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**Civilian Radioactive Waste Management System
Management & Operating Contractor**

CATALOG OF PLANNED BOREHOLES

for

SURFACE-BASED TESTING

SITE CHARACTERIZATION ACTIVITIES

Revision 0

September 29, 1993

Prepared for:

U. S. Department of Energy
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Date: September 29, 1993

M&O Program: Catalog of Planned Boreholes

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This Catalog of Planned Boreholes was prepared in accordance with M&O Procedure QAP-3-5, Rev 2. Technical Review performed per QAP-3-5, Rev 2, Section 5.4.

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INTRODUCTION

Background and Purpose

The Catalog of Planned Boreholes is an update and modification of a compilation of drilling program information made in 1988, called the Surface Based Investigations Plan (SBIP). The SBIP drew upon the general study descriptions contained in the Site Characterization Plan (SCP) (1988). Since that time, detailed Study Plans have been developed for most of the Surface Based Testing (SBT) activities. The development and acceptance of Study Plans involve an extensive review process at the Project Office and with the Nuclear Regulatory Commission. During this review, various site characterization activities are modified from the original descriptions, resulting in a modified field program. It is anticipated that as additional experience is obtained by the drilling operations, additional modifications may be needed. Thus, this catalog represents a working compilation of information current at the time of this revision.

In October and December, 1992, two borehole integration and prioritization meetings were held for purposes of gathering current information. Data needs and requirements of the various investigative programs included in site characterization activities involving the drilling program were compiled. During this effort, it was recognized that the program routinely operates in a funding-limited environment. Thus, funding limitations are likely to be imposed on the SBT program, with regard to the total footage of core that can be obtained in any fiscal year, and the analyses of the large number of samples anticipated in the SCP and Study Plans. As a result, a more focused plan for core utilization was developed during the drilling integration and prioritization meetings. Where possible, studies were coupled, and boreholes were consolidated through data integration without loss or compromise of any planned field activities. The results of this thinking are also contained in this catalog.

The catalog represents, therefore, a working compilation of information regarding drilling of boreholes as part of the SBT activities as currently envisioned. It provides the basis for the integration and coordination among activities deriving information from the drilling program. The goals of the catalog are to:

- compile the basic information of each planned borehole, including location, depth, WBS and SCP reference numbers, etc.;
- identify the requirements and rationale for each borehole and borehole program with respect to both proposed location and testing;
- identify data needs of other site characterization activities that may benefit from information acquired during the drilling, sampling, and testing of the various boreholes such that maximum utilization of boreholes is achieved;
- provide a compilation of information that is readily accessible to both program planners and investigators, such that the drilling program can be readily integrated into the long-range plan for site characterization activities;
- provide a document that parallels the "Map Data Supplement" that EG&G is preparing for the existing boreholes, to accompany the FY'93 Site Atlas.

Organization of the Catalog

The Catalog is organized by drilling program. Twelve drilling programs have been identified; one other drilling program, the drilling of neutron boreholes for natural infiltration studies in the unsaturated zone, under Study Plan 8.3.1.2.2.1, has been completed and therefore has not been included in this catalog. Another program, the Repository Facility (RF) drilling program under Study Plan 8.3.1.14.2, has also not been included under the understanding that the remaining RF boreholes will not be drilled. The twelve remaining programs are for the drilling of:

- unsaturated zone (UZ) boreholes
- boreholes for the systematic drilling (SD) program
- ramp boreholes to support ESF design (NRG/SRG boreholes)
- geologic (G) boreholes
- volcanic (V) boreholes
- the water table (WT) holes
- hydrology (H) boreholes
- boreholes for the Fortymile Wash recharge study (FMN/FM)
- boreholes for the Small-Plot/Large Plot Rainfall Simulation study (SPRS/LPRS)
- boreholes for the Southern Tracer Complex (STC)
- in-situ stress (ISS) boreholes
- boreholes to support the calcite-silica studies (PH).

Within the section for each drilling programs are: (1) an overview description of the program, identifying requirements of both the primary and secondary users of the borehole, and the prioritization given by the principal investigator (PI) for borehole construction; (2) a map showing the locations of the planned boreholes within each drilling program; and, (3) individual data sheets for each of these boreholes.

The individual data sheets present basic information about the borehole (i.e., PI, study plan number, etc.), followed by information on borehole location; borehole dimensions; scheduled start and completion dates; drilling and construction; logging, sampling and testing; environmental prerequisites; site restoration; and any comments or references.

The Appendices present activities or programs that are superimposed or applicable to the whole drilling program. The two that are included in this Catalog are geophysical logging (Appendix A) and the required pre-activity environmental surveys (Appendix B).

Review and Maintenance

The Catalog is being distributed in hard copy; it will be also maintained in the EG&G data base. A hard copy of the Catalog will be distributed twice yearly, in December and June. The first update will be distributed at the end of 1993. After the December '93 version is compiled, updates to this data base will be distributed as a monthly index of changes that have been made. As boreholes are drilled, they will be dropped from this catalog, but the data will be transferred to the current EG&G data base for existing and ongoing site activities.

REQUIREMENTS FOR DRILLING/TESTING

UNSATURATED ZONE BOREHOLES

Requirements of Primary User:

- Overall Objectives:¹
- To characterize fluid flow in the unsaturated zone (UZ) at Yucca Mountain by measuring the physical properties of the media and the hydrologic processes under which liquid and vapor flow occur.
 - To provide core and cuttings for stratigraphic, mineralogic, structural, hydrologic, and geochemical analysis of the unsaturated zone.
 - To provide borehole for air permeability testing, collection of hydrochemistry samples, the testing of natural gaseous phase circulation in the unsaturated zone, conducting vertical seismic profiling studies (VSP), long-term *in situ* monitoring, and possible gas tracer and water injection tests.
- Location Requirement:^{1,2}
- Planned boreholes are at locations outside of the repository block and at distributed locations across the site area of Yucca Mountain. These locations were selected to examine the effects of faulting, topographic relief, and the presence of a surface drainage on hydrologic conditions at depth.
 - At multiple borehole sites on a single drill pad, the boreholes are located within a distance of 100 to 150 ft of each other to provide an adequate facility for gas-tracer tests, cross-hole pneumatic tests, and VSP. The actual number of boreholes that will be constructed in a borehole cluster will be dependent on the results of previously conducted tests in other UZ boreholes and program data needs.
- Schedule Requirement: Site Characterization Goals:³
- Completion and instrumentation of about 30 per cent of the UZ boreholes is anticipated to incorporate a discussion on the matrix hydrologic properties and fluid flow into the Preliminary UZ Model;
 - Completion and instrumentation of 60 to 70 per cent of the UZ boreholes is anticipated to discuss transient effects in the deep unsaturated zone, the results of air permeability testing, and matrix hydrologic properties in the Interim UZ Hydrologic Model;
 - All of the UZ boreholes are to be drilled and instrumented a year before completion of the Final UZ Hydrology Model.
- Sequence of Tests:^{1,2}
- Air permeability tests are conducted after initial air and gas sampling has been completed.
 - A second phase of gas sampling is conducted after air permeability tests are complete.
 - After the above tests are completed, the borehole is instrumented for *in situ* UZ monitoring.
 - If field tracer tests are conducted, these will occur after the boreholes are stemmed and during the long-term monitoring phase.
 - If data analysis indicate that additional useful data can be gained by water injection tests, they would occur after adequate data have been collected from the monitoring and gas sampling program.
- Depth Requirement:¹
- The boreholes are to penetrate about 40 to 80 ft into the water table.
- Geologic Data Requirements:⁴
- Continuous geophysical logs from the ground surface to TD.
 - Continuous geologic log of the borehole, based on either core or cuttings.
- Drilling Method:⁴
- Dry, dual-wall, reverse circulation, with tracer metered into the drilling air.

Minimum Borehole Size: ⁴	Reamed to about 12 1/4 in. diameter to total depth to accommodate instrument package for long-term <i>in situ</i> monitoring.
Minimum Core Size: ⁴	HQ core (2.4" diameter). Preferred core size is HQ.
Cored Interval: ⁴	From ground surface to TD; at some locations, if geologic data from nearby holes are sufficient, the PI may identify only select portions of the borehole to be cored.
Testing/Sampling Requirements: ^{1,4,5}	<ul style="list-style-type: none"> - Borehole is to be drilled with air, using a rig having dual-wall reverse circulation capabilities. - The borehole should be drilled as straight (plumb) as possible; if it is to be used for VSP studies, the maximum allowable deviation is 3 degrees. - The unsaturated zone tests require that the borehole walls be kept dry and clear; i.e., protected from water and mudcake contamination. - As the water table is neared, the driller shall proceed slowly and core samples should be carefully examined for water content to assess at what depth the water occurs. - <i>If perched water is encountered:</i> <ul style="list-style-type: none"> - Upon completion of any water-pumping operations, care must be taken to prevent water in the discharge pipe from splashing out of the pipe and cascading downhole or onto the drill pad when the pipe is being disconnected. - If an encountered perched water zone continues to seep water into the borehole after completion of water-pumping from the zone, it must be sealed off with a grout mixture, while taking care not to contaminate the borehole walls, in order to maintain dry borehole walls when drilling continues. <p><u>Air Permeability Testing needs:</u>⁵</p> <ul style="list-style-type: none"> - Clean sides of borehole, with minimal clogging of fractures and the formation. - Removal of drilling air from borehole prior to testing - Packers for the injection of gas in selected stratigraphic intervals at a constant rate while monitoring transient pressure response. - Tracer(s), different from that used in the drilling air, to be added to injected air. - Electrical power to support trailer. - Dry, filtered compressed air supply. <p><u>UZ instrumentation needs:</u>^{5,6}</p> <ul style="list-style-type: none"> - Protection of UZ when drilling into water table - Installation of long-term <i>in situ</i> monitoring equipment - Installation of Hydrologic Data Acquisition System (HDAS) with protective shelters for monitoring down-hole sensors. <p><u>Hydrochemical Characterization of the UZ needs:</u>^{1,2,5,7}</p> <ul style="list-style-type: none"> - Monitoring of the input of tracer-tagged drilling air - Dry-coring of samples - Core samples from: <ul style="list-style-type: none"> - regularly spaced intervals of the core, - calcite-filled fractures and vugs containing calcite crystals, - lithologic contacts, - wet or moist zones, - Removal of tracer-tagged drilling air from borehole following drilling, using a vacuum unit; and sampling of formation gases and water vapor: - Installation of packer system to collect gas and water vapor samples from selected intervals, both before and after air permeability testing: - Isolation of 8 to 16 selected intervals by the <i>in situ</i> instrumentation, and collection of gas samples about twice a year from these intervals. <p><u>Matrix Hydrologic Properties of UZ needs:</u>⁸</p> <ul style="list-style-type: none"> - Samples from regularly spaced intervals of the core. See special handling requirements below.

Special Sample Handling Requirements:

Hydrochemistry Characterization of the UZ:⁷

- Wrap samples in saran wrap, weigh sample, place in capped and sealed lexan liner, seal in ProtecCore, weigh sample again, refrigerate the package.

Matrix Hydrologic Properties of UZ:⁸

- Place the sample of core in a lexan liner, with spacers at each end of the sample, then cap and seal the lexan liner and place it in ProtecCore.

Equipment Requirements⁵:
(to be supplied by USGS)

for Hydrochemistry Characterization of the Unsaturated Zone:

- the tracer input and sampling system
- the gas sampling packer system, and associated equipment to sample and analyze downhole gases.

for Air Permeability Testing:

- all downhole equipment for in-hole testing, and
- all equipment needed for installation and removal of the downhole equipment.

for Borehole Instrumentation:

- the IIS (insulated instrument shelters) with support columns and rectangular conduit.
- the DISAs (downhole instrument station apparatuses), including sensors, electrical cable and tubing; and mounting brackets

for Vertical Seismic Profiling:²

- the downhole geophone assembly cable.

Equipment Requirements^{5,6}:
(to be supplied by contractor)

- Drill rig and materials for borehole construction.
- *If perched water is encountered:*
 - A low capacity (i.e., 0.5 to 2 liters/min) submersible pump for small perched water sampling operations.
 - Temporary casing to protect the borehole walls during any water-pumping and drilling operations when water is present.

for Air Permeability Testing:

- A tracer gas injection and monitoring setup
- A generator or electrical power to support the air permeability trailer.
- A dry, filtered compressed air supply (50 CFM at 150 psi)

for UZ instrumentation:

- Stemming material (i.e., grout) for *in situ* instrumentation,
- An electrical power line to the IIS.
- Communication hookups, including data transmission and telephone facilities for the IIS facility.
- A sand-bag perimeter seal around the base of the IIS.

for Hydrochemistry Characterization of UZ:

- A vacuum unit for evacuating air from the borehole,
- Equipment for lowering and raising a packer string into and out of borehole.
- A compressor (50 CFM) to inflate packers or packer inflation gas.
- A generator or electrical power.

for Vertical Seismic Profiling:

- Stemming material for geophone emplacement.

