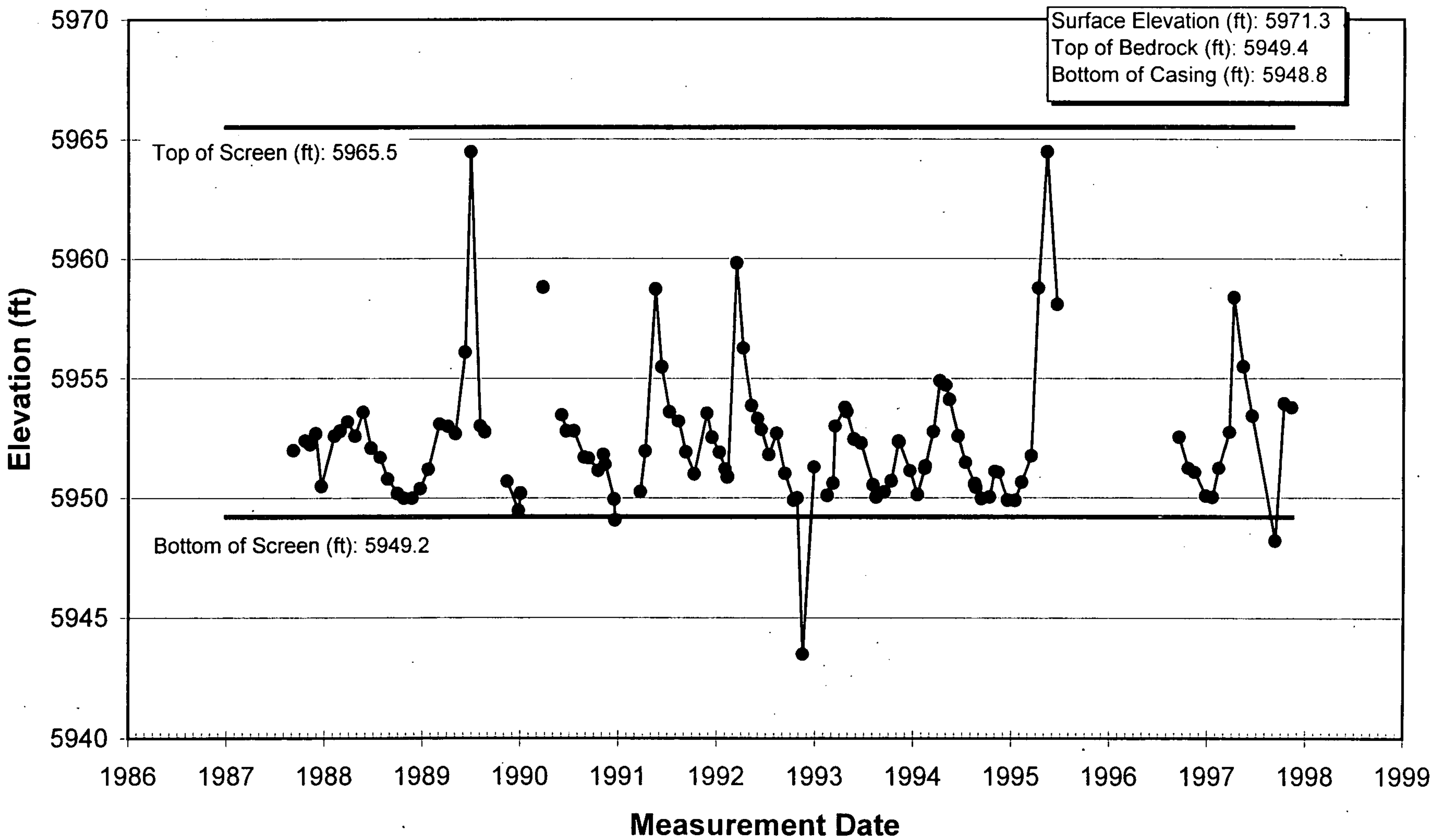
Figure 5-3
Solar Ponds Plume Well Installations
Organization Chart



Appendix A

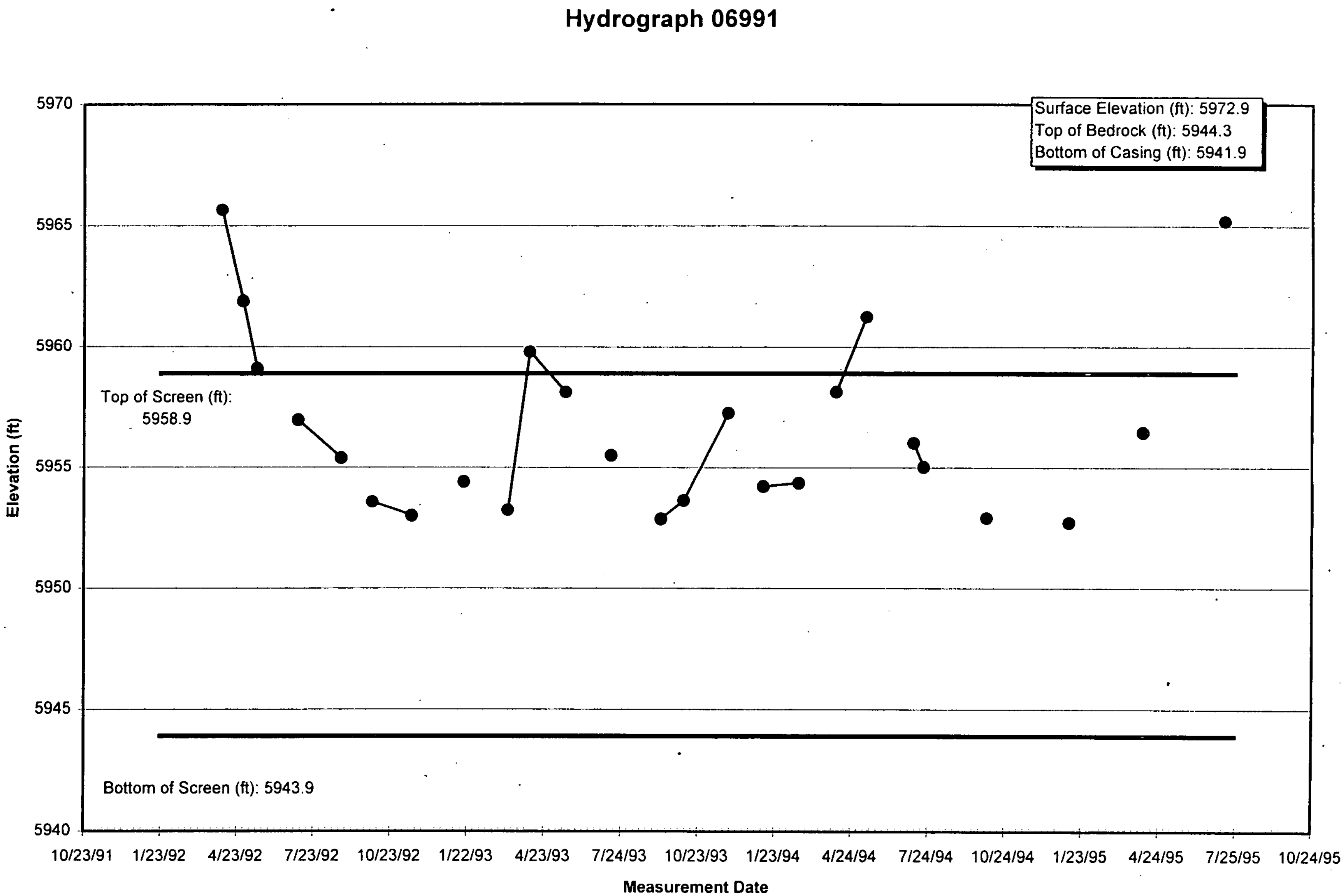
Well Logs and Hydrographs for Wells 1587, 06991, 11791, and P313489

Hydrograph 1587



S6 1587 4/7/99

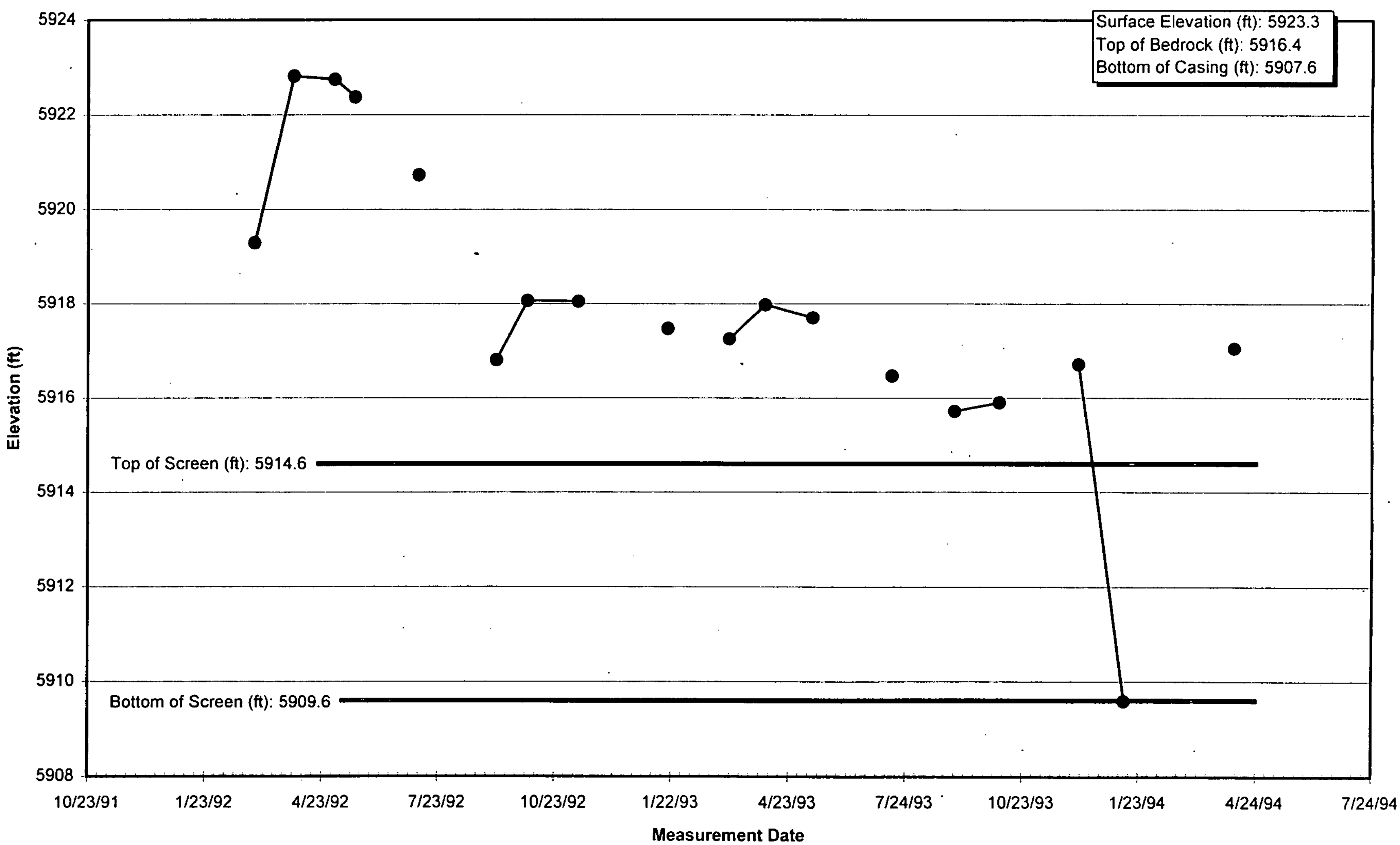
81



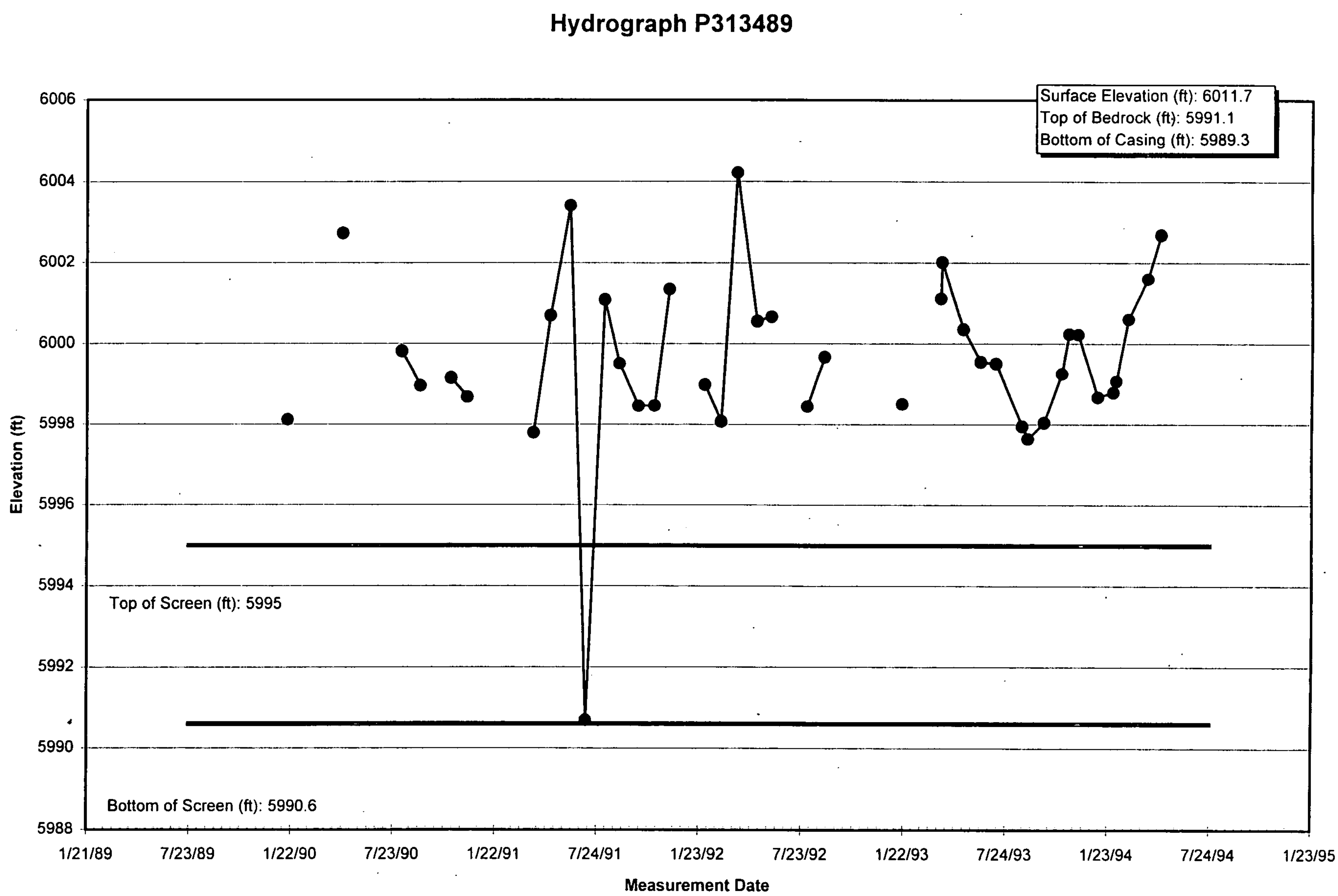
S4 06991 4/7/99

J2

Hydrograph 11791



S5 11791 4/7/99



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S22 P313489

STATE PLANE COORDINATE	TOTAL DEPTH (FT): 27.05	GROUND ELEVATION (FT): 5970.89	PROJECT NUMBER: 667.11
NORTH: 749010	AREA: 903 PAD	CASING DIAMETER (IN): 2 ID	GEOLOGIST: DCB/GCE
EAST: 2086249	LOCATOR NUMBER: N9	BOREHOLE DIAMETER (IN): 7.5	DATE DRILLED: 06/16/87

LOG OF BORING NUMBER

15-87

REMARKS: Hollow Stem Auger. Sample BH308720WT doubles as sample BH308722CT due to insufficient recovery for two samples

SAMPLE NUMBER	RECOVERY/INTERVAL	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
	0.95/1.1	GP:	GRAVEL - black (N1) to white (N9), sub-angular to rounded, poorly graded, some sand and silt, plant detritus at top of interval.
		GC:	Clayey Gravel, very light gray (N8), angular, poorly graded, some silt, clay fraction (5YR 3/2)
	0/0.9	NO SAMPLE:	
	0.15/0.15	GC:	As above. Lower portion of interval.
	1.25/1.25	GP:	Gravel in Caliche Matrix - light gray (N7), angular, poorly graded, caliche matrix is very pale orange (10YR 8/2)
	0/0.6	NO SAMPLE:	
BH30870010	1.2/1.2	GP:	As above, interval 2.15 to 3.4, with increase in max. gravel size to 7 cm.
	0/1.8	NO SAMPLE:	
	1.15/1.15	GP:	SANDY GRAVEL - medium light gray (N6), angular to sub-angular, poor to moderate grading, some clay.
	0/0.85	NO SAMPLE:	
	0/0.2	NO SAMPLE	
BH30871045	0.8/1.15	GP:	GRAVEL - med. gray (N5), sub-angular to sub-rounded, poorly graded

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 27 05	GROUND ELEVATION (FT)	5970 89	PROJECT NUMBER	667 11	LOG OF BORING NUMBER
NORTH	749010	AREA 903 PAD	CASING DIAMETER (IN)	2 10	GEOLOGIST	DCB/GCE	15-87
EAST	2086249	LOCATOR NUMBER N9	BOREHOLE DIAMETER (IN)	7 5	DATE DRILLED	06/16/87	

REMARKS: Hollow Stem Auger. Sample BH308720WT doubles as sample BH308722CT due to insufficient recovery for two samples

Sample Number	Recovery/Interval	Datum (FT)	Depth (FT)	Unified Soils Classification or Rock Type	Description
			10		
	0 /1.15	5960	11	NO SAMPLE	
	0.85 /1.2	5959	12	GW:	SANDY GRAVEL - medium light gray (N6), sub-angular to sub-rounded, well graded, trace of silt
	0 /1.3	5958	13	NO SAMPLE	
[illegible]071020	0.4 /0.7	5957	14	GP:	GRAVEL - light gray (N7), angular to sub-rounded, moderately graded, trace of sand and silt
	0 /1.3	5956	15	NO SAMPLE	
	0.85 /1.15	5955 / 5954	16–17	GP	Same as above (reference interval 14 0 to 14.7)
	0 /2.85	5953 / 5952 / 5951	18–20	NO SAMPLE	

Water level: 06/16/87 (approx. 20 ft)