Study Plan: 8.3.1.2.2.3

"Characterization of the Yucca Mountain Unsaturated-Zone Percolation Surface-Based Studies"

WBS No.: 1.2.3.3.2.2.3

Principal Investigator/User:

Michael Chornack, USGS
Joe Rousseau, USGS - UZ In situ Instrumentation
Gary LeCain, USGS - Air Permeability Testing
Alan Flint, USGS - Matrix Hydrological Testing

Requirements/Requests of Secondary Users:

Hydrochemistry of Saturated Zone:^{9,10}

- Collect 4 to 8 regularly spaced core samples from about 15 m above the water table to 15 m below the water table, regardless of the lithology, extent of welding, presence of fractures or lithologic contact, or perceived moisture content of the core.
- Place core in properly cleaned lexan-type liner, cap and tape liner on both ends, place in ProtecCore.
- Collect water samples from any perched water encountered, and from below the water table, prior to introducing any tracers, fluids or materials into the borehole, other than those used in the drilling process.

Potentiometric Surface:¹¹

- Measurement of water level when water is encountered during drilling and at completion of drilling. Measurement is to be made from a point for which a precise altitude is known or can be subsequently be measured.
- If possible, measurement of water level at least on a weekly basis until it has stabilized following drilling operations.
- Long-term monitoring of potentiometric surface.

Mineralogy/Petrology:¹²

- Collect continuous core
- In the non-welded to partially welded zones, with the exception of the thoroughly zeolitized Calico Hills unit, collect about a one-inch sample for every foot of sample taken for the UZ hydrochemistry study.

Alteration History and Transport Pathways:¹²

- A portion of the selected fractures or contacts in the moderately to densely welded zones should not be packaged in saran wrap (lexan and ProtecCore is acceptable) so that the samples can be viewed.
- A portion of the calcite fractures, wet fractures, or cross-cutting fractures should not be packaged in saran wrap (lexan and ProtecCore is acceptable) so that the samples can be viewed.

Water Movement Tracer Tests (Chlorine-36):¹³

- Dry drilling
- No tracers, fluids, or other materials, other than those specified in planning documents, can be introduced downhole prior to sample collection.
- Collect ream-bit cuttings from the same stratigraphic intervals from which core samples are specified for hydrochemical testing.
- If no hydrochemical samples are collected= collect cutting samples from the prescribed interval.
- Collect cuttings from a 0.5 to 1-ft-interval of ream-down; expected sample weight is 50 to 130 lbs.
- Collect additional cuttings from selected weathered fractures or fracture zones, as evidenced by iron staining in core, and determined by the drillsite geologist.

Geologic Model:⁴

- Continue coring through next major stratigraphic contact if within 50 to 100 ft.

Other comments:

- As the number of drilled boreholes increase, particularly at multiple UZ well complexes, if the stratigraphic data derived from the boreholes begin to become redundant, core may be collected from only select intervals in a borehole.

ENVIRONMENTAL CONCERNS

Use of Tracers:	- Tracer will be added to drilling medium.
	- Additional gas tracer(s) may be required for air permeability test, and water injection testing, if it is conducted.
Emissions/Effluent:	
Water Discharge:	None anticipated
Amount	
Rate	
Chemistry	
Discharge Point	
Will Study Intersect the Water Table?	Yes
Extent and Location of Ground Disturbance:	
Road Access	Dependent on specific borehole location.
Pad Construction:	Of sufficient dimension to position and drill with an LM-300 or comparable drilling rig.

BOREHOLE PRIORITIZATION BY PRINCIPAL INVESTIGATOR

(as of September 3, 1993)²

UE-25 UZ#16 - constructed
USW UZ-14 - in progress

USW UZ-7a
UE-25 UZ#9
UE-25 UZ#9a
USW UZ-8a
UE-25 UZ#9b

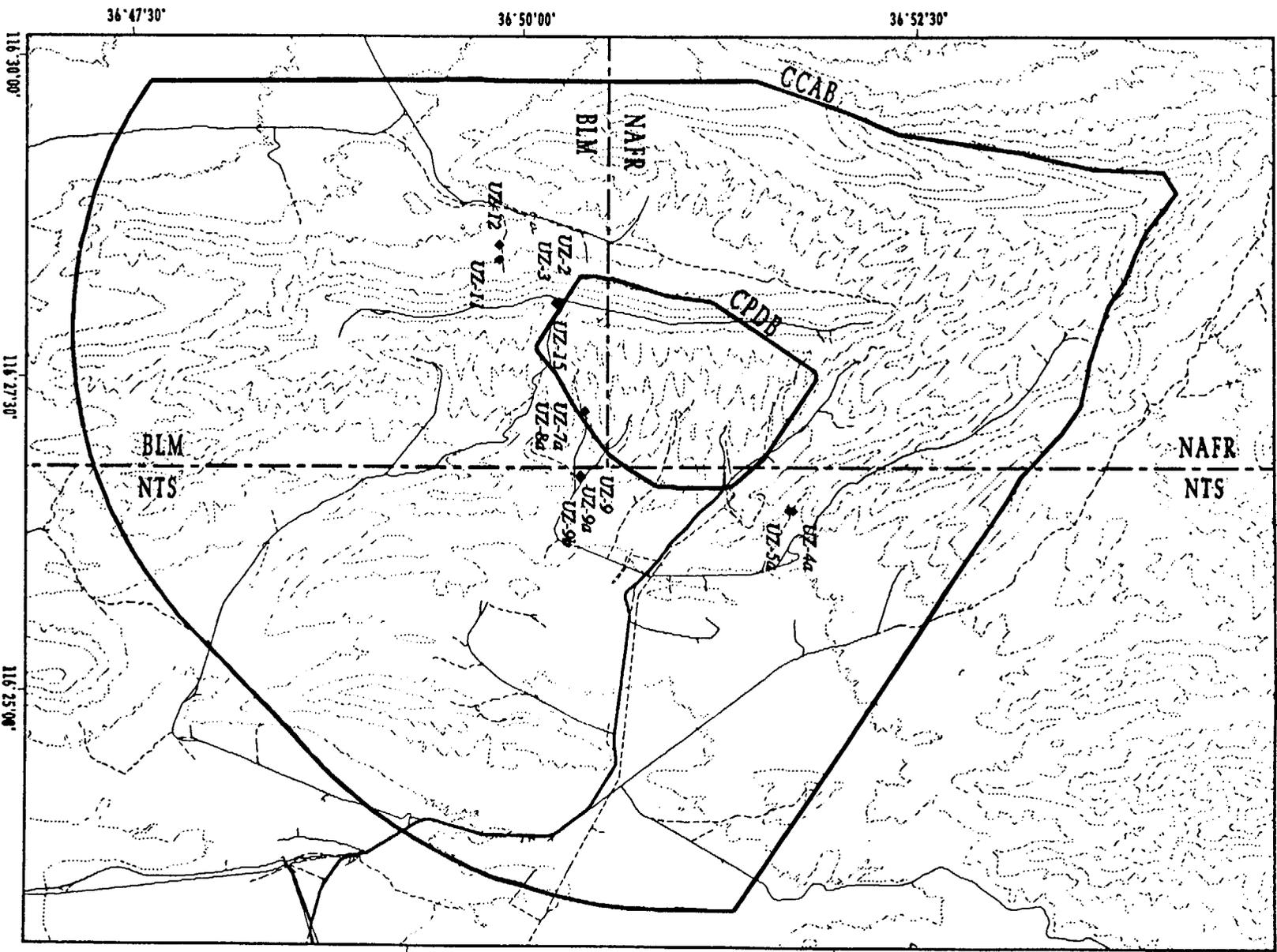
UE-25 UZ#4a
UE-25 UZ#5a

USW UZ-11
USW UZ-12
USW UZ-15
USW UZ-2
USW UZ-3

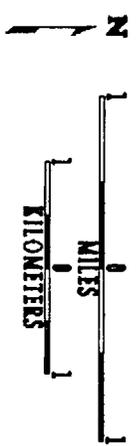
The above prioritization list for the remaining UZ borehole reflects two geographical groupings (UZ-4 and -5, are considered 'filler' boreholes): (a) those associated with VSP and cross-hole tests on the UZ-16 pad (UZ-9, -9a, and 9b), and the nearby studies on the Ghost Dance fault (UZ-7a and -8a); and (b) those associated with UZ studies in Solitario Canyon (UZ-11 and -12) and on top of Yucca Crest on the UZ-6 pad (UZ-2, -3, and -15). This grouping originated when two LM-300 drill rigs were anticipated for the surface-based studies, and reflects a logistical concern of minimizing distances for moving the drill rigs. If the Project continues with one LM-300 type rig, the above prioritization should be reconsidered. For example, the first three UZ holes are focused on structural features (UZ-16 = the imbricate fault zone, UZ-14 = the Drill Hole Wash structure, UZ-7a = the Ghost Dance fault). The YMP could decide to complete the drilling of structures and select one of the Solitario Canyon UZ holes as the fourth UZ hole, which is the top priority for the 'second LM-300' on the above list.²

Primary Sources of Information:

1. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
2. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3, 1993
3. FY 1994 Draft Annual Plan, Site Characterization, Yucca Mountain Project, Appendix D, Preliminary Compilation of Level 2 and 3 Integrated Milestones for the Site Investigations Long-Range Plan, April 1993.
4. Drilling prioritization meetings, October and December, 1993, Las Vegas.
5. USGS Criteria Letter dated July 22, 1992 (USGS-YMP-3343G-01-C4, R0) for drilling, testing, and instrumenting of UZ-14.
6. Personnel communication, Mike Chornack (USGS) to Norma Biggar (M&O/WCFS), August 30, 1993.
7. "Comments/Directions, Sample Request for USW SRG-5/SD-11," prepared by A. Yang, USGS.
8. Letter to Deborah Edwards (USGS) from Alan Flint (USGS), "Core Collection for SRG-5/SD-11," May 20, 1993.
9. Letter from Robert Craig (USGS) to Heidi Lohn (SAIC), "Request for Input for Test Planning Package T-93-09," August 9, 1993.
10. Work scope consolidation meeting, June 17, 1993, for planned FY'94 deep boreholes, Las Vegas.
11. Letter from Patrick Tucci (USGS) to Heidi Lohn (SAIC), reference to "Request for Input for Test Planning Package (TPP) T-93-09, USW SD-12 Drilling and Testing," August 2, 1993.
12. Memorandum from R. Oliver (LANL) to Russ Dyer (DOE-RSED), "Los Alamos National Laboratories Design and Test Related Input for Test Planning Package (TPP) T-93-09, USW SD-12," August 18, 1993.
13. Criteria Letter for "Collection of Ream-Bit Cuttings from Deep Dry-Drilled Surface-Based Boreholes, Yucca Mountain, Nevada," June Fabryka-Martin, TWS-INC-9-02-93-07.



◆ LEGEND
Planned Borehole



Contour Interval 200 Feet

YUCCA MOUNTAIN
SITE CHARACTERIZATION PROJECT
PLANNED UNSATURATED
ZONE BOREHOLES

EG&G WP-9-037.4

E539445ft
E535000m

E544660ft
E539000m

N753950ft
N407500m

N79210ft
N408000m

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW UZ-2

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: ~N759,769/E558,180
UTM: N4,076,745/E547,450.7

Ground Elevation of Borehole (above sea level): About 4925 ft (1540 m)

Location Description: At the southeast corner of the intersection of Highway Ridge and Yucca Crest Road. The borehole is part of a cluster of unsaturated zone boreholes (UZ-2, -3, -15, -6 [existing], and -6s [existing]) located on the same drill pad. The planned location of UZ-2 is near the existing UZ-6 borehole (Ref.1; see Comment 1, below). The three boreholes that will be used in field tracer tests are to be located within a 100- to 150-ft radius of each other (Ref. 2).

Access to Location: Accessible by existing road

Rationale for Location: To examine the influence of topographic relief and associated barometric effects on fluid flow in the unsaturated zone along the western boundary of Yucca Mountain. Paired with USW UZ-3 and UZ-6s (existing) or UZ-15 for cross-hole pneumatic and hydraulic tests and field tracer tests (Ref. 1).

Borehole Dimensions

Planned Borehole Depth: Between 2425 to 2600 ft depth (see Comment 2). LANL requests that either UZ-2 or UZ-3 be extended to 100 m (325 ft) below the water table for mineralogy/petrology studies (Ref. 2); this would result in a TD of about 2750 to 2925 ft deep. The study plan (Ref. 1) has estimated TDs of 2460 ft (750 m) and 2665 ft.

Elevation at Total Depth (above sea level):	2000 to 2500 ft. (605 to 755 m)
Planned Borehole Diameter:	Greater than or equal to 12 1/4 in to 40 to 80 ft below the water table; about 4 in to 6 in diameter (core hole diameter) for remainder of borehole to TD if borehole is extended to 100 m (325 ft) below the water table.
Planned Core Size:	2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry, dual-wall reverse circulation
Recommended Drill Rig:	LM-300
Drilling Fluids:	Air only
Tracers:	Gas tracer added to drilling air; different tracer (s) used for air permeability, field tracer, and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory summary sheet for unsaturated zone boreholes.
Sample Collection & Interval (cores/cuttings):	Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.
Geophysical Logging:	The geophysical logging suite for a Group I borehole (see Appendix A). If the borehole is drilled to 100 m (325 ft) below the water table, the logging suite for a Group II borehole will be collected.
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	1) Cross-hole pneumatic testing with N gas with USW UZ-3; 2) instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes; 3) CO ₂ and water vapor will be collected by peristaltic pumping; 4) following instrumentation, the well will be stemmed for a 3-5 year monitoring period; 5) gas access tubes will then inject water into the instrument station; constant head injection tests will be run.

Testing & Sampling to be Conducted as Listed in Study Plan:

1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor and conducting cross-hole pneumatic and hydraulic field tests; (7) field tracer tests during the period of long-term monitoring; and 8) possibly water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL), geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites**Land Ownership:**

BLM

Access:

Field work (not casual).

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B.

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

None anticipated; both the drill pad and access road already exists. May need to re-hab the pad to some extent.

Anticipated Area of Surface Disturbance:

No new disturbance anticipated.

Required Permits:

(1) Gas tracer added to drilling air; (2) other tracer(s) used in air permeability, water injection, and field tracer testing; (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

(1) The existing UZ-6 borehole was drilled in 1984 to a TD of 1887 ft (575 m) using a reverse-vacuum system. It has 26" to 20" I.D. casing in the upper 324 ft; the remaining borehole was drilled with a 17 1/2" bit to TD. Borehole UZ-6s was drilled to complete sampling that drilling problems precluded in UZ-6. It was drilled in 1985 to a TD of 519 ft (158 m) with the ODEX system. The upper 495 ft of the borehole was drilled with an 8-11/32" bit; the remainder of the hole to TD is a 4" hole. The upper 4' is cased (Refs. 1 and 4).

(2) The depth to the water table along the Yucca Crest between wells USW H-3 and H-5 is not well determined. The water table in wells USW H-3 (3000 ft to the south) and WT-2 (3800 ft to the east) is at an elevation of 2400 ft (Ref. 5); this would result in a UZ-2 borehole depth of about 2565 to 2600 ft (40 to 80 ft into the water table). If the more shallow potentiometric surface observed in wells in Solitario Canyon and at well USW H-5 (7000 ft to the north of UZ-2, on the crest) extends under Yucca Crest in the vicinity of UZ-2, the depth of the UZ-2 borehole may be less than the above derived depth, and about 2425 to 2465 ft depth (40 to 80 ft into the water table at 2540 ft elevation in borehole USW H-5 [Ref. 5]).

References:

1. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
2. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3 and 16, 1993.
3. Drilling prioritization meetings, October and December, 1993, Las Vegas.
4. Fenix & Scission, Inc., 1987, NNWSI Hole Histories, USW UZ-1, UE-25 UZ #4, UE-25 UZ #5, USW UZ-6, USW UZ-6s, USW UZ-7, USW UZ-8, USW UZ-13; DOE/NV/10322-20.
5. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW UZ-3

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: N759,625/E558,220
UTM: N4,076,701/E547,463

Ground Elevation of Borehole (above sea level): About 4925 ft (1540 m)

Location Description: At the southeast corner of the intersection of Highway Ridge and Yucca Crest Road. The borehole is part of a cluster of unsaturated zone boreholes (UZ-2, -3, -15, -6 [existing], and -6s [existing]) located on the same drill pad. The planned location of UZ-2 is near the existing UZ-6 borehole (Ref.1; see Comment 1 below). The three boreholes that will be used in field tracer tests are to be located within a 100- to 150-ft radius of each other (Ref. 2).

Access to Location: Accessible by existing road.

Rationale for Location: To examine the influence of topographic relief and associated barometric effects on fluid flow in the unsaturated zone along the western boundary of Yucca Mountain. Paired with USW UZ-3 and UZ-6s (existing) or UZ-15 for cross-hole pneumatic and hydraulic tests and field tracer tests (Ref. 1).

Borehole Dimensions

Planned Borehole Depth: Between 2425 to 2600 ft depth (see Comment 2). LANL requests that either UZ-2 or UZ-3 be extended to 100 m (325 ft) below the water table for mineralogy/petrology studies (Ref. 3); this would result in a TD of about 2750 to 2925 ft deep. The study plan (Ref. 1) has estimated TDs of 2460 ft (750 m) and 2665 ft.

Elevation at Total Depth (above sea level):	2000 to 2500 ft. (605 to 755 m)
Planned Borehole Diameter:	Greater than or equal to 12 1/4 in to 40 to 80 ft below the water table; about 4 in to 6 in diameter (core hole diameter) for remainder of borehole to TD if borehole is extended to 100 m (325 ft) below the water table.
Planned Core Size:	2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry, dual-wall reverse circulation
Recommended Drill Rig:	LM-300
Drilling Fluids:	Air only
Tracers:	Gas tracers added to drilling air; different tracer(s) used for air permeability, field tracer, and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory summary sheet for unsaturated zone boreholes.
Sample Collection & Interval (cores/cuttings):	Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.
Geophysical Logging:	The complete geophysical logging suite for a Group I borehole (see Appendix A). If the borehole is drilled to 100 m (325 ft) below the water table, the logging suite for a Group II borehole will be collected.
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	1) Cross-hole pneumatic testing with N gas with USW UZ-3; 2) instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes; 3) CO ₂ and water vapor will be collected by peristaltic pumping; 4) following instrumentation, the well will be stemmed for a 3-5 year monitoring period; 5) gas access tubes will then inject water into the instrument station; constant head injection tests will be run.

Testing & Sampling to be Conducted as Listed in Study Plan:

1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor and conducting cross-hole pneumatic and hydraulic field tests; (7) field tracer tests during the period of long-term monitoring; and 8) possibly water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analyses (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites**Land Ownership:**

BLM

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B.

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

None anticipated; both the drill pad and access road already exists. May need to re-hab the pad to some extent.

Anticipated Area of Surface Disturbance:

No new disturbance anticipated.

Required Permits:

(1) Gas tracer added to drilling air; (2) tracer(s) used in air permeability, water injection, and field tracer testing; (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

(1) The existing UZ-6 borehole was drilled in 1984 to a TD of 1887 ft (575 m) using a reverse-vacuum system. It has 26" to 20" I.D. casing in the upper 324 ft; the remaining borehole was drilled with a 17 1/2" bit to TD. Borehole UZ-6s was drilled to complete sampling that drilling problems precluded in UZ-6. It was drilled in 1985 to a TD of 519 ft (158 m) with the ODEX system. The upper 495 ft of the borehole was drilled with an 8-11/32" bit; the remainder of the hole to TD is a 4" hole. The upper 4' is cased (Refs. 1 and 4).

(2) The depth to the water table along the Yucca Crest between wells USW H-3 and H-5 is not well determined. The water table in wells USW H-3 (3000 ft to the south) and WT-2 (3800 ft to the east) is at an elevation of 2400 ft (Ref. 5); this would result in a UZ-2 borehole depth of about 2565 to 2600 ft (40 to 80 ft into the water table). If the more shallow potentiometric surface observed in wells in Solitario Canyon and at well USW H-5 (7000 ft to the north of UZ-2, on the crest) extends under Yucca Crest in the vicinity of UZ-2, the depth of the UZ-2 borehole may be less than the above derived depth, and greater than 2425 to 2465 ft depth (40 to 80 ft into the water table at 2540 ft elevation in borehole USW H-5 [Ref. 5]).

References:

1. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation, R0, effective date: April 22, 1991.
2. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3 and 16, 1993.
3. Drilling prioritization meetings, October and December, 1993, Las Vegas.
4. Fenix & Scission, Inc., 1987, NNWSI Hole Histories, USW UZ-1, UE-25 UZ #4, UE-25 UZ #5, USW UZ-6, USW UZ-6s, USW UZ-7, USW UZ-8, USW UZ-13; DOE/NV/10322-20.
5. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada", Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 UZ#4a

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: in the vicinity of N768,715.6/E556,139.3 (UZ-4 location);
UTM: in the vicinity of N4,079,469/E546,819.3 (UZ-4 location)

Ground Elevation of Borehole (above sea level): About 3940 ft (1205 m); the elevation of UE-25 UZ #4 is 3938.5 ft (1204.4 m) (Ref. 3).

Location Description: On road up Pagany Wash, approximately 1/2 mile west of intersection of Pagany Wash and West Exile Hill Road. The borehole will likely be located to the east of the existing neutron holes (Ref. 2), near existing borehole UZ-4 (Ref. 1; see Comment 1 below), and within 100 ft of planned borehole UZ-4a.

Access to Location: Accessible by existing road in Pagany Wash.

Rationale for Location: Borehole is sited in/adjacent to a large drainage to investigate the effects of large transient pulses of infiltration related to runoff. The borehole is paired with UE-25 UZ #5a for this investigation (Ref. 2).

Borehole Dimensions

Planned Borehole Depth: About 1580 to 1620 ft (40 to 80 ft below the water table at elevation of 2400 ft [Ref. 4]); estimated depths to TD in study plan (Ref. 5) are 1181 ft (360 m) and 1744 ft.

Elevation at Total Depth (above sea level): 2320 to 2360 ft (700 to 715 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in.
Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dual-wall reverse circulation
Recommended Drill Rig: LM-300
Drilling Fluids: Air
Tracers: Gas tracers added to drilling air; different tracer(s) used for air permeability and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.

Sample Collection & Interval (cores/cuttings): Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.

Geophysical Logging: The complete geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:
 Not stated. For UZ-4: "1) Enlarge well to appropriate size to receive instrument package; 2) will be instrumented and packed; 3) CO₂ and water vapor will be collected by peristaltic pumping in: (for CO₂) a molecular sieve and stainless steel collection cylinders; (for water vapor) pumping through a cold trap." See Comment 2 below.

Testing & Sampling to be Conducted as Listed in Study Plan:
 1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor; 7) water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:	Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).
Borehole Instrumentation:	Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of <i>in situ</i> pore gases and water vapor, and the measurement of the potentiometric surface.
Borehole Construction Requirements:	See introductory summary sheet for unsaturated zone boreholes.
<u>Environmental Prerequisites</u>	
Land Ownership:	NTS
Access:	Field work (not casual)
Required Pre-Activity Surveys:	See Introduction to Borehole Catalog, and Appendix B.
Estimated Amt. of Discharged Water:	None is anticipated at this time.
Required Surface Preparation:	A drill pad will need to be built to accommodate an LM-300 type rig; it might be possible to combine the drill pads for boreholes UZ-4 and UZ-5, depending on borehole locations. Approximately 0.5 mi of road in Pagany Wash may need to be improved to accommodate traffic.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracer added to drilling air; (2) tracer(s) used in air permeability and water injection testing, (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

- (1) The existing UZ#4 borehole was drilled in 1984 to a TD of 368 ft (112 m) using the ODEX system. It has 5-1/2" casing to TD (Ref. 6).
- (2) "The original plans called for the deepening of UE-25 UZ#4 from 367.5 ft. This redrill is required instead, for the following reasons: a) junk was left in the hole from previous drilling; one joint of 5 1/2" casing and one ODEX drive shoe and b) the existing borehole would have to be reamed from 6" to 12-14" and dry reaming is not recommended here" (Ref. 1).

References:

1. United States Department of Energy, 1988, Yucca Mountain Project, Surfaced-Based Investigations Plan, YMP/88-25.
2. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3, 1993.
3. United States Department of Energy, 1992, Yucca Mountain Site Characterization Project Site Atlas, prepared by EG&G Energy Measurements Inc., Remote Sensing Laboratory, September, 1992.
4. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
5. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
6. Fenix & Scission, Inc., 1987, NNWSI Hole Histories, USW UZ-1, UE-25 UZ #4, UE-25 UZ #5, USW UZ-6, USW UZ-6s, USW UZ-7, USW UZ-8, USW UZ-13; DOE/NV/10322-20.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 UZ#5a

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: in the vicinity of N768,591/E566,135 (UZ-5 location)
UTM: in the vicinity of N4,079,431/E546,818 (UZ-5 location)

Ground Elevation of Borehole (above sea level): About 3950 ft (1204 m); the elevation of UZ-5 is 3951.6 ft (1204.4 m) (Ref. 3).

Location Description: On road up Pagany Wash, approximately 1/2 mile west of intersection of Pagany Wash and West Exile Hill Road. The borehole will likely be located to the east of the existing neutron holes (Ref. 2), near existing borehole UZ-5 (Ref. 1; see Comment 1 below) and within 100 ft of planned borehole UZ-4a.

Access to Location: Accessible by existing road in Pagany Wash.

Rationale for Location: Borehole is sited in/adjacent to a large drainage to investigate the effects of large transient pulses of infiltration related to runoff. The borehole is paired with UE-25 UZ #4a for this investigation (Ref. 2).

Borehole Dimensions

Planned Borehole Depth: About 1590 to 1630 ft (40 to 80 ft below the water table at 2400 ft elevation [Ref. 4]). Estimated depths to TD in study plan (Ref. 5) were 1197 ft (365 m) and 1757 ft.

Elevation at Total Depth (above sea level): 2320 to 2360 ft (702 to 715 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in
Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry, dual-wall reverse circulation.
Recommended Drill Rig: LM-300
Drilling Fluids: Air
Tracers: Gas tracers added to drilling air; different tracer(s) used for air permeability and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.

Sample Collection & Interval (cores/cuttings): Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.

Geophysical Logging: The complete geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:
 Not stated. For UZ-5: "1) Enlarge hole as needed to receive instrument packages; 2) instrument hole with hot-wire anemometer flow meter; 3) hole will be shut in and the pressure differential between the well and atmospheric pressure will be measured; 4) hole will then be logged as listed above; 5) well will then be instrumented for sample collection and then packed; 6) CO₂ and water vapor will be collected by peristaltic pumping in: (for CO₂) a molecular sieve and stainless steel collection cylinders; (for water vapor) pumping through a cold trap." See Comment 2 below.

Testing & Sampling to be Conducted as Listed in Study Plan:
 1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for

long-term monitoring, and access tubing for sampling of pore gas and water vapor ; 7) water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites**Land Ownership:**

NTS

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B.