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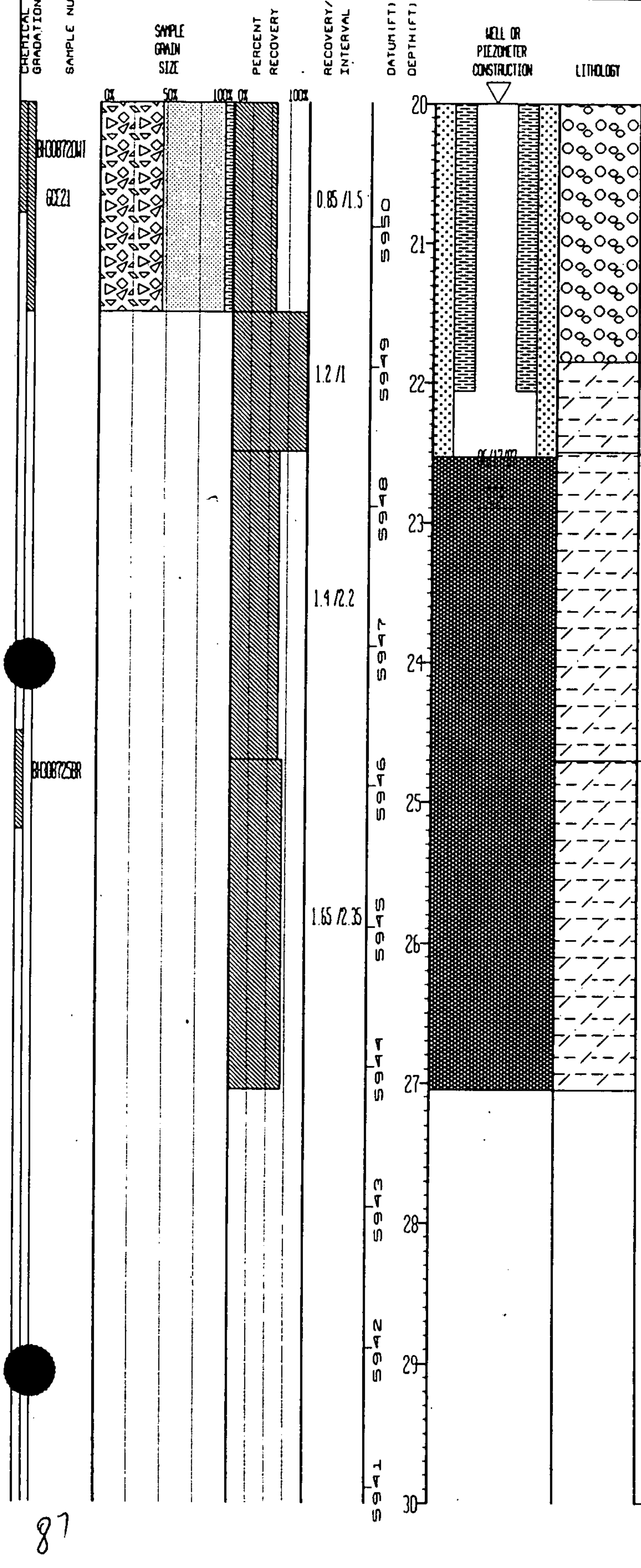
STATE PLANE COORDINATE		TOTAL DEPTH (FT) 27.05	GROUND ELEVATION (FT) 5970.89	PROJECT NUMBER 667 11	LOG OF BORING NUMBER
NORTH: 749010		AREA: 903 PAD	CASING DIAMETER (IN) 2.10	GEOLOGIST DCB/GCE	15-87
EAST: 2086249		LOCATOR NUMBER: N9	BOREHOLE DIAMETER (IN) 7.5	DATE DRILLED 06/16/87	

REMARKS: Hollow Stem Auger Sample BH3087220WT doubles as sample BH308722CT due to insufficient recovery for two samples



UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
GW	SANDY GRAVEL - medium gray (N5), sub-angular to sub-rounded, well graded, trace of silt
SILTY CLAYSTONE	Top of Bedrock Interval changes gradational to a silty claystone, very light gray (N8), moderate plasticity, trace of fine sandstone
SILTY CLAYSTONE	As above, mottled coloring, pale yellowish orange (10YR 8/6) and very light gray (N8)
SILTY CLAYSTONE	As above

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STATE PLANE COORDINATE | TOTAL DEPTH (FT) 35 0 | GROUND ELEVATION (FT) 5972 91 | PROJECT NUMBER 0U2/RI | LOG OF BORING NUMBER

NORTH 749167 76 | AREA: 903 PAD | CASING DIAMETER (IN) 2 0 | GEOLOGIST J P O'BRIEN

EAST 2085989 57 | LOCATOR NUMBER M9 | BOREHOLE DIAMETER (IN) 10 0 | DATE DRILLED 02/27/92

06991

REMARKS HOLLOW-STEM AUGER. BENTONITE SEAL 12 0 FT - 8 9 FT BACKFILL MATERIAL BENTONITE 35 0 FT - 31.0 FT

* = GRAIN SIZE DISTRIBUTION AND DESCRIPTION ESTIMATED

CHEMICAL GRADATION / SAMPLE DEPTH | SAMPLE NUMBER | SAMPLE GRAIN SIZE (0% 50% 100%) | PERCENT RECOVERY (0% 100%) | RECOVERY/INTERVAL | DATUM (FT) | DEPTH (FT) | WELL OR PIEZOMETER CONSTRUCTION | LITHOLOGY | UNIFIED SOILS CLASSIFICATION OR ROCK TYPE | DESCRIPTION

Sample Number	Recovery/Interval	Unified Soils Classification	Description
			Top soil, start of boring at 0 90 Ft.
	0.80 /2.00	CL	Silty Clay with some gravel and sand * - grayish red (5R4/2) maximum gravel diameter 1', average 03', fine- to coarse-grained sand, well graded, gravel is rounded, sand is sub-angular to sub-rounded, high plasticity, gravel is primarily quartzite, sand contains abundant carbonaceous/organic material, quartz, some rock fragments, trace feldspar, mica, moist *20% gravel, 10% sand, 30% silt, 40% clay
		GC	Clayey Gravel with some sand and silt * - very pale orange (10YR8/2) to yellowish gray (5Y7/2), as described below
BH00350WC02	0.50 /0.50		No recovery for this interval.
		GC	Clayey Gravel with some sand and silt * - very pale orange (10YR8/2) to yellowish gray (5Y7/2), as described below
	0.00 /0.80		VOA sample obtained from this interval
		GC	Clayey Gravel with some sand and silt * - very pale orange (10YR8/2) to yellowish gray (5Y7/2), as described below
			No recovery for this interval
BH00701WC02	0.90 /2.20	GC	Clayey Gravel with some sand and silt * - very pale orange (10YR8/2) at 1 6-3 4', to yellowish gray (5Y7/2), maximum gravel diameter > 25', average 13', fine- to medium-grained, well graded, sub-angular to sub-rounded, moderate to high plasticity, gravel is primarily caliche coated quartzite, sand contains abundant calcrete/caliche, quartz, some rock fragments, feldspar, slightly moist *50% gravel, 10% sand, 10% silt, 30% clay
	0.00 /0.50		No recovery for this interval
		GC	Clayey Gravel with some sand and silt * - very pale orange (10YR8/2) to yellowish gray (5Y7/2), as described above
	0.20 /2.00		No recovery for this interval
		GC	Clayey Gravel with some silt and sand - grayish orange (10YR7/4) to moderate yellowish brown (10YR5/4), maximum gravel diameter 2', average 1', fine- to coarse-grained sand, well graded, angular to sub-rounded, low plasticity, gravel is primarily quartzite, sand contains abundant quartz, some rock fragments, feldspar, trace dark minerals, kaolinized feldspar, iron stain, mica, slightly moist 56% gravel, 10% sand, 12% silt, 22% clay
	0.80 /2.00		No recovery for this interval

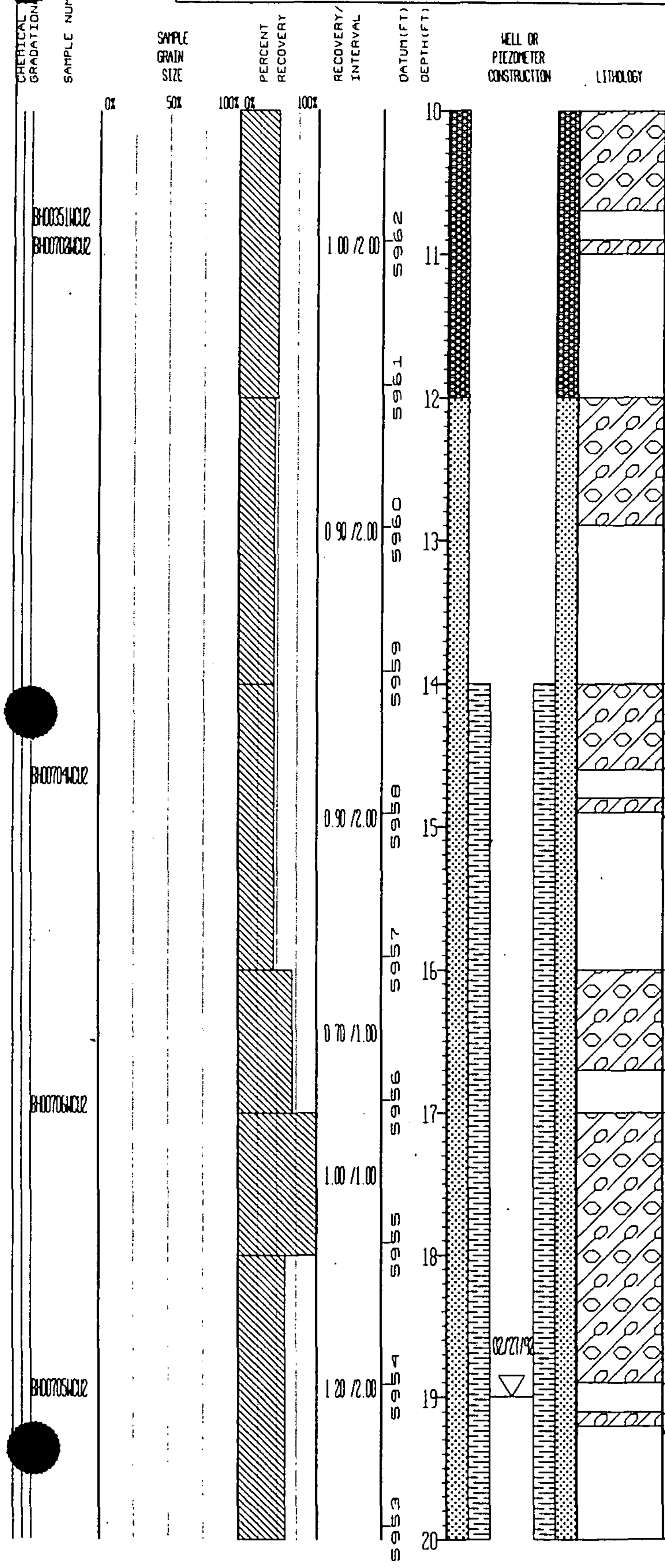
Depth (FT): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Datum (FT): 5972, 5971, 5970, 5969, 5968, 5967, 5966, 5965, 5964, 5963

STATE PLANE COORDINATE		TOTAL DEPTH (FT): 35.0	GROUND ELEVATION (FT)	5972.91	PROJECT NUMBER	OU2/RI	LOG OF BORING NUMBER
NORTH	749167.76	AREA: 903 PAD	CASING DIAMETER (IN)	2.0	GEOLOGIST:	J.P. O'BRIEN	06991
EAST	2085989.57	LOCATOR NUMBER: M9	BOREHOLE DIAMETER (IN)	10.0	DATE DRILLED	02/27/92	

REMARKS: HOLLOW-STEM AUGER. BENTONITE SEAL 12.0 FT. - 8.9 FT. BACKFILL MATERIAL: BENTONITE 35.0 FT. - 31.0 FT.

* = GRAIN SIZE DISTRIBUTION AND DESCRIPTION ESTIMATED



UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
GC	Clayey Gravel with some sand and silt - moderate brown (5YR4/4), as described below
	VOA sample obtained from this interval
GC	Clayey Gravel with some sand and silt - moderate brown (5YR4/4), as described above
	No recovery for this interval
GC	Clayey Gravel with some sand and silt - moderate brown (5YR4/4), maximum gravel diameter > .25', average .06', fine- to coarse-grained sand, well graded, angular to sub-rounded, low plasticity, gravel is primarily quartzite, sand contains abundant quartz, some rock fragments, dark minerals, feldspar, trace kaolinized feldspar, mica, abundant kaolinized feldspar at 12.8-16.0', slightly moist at 10.0-14.0', moist at 14.0-16.0' 50% gravel, 15% sand, 11% silt, 24% clay
	No recovery for this interval
GC	Clayey Gravel with some sand and silt - moderate brown (5YR4/4), as described above.
	VOA sample obtained from this interval
GC	Clayey Gravel with some sand and silt - moderate brown (5YR4/4), as described above
	No recovery for this interval.
GC	Clayey Gravel with some sand and silt - moderate yellowish brown (10YR5/4) to yellowish gray (5Y8/1), as described below
	No recovery for this interval
GC	Clayey Gravel with some sand and silt - moderate yellowish brown (10YR5/4) to yellowish gray (5Y8/1) at 17.0-18.0', 18.6-18.9', maximum gravel diameter > .25', average .13', fine- to coarse-grained sand, well graded, angular to sub-rounded, low to moderate plasticity, gravel is primarily quartzite with trace weathered granite and friable arkosic arenite, sand contains abundant quartz, some rock fragments, feldspar, trace dark minerals, kaolinized feldspar, mica, moist to 20.0', saturated at 20.0-21.0' 42% gravel, 12% sand, 10% silt, 36% clay
	VOA sample obtained from this interval
GC	Clayey Gravel with some sand and silt - moderate yellowish brown (10YR5/4) to yellowish gray (5Y8/1), as described above
	No recovery for this interval

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STATE PLANE COORDINATE		TOTAL DEPTH (FT) 35 0	GROUND ELEVATION (FT)	5972 91	PROJECT NUMBER	OU2/RI
NORTH	749167 76	AREA 903 PAD	CASING DIAMETER (IN)	2 0	GEOLOGIST	J P O'BRIEN
EAST	2085989 57	LOCATOR NUMBER M9	BOREHOLE DIAMETER (IN)	10 8	DATE DRILLED	02/27/92

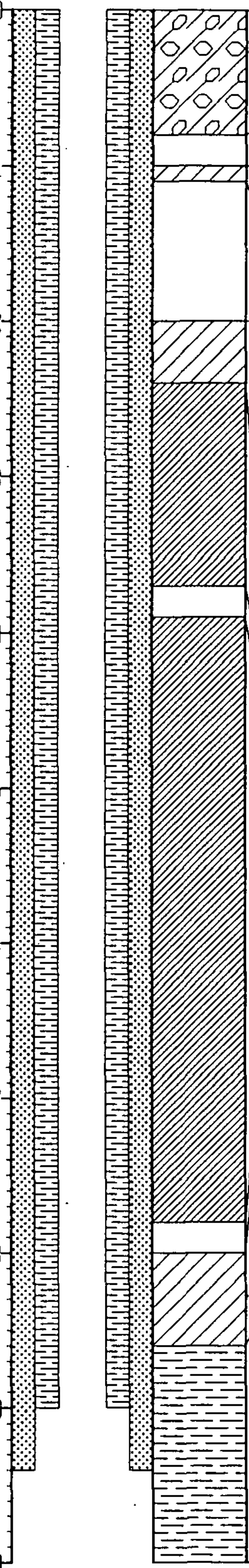
LOG OF BORING NUMBER

06991

REMARKS HOLLOW-STEM AUGER BENTONITE SEAL 12.0 FT - 8 9 FT BACKFILL MATERIAL BENTONITE 35 0 FT - 31 0 FT

* = GRAIN SIZE DISTRIBUTION AND DESCRIPTION ESTIMATED

CHEMICAL DEPTH / GRADATION SAMPLE DEPTH | SAMPLE NUMBER | SAMPLE GRAIN SIZE (0% 50% 100%) | PERCENT RECOVERY (0% 100%) | RECOVERY/INTERVAL | DATUM (FT) | DEPTH (FT) | WELL OR PIEZOMETER CONSTRUCTION | LITHOLOGY | UNIFIED SOILS CLASSIFICATION OR ROCK TYPE | DESCRIPTION



Sample number	Recovery/Interval	Datum (ft)
BH00707WC02	1.10 /2.00	5952
		5951
BH00708WC02	2.00 /2.00	5950
BH00709WC02		5949
	2.00 /2.00	5948
		5947
	1 80 /2 00	5946
		5945
	1.00 /1 00	
BH00710WC02		5944
	1 00 /1 00	5943

Depth (ft): 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Unified Soils Classification or Rock Type	Description
GC	Clayey Gravel with some sand and silt - moderate yellowish brown (10YR5/4) to yellowish gray, as described above
	VOA sample obtained from this interval
CL	Silty Clay with some gravel and sand - moderate yellowish brown (10YR5/4), as described below.
	No recovery for this interval
CL	Silty Clay with some gravel and sand - moderate yellowish brown (10YR5/4), maximum gravel diameter .05', average 02', fine- to coarse-grained sand, well graded, angular to well rounded, moderate plasticity, gravel is primarily quartzite, sand contains abundant quartz, some rock fragments, dark minerals, feldspar, trace iron stain, kaolinized feldspar, mica 03'x.03' yellowish gray silty clay rip-up clasts throughout, contact with underlying unit is sharp, surface is irregular and iron stained, saturated 20% gravel, 19% sand, 25% silt, 36% clay
CH*	Clay with some silt - light olive gray (5Y5/2) with some pale yellowish orange (10YR8/6) iron stain, as described below
	VOA sample obtained from this interval.
CH*	Clay with some silt - light olive gray (5Y5/2) with some pale yellowish orange (10YR8/6) iron stain, silt and clay, poorly graded, rounded, high plasticity, mottled, re-worked bedrock material, moist 0% gravel, 0% sand, 8% silt, 92% clay.
	No recovery for this interval.
CL	Gravelly Clay with some silt and sand - pale brown (5YR5/2), maximum gravel diameter 1', average 05', fine- to coarse-grained sand, well graded, angular to rounded, moderate plasticity, gravel is primarily quartzite with some granite and .1'x.1' clay (bedrock) rip-up clasts at 28.5', sand contains abundant frosted quartz, clear quartz, rock fragments, some feldspar, dark minerals, trace mica, saturated to 28 6' 21% gravel, 16% sand, 20% silt, 53% clay Top of bedrock at 28 6 ft
CLAYSTONE	Claystone - light olive gray (5Y5/2), very fine-grained, very well sorted, sub-angular, approximately 2% porosity, argillaceous cement, non-friable, abundant quartz, dark minerals, mottled to thinly bedded with carbonaceous, material along laminea which are at 06' intervals at 31.5-32.0, abundant carbonaceous material (plant-wood fragments) at 32 8-34.2' discordent iron stain along laminea, slightly moist. 2% sand, 3% silt, 95% clay

STATE PLANE COORDINATE
NORTH: 749167.76
EAST: 2085989.57

TOTAL DEPTH (FT) 35.0
AREA 903 PAD
LOCATOR NUMBER M9

GROUND ELEVATION (FT) 5972.91
CASING DIAMETER (IN) 2.0
BOREHOLE DIAMETER (IN) 10.0

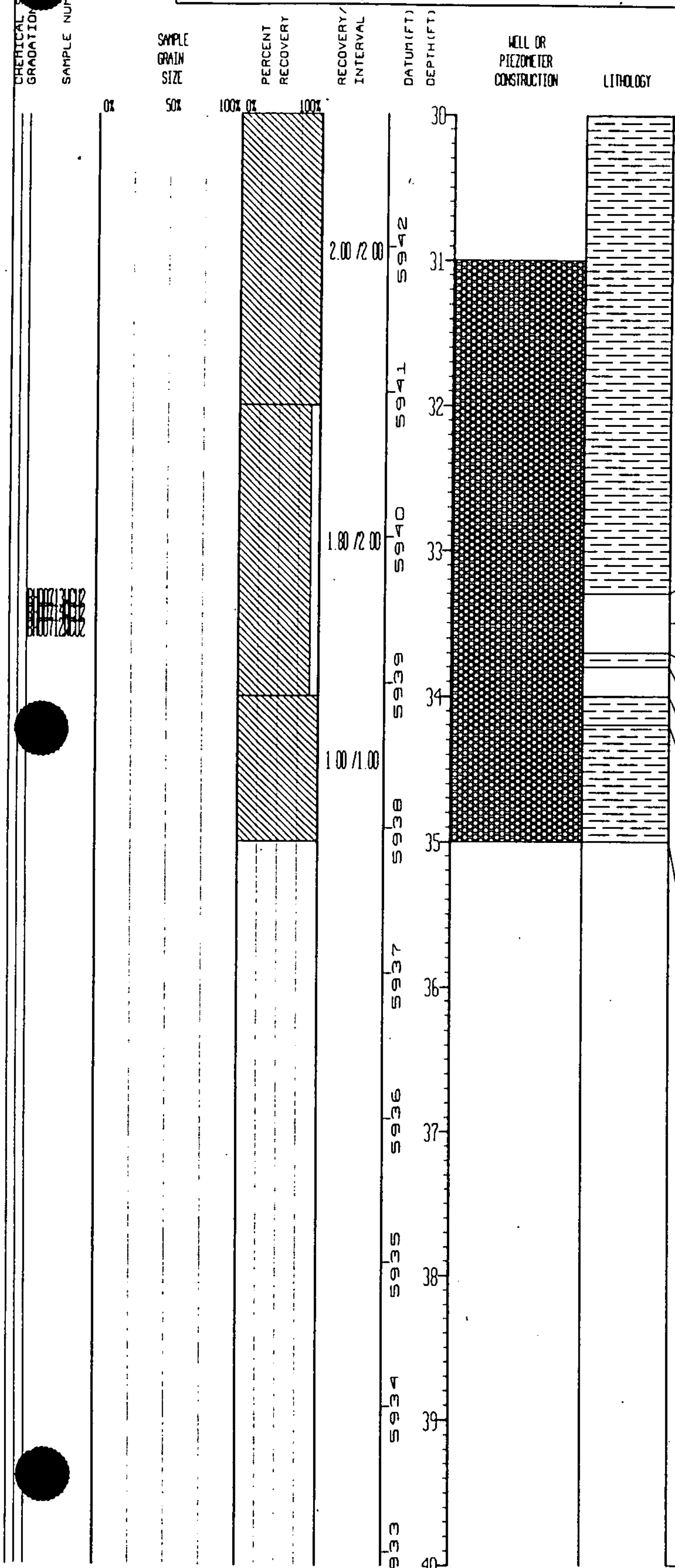
PROJECT NUMBER OU2/RI
GEOLOGIST J P O'BRIEN
DATE DRILLED 02/27/92

LOG OF BORING NUMBER

06991

REMARKS: HOLLOW-STEM AUGER. BENTONITE SEAL 12.0 FT - 8.9 FT BACKFILL MATERIAL BENTONITE 35.0 FT - 31.0 FT

* = GRAIN SIZE DISTRIBUTION AND DESCRIPTION ESTIMATED



UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
	VOA sample obtained from this interval
	VOA sample obtained from this interval
CLAYSTONE:	Claystone - light olive gray (5Y5/2), as described above.
	No recovery for this interval.
CLAYSTONE:	Claystone - light olive gray (5Y5/2), as described above
CLAYSTONE:	Claystone - light olive gray (5Y5/2) with dark yellowish orange (10YR6/6) iron stain throughout, very fine-grained, very well sorted, sub-angular to rounded, argillaceous cement, slightly friable, abundant frosted quartz, trace dark minerals, iron stain, multiple iron stained fractures, dry. 3% sand, 5% silt, 92% clay

Total depth at 35.0 ft

91

STATE PLANE COORDINATE | TOTAL DEPTH (FT) 15 8 | GROUND ELEVATION (FT) 5923 29 | PROJECT NUMBER 002/RI | LOG OF BORING NUMBER

NORTH 748900 08 | AREA 903 PAD | CASING DIAMETER (IN) 2 0 | GEOLOGIST L A GUST

EAST 2086785 87 | LOCATOR NUMBER N8 | BOREHOLE DIAMETER (IN) 10 0 | DATE DRILLED 10/16/91

11791

REMARKS HOLLOW STEM AUGER BENTONITE SEAL 8 2 FT - 4 9 FT BACKFILL MATERIAL BENTONITE 15 8 FT - 15 7 FT OFFSET TO 00391, CUTTINGS COLLECTED EVERY TWO FEET WITH THE EXCEPTION OF 13 7 FT - 15 8 FT

CHEMICAL GRADATION DEPTH / SAMPLE DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE (0% 50% 100%)	PERCENT RECOVERY (0% 100%)	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
				0.00 /0.90	5923	0				Top soil, start of boring at 0 90 ft
				0.00 /2.00	5922, 5921	1–3			CL	Organic Sandy Clay with some silt - dark gray (N3), medium- to fine-grained sand, poorly graded, sub-angular, medium plasticity, dominant lithology sand quartz with some rock fragments and dark minerals, no apparent bedding, moist, trace caliche throughout interval, some root present 28% sand, 85 silt, 64% clay
					5920, 5919, 5918, 5917	3–7			CL	Silty Clay with some sand - light olive (10Y5/4) to dark yellowish orange (10YR6/6), very fine-grained sand, poorly graded, angular to sub-angular, medium plasticity, dominant lithology quartz rose, milky and clear, with some K-spar and trace mica and dark minerals, abundant iron staining on grains, some caliche throughout interval, no apparent bedding due to cutting sample, moist, some root present 20% sand, 32% silt, 48% clay Top of bedrock at 6 9 ft
				0.00 /10.80	5916, 5915, 5914	7–10			SANDY CLAYSTONE	Sandy Claystone with some silt - light olive (10Y5/4), very fine-grained sand, well sorted, sub-angular, approximately 15% porosity, argillaceous cement, slightly friable, dominant lithology sand clear quartz with some dark minerals, trace mica, trace iron staining on grains, no apparent bedding or fractures due to cuttings sample, moist, weathered 29% sand, 7% silt, 64% clay

92

STATE PLANE COORDINATE
NORTH 748900.08
EAST 2086785.87

TOTAL DEPTH (FT) 15.8
AREA 903 PAD
LOCATOR NUMBER: N8

GROUND ELEVATION (FT): 5923.29
CASING DIAMETER (IN): 2.0
BOREHOLE DIAMETER (IN): 10.0

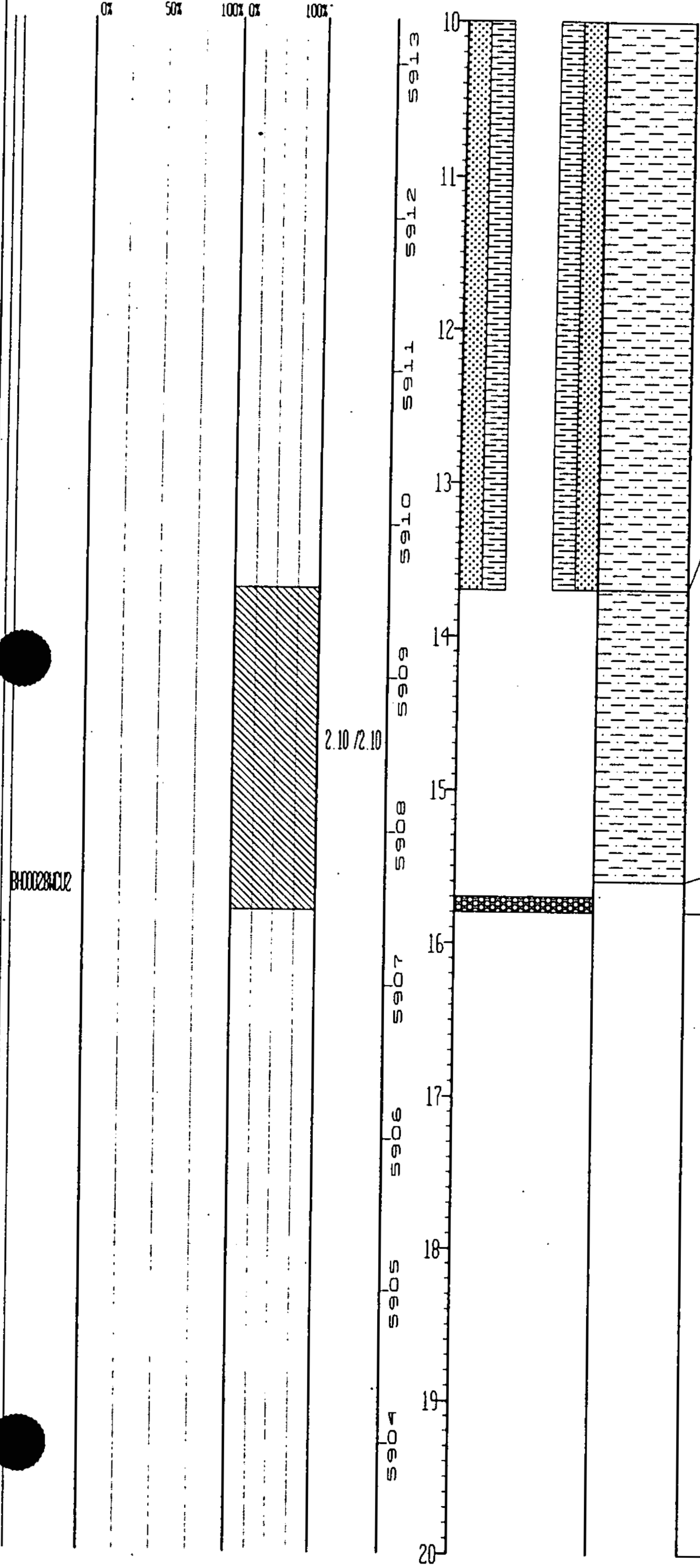
PROJECT NUMBER OU2/RI
GEOLOGIST L.A. GUST
DATE DRILLED 10/16/91

LOG OF BORING NUMBER

11791

REMARKS HOLLOW STEM AUGER. BENTONITE SEAL 8.2 FT. - 4.9 FT. BACKFILL MATERIAL: BENTONITE 15.8 FT - 15.7 FT. OFFSET TO 00391, CUTTINGS COLLECTED EVERY TWO FEET WITH THE EXCEPTION OF 13.7 FT - 15.8 FT

CHEMICAL SAMPLE DEPTH | GRADATION SAMPLE DEPTH | SAMPLE NUMBER | SAMPLE GRAIN SIZE | PERCENT RECOVERY | RECOVERY/INTERVAL | DATUM(FT) | DEPTH(FT) | WELL OR PIEZOMETER CONSTRUCTION | LITHOLOGY | UNIFIED SOILS CLASSIFICATION OR ROCK TYPE | DESCRIPTION



SANDY CLAYSTONE Sandy Claystone with some silt and interbedded sandstone layers - pale olive (10Y6/2) to moderate yellowish brown (10YR5/4); very fine-grained sand, well sorted, approximately 15% porosity, sub-angular, argillaceous cement, slight to moderately friable, dominant lithology sand clear quartz with some dark minerals and trace mica, some iron staining on grains and throughout interval, trace carbonaceous material, no apparent bedding, vertical to 45 degree fractures healed with gray gouge throughout interval sand layer at 13.9-14.2', some soft sediment deformation at 13.8', moist, weathered.
38% sand, 15% silt, 47% clay

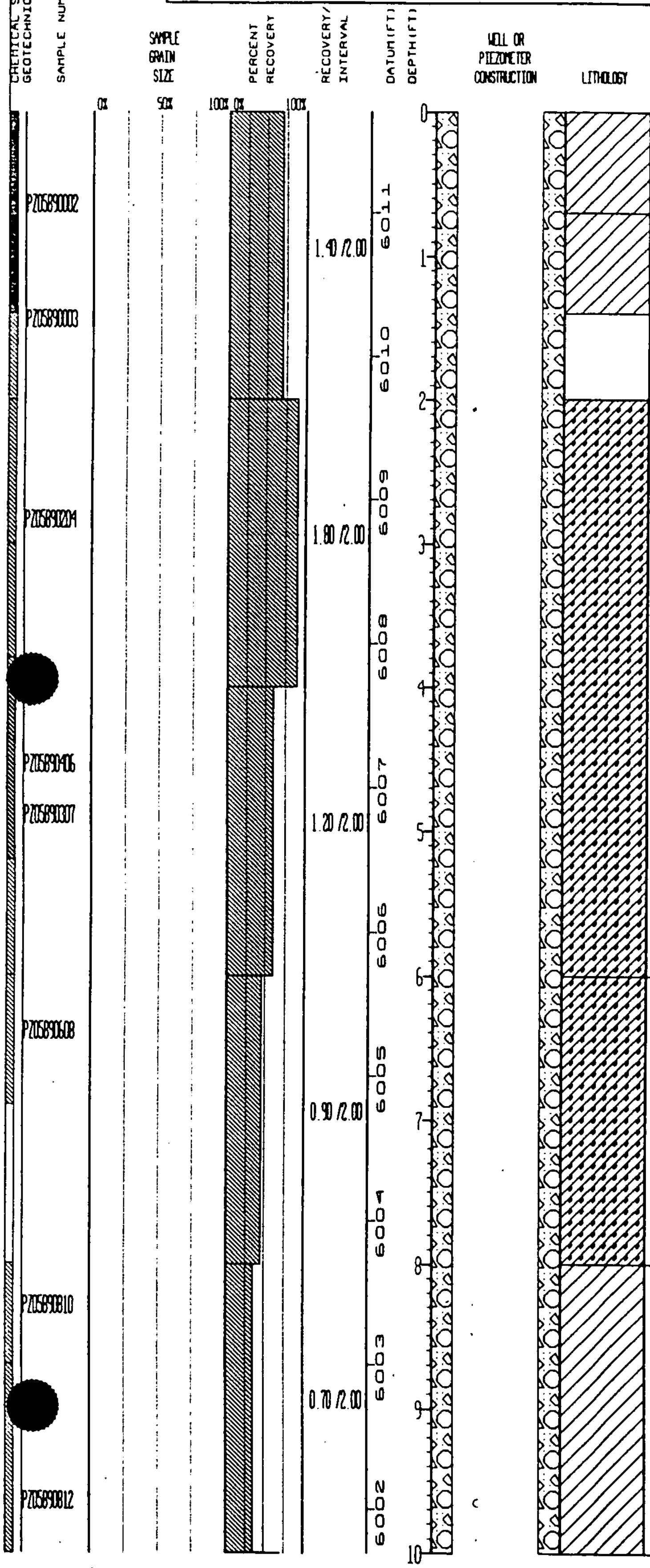
VOA sample obtained from this interval

Total depth at 15.8 ft

93

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 24.0	GROUND ELEVATION (FT): 6011.70	OLD WELL NUMBER: PZ05-89	LOG OF BORING NUMBER:
NORTH: 748913	AREA: PLANT	CASING DIAMETER (IN): 2-3/8 O.D.	GEOLOGIST: TAL	P313489
EAST: 2083062	LOCATOR NUMBER: K9	BOREHOLE DIAMETER (IN): 7.25	DATE DRILLED: 10/11/89	

REMARKS: Hollow Stem Auger. Weston Log.



UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
CL:	Sandy Gravelly Clay - mod. brown (5 YR 3/4). Non-stratified, f.g. to c.g. quartzose sand, sub-rounded to sub-angular. 1 cm. to 3 cm. broken quartzose gravels. Non to low plasticity, caliche, mod. HCl reaction, stiff, damp.
CL:	Sandy Gravelly Clay - same as above with light brown (5 YR 6/4) to grayish orange (10 YR 7/4). 4 cm. to 7 cm. gravels.
NO SAMPLE:	NO SAMPLE.
SC:	Gravelly Clayey Sand - light brown (5 YR 6/4) to pale yellowish orange (10 YR 8/6). F.g. to c.g. quartzose sand, sub-angular to sub-rounded. 3 cm. to 5 cm. broken gravels. Iron staining, trace mica, some silt. Caliche with mod. HCl reaction, stiff, dry.
SC:	Gravelly Clayey Sand - same as above with color change to light brown (5 YR 5/6).
CL:	Gravelly Sandy Clay - same as above with low plasticity.

94

STATE PLANE COORDINATE	TOTAL DEPTH (FT): 24.0	GROUND ELEVATION (FT): 6011.70
NORTH: 748913	AREA: PLANT	CASING DIAMETER (IN): 2-3/8 O.D.
EAST: 2083062	LOCATOR NUMBER: K9	BOREHOLE DIAMETER (IN): 7.25

OLD WELL NUMBER: PZ05-89
GEOLOGIST: TAL
DATE DRILLED: 10/11/89

LOG OF BORING NUMBER:

P313489

REMARKS: Hollow Stem Auger. Weston Log.