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

A drill pad will need to be built to accommodate an LM-300 type rig; it might be possible to combine the pads for boreholes UZ-4 and UZ-5, depending on the borehole locations. Approximately 0.5 mi of road in Pagany Wash may need to be improved to accommodate traffic.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling air; (2) tracer(s) used in air permeability and water injection testing, (3) intersection of water table.

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

- (1) The existing UZ#5 borehole was drilled in 1984 to a TD of 365 ft (111 m) using air and the ODEX system. It has 5-1/2" casing to 18 ft; the remainder of the hole is about 6" in diameter (Ref. 6).
- (2) "The original plans called for the deepening of UE-25 UZ#5 from 365 ft. This redrill is recommended for the following reasons: a) junk was left in the hole from previous drilling; one 2' long ODEX drive shoe. b) The existing hole would have to be reamed from 6" to 12-14" and dry reaming is not recommended here." (Ref. 1).

References:

1. United States Department of Energy, 1988, Yucca Mountain Project, Surfaced-Based Investigations Plan, YMP/88-25.
2. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3, 1993.
3. United States Department of Energy, 1992, Yucca Mountain Site Characterization Project Site Atlas, prepared by EG&G Energy Measurements Inc., Remote Sensing Laboratory, September, 1992.
4. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
5. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
6. Fenix & Scission, Inc., 1987, NNWSI Hole Histories, USW UZ-1, UE-25 UZ #4, UE-25 UZ #5, USW UZ-6, USW UZ-6s, USW UZ-7, USW UZ-8, USW UZ-13; DOE/NV/10322-20.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW UZ-7a

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: N760,645/E562,325 (ft); N231,845/E171,397 (m)
UTM: N4,077,016/E548,712

Ground Elevation of Borehole (above sea level): About 4237 ft (1291 m)

Location Description: In UZ-16 (WT-2) Wash at the Ghost Dance fault; designed along with USW UZ-8a to straddle Ghost Dance fault (Ref. 1). Borehole UZ-7a is about 122 m (400 ft) east of borehole USW WT-2, and about 34 m (110 ft) of the existing UZ-8 borehole (see Comments 1 and 2 below). The existing borehole UZ-7 is about 187 m (614 ft) to the east.

Access to Location: Accessible by existing road in UZ-16 (WT-2) Wash.

Rationale for Location: To investigate geohydrologic characteristics of the Ghost Dance fault (Ref 2).

Borehole Dimensions

Planned Borehole Depth: About 582 m (1910 ft) (24 m [80 ft] below the water table at 731 m (2400 ft) elevation [Ref. 3]); estimated depths to TD of 480 m (1574 ft) and 602 m (1974 ft) stated in study plan (Ref. 4).

Elevation at Total Depth (above sea level): 709 m (2325 ft)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in

Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: December, 1994 (Ref. 7)
 Scheduled Completion Date: June, 1995 (Ref. 7)

Drilling and Construction

Drilling Method: Dry, dual-wall reverse circulation
 Recommended Drill Rig: LM-300
 Drilling Fluids: Air
 Tracers: Gas tracers added to drilling air; different tracer(s) used for air permeability and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.

Sample Collection & Interval (cores/cuttings): Entire borehole will be cored.

Geophysical Logging: The complete geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

None stated. For UZ-7: "1) Enlarge well to appropriate size to receive instrument package; 2) instrument and pack well; 3) collect CO₂ and water vapor by peristaltic pumping in: (for CO₂) a molecular sieve and stainless steel collection cylinders; (for water vapor) pumping through a cold trap." See Comment 1, below.

Testing & Sampling to be Conducted as Listed in Study Plan:

1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor; 7) water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework, natural resource assessment, opaline vein silica deposits (USGS); mineralogy-petrology, fracture mineralogy and alteration history, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:	Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of <i>in situ</i> pore gases and water vapor, and the measurement of the potentiometric surface.
Borehole Construction Requirements:	See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites

Land Ownership:	BLM
Access:	Field work (not casual)
Required Pre-Activity Surveys:	See Introduction to Borehole Catalog, and Appendix B.
Estimated Amt. of Discharged Water:	None is anticipated at this time.
Required Surface Preparation:	The access road already exist; however it will need to be modified to grade to the planned pad, which is to be of sufficient size to accommodate the LM-300 drill rig.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air; (2) tracer(s) used in air permeability and water injection testing, (3) intersection of water table

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

(1) The existing UZ-8 borehole was drilled with air in 1986 to a TD of 57 ft (17 m) using air and the ODEX system. It has 5-1/2" casing to 55 ft depth; the remaining hole is 4-1/4" diameter (Ref. 5). The study plan (Ref. 4) states that the borehole has a TD of 350 ft (107 m).

(2) "Original plans called for the deepening of UZ-7 from 207 ft. This re-drill is recommended because UZ-7 would have to be reamed from 6" to 12-14" and dry reaming is not recommended here." (Ref. 5).

References:

1. Personnel communicaiton, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3, 1993.
- | 2. Letter from Richard W. Spengler (USGS) to Joe DLugosz (DOE/SP): "Geologic Information Relevant to the Siting of USW UZ-7a (compiled by USGS Rock Characteristics Section), March 28, 1994";
- | 3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation." R0, effective date: April 22, 1991.
5. United States Department of Energy, 1988, Yucca Mountain Project, Surfaced-Based Investigations Plan. YMP/88-25.
6. Fenix & Scission, Inc., 1987, NNWSI Hole Histories, USW UZ-1, UE-25 UZ #4, UE-25 UZ #5, USW UZ-6, USW UZ-6s, USW UZ-7, USW UZ-8, USW UZ-13; DOE/NV/10322-20.
- | 7. FY'94-95 Drilling Schedule prepared by RSN, 6/15/94.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW UZ-8a

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: near N760,762.2/E562,293.5 (location of UZ-8)
UTM: near N4,077,052/E548,703.1 (location of UZ-8)

Ground Elevation of Borehole (above sea level): About 4230 ft (1289 m); UZ-8 has an elevation of 4227 ft (Ref. 2).

Location Description: In UZ-16 (WT-2) Wash at the Ghost Dance fault; designed along with USW UZ-7a to straddle the Ghost Dance fault (Ref. 1). Borehole UZ-8a is about 400 ft east of borehole USW WT-2, and near the existing UZ-8 borehole (See Comment 1). The existing borehole UZ-7 is about 600 ft to the east of UZ-8.

Access to Location: Accessible by existing road in UZ-16 (WT-2) Wash.

Rationale for Location: To investigate geohydrologic characteristics related to the Ghost Dance fault.

Borehole Dimensions

Planned Borehole Depth: About 1870 to 1910 ft (40 to 80 ft below the water table at 2400 ft elevation [Ref. 3]); estimated depths to TD of 1574 (480 m) and 1974 ft stated in study plan (Ref. 4).

Elevation at Total Depth (above sea level): 2320 to 2360 ft (702 to 715 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in

Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry, dual-wall reverse circulation

Recommended Drill Rig: LM-300

Drilling Fluids: Air

Tracers: Gas tracers added to drilling air; different tracer(s) used for air permeability and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.

Sample Collection & Interval (cores/cuttings): Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.

Geophysical Logging: The complete geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

Not stated. For UZ-8: 1) pneumatic testing with N gas immediately following drilling; 2) well enlarged as appropriate to receive instrument packages; 3) well will be instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes; 4) CO₂ and water vapor will be collected by peristaltic pumping in: (for CO₂) a molecular sieve and stainless steel collection cylinders; (for water vapor) pumping through a cold trap; 5) following instrumentation, the well will be stemmed for a 3-5 year monitoring period; 6) on completion of monitoring, gas access tubes will then inject water into the instrument station; constant head injection tests will be run until steady state conditions are achieved.

Testing & Sampling to be Conducted as Listed in Study Plan:

1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring and access tubing for sampling of pore

gas and water vapor; 7) water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites

Land Ownership:

BLM

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B.

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

The access road already exist; however the drill pad will need to be enlarged to accommodate the LM-300 drill rig.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracers added to drilling air; (2) tracer(s) used in air permeability and water injection testing; (3) intersection of water table

Restoration

Borehole Closure Requirements:

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

(1) The existing UZ-8 borehole was drilled with air in 1986 to a TD of 57 ft (17 m) using air and the ODEX system. It has 5-1/2" casing to 55 ft depth; the remaining hole is 4-1/4" diameter (Ref. 5). The study plan (Ref. 4) states that the borehole has a TD of 350 ft (107 m).

References:

1. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3, 1993.
2. United States Department of Energy, 1992, Yucca Mountain Site Characterization Project Site Atlas, prepared by EG&G Energy Measurements Inc., Remote Sensing Laboratory, September, 1992.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
5. Fenix & Scission, Inc., 1987, NNWSI Hole Histories, USW UZ-1, UE-25 UZ #4, UE-25 UZ #5, USW UZ-6, USW UZ-6s, USW UZ-7, USW UZ-8, USW UZ-13; DOE/NV/10322-20.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 UZ#9

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: N760,600/E564,750
UTM: N4,077,005/E549,451.8

Ground Elevation of Borehole (above sea level): About 4000 ft; elevation of UZ-16 is 4000 ft (Ref. 2).

Location Description: Within 100 to 150 ft of borehole UE25 UZ-16 (coordinates N760,535.32/E564,856.9), at the juncture of two drainages (eastern end of Whaleback Ridge) on the Met Tower Road . Part of a multiple borehole cluster including UE-25 UZ #9a, UE-25 UZ #9b, and UE-25 UZ#16.

Access to Location: Accessible by existing road.

Rationale for Location: Positioned to test the concepts of lateral flow, perched water accumulations, and diversion of flow along secondary structural pathways that may be associated with faulting and fracturing. Paired with UE-25 UZ#9a and UE-25 UZ#9b for cross-hole pneumatic, hydraulic, and gas tracer tests (Ref. 1).

Borehole Dimensions

Planned Borehole Depth: About 1645 to 1685 ft, which is 40 to 80 ft below the water table at 1605 ft. depth in UZ-16 (Ref. 3). Estimated depths of 1460ft (445 m) and 1815 ft stated in study plan (Ref. 1).

Elevation at Total Depth (above sea level): 2315 to 2355 ft (701 to 713 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in

Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry, dual-wall reverse circulation

Recommended Drill Rig: LM-300

Drilling Fluids: Air

Tracers: Gas tracer added to drilling air; different tracer (s) used for air permeability, field tracer, and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory data sheet for unsaturated zone boreholes.

Sample Collection & Interval (cores/cuttings): Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.

Geophysical Logging: The complete geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

1) Cross-hole pneumatic and hydraulic testing with N gas with UZ-9a and UZ-9b; 2) instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes; 3) CO₂ and water vapor will be collected by peristaltic pumping; 4) following instrumentation, the well will be stemmed for a 3-5 year monitoring period; 5) gas access tubes will then inject water into the instrument station; constant head injection tests will be run.

Testing & Sampling to be Conducted as Listed in Study Plan:

1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor and conducting cross-hole pneumatic and hydraulic field tests; 7) field tracer tests during the period of long-term monitoring; and 8) possibly water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:	Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).
Borehole Instrumentation:	Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of <i>in situ</i> pore gases and water vapor, and the measurement of the potentiometric surface.
Borehole Construction Requirements:	See introductory summary sheet for unsaturated zone boreholes.
<u>Environmental Prerequisites</u>	
Land Ownership:	NTS
Access:	Field work (not casual)
Required Pre-Activity Surveys:	See Introduction to Borehole Catalog, and Appendix B
Estimated Amt. of Discharged Water:	None is anticipated at this time.
Required Surface Preparation:	None anticipated; both the drill pad and access road already exist.
Anticipated Area of Surface Disturbance:	No new disturbance anticipated.
Required Permits:	(1) Gas tracer added to drilling air; (2) gas tracer(s) used in air permeability, field tracer, and water injection testing; (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

References:

1. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
2. "UE-25 UZ-16 (VSP-2), Vertical Seismic Profile (VSP) Borehole Work Program," Rev. 2, from RSN to REEC Co Drilling, August 4, 1993.
3. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 16, 1993.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 UZ#9a

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: N760,600/E564,800;
UTM: N4.077,005/E549,467

Ground Elevation of Borehole (above sea level): About 4000 ft; elevation of UZ-16 is 4000 ft (Ref. 2)

Location Description: Within 100 to 150 ft of borehole UE25 UZ-16 (coordinates N760,535.32/E564,856.9), at the juncture of two drainages (eastern end of Whaleback Ridge) on the Met Tower Road. Part of a multiple borehole cluster including UE-25 UZ #9a, UE-25 UZ #9b, and UE-25 UZ#16.

Access to Location: Accessible by existing road.

Rationale for Location: Positioned to test the concepts of lateral flow, perched water accumulations, and diversion of flow along secondary structural pathways that may be associated with faulting and fracturing. Paired with UE-25 UZ#9 and UE-25 UZ#9b for cross-hole testing (Ref. 1).

Borehole Dimensions

Planned Borehole Depth: About 1645 to 1685 ft, which is 40 to 80 ft below the water table at 1605 ft. depth in UZ-16 (Ref. 3). Estimated depths of 1460ft (445 m) and 1815 ft stated in study plan (Ref. 1).