GEOTECHNICAL SAMPLE DEPTH / SAMPLE NUMBER	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
PZ05891012	1.40 /2.00	6001	10–11.4	CL:	Sandy Clay - light olive gray (5 Y 6/1) to mod. reddish brown (10 R 4/6). Non-stratified, f.g. to c.g. quartzose sand, sub-angular to sub-rounded. Some 1 cm. to 4 cm., sub-rounded quartzose gravels. Low to med. plasticity, stiff, dry.
		6000	11.4–12.0	NO SAMPLE:	NO SAMPLE.
			12.0–12.4	CL:	Sandy Clay - same as above (reference interval 10.2' to 11.4').
PZ05891214	2.00 /2.00	5999, 5998	12.4–16.0	CL:	Gravelly Sandy Clay - light brown (5 YR 6/4) to pale yellowish orange (10 YR 8/6). F.g. to c.g. quartzose sand, sub-rounded to sub-angular. 3 cm. to 5 cm broken quartzose gravels. Med. plasticity, stiff, damp.
PZ05891216 / PZ05891218	0.20 /2.00	5997, 5996			
PZ05891618	0.80 /2.00		16.0–16.4	CL	Sandy Clay - same as above (reference interval 12.0' to 12.4').
		5995	16.4–16.8	CL:	Gravelly Sandy Clay - same as above (reference interval 12.4' to 14.0') with some silt, wet.
		5994	16.8–18.0	NO SAMPLE	NO SAMPLE.
PZ05891820	1.30 /2.00	5993	18.0–18.3	SM:	Gravelly Silty Sand - pale yellowish brown (10 YR 6/2) to dark reddish brown (10 YR 3/4) Non-stratified, v.f.g. to c.g. quartzose sand. 3 cm. to 5 cm. broken quartzose gravels. Trace clay, stiff, moist.
PZ05891821			18.3–19.3	CL:	Gravelly Sandy Clay - same as above (reference interval 12.4' to 14.0'), with grayish orange (10 YR 7/4), damp to moist.
		5992	19.3–20	NO SAMPLE:	NO SAMPLE.

Column headings: SAMPLE GRAIN SIZE (0% 50% 100%); PERCENT RECOVERY (0% 100%); WELL OR PIEZOMETER CONSTRUCTION; LITHOLOGY.

95

STATE PLANE COORDINATE: NORTH: 748913 EAST: 2083062

TOTAL DEPTH (FT): 24.0
AREA: PLANT
LOCATOR NUMBER: K9

GROUND ELEVATION (FT): 6011.70
CASING DIAMETER (IN): 2-3/8 O.D.
BOREHOLE DIAMETER (IN): 7.25

OLD WELL NUMBER: PZ05-89
GEOLOGIST: TAL
DATE DRILLED: 10/11/89

LOG OF BORING NUMBER: P313489

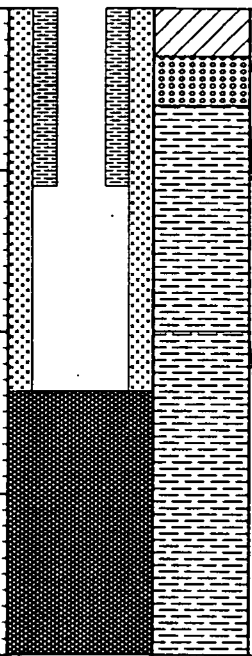
REMARKS: Hollow Stem Auger. Weston Log.

CHEMICAL SAMPLE DEPTH / GEOTECHNICAL SAMPLE DEPTH | SAMPLE NUMBER | SAMPLE GRAIN SIZE (0% 50% 100%) | PERCENT RECOVERY (0% 100%) | RECOVERY/INTERVAL | DATUM (FT) | DEPTH (FT) | WELL OR PIEZOMETER CONSTRUCTION | LITHOLOGY | UNIFIED SOILS CLASSIFICATION OR ROCK TYPE | DESCRIPTION

Sample Number	Recovery/Interval
PZ05892022	2.00 /2.00
PZ05892124	
PZ05892224	2.00 /2.00

Datum (ft): 5991, 5990, 5989, 5988, 5987, 5986, 5985, 5984, 5983, 5982

Depth (ft): 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

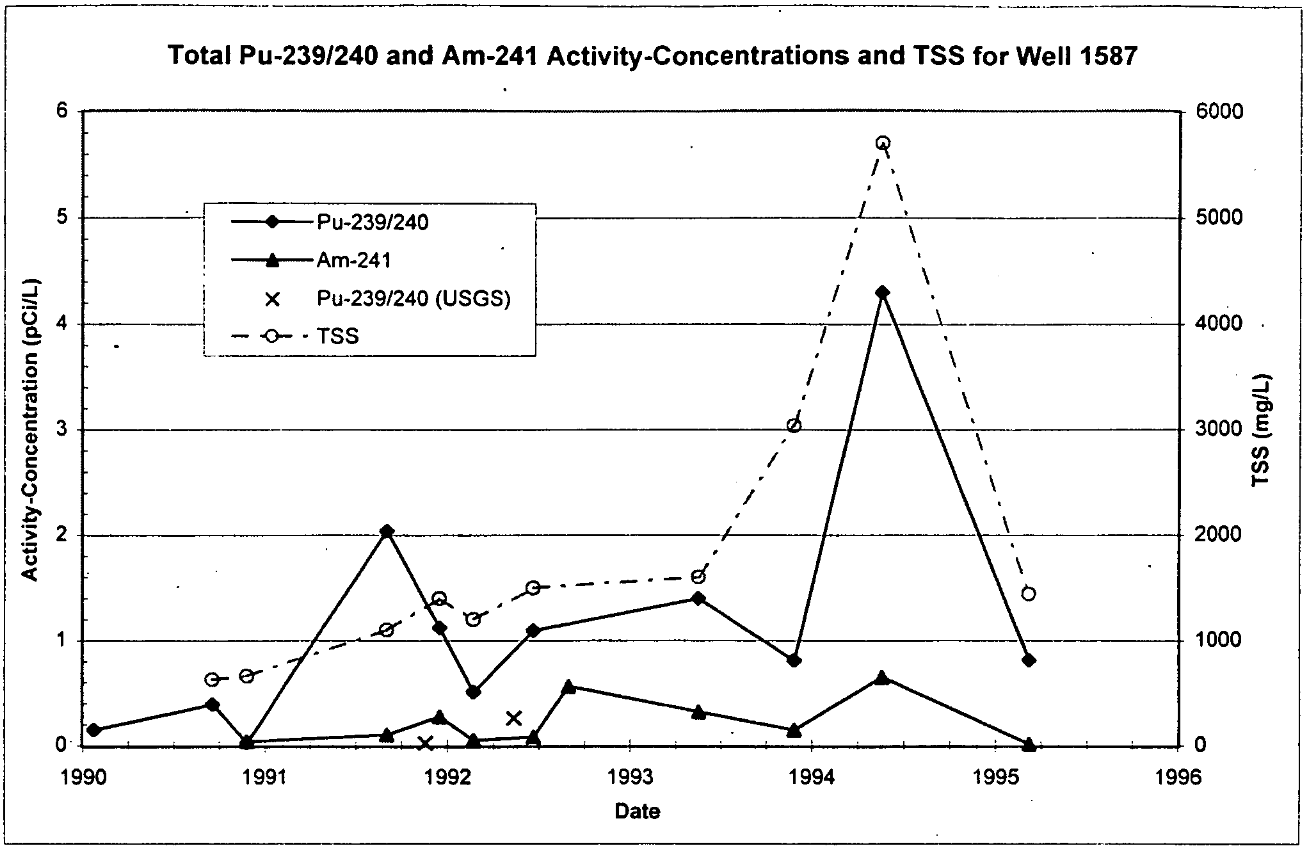


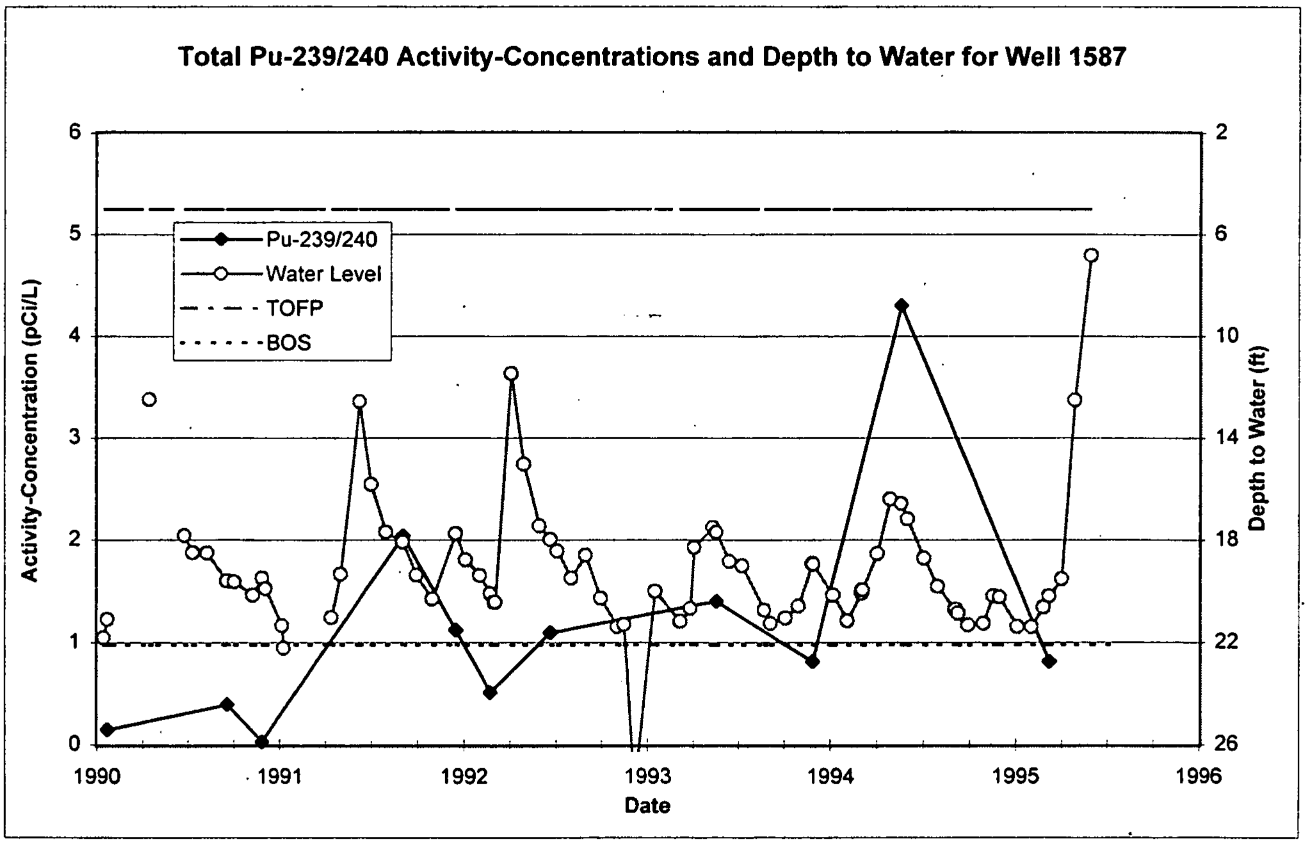
USCS / Rock Type	Description
CL:	Gravelly Sandy Clay - same as above (reference interval 18.3' to 19.3').
SW:	Gravelly Sand - pale yellowish orange (10 YR 8/6), non-stratified. Predom. f.g., quartzose, occasionally m.g. to c.g., sub-rounded to sub-angular. Trace silt. 2 cm. to 4 cm. broken quartzose gravels. Iron stained, trace clay, stiff, moist.
CLAYSTONE:	Top of Bedrock. Olive gray (5 Y 4/1) to olive black (5 Y 2/1), non-stratified, dense. Trace silt, blocky, med. to high plasticity, dry.
CLAYSTONE:	Same as above (reference interval 20.6' to 22.0'), with grayish brown (5 YR 3/2) to brownish gray (5 Y 4/1) and mod. yellowish brown (10 YR 5/4), with iron staining.
:	Total Drilled Depth = 24.0'.

96

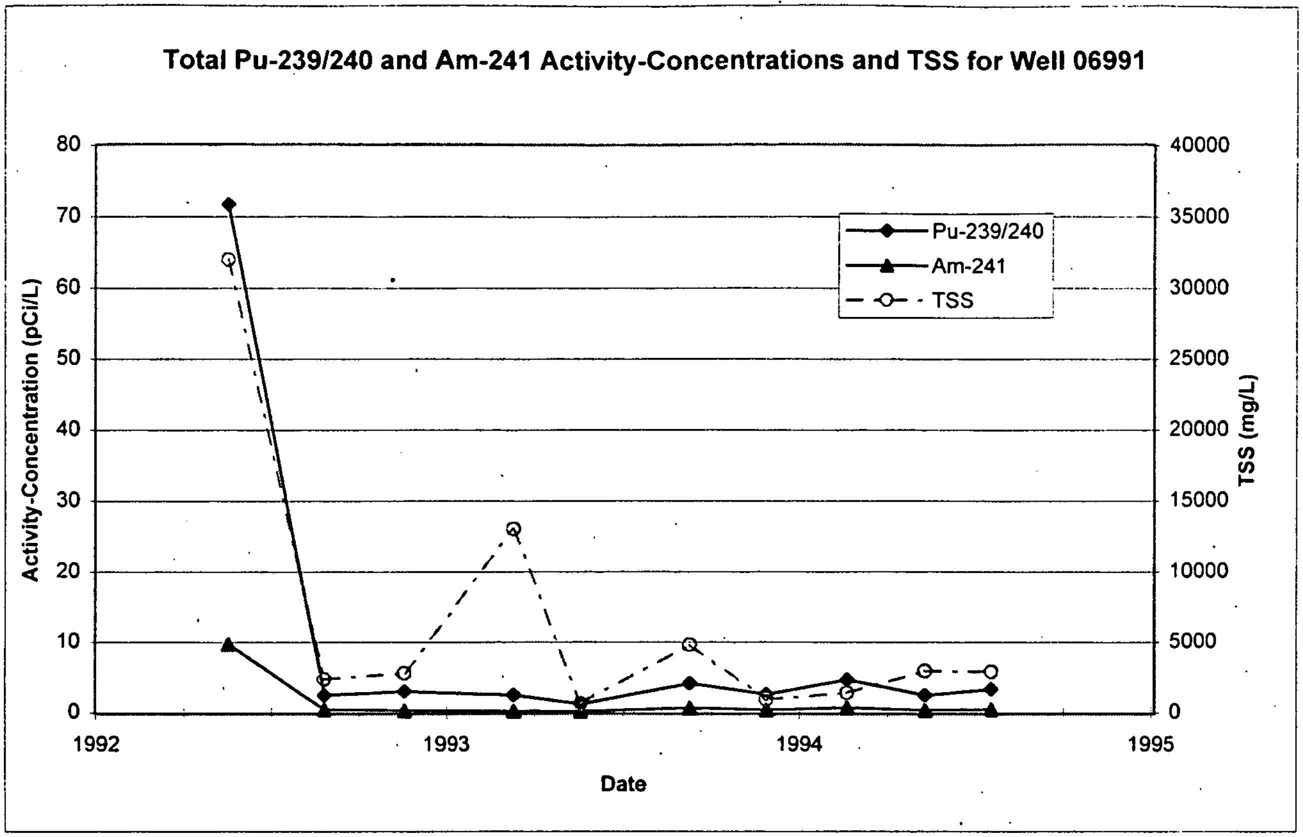
Appendix B

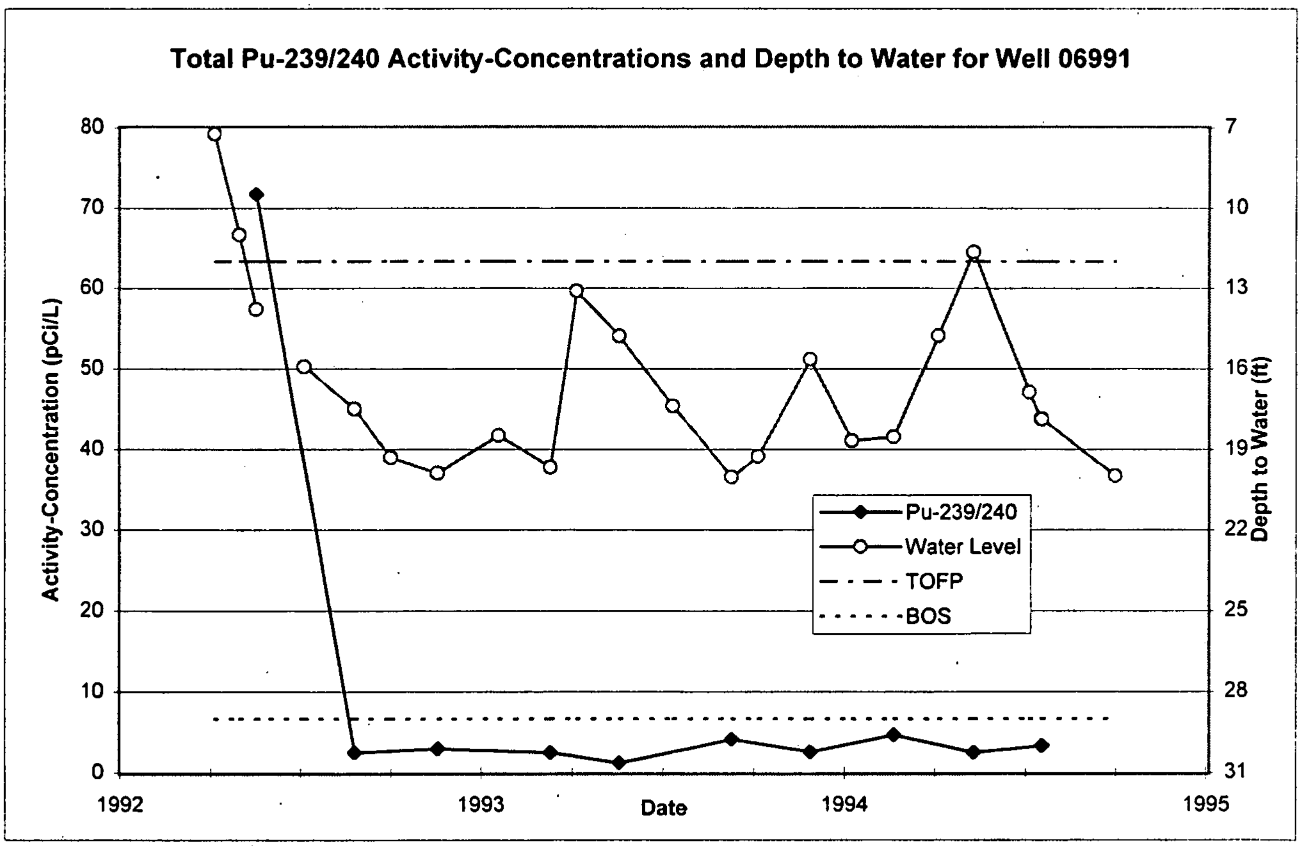
Trend Plots of Pu-239/240 and Am-241 for Wells 1587, 06991, 11791, and P313489

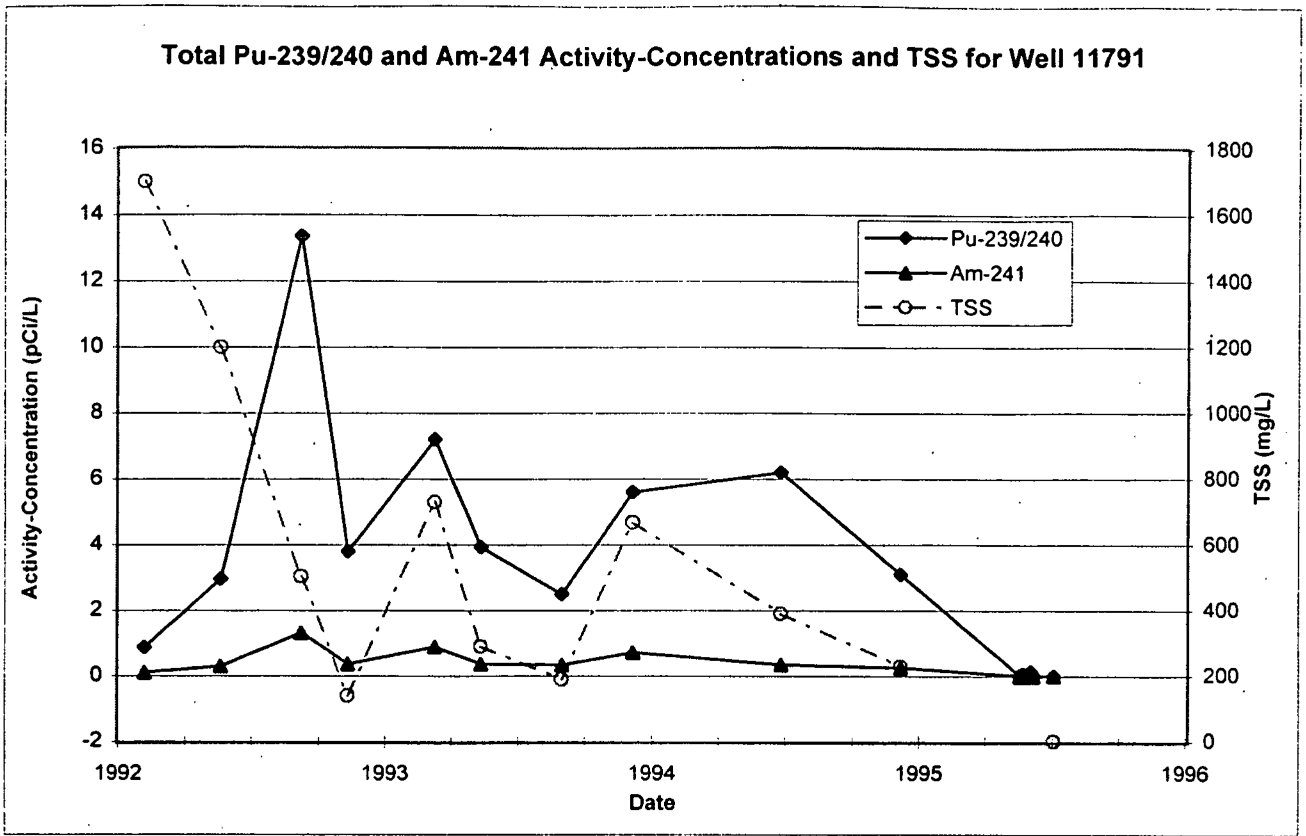

Total Pu-239/240 and Am-241 Activity-Concentrations and TSS for Well 1587
Pu-239/240
Am-241
Pu-239/240 (USGS)
TSS
Activity-Concentration (pCi/L)
TSS (mg/L)
Date
0
1
2
3
4
5
6
0
1000
2000
3000
4000
5000
6000
1990
1991
1992
1993
1994
1995
1996

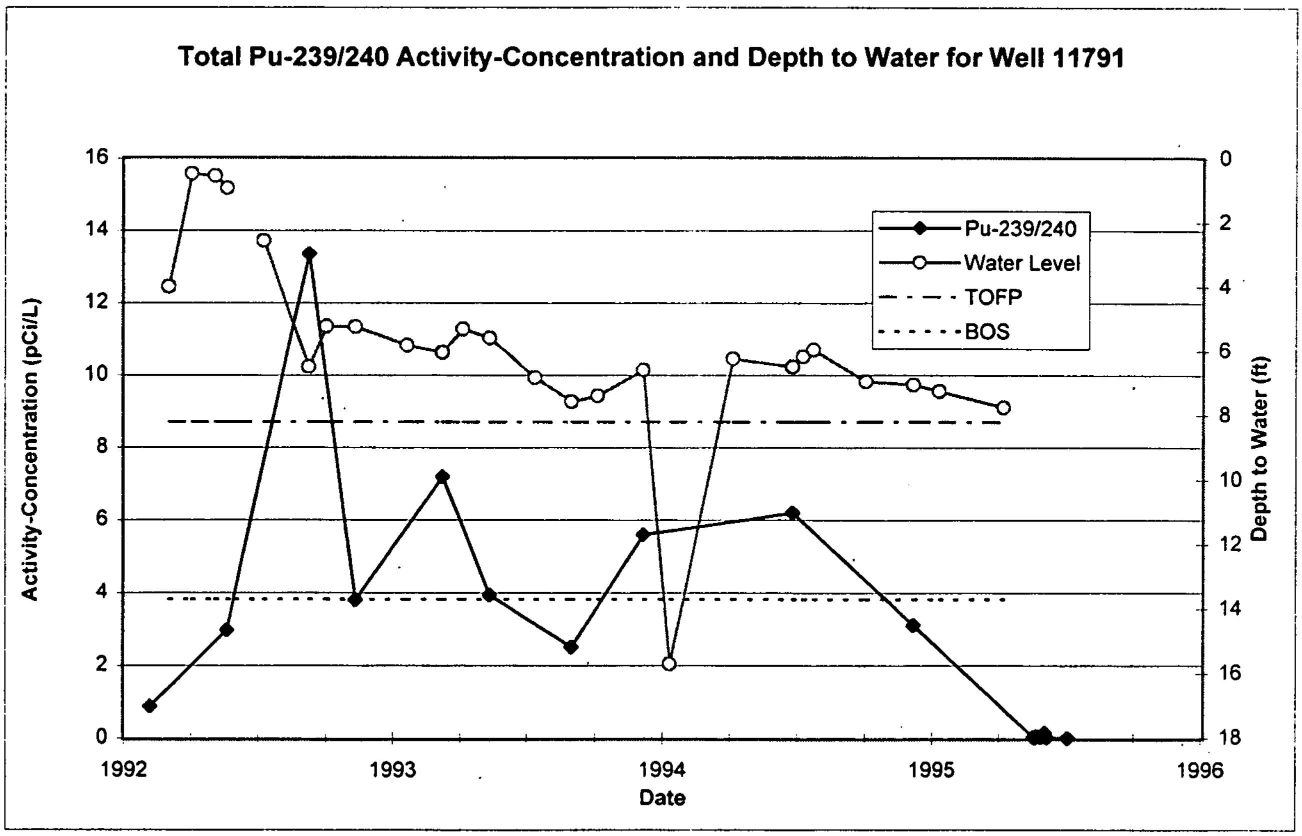

Total Pu-239/240 Activity-Concentrations and Depth to Water for Well 1587
Pu-239/240
Water Level
TOFP
BOS
Activity-Concentration (pCi/L)
Depth to Water (ft)
Date
0
1
2
3
4
5
6
2
6
10
14
18
22
26
1990
1991
1992
1993
1994
1995
1996

98

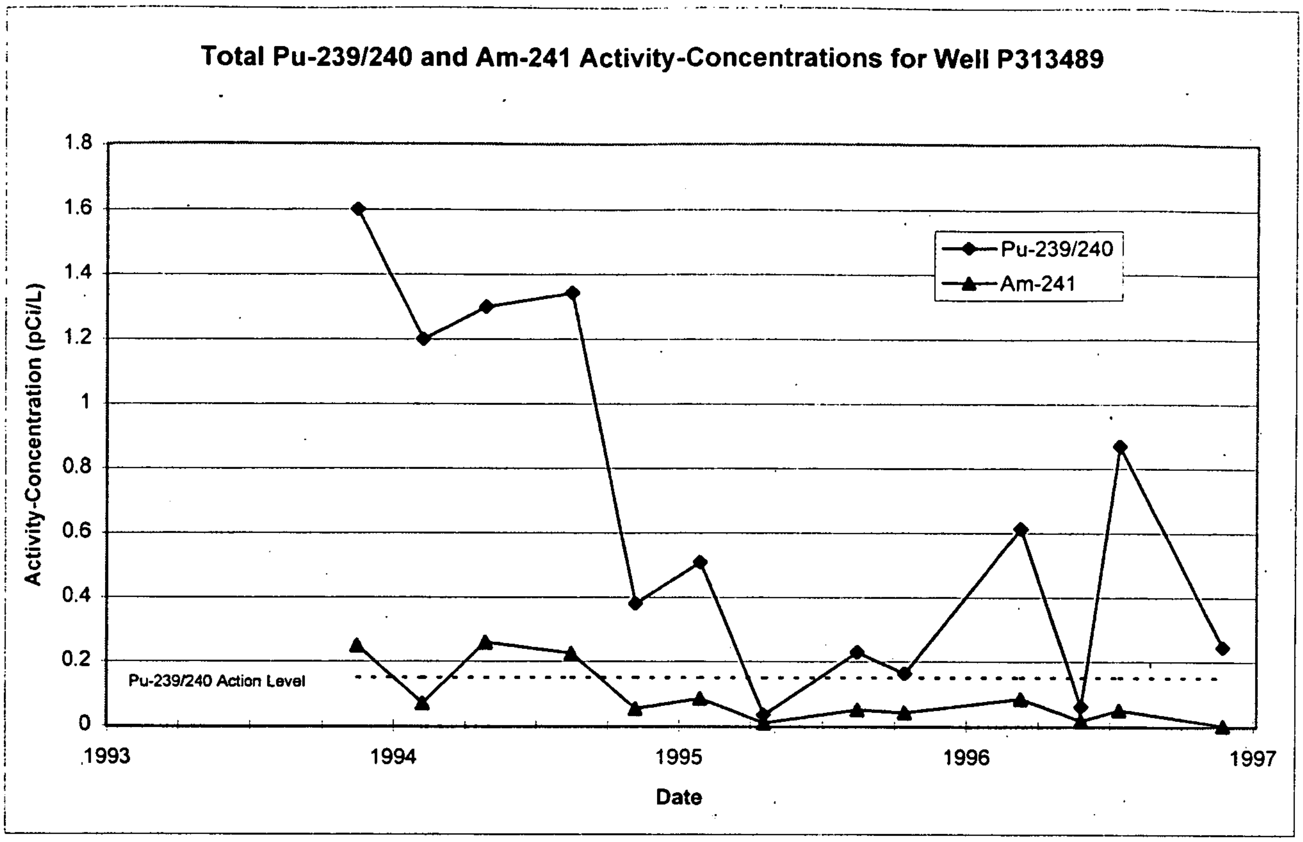

Total Pu-239/240 and Am-241 Activity-Concentrations and TSS for Well 06991
Activity-Concentration (pCi/L)
TSS (mg/L)
Date
Pu-239/240
Am-241
TSS
0
10
20
30
40
50
60
70
80
0
5000
10000
15000
20000
25000
30000
35000
40000
1992
1993
1994
1995


Total Pu-239/240 Activity-Concentrations and Depth to Water for Well 06991
Activity-Concentration (pCi/L)
Depth to Water (ft)
Date
Pu-239/240
Water Level
TOFP
BOS
0
10
20
30
40
50
60
70
80
7
10
13
16
19
22
25
28
31
1992
1993
1994
1995


Total Pu-239/240 and Am-241 Activity-Concentrations and TSS for Well 11791
Activity-Concentration (pCi/L)
TSS (mg/L)
Date
Pu-239/240
Am-241
TSS
16
14
12
10
8
6
4
2
0
-2
1800
1600
1400
1200
1000
800
600
400
200
0
1992
1993
1994
1995
1996


Total Pu-239/240 Activity-Concentration and Depth to Water for Well 11791
Activity-Concentration (pCi/L)
Depth to Water (ft)
Date
Pu-239/240
Water Level
TOFP
BOS
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
1992
1993
1994
1995
1996

100



Total Pu-239/240 and Am-241 Activity-Concentrations for Well P313489
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Activity-Concentration (pCi/L)
Pu-239/240
Am-241
Pu-239/240 Action Level
1993
1994
1995
1996
1997
Date

101

Appendix C

Selected VOC Analyses for Foundation Drain and Incidental Waters

Appendix C
Selected VOC Analyses for Foundation Drain Waters from Buildings 707, 883, and 865

Location	Collection Date	Sample Type	Analyte	Result	Qualifier Code	Units	Validation Code
FD-707-1	7/25/92	REAL	1,2-DICHLOROETHANE	5	U	ug/L	Z
BS-707-2	7/25/92	REAL	1,2-DICHLOROETHANE	5	U	ug/L	Z
BS-707-2	3/27/93	REAL	1,2-DICHLOROETHANE	5	U	ug/L	Z
BS-707-2	9/18/93	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-707-2	12/5/93	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-707-2	3/13/94	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-707-2	5/15/94	REAL	1,2-DICHLOROETHANE	0.5	U	ug/L	Z
BS-865-1	7/25/92	REAL	1,2-DICHLOROETHANE	5	U	ug/L	Z
BS-865-1	3/27/93	REAL	1,2-DICHLOROETHANE	5	U	ug/L	Z
BS-865-1	9/11/93	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-865-1	12/12/93	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-865-1	3/20/94	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-865-1	5/22/94	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-865-1	9/25/94	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
BS-865-2	3/27/93	REAL	1,2-DICHLOROETHANE	5	U	ug/L	Z
BS-883-1	5/22/94	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
FD-883-1	7/25/92	REAL	1,2-DICHLOROETHANE	5	U	ug/L	Z
FD-883-1	5/1/93	REAL	1,2-DICHLOROETHANE	5	U	ug/L	
FD-883-1	9/11/93	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
FD-883-1	3/20/94	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
FD-883-1	9/25/94	REAL	1,2-DICHLOROETHANE	1	U	ug/L	
FD-707-1	7/25/92	REAL	TETRACHLOROETHENE	5	U	ug/L	Z
BS-707-2	7/25/92	REAL	TETRACHLOROETHENE	5	U	ug/L	Z
BS-707-2	3/27/93	REAL	TETRACHLOROETHENE	5	U	ug/L	Z
BS-707-2	9/18/93	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-707-2	12/5/93	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-707-2	3/13/94	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-707-2	5/15/94	REAL	TETRACHLOROETHENE	0.5	U	ug/L	Z
BS-865-1	7/25/92	REAL	TETRACHLOROETHENE	5	U	ug/L	Z
BS-865-1	3/27/93	REAL	TETRACHLOROETHENE	5	U	ug/L	Z
BS-865-1	9/11/93	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-865-1	12/12/93	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-865-1	3/20/94	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-865-1	5/22/94	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-865-1	9/25/94	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-865-2	3/27/93	REAL	TETRACHLOROETHENE	5	U	ug/L	Z
BS-883-1	5/22/94	REAL	TETRACHLOROETHENE	5		ug/L	
FD-883-1	7/25/92	REAL	TETRACHLOROETHENE	5	U	ug/L	Z
FD-883-1	5/1/93	REAL	TETRACHLOROETHENE	6		ug/L	
FD-883-1	9/11/93	REAL	TETRACHLOROETHENE	1	U	ug/L	
FD-883-1	3/20/94	REAL	TETRACHLOROETHENE	5		ug/L	
FD-883-1	9/25/94	REAL	TETRACHLOROETHENE	1	U	ug/L	
BS-707-2	9/18/93	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-707-2	12/5/93	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-707-2	3/13/94	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-707-2	5/15/94	REAL	cis-1,2-DICHLOROETHENE	0.5	U	ug/L	Z
BS-865-1	9/11/93	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	12/12/93	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	3/20/94	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	5/22/94	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	9/25/94	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	

Appendix C
Selected VOC Analyses for Foundation Drain Waters from Buildings 707, 883, and 865

Location	Collection Date	Sample Type	Analyte	Result	Qualifier Code	Units	Validation Code
BS-883-1	5/22/94	REAL	cis-1,2-DICHLOROETHENE	0.6	J	ug/L	
FD-883-1	9/11/93	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
FD-883-1	3/20/94	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
FD-883-1	9/25/94	REAL	cis-1,2-DICHLOROETHENE	1	U	ug/L	
BS-707-2	9/18/93	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-707-2	12/5/93	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-707-2	3/13/94	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-707-2	5/15/94	REAL	trans-1,2-DICHLOROETHENE	0.5	U	ug/L	Z
BS-865-1	9/11/93	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	12/12/93	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	3/20/94	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	5/22/94	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-865-1	9/25/94	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
BS-883-1	5/22/94	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
FD-883-1	9/11/93	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
FD-883-1	3/20/94	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
FD-883-1	9/25/94	REAL	trans-1,2-DICHLOROETHENE	1	U	ug/L	
FD-707-1	7/25/92	REAL	1,2-DICHLOROETHENE	5	U	ug/L	Z
BS-707-2	7/25/92	REAL	1,2-DICHLOROETHENE	5	U	ug/L	Z
BS-707-2	3/27/93	REAL	1,2-DICHLOROETHENE	5	U	ug/L	Z
BS-865-1	7/25/92	REAL	1,2-DICHLOROETHENE	5	U	ug/L	Z
BS-865-1	3/27/93	REAL	1,2-DICHLOROETHENE	5	U	ug/L	Z
BS-865-2	3/27/93	REAL	1,2-DICHLOROETHENE	5	U	ug/L	Z
FD-883-1	7/25/92	REAL	1,2-DICHLOROETHENE	5	U	ug/L	Z
FD-883-1	5/1/93	REAL	1,2-DICHLOROETHENE	5	U	ug/L	
FD-707-1	7/25/92	REAL	CARBON TETRACHLORIDE	5	U	ug/L	Z
BS-707-2	7/25/92	REAL	CARBON TETRACHLORIDE	5	U	ug/L	Z
BS-707-2	3/27/93	REAL	CARBON TETRACHLORIDE	5	U	ug/L	Z
BS-707-2	9/18/93	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-707-2	12/5/93	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-707-2	3/13/94	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-707-2	5/15/94	REAL	CARBON TETRACHLORIDE	0.5	U	ug/L	Z
BS-865-1	7/25/92	REAL	CARBON TETRACHLORIDE	5	U	ug/L	Z
BS-865-1	3/27/93	REAL	CARBON TETRACHLORIDE	5	U	ug/L	Z
BS-865-1	9/11/93	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-865-1	12/12/93	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-865-1	3/20/94	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-865-1	5/22/94	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-865-1	9/25/94	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
BS-865-2	3/27/93	REAL	CARBON TETRACHLORIDE	5	U	ug/L	Z
BS-883-1	5/22/94	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
FD-883-1	7/25/92	REAL	CARBON TETRACHLORIDE	5	U	ug/L	Z
FD-883-1	5/1/93	REAL	CARBON TETRACHLORIDE	5	U	ug/L	
FD-883-1	9/11/93	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
FD-883-1	3/20/94	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
FD-883-1	9/25/94	REAL	CARBON TETRACHLORIDE	1	U	ug/L	
FD-707-1	7/25/92	REAL	CHLOROFORM	2	J	ug/L	Z
BS-707-2	7/25/92	REAL	CHLOROFORM	5	U	ug/L	Z
BS-707-2	3/27/93	REAL	CHLOROFORM	5	U	ug/L	Z
BS-707-2	9/18/93	REAL	CHLOROFORM	1	U	ug/L	
BS-707-2	12/5/93	REAL	CHLOROFORM	1	U	ug/L	