Elevation at Total Depth (above sea level): 2315 to 2355 ft (701 to 713 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in

Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry, dual-wall reverse circulation

Recommended Drill Rig: LM-300

Drilling Fluids: Air

Tracers: Gas tracers added to drilling air; different tracer(s) used for air permeability, field tracer, and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.

Sample Collection & Interval (cores/cuttings): Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.

Geophysical Logging: The complete geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

- 1) Pneumatic testing with N gas immediately following drilling, including cross-hole test with UZ-9 and UZ-9b;
- 2) instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes;
- 3) CO₂ and water vapor will be collected by peristaltic pumping in: (for CO₂) a molecular sieve and stainless steel collection cylinders; (for water vapor) pumping through a cold trap;
- 4) following instrumentation, the well will be stemmed for a 3-5 year monitoring period;
- 5) gas access tubes will then inject water into the instrument station; constant head injection tests will be run.

Testing & Sampling to be Conducted as Listed in Study Plan:

- 1) Collection of samples for physical and matrix hydrologic properties testing;
- 2) on-site lithologic core descriptions and hydrologic measurements;
- 3) borehole geophysical surveys;
- 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core;
- 5) *in situ* pneumatic tests; cross-hole pneumatic and hydraulic field tests;
- 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor;
- 7) field tracer tests during the period of long-term monitoring;

and 8) possibly water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites

Land Ownership:

NTS

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

None anticipated; both the drill pad and access road already exists.

Anticipated Area of Surface Disturbance:

No new disturbance anticipated.

Required Permits:

(1) Gas tracer added to drilling air; (2) gas tracer(s) used in air permeability, field tracer, and water injection testing; (3) intersection of water table.

Restoration

Borehole Closure Requirements:

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

References:

1. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
2. "UE-25 UZ-16 (VSP-2), Vertical Seismic Profile (VSP) Borehole Work Program," Rev. 2, from RSN to REEC Co Drilling, August 4, 1993.
3. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 16, 1993.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 UZ#9b

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: N760,600/E564,850
UTM: N4,077,005/E549,482.3

Ground Elevation of Borehole (above sea level): About 4000 ft; elevation of UZ-16 is 4000 ft (Ref. 2).

Location Description: Within 100 to 150 ft of borehole UE25 UZ-16 (coordinates N760,535.32/E564,856.9), at the juncture of two drainages (eastern end of Whaleback Ridge) on the Met Tower Road. Part of a multiple borehole cluster including UE-25 UZ #9, UE-25 UZ #9a, and UE-25 UZ#16. See Comment 1 below.

Access to Location: Accessible by existing road.

Rationale for Location: Positioned to test the concepts of lateral flow, perched water accumulations, and diversion of flow along secondary structural pathways that may be associated with faulting and fracturing. Paired with UE-25 UZ#9 and UE-25 UZ#9a for cross-hole pneumatic, hydraulic, and gas tracer tests (Ref. 1).

Borehole Dimensions

Planned Borehole Depth: About 1645 to 1685 ft, which is 40 to 80 ft below the water table at 1605 ft. depth in UZ-16 (Ref. 3). Estimated depths of 1460ft (445 m) and 1815 ft stated in study plan (Ref. 1).

Elevation at Total Depth (above sea level): 2315 to 2355 ft (701 to 713 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in

Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry, dual-wall reverse circulation

Recommended Drill Rig: LM-300

Drilling Fluids: Air only

Tracers: Gas tracers added to drilling air; different tracer(s) used for air permeability, field tracer, and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.

Sample Collection & Interval (cores/cuttings): Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.

Geophysical Logging: The complete geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

1) Pneumatic testing with N gas immediately following drilling, including cross-hole tests with UZ-9a and UZ-9b; 2) well enlarged as appropriate to receive instrument package; 3) well will be instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes; 4) CO₂ and water vapor will be collected by peristaltic pumping in: (for CO₂) a molecular sieve and stainless steel collection cylinders; (for water vapor) pumping through a cold trap; 5) following instrumentation, the well will be stemmed for a 3-5 year monitoring period; 6) on completion of monitoring, gas access tubes will then inject water into the instrument station; constant head injection tests will be run until steady state conditions are achieved.

Testing & Sampling to be Conducted as Listed in Study Plan:

1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; cross-hole pneumatic and hydraulic field tests; 6)

installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor; (7) field tracer tests during the period of long-term monitoring; and 8) possibly water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites**Land Ownership:**

BLM

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

None anticipated; both the drill pad and access road already exists.

Anticipated Area of Surface Disturbance:

No new disturbance anticipated.

Required Permits:

(1) Gas tracer added to drilling air; (2) gas tracer(s) used in air permeability, field tracer, and water injection testing; (3) intersection of water table

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

- (1) This borehole is potentially optional, depending on the results of the UZ program to date.

References:

1. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
2. "UE-25 UZ-16 (VSP-2), Vertical Seismic Profile (VSP) Borehole Work Program," Rev. 2, from RSN to REECo Drilling, August 4, 1993.
3. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3 and 16, 1993.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW UZ-11

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: approximately N757,400/E556,614
UTM: approximately N4,076,022/E546,976

Ground Elevation of Borehole (above sea level): About 4200 ft. (1280 m)

Location Description: The above, tentative location of the borehole is on the southeastern slope of Solitario Canyon, east of UZ-11 and directly east of the Solitario Canyon fault; in the vicinity of neutron boreholes USW UZN-78 and -79.

Access to Location: The proposed site is accessible by road to the neutron holes; however, the road has not been checked recently with regard to access with the LM-300 drill rig. It may be necessary to relocate the boreholes to another, more accessible location along the fault. The borehole should be somewhat in line with UZ-6 and UZ-16 (Ref. 1).

Rationale for Location: The borehole is located next to the Solitario Canyon fault in order to investigate its geohydrologic characteristics. It is paired with UZ-12 to study the changes in geologic character and hydrologic properties across the fault (Ref. 2).

Borehole Dimensions

Planned Borehole Depth: About 1700 to 1740 ft depth (40 to 80 ft below the water table at about 2544 ft elevation [Ref. 3]). Estimated depths to TD in study plan (Ref. 2) are 1853 ft (565 m) and 1949 ft.

Elevation at Total Depth (above sea level): 2460 to 2500 ft (745 to 757 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in
Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dual-wall reverse circulation
Recommended Drill Rig: LM-300
Drilling Fluids: Air only
Tracers: Gas tracer added to drilling air; different tracer (s) used for air permeability, field tracer, and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.
Sample Collection & Interval (cores/cuttings): Entire borehole will likely be cored because of its proximity to the fault.
Geophysical Logging: The geophysical logging suite for a Group I borehole (see Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:
 1) Pneumatic testing with N gas immediately following drilling; 2) instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes; 3) CO₂ and water vapor collected by peristaltic pumping in: (for CO₂) a molecular sieve and stainless steel collection cylinders; (for water vapor) pumping through a cold trap; 4) following instrumentation, the well will be stemmed for a 3-5 year monitoring period; 5) gas access tubes will then inject water into the instrument station; constant head injection tests will be run.

Testing & Sampling to be Conducted as Listed in Study Plan:
 1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; cross-hole pneumatic and hydraulic field tests; 6) installation of *in situ* sensors (thermocouple psychrometers,

pressure transducers, thermal sensors) for long-term monitoring, and access tubing for sampling of pore gas and water vapor; 7) field tracer tests during the period of long-term monitoring; and 8) possibly water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites**Land Ownership:**

BLM

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B.

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

Construction of a drill pad, improvement of the existing road, and construction of a short access road will be needed at the existing location. As stated above, borehole may be moved if a more accessible location can be found.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling air; (2) Other tracer(s) used in air permeability and water injection testing; (3) Intersection of water table

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

References:

1. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3, 1993.
2. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW UZ-12

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: N757,400/E556,055
UTM: N4,076,021/E546,805.7

Ground Elevation of Borehole (above sea level): About 4130 ft. (1260 m)

Location Description: The above, tentative location of the borehole is on the southeastern slope of Solitario Canyon, east of UZ-11 and directly east of the Solitario Canyon fault; in the vicinity of neutron boreholes USW UZN-78 and -79.

Access to Location: The proposed site is accessible by road to the neutron holes; however, the road has not been checked recently with regard to access with the LM-300 drill rig. It may be necessary to relocate the boreholes to another, more accessible location along the fault. The borehole should be somewhat in line with UZ-6 and UZ-16 (Ref. 1).

Rationale for Location: The borehole is located next to the Solitario Canyon fault in order to investigate its geohydrologic characteristics. It is paired with UZ-11 to study the changes in geologic character and hydrologic properties across the fault (Ref. 2).

Borehole Dimensions

Planned Borehole Depth: About 1625 to 1665 ft depth (40 to 80 ft below the water table at about 2544 ft elevation [Ref. 3]). Estimated depths to TD in study plan (Ref. 2) are 1771 ft (540 m) and 1857 ft.

Elevation at Total Depth (above sea level): 2465 to 2500 ft (746 to 757 m)

Planned Borehole Diameter: Greater than or equal to 12 1/4 in
Planned Core Size: 2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dual-wall reverse circulation
Recommended Drill Rig: LM-300
Drilling Fluids: Air only
Tracers: Gas tracer added to drilling air; different tracer (s) used for air permeability, field tracer, and water injection testing, if conducted.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for unsaturated zone boreholes.
Sample Collection & Interval (cores/cuttings): Entire borehole will likely be cored because of its proximity to the fault.
Geophysical Logging: The geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

1) Pneumatic testing with N gas immediately following drilling; 2) instrumented with a pressure transducer, thermocouple psychrometer, heat dissipation probe, thermal sensor and gas sampling access tubes; 3) CO₂ and water vapor collected by peristaltic pumping; 4) following instrumentation, the well will be stemmed for a 3-5 year monitoring period; 5) gas access tubes will then inject water into the instrument station; constant head injection tests will be run.

Testing & Sampling to be Conducted as Listed in Study Plan:

1) Collection of samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) *in situ* pneumatic tests; cross-hole pneumatic and hydraulic field tests; 6) installation of *in situ* sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for long-term monitoring and access tubing for sampling of pore gas and

water vapor; 7) field tracer tests during the period of long-term monitoring; and 8) possibly water injection tests (in unsaturated zone after long-term monitoring).

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of an instrument stations that include, but are not limited to, (1) thermocouple psychrometer, (2) pressure transducers, (3) thermal sensors, to measure and monitor total fluid (liquid, gas, and vapor) potential field in the unsaturated zone for a period of three to five years. The instrument string includes access tubing for the vacuum recovery of *in situ* pore gases and water vapor, and the measurement of the potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites**Land Ownership:**

BLM

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See introductory summary sheet for unsaturated zone boreholes.

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

Construction of a drill pad, improvement of the existing road, and construction of a short access road will be needed at the existing location. As stated above, borehole may be moved if a more accessible location can be found.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling air; (2) Other tracer(s) used in air permeability and water injection testing; (3) Intersection of water table

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

References:

1. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3, 1993.
2. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW UZ-15

Type of Investigation: Unsaturated Zone

WBS No.: 1.2.3.3.1.2.3

Study Plan No.: 8.3.1.2.2.3

Study Plan Title: Characterization of the Percolation in the Unsaturated Zone - Surface-Based Study

Principal Organization: USGS

Principal Investigators: Joe Rousseau, USGS

Other Participant Organizations: LANL, SNL

Purpose of Activity: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the unsaturated zone.

Location

Coordinates: NVSPC: N759,731.5/E558,325
UTM: N4,076,734/E547,494.9

Ground Elevation of Borehole (above sea level): About 4925 ft (1540 m)

Location Description: At the southeast corner of the intersection of Highway Ridge and Yucca Crest Road. The borehole is part of a cluster of unsaturated zone boreholes (UZ-2, -3, -15, -6 [existing], and -6s [existing]) located on the same drill pad (Ref. 1).

Access to Location: Accessible by existing road.

Rationale for Location: UZ-15 is a contingency borehole. If it is drilled, it will be either: (1) a VSP borehole, if the VSP studies in borehole UZ-16 are successful and if the existing UZ-6 borehole on the pad cannot be used for VSP studies; or (2) a borehole to be used in the 3-borehole cluster for cross-hole tests, if the existing UZ-6s borehole (TD of 518 ft [158 m]) is assessed by the PI to be too shallow for satisfactorily conducting the planned cross-hole tests, and it is necessary to have all boreholes of the cluster extend to the water table (Ref. 2; see also Comment 1).

If VSP is carried out in both the UZ-16 and UZ-6/15 boreholes, it will provide baseline information that can be used to extend hydrologic properties data measured in adjacent boreholes across the southern half of the repository block. In the study plan (Ref. 1), borehole UZ-15 was a VSP borehole paired with UZ-9, -9a, and 9b.

Borehole Dimensions

Planned Borehole Depth:	Between 2425 to 2600 ft depth (see Comment 2).
Elevation at Total Depth (above sea level):	2325 to 2500 ft (704 to 757 m)
Planned Borehole Diameter:	Greater than or equal to 12 1/4 in.
Planned Core Size:	2.44 in (HQ core); 1.9 in (NQ core) minimum size.