Appendix C
Selected VOC Analyses for Foundation Drain Waters from Buildings 707, 883, and 865

Location	Collection Date	Sample Type	Analyte	Result	Qualifier Code	Units	Validation Code
BS-707-2	3/13/94	REAL	CHLOROFORM	1	U	ug/L	
BS-707-2	5/15/94	REAL	CHLOROFORM	0.5	U	ug/L	Z
BS-865-1	7/25/92	REAL	CHLOROFORM	5	U	ug/L	Z
BS-865-1	3/27/93	REAL	CHLOROFORM	5	U	ug/L	Z
BS-865-1	9/11/93	REAL	CHLOROFORM	1	U	ug/L	
BS-865-1	12/12/93	REAL	CHLOROFORM	1	U	ug/L	
BS-865-1	3/20/94	REAL	CHLOROFORM	1	U	ug/L	
BS-865-1	5/22/94	REAL	CHLOROFORM	1	U	ug/L	
BS-865-1	9/25/94	REAL	CHLOROFORM	1	U	ug/L	
BS-865-2	3/27/93	REAL	CHLOROFORM	5	U	ug/L	Z
BS-883-1	5/22/94	REAL	CHLOROFORM	1	U	ug/L	
FD-883-1	7/25/92	REAL	CHLOROFORM	5	U	ug/L	Z
FD-883-1	5/1/93	REAL	CHLOROFORM	5	U	ug/L	
FD-883-1	9/11/93	REAL	CHLOROFORM	1	U	ug/L	
FD-883-1	3/20/94	REAL	CHLOROFORM	1	U	ug/L	
FD-883-1	9/25/94	REAL	CHLOROFORM	1	U	ug/L	
FD-707-1	7/25/92	REAL	VINYL CHLORIDE	10	U	ug/L	Z
BS-707-2	7/25/92	REAL	VINYL CHLORIDE	10	U	ug/L	Z
BS-707-2	3/27/93	REAL	VINYL CHLORIDE	10	U	ug/L	Z
BS-707-2	9/18/93	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-707-2	12/5/93	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-707-2	3/13/94	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-707-2	5/15/94	REAL	VINYL CHLORIDE	0.5	U	ug/L	Z
BS-865-1	7/25/92	REAL	VINYL CHLORIDE	10	U	ug/L	Z
BS-865-1	3/27/93	REAL	VINYL CHLORIDE	10	U	ug/L	Z
BS-865-1	9/11/93	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-865-1	12/12/93	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-865-1	3/20/94	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-865-1	5/22/94	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-865-1	9/25/94	REAL	VINYL CHLORIDE	1	U	ug/L	
BS-865-2	3/27/93	REAL	VINYL CHLORIDE	10	U	ug/L	Z
BS-883-1	5/22/94	REAL	VINYL CHLORIDE	1	U	ug/L	
FD-883-1	7/25/92	REAL	VINYL CHLORIDE	10	U	ug/L	Z
FD-883-1	5/1/93	REAL	VINYL CHLORIDE	10	U	ug/L	
FD-883-1	9/11/93	REAL	VINYL CHLORIDE	1	U	ug/L	
FD-883-1	3/20/94	REAL	VINYL CHLORIDE	1	U	ug/L	
FD-883-1	9/25/94	REAL	VINYL CHLORIDE	1	U	ug/L	
FD-707-1	7/25/92	REAL	METHYLENE CHLORIDE	2	BJ	ug/L	Z
BS-707-2	7/25/92	REAL	METHYLENE CHLORIDE	2	BJ	ug/L	Z
BS-707-2	3/27/93	REAL	METHYLENE CHLORIDE	5	U	ug/L	Z
BS-707-2	9/18/93	REAL	METHYLENE CHLORIDE	1	U	ug/L	
BS-707-2	12/5/93	REAL	METHYLENE CHLORIDE	1	U	ug/L	
BS-707-2	3/13/94	REAL	METHYLENE CHLORIDE	1	U	ug/L	
BS-707-2	5/15/94	REAL	METHYLENE CHLORIDE	0.5	U	ug/L	Z
BS-865-1	7/25/92	REAL	METHYLENE CHLORIDE	2	BJ	ug/L	Z
BS-865-1	3/27/93	REAL	METHYLENE CHLORIDE	5	U	ug/L	Z
BS-865-1	9/11/93	REAL	METHYLENE CHLORIDE	1	U	ug/L	
BS-865-1	12/12/93	REAL	METHYLENE CHLORIDE	2	B	ug/L	
BS-865-1	3/20/94	REAL	METHYLENE CHLORIDE	4		ug/L	
BS-865-1	5/22/94	REAL	METHYLENE CHLORIDE	1	U	ug/L	
BS-865-1	9/25/94	REAL	METHYLENE CHLORIDE	1	U	ug/L	

Appendix C
Selected VOC Analyses for Foundation Drain Waters from Buildings 707, 883, and 865

Location	Collection Date	Sample Type	Analyte	Result	Qualifier Code	Units	Validation Code
BS-865-2	3/27/93	REAL	METHYLENE CHLORIDE	0.4	BJ	ug/L	Z
BS-883-1	5/22/94	REAL	METHYLENE CHLORIDE	1	U	ug/L	
FD-883-1	7/25/92	REAL	METHYLENE CHLORIDE	2	BJ	ug/L	Z
FD-883-1	5/1/93	REAL	METHYLENE CHLORIDE	5	U	ug/L	
FD-883-1	9/11/93	REAL	METHYLENE CHLORIDE	1	U	ug/L	
FD-883-1	3/20/94	REAL	METHYLENE CHLORIDE	0.9	J	ug/L	
FD-883-1	9/25/94	REAL	METHYLENE CHLORIDE	1	U	ug/L	
FD-707-1	7/25/92	REAL	TRICHLOROETHENE	5	U	ug/L	Z
BS-707-2	7/25/92	REAL	TRICHLOROETHENE	5	U	ug/L	Z
BS-707-2	3/27/93	REAL	TRICHLOROETHENE	5	U	ug/L	Z
BS-707-2	9/18/93	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-707-2	12/5/93	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-707-2	3/13/94	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-707-2	5/15/94	REAL	TRICHLOROETHENE	0.5	U	ug/L	Z
BS-865-1	7/25/92	REAL	TRICHLOROETHENE	5	U	ug/L	Z
BS-865-1	3/27/93	REAL	TRICHLOROETHENE	5	U	ug/L	Z
BS-865-1	9/11/93	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-865-1	12/12/93	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-865-1	3/20/94	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-865-1	5/22/94	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-865-1	9/25/94	REAL	TRICHLOROETHENE	1	U	ug/L	
BS-865-2	3/27/93	REAL	TRICHLOROETHENE	5	U	ug/L	Z
BS-883-1	5/22/94	REAL	TRICHLOROETHENE	1	U	ug/L	
FD-883-1	7/25/92	REAL	TRICHLOROETHENE	5	U	ug/L	Z
FD-883-1	5/1/93	REAL	TRICHLOROETHENE	5	U	ug/L	
FD-883-1	9/11/93	REAL	TRICHLOROETHENE	1	U	ug/L	
FD-883-1	3/20/94	REAL	TRICHLOROETHENE	1	U	ug/L	
FD-883-1	9/25/94	REAL	TRICHLOROETHENE	1	U	ug/L	

BS = Building Sump; FD = Foundation Drain

VOC Data from Incidental Waters Database

LOCATION (BLDG)	LOCATION TYPE	LOCATION DESCRIPTION	DATE	IWIC NO	VOC's
116	Manhole	Manhole #16-Sage N of B116	10/9/97	98004	Tetrachloroethene = 18 ug/L
121	Excavation	SW corner of bldg	2/4/98	98047	Acetone = 170 ug/L, 2-Butanone = 150 ug/L, 4-Methyl-2-pentanone = 57 ug/L
444	Foundation Drain	Room 10; basement	7/7/98	98087	cis-1,2-Dichloroethene = 74 ug/L
444	Foundation Drain	Room 10 in basement	9/1/98	98141	1,2-Dichloroethene (cis) = 52 ug/L
559	Utility Pit		11/7/94	94241	Carbon Tet = 230 ug/L, TCE = 170 ug/L, 1,1-Dichloroethene = 35 ug/L, Tetrachloroethene = 12 ug/L
559	Utility Pit		4/12/96	96038	Carbon Tet = 172 ug/ L, TCE = 222 ug/L
559	Water Main Break	E side of bldg; W of 707 at guard shack	11/11/97	98017	Chloroform = 81 ug/L; Dibromochloromethane = 6.7 ug/L
569	Excavation	Parking area 50 just W of PACS 1	11/14/96	97017	TCE = 320 ug/L
569	Excavation	Parking area 50; water contained in poly tanks	12/3/96	97028	TCE = 220 ug/L
569	Excavation	Steam line excavation inside P.A. N of parking area 50; water contained in poly tank	1/21/97	97039	TCE = 87 ug/L
569	Excavation	Excavation for steam line at parking area 50	4/14/97	97066	TCE = 200 ug/L
569	Excavation	Excavation for steam line S of B569	4/14/97	97067	TCE = 260 ug/L
569	Excavation	North Steam Pit	12/5/97	98021	TCE = 130 ug/L
569	Excavation	South Steam Pit	12/5/97	98022	TCE = 460 ug/L
707	Secondary Containment	Carbon Tet tank	12/8/94	94257	Carbon Tet = 360 ug/L
750	Water Pipe Break	Courtyard of bldg	12/1/94	94256	Chloroform = 10 ug/L
750LOT	Excavation	E end of parking lot	5/5/95	95112	Acetone = 26 ug/L, Chloroform = 1.2 ug/L, 2-Butanone = 52 ug/L, 2-Hexanone = 4.5 ug/L
771	Manhole	Near restroom trailers	6/2/98	98084	Carbon tet = 7 ug/L; Chloroform = 8.9 ug/L
881	Flooding	Groundwater collection room 10	1/15/97	97037	Chloroform = 6.3 ug/L; Tetrachloroethene = 6.4 ug/L
991	Secondary Containment	South side of bldg	9/9/97	97131	TCE = 1.4ug/L; Tetrachloroethene = 1.4 ug/L

MOUND	Excavation	Mound site; water contained in poly tank	4/25/97	97075	Tetrachloroethene = 3.9 ug/L
MOUND	Excavation	Mound site; contaminated soil feed berm;poly tank	4/25/97	97076	Tetrachloroethene = 16 ug/L
MOUND	Excavation	On hillside N of T-1	7/8/98	98128	TCE = 200 ug/L; Carbon Tet = 180 ug/L; Tetrachloroethylene = 140 ug/L

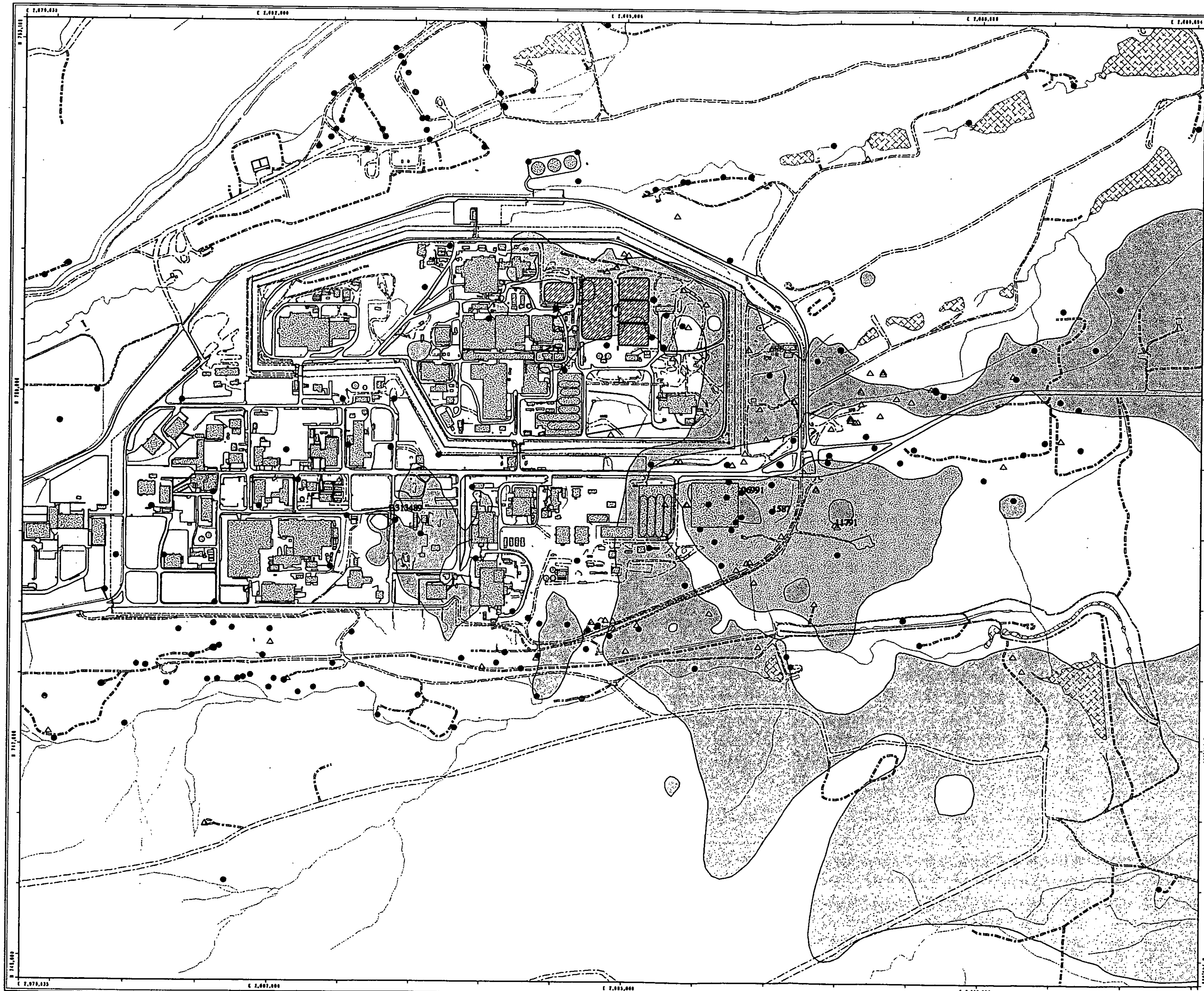


Figure 1-1

Unfiltered Plutonium 239/240 in UHSU Groundwater 1991-1995 Plutonium 239/240 Activity-Concentration (pCi/L)

EXPLANATION

Plutonium 239/240 Activity-Concentration (pCi/L) in groundwater

- 0.0 - 0.05
- 0.05 - 0.15
- 0.15 - 0.5
- 0.5 - 1.0
- > 1.0

Alluvium Wells

Bedrock Wells

Pu 239/240 Activity-Concentration in Surface Soils

BACKGROUND BENCHMARK = 0.047 pCi/L

- 1 pCi/g or greater but less than 10 pCi/g
- 10 pCi/g or greater but less than 100 pCi/g
- 100 pCi/g or greater but less than 1000 pCi/g
- 1000 pCi/g or greater

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

Scale = 1 : 10540
1 inch represents approximately 878 feet

250 0 500 1000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0222

July 26, 1999

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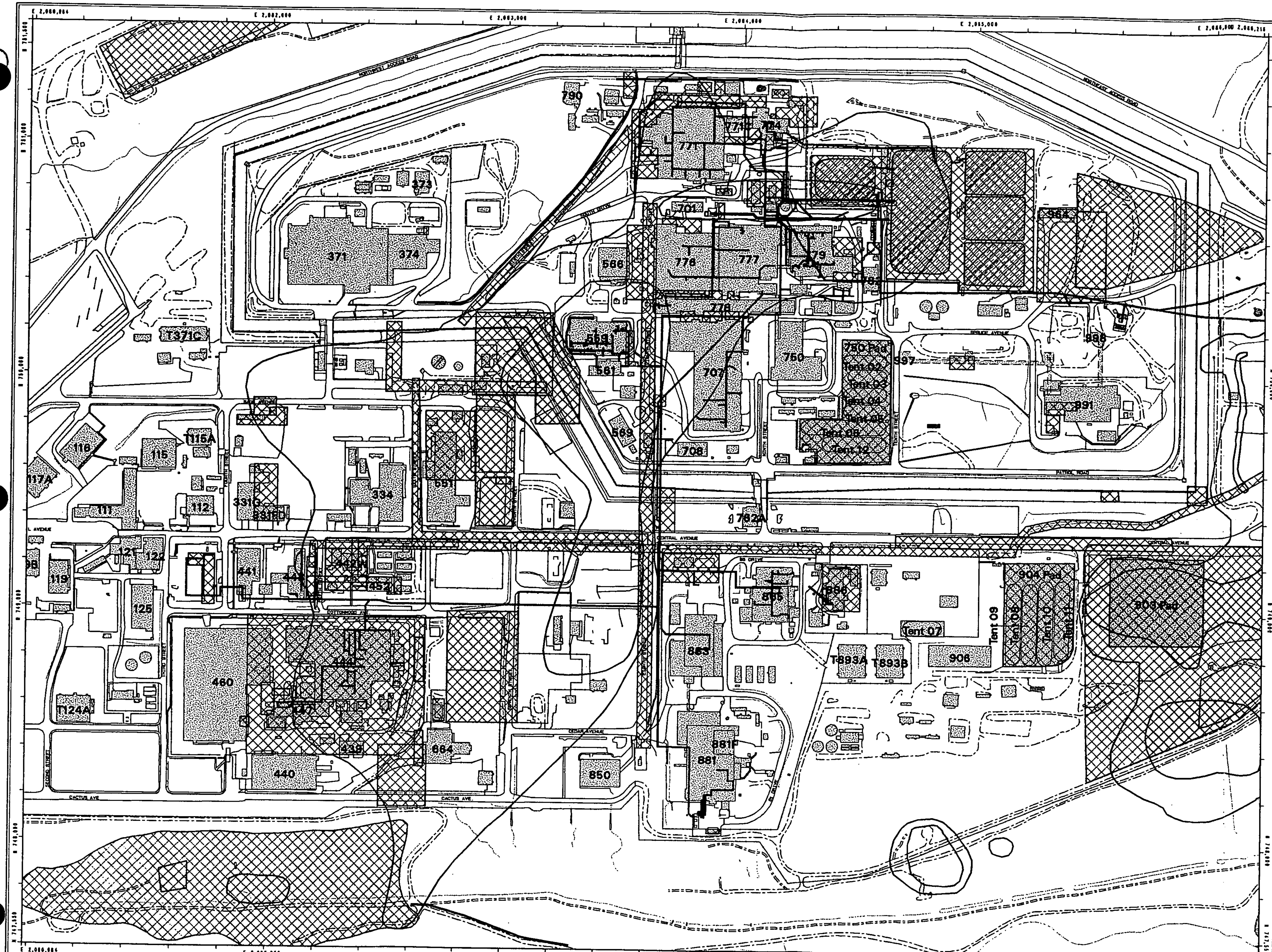