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry, dual-wall reverse circulation
Recommended Drill Rig:	LM-300
Drilling Fluids:	Air only
Tracers:	Gas tracer added to drilling air; different gas tracer(s) used in air permeability testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory summary sheet for unsaturated zone boreholes.
Sample Collection & Interval (cores/cuttings):	Entire borehole will be cored unless an adjacent borehole can provide sufficient stratigraphic information, in which case, only intermittent core may be collected.
Geophysical Logging:	The complete geophysical logging suite for a Group I borehole (see Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	Borehole was not included in the SBIP.
Testing & Sampling to be Conducted as Listed in Study Plan:	1) Collection of core samples for physical and matrix hydrologic properties testing; 2) on-site lithologic core descriptions and hydrologic measurements; 3) borehole geophysical surveys; 4) determination of fracture frequency, spacing, and orientation by detailed analysis of core; 5) <i>in situ</i> pneumatic tests (air permeability testing); 6) collection of gas chemistry samples; and 7) installation of geophones for vertical seismic profiling studies, if the borehole is drilled for VSP testing; <u>or</u> 6) installation of <i>in situ</i> sensors (thermocouple psychrometers, pressure transducers, thermal sensors) for

long-term monitoring, and access tubing for sampling of pore gas and water vapor and conducting cross-hole pneumatic and hydraulic field tests; (7) field tracer tests during the period of long-term monitoring; and 8) possibly water injection tests (in unsaturated zone after long-term monitoring) if the borehole is drilled for cross-hole testing.

Testing & Sampling Currently Planned:

Same tests as stated in the study plan for the unsaturated zone, plus hydrochemical analyses of the saturated zone, gaseous phase circulation in the unsaturated zone, geologic framework (USGS); mineralogy-petrology, chlorine-36 (LANL); geostatistical analysis (SNL).

Borehole Instrumentation:

Installation of geophones for vertical seismic profiling studies.

Borehole Construction Requirements:

See introductory summary sheet for unsaturated zone boreholes.

Environmental Prerequisites**Land Ownership:**

BLM

Access:

Field work (not casual)

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog, and Appendix B

Estimated Amt. of Discharged Water:

None is anticipated at this time.

Required Surface Preparation:

None anticipated; both the drill pad and access road already exists. May need to re-hab the pad to some extent.

Anticipated Area of Surface Disturbance:

No new disturbance anticipated.

Required Permits:

(1) Gas tracer added to drilling air; (2) gas tracer(s) used in air permeability testing; (3) intersection of water table

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

(1) The existing UZ-6 borehole was drilled in 1984 to a TD of 1887 ft (575 m) using a reverse-vacuum system. It has 26" to 20" I.D. casing in the upper 324 ft; the remaining borehole was drilled with a 17 1/2" bit to TD. Borehole UZ-6s was drilled to complete sampling that drilling problems precluded in UZ-6. It was drilled in 1985 to a TD of 519 ft (158 m) with the ODEX system. The upper 495 ft of the borehole was drilled with an 8-11/32" bit; the remainder of the hole to TD is a 4" hole. The upper 4' is cased (Refs. 1 and 5).

(2) The depth to the water table along the Yucca Crest between wells USW H-3 and H-5 is not well determined. The water table in wells USW H-3 (3000 ft to the south) and WT-2 (3800 ft to the east) is at an elevation of 2400 ft (Ref. 3); this would result in a UZ-2 borehole depth of about 2565 to 2600 ft (40 to 80 ft into the water table). If the more shallow potentiometric surface observed in wells in Solitario Canyon and at well USW H-5 (7000 ft to the north of UZ-2, on the crest) extends under Yucca Crest in the vicinity of UZ-2, the depth of the UZ-2 borehole may be less than the above derived depth, and greater than 2425 to 2465 ft depth (40 to 80 ft into the water table at 2540 ft elevation in borehole USW H-5 [Ref. 3]).

(3) This borehole may be eliminated if it is possible to use the existing UZ-6 as a VSP borehole and UZ-6s for cross-hole testing.

References:

1. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
2. Personnel communication, Joe Rousseau (USGS) to Norma Biggar (M&O/WCFS), September 3 and 16, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Fenix & Scission, Inc., 1987, NNWSI Hole Histories, USW UZ-1, UE-25 UZ #4, UE-25 UZ #5, USW UZ-6, USW UZ-6s, USW UZ-7, USW UZ-8, USW UZ-13; DOE/NV/10322-20.

REQUIREMENTS FOR DRILLING/TESTING

SYSTEMATIC DRILLING BOREHOLES

Requirements of Primary User:

- Overall Objective:¹ To acquire geologic and engineering data of the repository block through the analysis of physical properties of core collected from systematically distributed boreholes.
- Location Requirements:¹ - At a location within the proposed repository area and equidistant from other deep boreholes from which core will be collected.
- Schedule Requirements: Engineering Design Packages:²
- Acquisition of stratigraphic and rock properties data from the main drift horizon in
 - boreholes SD-9 and -10 for ESF Design Package 2c for the North Ramp - current start date is January 1994, due April 1994;
 - boreholes SD-7 and -12 for ESF Design Package 8a for the Main Drift - current start date is January 1994, due December 1994;
 - borehole SRG-5/SD-12 for ESF Design Package 8c for the South Ramp Extension - current start date is April 1995, due first quarter of 1996.
- Site Characterization Goals:³
- Completion of drilling and analysis of about 30% of the SD boreholes for stratigraphic input to
 - the Preliminary Stratigraphy Model/Report and an Advance Definition of Spatial Distribution of Stratigraphic Units;
 - the Preliminary Structural Model/Report and an evaluation of structural scenarios.
 - the Preliminary Geology Model/Report
 - Completion of drilling and preliminary analysis of hydrologic data of the SD-6/H-7 borehole for the Interim Saturated Zone Model;
 - Completion and analysis of about 60 to 70% of the SD boreholes for stratigraphic input to the Intermittent Stratigraphy Model/Report, Structural Model/Report, and the Geology Model/Report.
 - Completion and analysis of 100% of the SD boreholes for stratigraphic input to the Final Stratigraphy Model/Report, Structural Model/Report, and the Geology Model/Report.
- Depth Requirement:¹ To a depth of 325 ft (100 m) below the water table.
- Geologic Data Requirements:⁴ Continuous geologic log from the ground surface to TD.
- Drilling Method:⁴ Dry (within block).
- Minimum Borehole Size:⁴ The diameter required for acquiring geophysical logs: $\geq 5 \frac{1}{2}$ "
- Minimum Core Size:¹ NC or HQ core (2.4" diameter). Preferred core size is HQ
- Cored Interval:⁴ From ground surface to TD; at some locations, if geologic data from nearby holes are sufficient, the PI may identify only select portions of the borehole to be cored.
- Sample/Testing Requirements:^{1,5} Regularly spaced samples (about 8-inches long) of the core will be taken for the following tests:
 - Bulk density
 - Particle density

Porosity
Water content: gravimetric, volumetric
Matrix permeability: water saturated

Special Sample Handling Requirements:^{5,6} About one-quarter of the 8-inch sample is to be sealed in a metal can as quickly as possible at the well-head. The remaining portion is to be wrapped in saran wrap, weighed, placed in a lexan liner that is then capped and sealed, then sealed in ProtecCore, weighed, and refrigerated.

Equipment Required - to be Supplied by Participant:¹ N/A

Equipment Required - to be Supplied by Contractor:¹ Drill rig and associated materials for borehole construction.

Study Plan: 8.3.1.4.3.1 Systematic Acquisition of Site Specific Subsurface Information
WBS No.: 1.2.3.2.2.2.1 same

Principal Investigator/User: Chris Rautman, SNL

Requirements/Requests of Secondary Users:

Engineering Design:⁷

- Stratigraphic data (depth to stratigraphic contacts, rock quality data in the vicinity of drift interval) for SD boreholes along ESF alignment.

Air Permeability Testing:⁸

- Clean sides of borehole, with minimal clogging of fractures and the formation.
- Removal of drilling air from borehole prior to testing
- Injection of gas in selected intervals at a constant rate while monitoring transient pressure response.
- Tracer(s), different from that used in the drilling air, to be added to injected air.
- Electrical power to support trailer.
- Dry, filtered compressed air supply.
- Conduct tests after initial air and gas sampling has been completed, and before instrumentation of borehole for *in situ* UZ monitoring.

UZ instrumentation:⁸

- Borehole is drilled with air, using a drilling rig having dual-wall reverse circulation.
- Protection of UZ when drilling into water table
- Installation of long-term *in situ* monitoring equipment
- Installation of HDAS (hydrologic data acquisition system) with protective shelters for monitoring down-hole sensors.

Hydrochemical Characterization of the UZ:^{6,8,9,10}

- Monitoring of the input of tracer-tagged drilling air
- Dry-coring of samples
- Core samples (wrapped in saran wrap, weighed, placed in capped and sealed lexan liner, sealed in ProtecCore, weighed again, and refrigerated) from:
 - regularly spaced intervals of the tuff units
 - calcite-filled fractures and/or vugs
 - lithologic contacts
 - wet or moist zones.
- Removal of tracer-tagged drilling air from borehole following drilling, using a vacuum unit; and sampling of formation gases and water vapor:
- Installation of packer system to collect gas and water vapor samples from selected intervals, both before and after air permeability testing:
- Isolation of 8 to 16 selected intervals by the *in situ* instrumentation, and collection of gas samples about a year from these intervals.

Mineralogy/Petrology:^{4,11}

- Collect continuous core.
- In the non-welded to partially welded zones, with the exception of the thoroughly zeolitized Calico Hills unit, collect about a one-inch sample for every foot of sample taken for the UZ hydrochemistry study.

Alteration History and Transport Pathways:¹¹

- A portion of the selected fractures or contacts in the moderately to densely welded zones should not be packaged in saran wrap (lexan and protecCore is acceptable) so that the samples can be viewed.
- A portion of the calcite fractures, wet fractures, or cross-cutting fractures should not be packaged in saran wrap (lexan and protecCore is acceptable) so that the samples can be viewed.

Potentiometric Surface Measurement:¹²

- Measurement of water level when water is encountered during drilling and at completion of drilling. Measurement is to be made from a point for which a precise altitude is known or can be subsequently be measured.
- Measurement of water level in the borehole at least on a weekly basis until it has stabilized following drilling operations.
- Long-term monitoring of potentiometric surface.

Hydrochemistry of Saturated Zone:^{6,13}

- Collect 4 to 8 regularly spaced core samples from about 15 m above the water table to 15 m below the water table, regardless of the lithology, extent of welding, presence of fractures or lithologic contacts, or perceived moisture content of the core.
- Place core in properly cleaned lexan-type liner, cap and tape liner on both ends, place in ProtecCore.
- Collect water samples from any perched water encountered, and from below the water table, prior to introducing any tracers, fluids or materials into the borehole, other than those used in the drilling process.

Chlorine-36 (water movement tracer tests):¹⁴

- Dry drilling
- No tracers, fluids, or other materials, other than those specified in planning documents, can be introduced downhole prior to sample collection.
- Collect ream-bit cuttings from the same stratigraphic intervals from which core samples are specified for hydrochemical testing.
- If no hydrochemical samples are collected, collect cutting samples from the prescribed interval.
- Collect cuttings from a 0.5 to 1-ft-interval of ream-down; expected sample weight is 50 to 130 lbs.
- Collect additional cuttings from selected weathered fractures or fracture zones, as evidenced by iron staining in core, and determined by the drillsite geologist.

Geologic Model:⁴

- Continue coring through next major stratigraphic contact if within 50 to 100 ft.

ENVIRONMENTAL CONCERNS

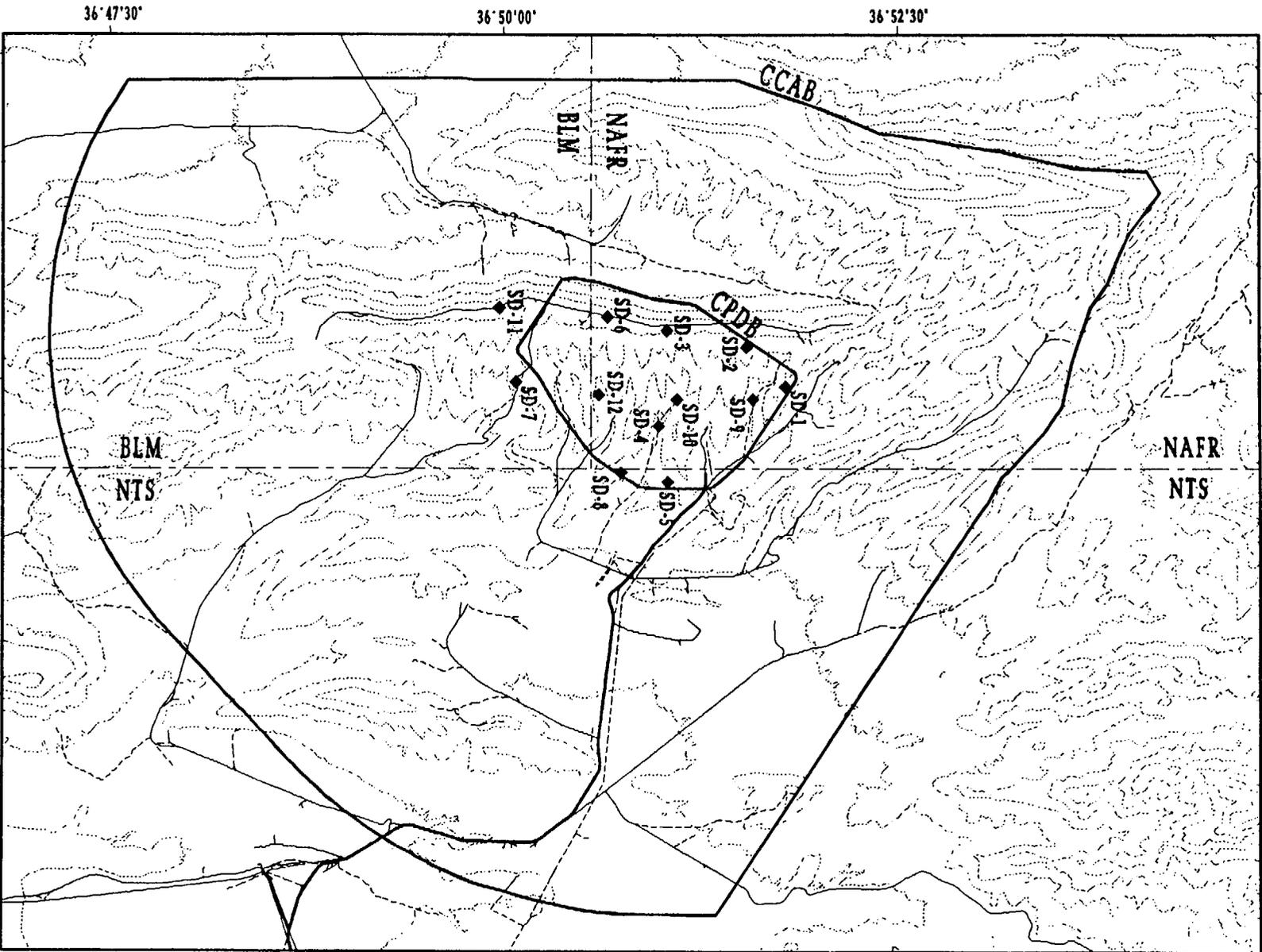
Use of Tracers:	-	Tracer will be added to drilling medium.
	-	Additional gas tracer(s) may be required for air permeability test, and water injection testing, if the borehole is utilized for UZ studies.
Emissions/Effluent:		
Water Discharge:	-	None anticipated for most of the SD boreholes. The exception is the combined USW SD-6/H-7 borehole, where long-term pump tests are planned.
Amount	-	Pumping may continue for several months at USW SD-6/H-7.
Rate	-	Up to 200 gal/min at USW SD-6/H-7.
Chemistry	-	TBD
Discharge Point	-	TBD
Will Study Intersect the Water Table?	-	Yes
Extent and Location of Ground Disturbance:		
Road Access	-	Dependent on specific borehole location.
Pad Construction:	-	Of sufficient dimension to position and drill with an LM-300 or Stratmaster drill rig, or a rig of comparable capability.

BOREHOLE PRIORITIZATION BY PRINCIPAL INVESTIGATOR
(as of September 8, 1993)¹⁵

USW SD-12
USW SD-9
USW SD-7
USW SD-6/H-7
UE-25 SD#8
USW SD-4
USW SD-2
USW SRG-5/SD-11
USW SD-3
USW SD-10
UE-25 SD#5
USW SD-1

Primary Sources of Information:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
2. Oral and written communication, ESF Design Group, M&O contractor, Yucca Mountain Project.
3. FY 1994 Draft Annual Plan, Site Characterization, Yucca Mountain Project, Appendix D, Preliminary Compilation of Level 2 and 3 Integrated Milestones for the Site Investigations Long-Range Plan, April 1993.
4. Drilling prioritization meetings, October and December, 1993, Las Vegas.
5. Letter from Christopher A. Rautman (SNL) to Russ Dyer (DOE-RSED), "Input to Test Planning Package for SRG-5/SD-11 Regarding Sample Packaging," June 4, 1993.
6. Letter from Robert Craig (USGS) to Heidi Lohn (SAIC), "Request for Input for Test Planning Package T-93-09," August 9, 1993.
7. "Recommended Drilling Program for the Proposed Enhanced ESF Topopah Springs Main Drift Design," by Robert Elayer, M&O/M-K, July 22, 1993.
8. USGS Criteria Letter dated July 22, 1992 (USGS-YMP-3343G-01-C4, R0) for drilling, testing, and instrumenting of UZ-14.
9. "Comments/Directions, Sample Request for USW SRG-5/SD-11," prepared by A. Yang, USGS.
10. Study Plan 8.3.1.2.2.3: "Characterization of the Yucca Mountain Unsaturated-Zone Percolation," R0, effective date: April 22, 1991.
11. Memorandum from Ron Oliver (LANL) to Russ Dyer (DOE-RSED), "Los Alamos National Laboratories Design and Test Related Input for Test Planning Package (TPP) T-93-09, USW SD-12," August 18, 1993.
12. Letter from Patrick Tucci (USGS) to Heidi Lohn (SAIC), reference to "Request for Input for Test Planning Package (TPP) T-93-09, USW SD-12 Drilling and Testing," August 2, 1993.
13. Workscope consolidation meeting, June 17, 1993, for planned FY'94 deep boreholes, Las Vegas.
14. Criteria Letter for "Collection of Ream-Bit Cuttings from DeepDry-Drilled Surface-Based Boreholes, Yucca Mountain, Nevada," June Fabryka-Martin, TWS-INC-9-02-93-07.
15. Facsimile transmission from Christopher A. Rautman (SNL) to Norma Biggar (M&O/WCFS), "Summary Description of Systematic Drilling Program," September 8, 1993.



E559245E
E550000N

E566601E
E550000N

N753950E
N4075000E

N702101E
N4080000E

YUCCA MOUNTAIN

SITE CHARACTERIZATION PROJECT

PLANNED SYSTEMATIC
DRILLING BOREHOLES

LEGEND

◆ Planned Borehole

N



Contour Interval 200 Feet

EG&G MAP-92-036.4

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-1

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N769,200/E561,300
UTM: N4,079,622/E548,391

Ground Elevation of Borehole (above sea level): About 4600 ft

Location Description: On Diabolis Ridge, just inside perimeter boundary, about 2200 ft east of the North Yucca Crest Road, about 1.9 mi. north of the junction of the Yucca Mountain Road on Highway Ridge with the Yucca Crest Road. See Comment (4), below.

Access to Location: Access is via North Yucca Crest Road; location will require construction of an access road from North Yucca Crest Road.

Rationale for Location: Located to obtain stratigraphic and structural data in the updip portion of the potential repository, in an area influenced by Drill Hole Wash to the north and a small northeast-trending fault to the west. Spatially located relative to boreholes UZ-14, SD-9, NRG-7, and SD-2. Can be used to assess the southward extent of perched water encountered in borehole G-1 (1400 ft to the north) and UZ-14 (2400 ft to the northwest). Located at a distance from the cliff face of Solitario Canyon in order that it may be minimally affected by the topography.

Borehole Dimensions

Planned Borehole Depth: About 2525 ft (about 325 ft below water table at 2400 ft elevation)

Elevation at Total Depth (above sea level):	2075 ft (628 m)
Planned Borehole Diameter:	≥ 5 1/2"
Planned Core Size:	2.4 inches (HQ core)

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry
Recommended Drill Rig:	Stratmaster or LM-300
Drilling Fluids:	Air
Tracers:	Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient for select stratigraphic intervals.
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A)
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	Continuous core
Testing & Sampling to be Conducted as Listed in Study Plan:	Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.
Testing & Sampling Currently Planned:	Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, <i>in situ</i> long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).

Borehole Instrumentation: Instrumented to measure potentiometric surface.

Borehole Construction Requirements: See introductory section for SD boreholes.

Environmental Prerequisites

Land Ownership: Air Force

Access: Field Work

Required Pre-Activity Surveys: See Appendix B

Estimated Amt. of Discharged Water: None anticipated, unless perched water zone is encountered.

Required Surface Preparation: Construction of a drill pad and an access road, possibly up to 2200 ft long, is required.

Anticipated Area of Surface Disturbance: TBD

Required Permits: (1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration

Borehole Closure Requirements: TBD

Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

- (1) The original location of the SD-1 borehole was at about NVSPC coordinates N768,220/E563,370, at the northeast edge of the repository block, south of the Drill Hole Wash structure, and spatially situated relative to the Exploratory "shaft" boreholes and SD-2 and SD-9 (Refs. 1, 5).
- (2) After the ESF became a ramp facility, SD-1 was proposed as a dual-purpose borehole with the ramp borehole NRG-6 (Ref. 4). This combined borehole concept was abandoned due to schedule restrictions in obtaining the ramp horizon data.
- (3) In June '93 the locations of three of the planned SD boreholes (SD-10, -11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The adjustment in the location of these three boreholes caused a shift in the locations of other SD boreholes in order to maintain a grid spacing for obtaining systematic data. As a result, the SD-1 borehole was moved to about N766,508/E565,000 (Ref. 2)
- (4) The location of SD-1 was shifted again in September '93 from that shown in Ref. 2 to its present location because: a) there are already other deep boreholes in Drill Hole Wash (G-1, UZ-14); b) due to the proximity of the former location of SD-1 (Ref. 2) to the existing NRG-6 borehole, NRG-6 could potentially be deepened to SD depth to accommodate SD data needs in that area; c) many SD boreholes (SD-9, -10, and -12) have been moved from their original ridge-top locations to valley bottoms for ease of access; therefore SD-1 was moved to a ridgetop location to obtain stratigraphic

and hydrologic data from the interval that is missing at the stream bottom locations; and d) it is desirable to obtain unsaturated zone hydrologic data from a ridge-top borehole, as many of the planned deep boreholes are located in valley bottoms. If it is not possible to deepen the NRG-6 borehole, the PI for the SD program may choose to locate an SD borehole in the vicinity of the coordinates indicated in Comment (3), above.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information;" Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-2

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N767,700/E559,800
UTM: N4,079,163/E547,936

Ground Elevation of Borehole (above sea level): About 4750 ft.

Location Description: On Yucca Crest, about 900 ft east of North Yucca Crest Road, 1300 ft northeast of borehole USW H-5, and 1 1/2 mi north of the intersection with the Yucca Mountain Road on Highway Ridge and the Yucca Crest Road.

Access to Location: Access is via the North Yucca Crest Road; location requires the construction of an access road about 800 ft long east from the road.

Rationale for Location: Half-grid location modified by topography, drift configuration, proximity to holes UZ-14, WT-9 (Ref. 2). Located at the northwest margin of the potential repository to provide control on the updip portion of the repository south of Drill Hole Wash. Location is spatially balanced against UZ-14 to the north (Ref. 4).

Borehole Dimensions

Planned Borehole Depth: About 2600 ft (325 ft below water table at 2480 ft elevation in borehole USW H-5 [Ref.3])

Elevation at Total Depth (above sea level): 2150 ft (651 m)

Planned Borehole Diameter: $\geq 5 \frac{1}{2}$ "; preferably $12 \frac{1}{4}$ " to accommodate the standard UZ *in situ* monitoring package.

Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry; dual-wall reverse circulation preferred.

Recommended Drill Rig: The LM-300 is preferred to allow instrumentation with the standard UZ *in situ* monitoring package. The Stratmaster drilling rig could potentially be used; it would create a borehole that requires instrumenting with a smaller monitoring package.

Drilling Fluids: Air

Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A)

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core.

Testing & Sampling to be Conducted as Listed in Study Plan: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); determine time variation of water table elevation, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, *in situ* long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).

Borehole Instrumentation: Instrumented to measure potentiometric surface.

Borehole Construction Requirements: See introductory section for SD boreholes.

Environmental Prerequisites

Land Ownership: Air Force

Access: Field Work

Required Pre-Activity Surveys: See Appendix B.

Estimated Amt. of Discharged Water: None anticipated, unless perched water zone is encountered.

Required Surface Preparation: Construction of a drill pad and an access road about 900 ft long is required.

Anticipated Area of Surface Disturbance: TBD

Required Permits: (1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration

Borehole Closure Requirements: TBD

Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

- (1) The location of the SD-2 borehole given in Refs. 1 and 5 was on a hillslope at the head of Wren Wash, at NVSPC coordinates N767,875/E560,665.
- (2) In June '93 the locations of three of the planned SD boreholes (SD-10, -11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The adjustment in the location of these three boreholes caused a shift in the locations of other SD boreholes in order to maintain a grid spacing for obtaining systematic data. As a result, the SD-2 borehole was moved to about N767,334/E559,352 (Ref. 2)
- (3) The location of SD-2 was shifted again in September '93 from that shown in Ref. 2 to its present location in order to (a) maintain an east-west alignment with SD-9, which was relocated into Wren Wash from its location given in Ref. 2 for logistical reasons, and (b) move the borehole as far as logistically possible from the Solitario Canyon face to minimize the effect of topography on hydrologic properties to be tested in the borehole.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.

2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993, Figure 1.3.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-3

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N764,610/E559,175
UTM: N4,078,221/E547,749

Ground Elevation of Borehole (above sea level): About 4725 ft

Location Description: On Yucca Crest, about 250 ft east of North Yucca Crest Road, 2000 ft south of borehole USW H-5, and 0.9 mi north of the intersection with the Highway Ridge Road and the crest road.

Access to Location: Location will require construction of an access road from North Yucca Crest Road.

Rationale for Location: Grid location modified by topography, drift configuration (Ref. 2). Located along the western margin of the repository to provide control on updip stratigraphy. Aligned parallel to dip with boreholes SD-10, -4, and -5 (Ref. 4).