Figure 1-2

Location Map
Industrial Area VOC Plume
East Boundary Investigation

EXPLANATION

- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- Individual Hazardous Substance Sites (IHSS)
- Process Waste Lines
- Geoprobe well siting area

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

100 0 200 400ft

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0217

July 26, 1999

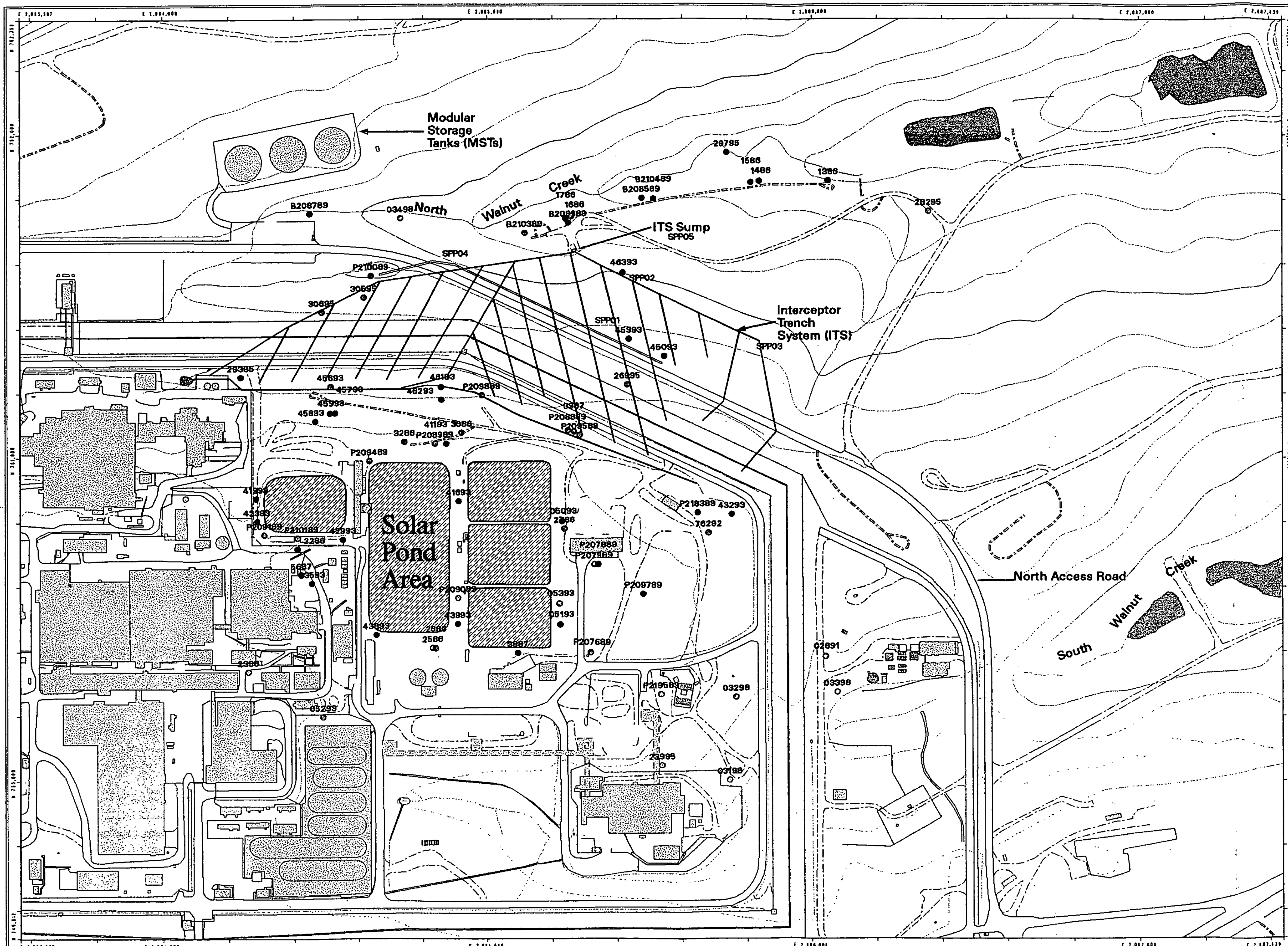

Figure 1-3
Plan View of Reactive Barrier Treatment System Solar Ponds Plume

EXPLANATION

- LHSU Bedrock Monitoring Well
- UHSU Bedrock Monitoring Well
- Bedrock/Alluvium Monitoring Well
- Alluvium Monitoring Well
- Collection Trench

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 3860
1 inch represents approximately 322 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.

MAP ID: 98-0245 June 09, 1999

69

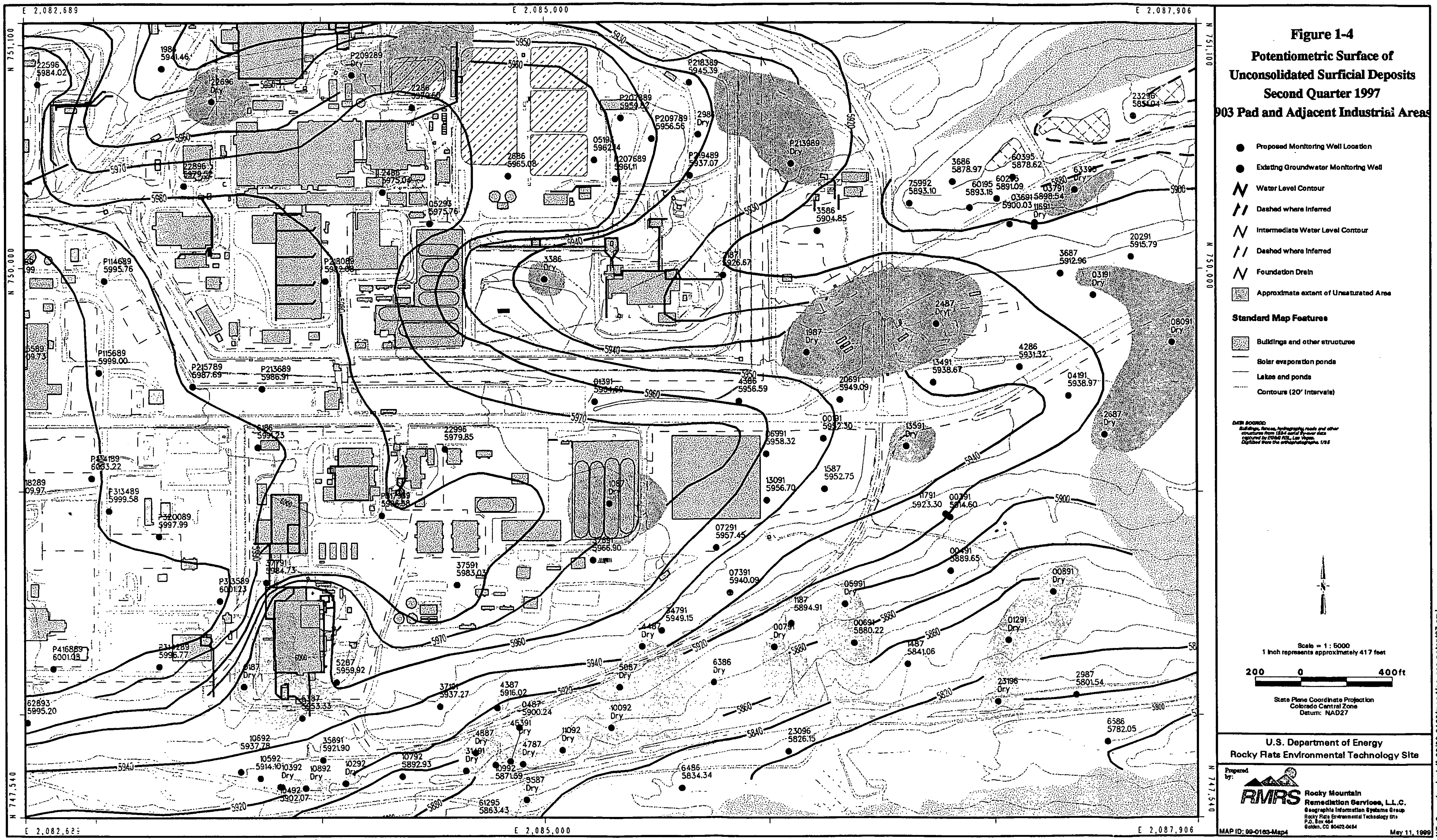

Figure 1-4
Potentiometric Surface of
Unconsolidated Surficial Deposits
Second Quarter 1997
903 Pad and Adjacent Industrial Areas
Proposed Monitoring Well Location
Existing Groundwater Monitoring Well
Water Level Contour
Dashed where Inferred
Intermediate Water Level Contour
Dashed where Inferred
Foundation Drain
Approximate extent of Unsaturated Area
Standard Map Features
Buildings and other structures
Solar evaporation ponds
Lakes and ponds
Contours (20' Intervals)
Scale = 1 : 5000
1 inch represents approximately 417 feet
200 0 400ft
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
RMRS
Rocky Mountain Remediation Services, L.L.C.
MAP ID: 99-0163-Map4
May 11, 1999
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E 2,085,000
E 2,087,906
N 751,100
N 750,000
N 747,540

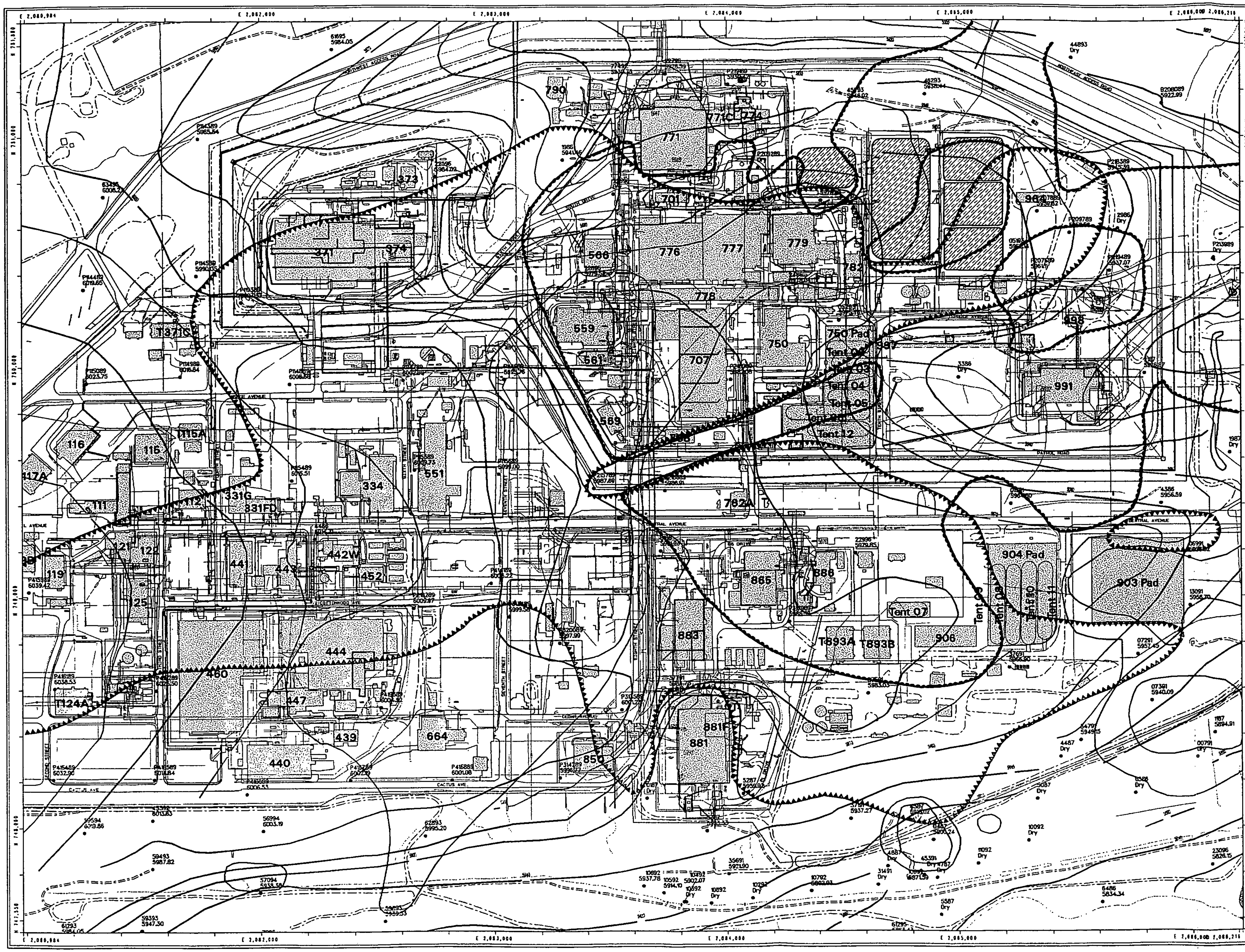

Fig. 1-5
Potentiometric Surface of Unconsolidated Surficial Deposits, Second Quarter 1997, Industrial Area VOC Plume East Boundary Investigation

EXPLANATION

- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- Wells with measured Water Level
- Water Level Contour
- Dashed where inferred
- Intermediate Water Level Contour
- Dashed where inferred
- Foundation Drain
- Utility Lines-- Process Waste, Sanitary Sewer, Electrical (above/below ground), Domestic Water (above/below ground), Steam (above/below ground), and Abandoned
- Average depth to water, 10 feet or less (Modified from EG&G, 1995 b)
- Depth to bedrock, 10 feet or less (Modified from EG&G, 1995 a)

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

100 0 200 400ft

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Rocky Flats Environmental Technology Site

Prepared by:

Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0217

July 27, 1999

71

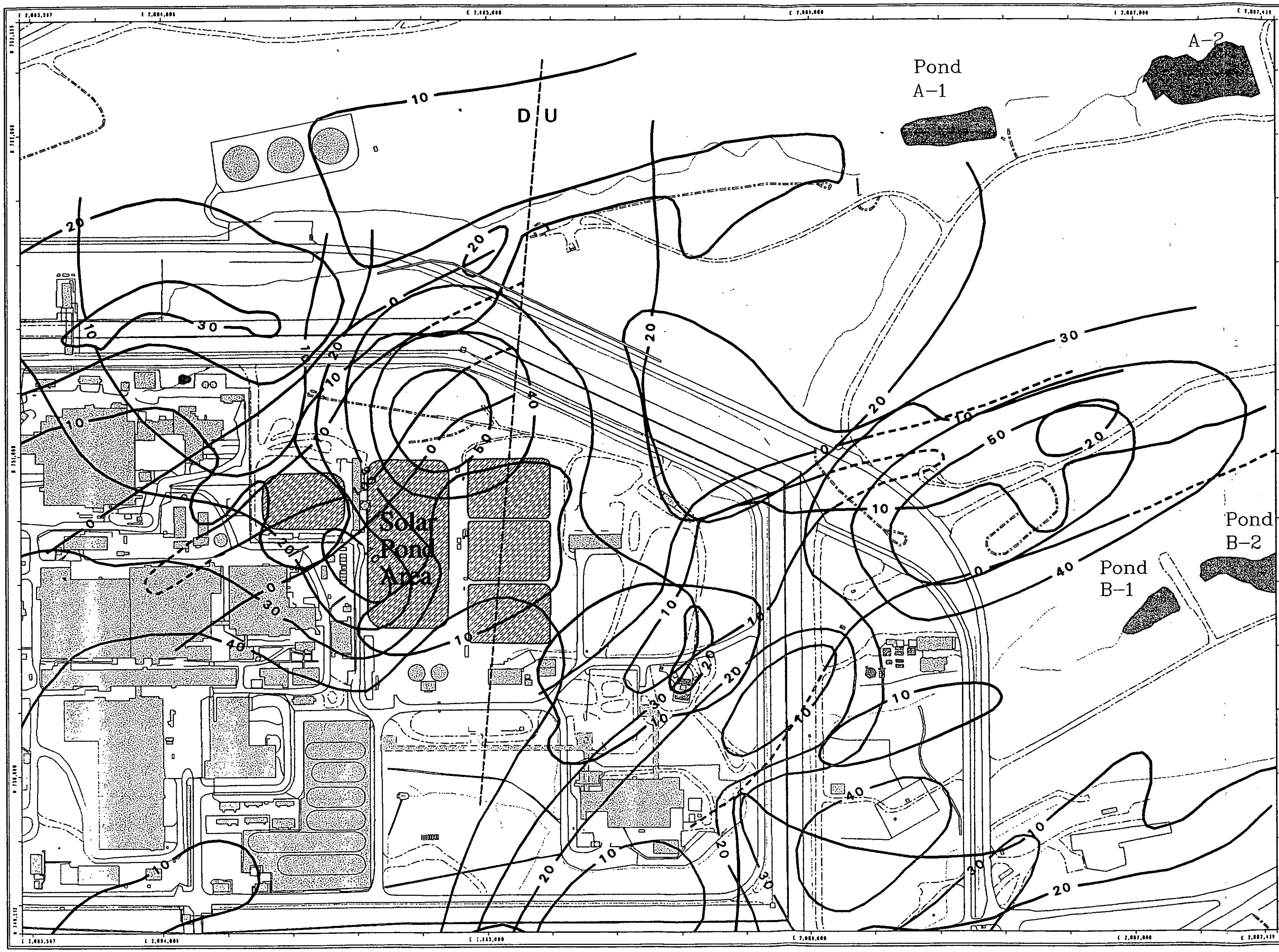

Figure 1-6
Isopach of Unconsolidated Deposits and Weathered Bedrock Solar Ponds Plume

LEGEND

- Collection Trench
- Isopach of Unconsolidated Deposits
- Isopach of Weathered Bedrock
- Arapahoe Channel Deposits
- Suspect Fault

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

Scale = 1 : 3860
1 inch represents approximately 322 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0222 July 26, 1999

NT_Svr w:/projects/fy99/99-0222/isopach.aml

12

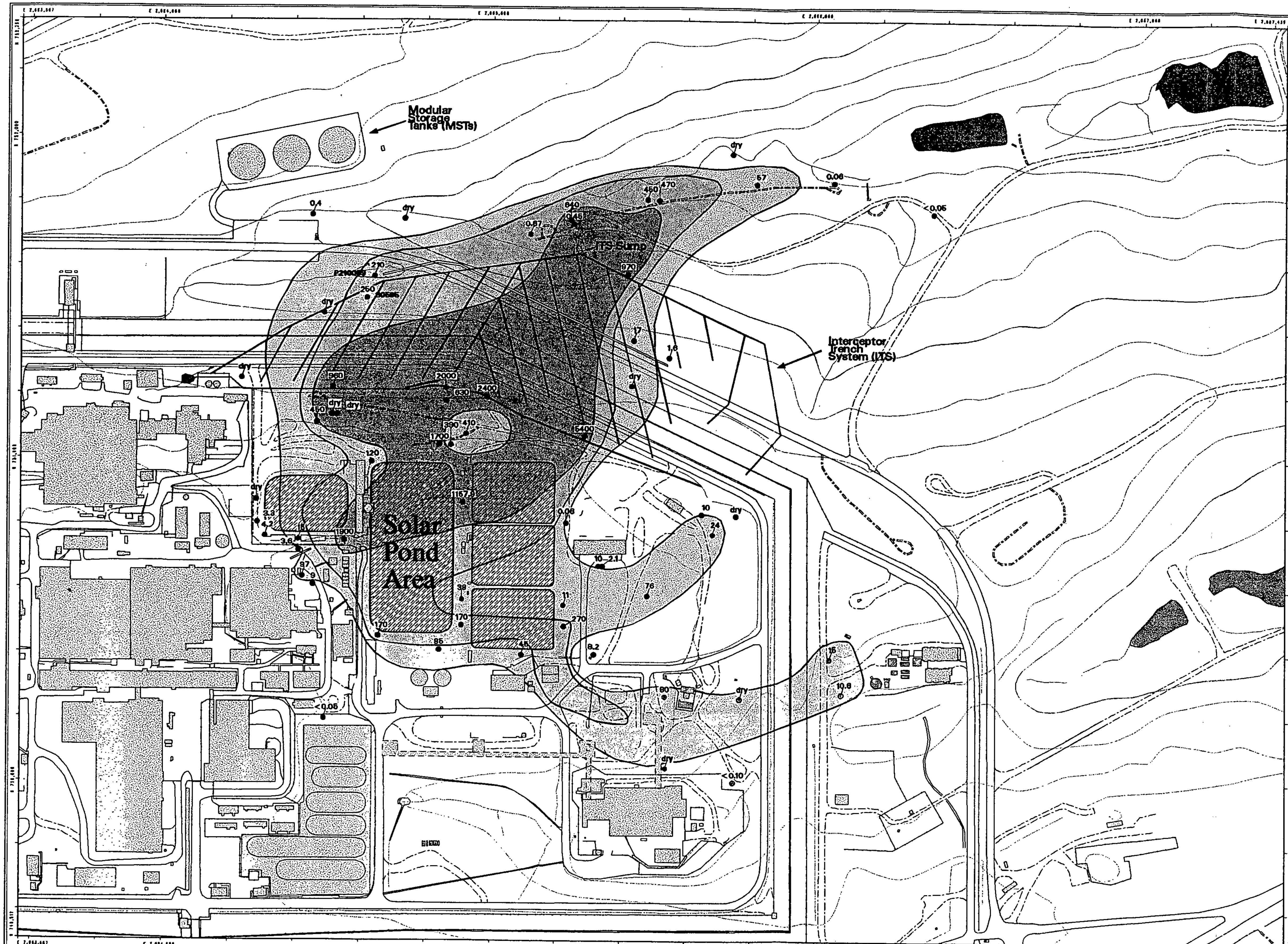

Figure 1-7
Nitrate Concentrations in the UHSU Fall 1997 / Winter 1998 Data
Solar Ponds Plume

LEGEND

- Collection Trench
- UHSU Bedrock Monitoring Well
- Bedrock/Alluvium Monitoring Well
- Alluvium Monitoring Well
- > 10 Nitrate (mg/L) (surface water standard)
- > 100 Nitrate (mg/L) (interim surface water standard)
- > 500 Nitrate (mg/L)
- < Indicates Nitrate not detected

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

Scale = 1 : 3780
1 inch represents 315 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0222 July 26, 1999

NT_Svr w:/projects/fy99/99-0222/app-nitrate/nitrate_cono.aml

73

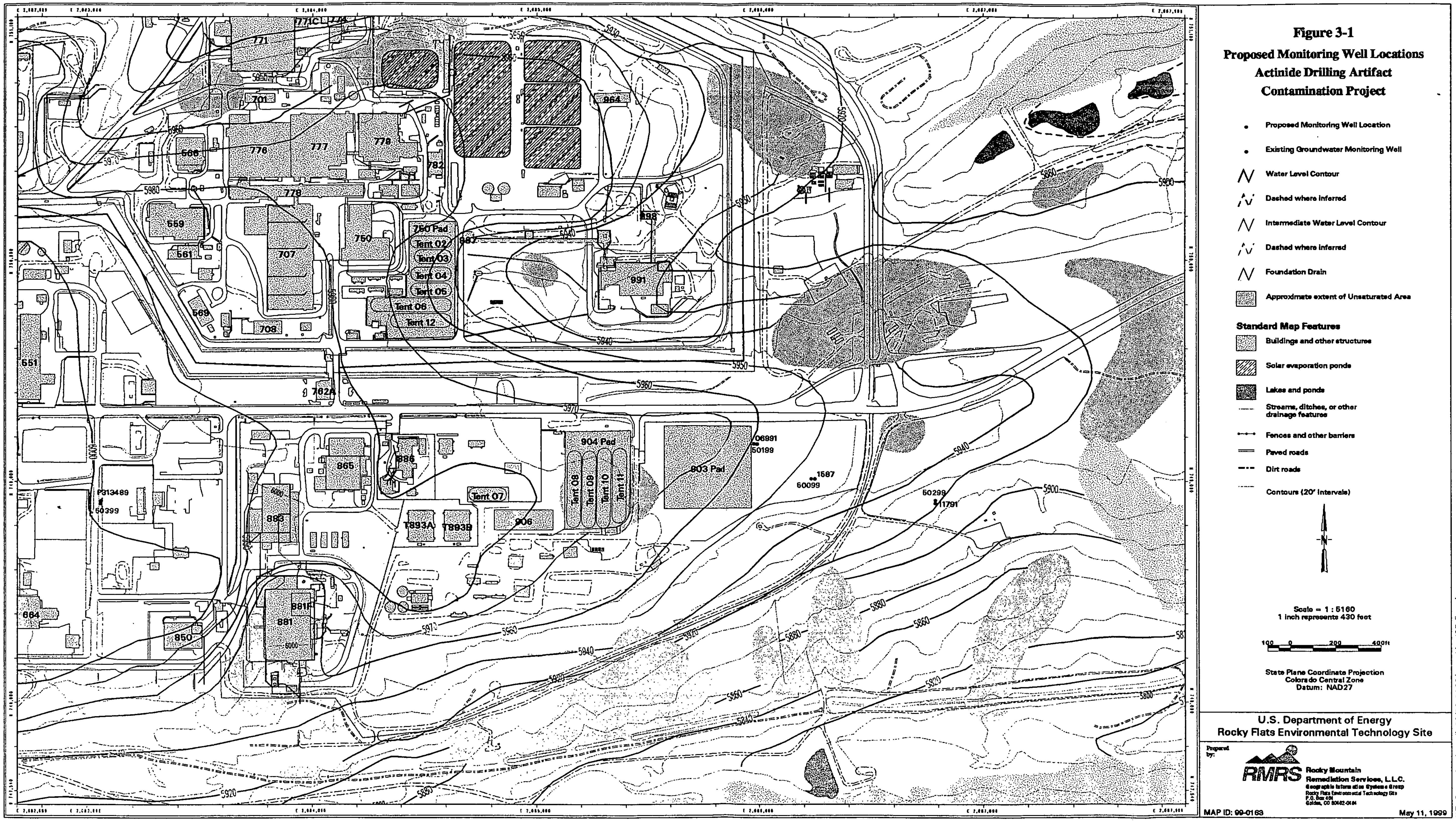
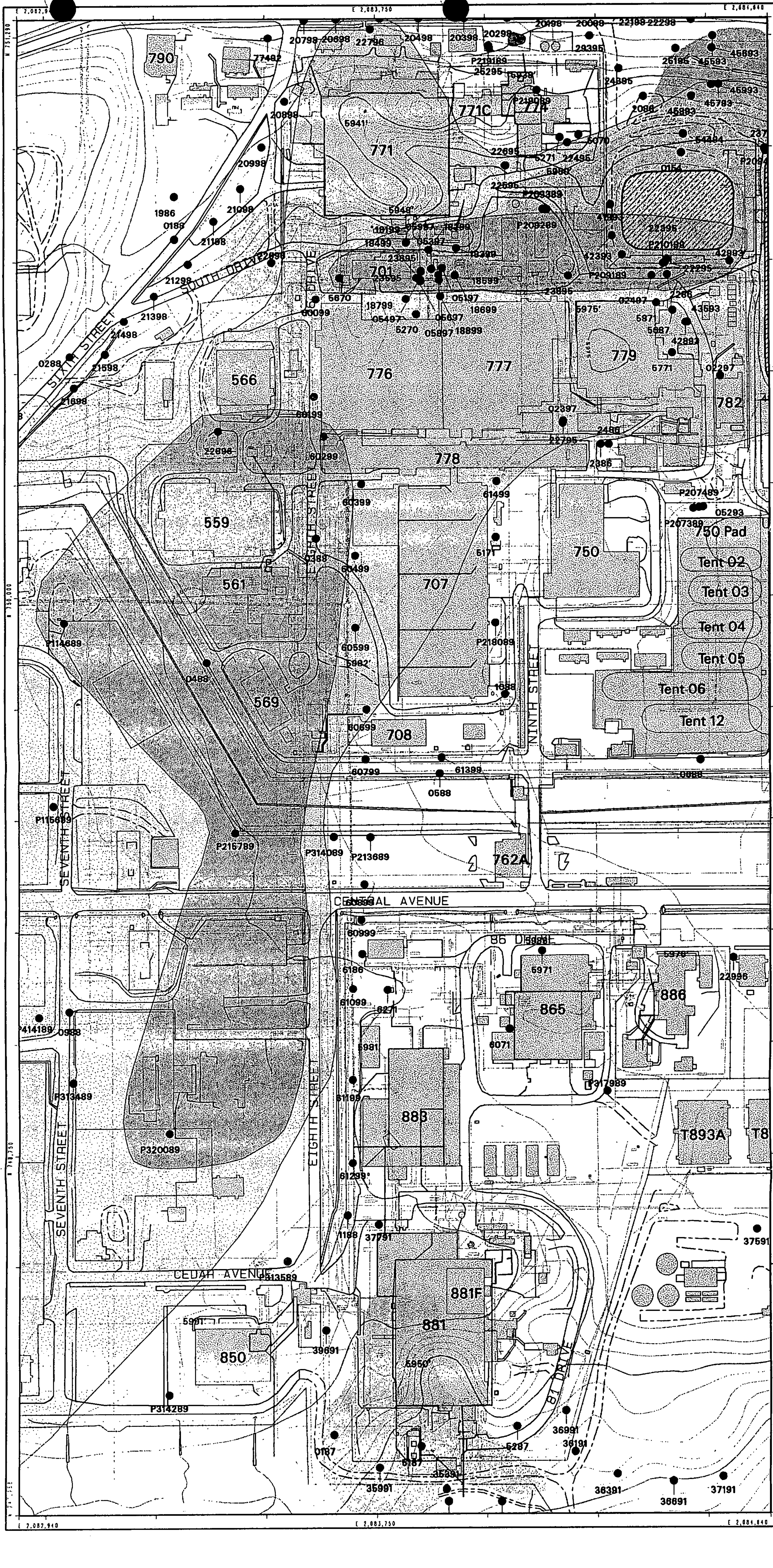


Figure 3-1
Proposed Monitoring Well Locations
Actinide Drilling Artifact
Contamination Project

74

75

Figure 3-2
Proposed Monitoring Well Locations Industial Area VOC Plume Unconsolidated Surficial Deposits East Boundary Investigation



EXPLANATION

- Proposed Geoprobe Locations
- Groundwater Monitoring Well
- Foundation Drain
- Composite VOC Groundwater Plume (concentration equal to MCL)
- Composite VOC Groundwater Plume (100 X MCL)
- Approximate extent of Unsaturated Area
- Utility Lines— Process Waste, Sanitary Sewer, Electrical (above/below ground), Domestic Water (above/below ground), Steam (above/below ground), and Abandoned

Standard Map Features

- Buildings and other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

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Rocky Mountain Remediation services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

Scale = 1 : 1804
1 inch represents approximately 150 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

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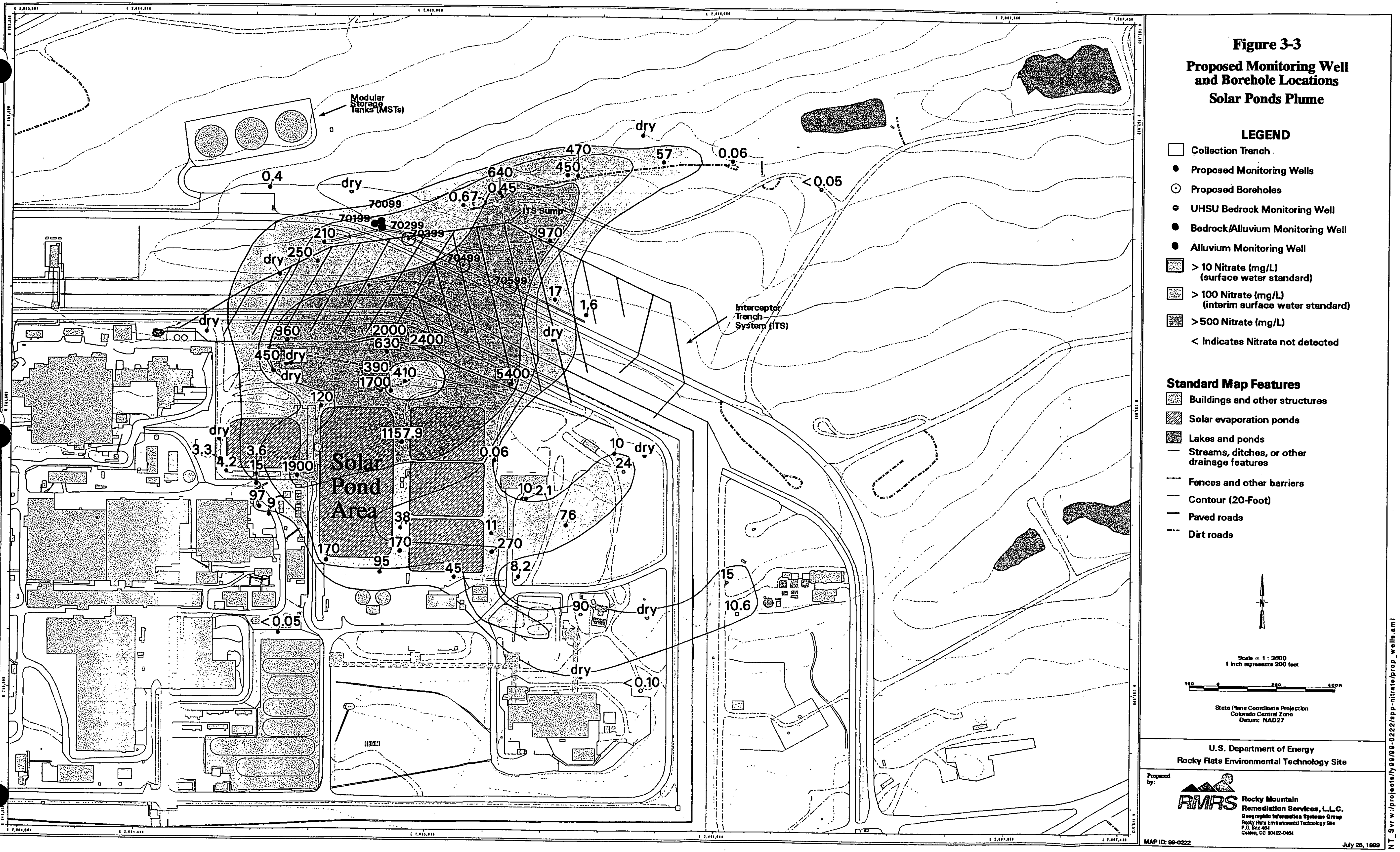
Figure 3-3
Proposed Monitoring Well and Borehole Locations
Solar Ponds Plume
LEGEND
Collection Trench
Proposed Monitoring Wells
Proposed Boreholes
UHSU Bedrock Monitoring Well
Bedrock/Alluvium Monitoring Well
Alluvium Monitoring Well
> 10 Nitrate (mg/L) (surface water standard)
> 100 Nitrate (mg/L) (interim surface water standard)
> 500 Nitrate (mg/L)
< Indicates Nitrate not detected
Standard Map Features
Buildings and other structures
Solar evaporation ponds
Lakes and ponds
Streams, ditches, or other drainage features
Fences and other barriers
Contour (20-Foot)
Paved roads
Dirt roads
Scale = 1 : 3600
1 inch represents 300 feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
RMRS Rocky Mountain Remediation Services, L.L.C.
MAP ID: 99-0222
July 26, 1999
Modular Storage Tanks (MSTs)
Interceptor Trench System (ITS)
ITS Sump
Solar Pond Area
70099
70199
70299
70399
70499
70599
dry
470
57
0.06
< 0.05
0.4
640
450
0.67
0.45
210
250
970
17
1.6
960
2000
630
2400
450
390
410
1700
5400
120
1157.9
0.06
3.3
4.2
3.6
15
1900
10
24
97
9
10
2.1
76
38
11
170
270
170
95
45
8.2
15
90
10.6
< 0.05
< 0.10

78