Borehole Dimensions

Planned Borehole Depth: About 2500 ft (325 ft below water table at an elevation of 2540 ft. in borehole USW H-5 [Ref.3]) to 2650 ft (325 ft below water table at an elevation of 2400 ft. in boreholes USW H-3 and USW W-2 [Ref.3]).

Elevation at Total Depth (above sea level): 2075 to 2225 ft (628 to 674 m)

Planned Borehole Diameter: $\geq 5 \frac{1}{2}$ " ; preferably $12 \frac{1}{4}$ " to accommodate the standard UZ *in situ* monitoring package.

Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry; dual-wall reverse circulation preferred.

Recommended Drill Rig: The LM-300 is preferred to allow instrumentation with the standard UZ *in situ* monitoring package. The Stratmaster drilling rig could potentially be used; it would create a borehole that requires instrumenting with a smaller monitoring package.

Drilling Fluids: Air

Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A)

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core, vertical seismic profiling and seismic tomography between boreholes.

Testing & Sampling to be Conducted as Listed in Study Plan: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sample interval may change depending on rock properties.

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); determine time variation of water table elevation, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, *in situ* long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).

Borehole Instrumentation:	Instrumented to measure potentiometric surface.
Borehole Construction Requirements:	See introductory section for SD boreholes.

Environmental Prerequisites

Land Ownership:	Air Force
Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated, unless perched water zone is encountered.
Required Surface Preparation:	Construction of a drill pad and short road access is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

(1) The location of the SD-3 borehole given in Refs. 1 and 5 was about 200 ft northwest of its present location, at NVSPC coordinates N764,760/E559,345.

(2) In June '93 the locations of three of the planned SD boreholes (SD-10, -11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The adjustment in the location of these three boreholes caused a shift in the locations of other SD boreholes in order to maintain a grid spacing for obtaining systematic data. As a result, the SD-3 borehole was moved to its present location shown in Ref. 2.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.

4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-4
Type of Investigation: Systematic Drilling
WBS No.: 1.2.3.2.2.2.1
Study Plan No.: 8.3.1.4.3.1
Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information
Principal Organization: SNL
Principal Investigators: Chris Rautman
Other Participant Organizations: USGS, LANL
Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N764,265/E562,800
UTM: N4,078,120 / E548,854

Ground Elevation of Borehole (above sea level): About 4175 ft.

Location Description: Borehole is located in Split Wash, about 400 ft east of the main trace of the Ghost Dance fault.

Access to Location: Access is by the road up Split Wash, which turns off from the Met Tower Road, about 1/3 mi southwest of its intersection with Drill Hole Wash Road..

Rationale for Location: The borehole is paired with USW SD-10, which is located in the northeastern fork of Split Wash, about 600 ft west of the main trace of the Ghost Dance fault, in order to assess amount of structural throw and extent of lithologic change across the fault (Ref.2). Aligned with boreholes SD-3, -10, and -5 to be parallel to stratigraphic dip. See Comment 1.

Borehole Dimensions

Planned Borehole Depth: About 2100 ft (325 ft below the water table at 2400 ft elevation [Ref. 3])

Elevation at Total Depth (above sea level): 2075 ft (628 m)

Planned Borehole Diameter: $\geq 5 \frac{1}{2}$ "

Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry
Recommended Drill Rig: Stratmaster, or LM-300
Drilling Fluids: Air
Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II bore holes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Vertical seismic profiling and seismic tomography between boreholes; continuous core.

Testing & Sampling to be Conducted as Listed in Study Plan: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); unsaturated and saturated zone hydrochemistry, measurement of potentiometric surface, geologic framework-geologic model for repository block (USGS); mineralogy and petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).

Borehole Instrumentation: Instrumented to measure potentiometric surface.

Borehole Construction Requirements: See introductory section for SD boreholes.

Environmental Prerequisites

Land Ownership:	Air Force
Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated, unless perched water zone is encountered.
Required Surface Preparation:	Construction of a drill pad is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air, and (2) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

- (1) The present borehole location is very close to neutron boreholes N-31 and N-32; the potential of interfering with the monitoring being conducted in the neutron boreholes will require a review of the proposed location of the SD-4 borehole.
- (2) The location of the SD-4 borehole given in Refs. 1 and 4 was about 350 ft west of its present location and almost on the main trace of the Ghost Dance fault, at NVSPC coordinates N764,390/E562,375.
- (3) In June '93 the locations of three of the planned SD boreholes (SD-10, -11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The adjustment in the location of these three boreholes caused a shift in the locations of other SD boreholes in order to maintain a grid spacing for obtaining systematic data. Borehole SD-4 was moved to the east to its present location (Ref. 2), in order to both (a) maintain the grid spacing, and (b) maximize information on the offset of the Ghost Dance fault at depth, resulting in a shorten grid spacing between SD-4 and SD-10.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information", Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information", Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada", Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 SD#5
Type of Investigation: Systematic Drilling
WBS No.: 1.2.3.2.2.2.1
Study Plan No.: 8.3.1.4.3.1
Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information
Principal Organization: SNL
Principal Investigators: Chris Rautman
Other Participant Organizations: USGS, LANL
Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N764,630/E564,970
UTM: N4,078,233/E549,515

Ground Elevation of Borehole (above sea level): About 4025 ft

Location Description: The borehole is located about 1500 ft west of the Drillhole Wash Road, in a short drainage that joins Drillhole Wash in the vicinity of boreholes UE-25 UZNC #1 and #2, and UE-25a #1.

Access to Location: Access will need to be developed. A trail is shown in the small drainage on topo maps, but it does not directly connect with the Drillhole Wash Road.

Rationale for Location: Half-grid location modified by topography, drift configuration (Ref 2). Located on the eastern margin of the repository to provide downdip control on stratigraphy. Aligned parallel to stratigraphic dip with boreholes SD-3, -10, and -4. This region is the closest approach of the conceptual design repository to the water table, in a region of dominant zeolitic materials in the tuffaceous beds of Calico Hills. It is important to understand the zeolitic/vitric transition and the specific thicknesses of the various units between the disturbed area around the repository and the water table in this region (Ref. 4).

Borehole Dimensions

Planned Borehole Depth: About 1950 ft (325 ft below water table at 2400 ft elevation [Ref. 3]).

Elevation at Total Depth (above sea level): 1950 ft (590 m)

Planned Borehole Diameter: $\geq 5 \frac{1}{2}$ " ; preferably $12 \frac{1}{4}$ " to accommodate the standard UZ *in situ* monitoring package.

Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry; dual-wall reverse circulation preferred.

Recommended Drill Rig: The LM-300 is preferred to allow instrumentation with the standard UZ *in situ* monitoring package. The Stratmaster drilling rig could potentially be used; it would create a borehole that requires instrumenting with a smaller monitoring package.

Drilling Fluids: Air

Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:
Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling to be Conducted as Listed in Study Plan:
Continuous core

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of the potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests,

in situ long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).

Borehole Instrumentation:

Instrumented to measure potentiometric surface.

Borehole Construction Requirements:

See introductory section for SD boreholes.

Environmental Prerequisites**Land Ownership:**

NTS

Access:

Field Work

Required Pre-Activity Surveys:

See Appendix B

Estimated Amt. of Discharged Water:

None anticipated, unless perched water zone is encountered.

Required Surface Preparation:

Construction of a drill pad and road access is required.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

(1) The SD-5 borehole location in the SCP was to the south of Split Wash, equally spaced among planned borehole SD-4, the borehole complex around UZ-9, and the exploratory shaft boreholes (Ref. 5).

(2) The location of the SD-5 borehole was moved to its present location in the drainage north of Split Wash to improve areal coverage after the elimination of the shaft boreholes, and to establish, with boreholes SD-3 and -4, an east-west alignment of the grid (Refs. 1 and 2).

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.

3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-6/H-7

Type of Investigation: Systematic Drilling / Hydrology

WBS No.: 1.2.3.2.2.2.1 / 1.2.3.3.1.3.1

Study Plan No.: 8.3.1.4.3.1 / 8.3.1.2.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information / Characterization of the Saturated-Zone Ground-Water Flow System.

Principal Organization: SNL / USGS

Principal Investigators: Chris Rautman / Dick Luckey

Other Participant Organizations: LANL

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis, and to assess the change of hydrologic parameters across the Solitario Canyon fault.

Location

Coordinates: NVSPC: N762,290/E558,650
UTM: N4,077,514/E547,591

Ground Elevation of Borehole (above sea level): About 4900 ft

Location Description: On the Yucca Crest Road (east of the Solitario Canyon fault), about 1/2 mi. north of the intersection of the Highway Ridge Road and Yucca Crest.

Access to Location: Access is by Yucca Crest Road.

Rationale for Location: This is a dual-purpose borehole, combining an SD borehole with a planned borehole for the saturated zone testing program. For the SD program, the location is a grid location modified by topography, drift configuration, proximity to holes WT-8, H-7 (Ref. 2). The location provides updip control on stratigraphy of repository block, and is aligned with SD-8 and -12, parallel to the stratigraphic dip. The borehole is also targeted to explore the vitric-to-zeolite transition within the tuffs of Calico Hills; this transition is essentially unknown in this portion of the repository block (Ref. 4). For the saturated zone studies, the location is at a minimal distance east of the fault, on Yucca Crest, and aligned with boreholes USW H-6 and USW WT-8.

Borehole Dimensions

Planned Borehole Depth:	About 3100 ft (midway to three-fourths of the distance through the Tram Member, Ref. 6) to 4000 ft (Ref. 7).
Elevation at Total Depth (above sea level):	1800 ft (545 m)
Planned Borehole Diameter:	$\geq 5 \frac{1}{2}$ "; diameter of 8.75" given in Ref. 6 for borehole H-7; diameter of $9 \frac{7}{8}$ " given in Ref. 7 for borehole H-7.
Planned Core Size:	2.4 inches (HQ core)

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry
Recommended Drill Rig:	Stratmaster or LM-300
Drilling Fluids:	Air
Tracers:	Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment, gas sampling equipment and containers, tracer gas injection and monitoring equipment, submersible pump, generator to operate pump, discharge line or alternative means of water disposal, access tubing and screens, gas and water sampling equipment and containers, packers for gas and water sampling, water level monitoring equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core from surface to about 325 ft below the water table, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals. Selectively core intervals below the water table to characterize stratigraphy (Ref. 8).
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	<u>For USW SD-6:</u> vertical seismic profiling and seismic tomography between boreholes; continuous core. <u>For USW H-7:</u> 1) Borehole flow survey; 2) pump test conducted in conjunction with USW H-6, pumping on H-6

at ~400 GPM while monitoring H-7; reverse pumping at ~400 GPM on H-7 while monitoring H-6. Continuous core required for systematic drilling program overlap; cuttings and water samples from completed test hole.

Testing & Sampling to be Conducted as Listed in Study Plan:

For SD-6: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sample interval may change depending on rock properties.

For H-7: geophysical logging, water sampling and analysis, hydraulic tests (tracer injection survey, long-term pumping tests up to 30 days duration, pumping at about 15 liters/second [400 gal/min], possibly single-well pump tests, and large-scale tracer tests).

Testing & Sampling Currently Planned:

Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); pump tests to monitor response in borehole USW H-6, measurement of potentiometric surface, unsaturated and saturated zone hydrochemistry, geologic framework-geologic model for repository block (USGS); mineralogy and petrology in the upper 3000 ft, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).

Borehole Instrumentation:

After pumping tests to measure hydrologic properties, boreholes will be instrumented to measure potentiometric surface.

Borehole Construction Requirements:

See introductory section for H boreholes.

Environmental Prerequisites

Land Ownership:

Air Force

Access:

Field Work

Required Pre-Activity Surveys:

See Appendix B

Estimated Amt. of Discharged Water:

Pump tests, pumping at a rate TBD (likely ≤ 500 gal/min), may be conducted for a duration of several months (Ref. 6).

Required Surface Preparation:

Construction of a drill pad is required.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracers added to drilling air, (2) additional tracers may be used for hydrologic tests, (3) intersection of water table, and (4) water discharge.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

(1) The location of the SD-6 borehole given in the SCP (Ref. 5) was directly south of SD-3, to provide areal coverage among planned deep boreholes SD-3, -4, H-7, WT-8, UZ-2 and -3 and UZ-7 and -8.

(2) The location shown in Ref. 1 for the borehole is farther west relative to SD-3, at about coordinates N762,230/E559,375, on a steep hillslope about 800 ft east of Yucca Crest.

(3) During the drilling prioritization meetings in Las Vegas in October and December 1992, the PIs for the Systematic Drilling and Hydrology drilling programs agreed to combine boreholes SD-6 and H-7 and locate the borehole on Yucca Crest, as close as possible to the Solitario Canyon fault.

(4) In June 1993 the locations of three of the planned SD boreholes (SD-10, -11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The adjustment in the location of these three boreholes caused a shift in the locations of other SD boreholes in order to maintain a grid spacing for obtaining systematic data. This re-alignment of the SD boreholes supported the present crest location that was proposed for the combined SD-6/H-7 borehole.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1.
6. Study Plan 8.3.1.2.3.1: "Characterization of the Saturated-Zone Ground-Water Flow System," Rev. 0, Effective date: February 26, 1991.
7. 1992 drilling prioritization meetings, October and December, 1992, Las Vegas.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-7

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL, M&O

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N758,800/E561,100
UTM: N4,076,452/E548,341

Ground Elevation of Borehole (above sea level): About 4525 ft.

Location Description: Adjacent to and on the north side of the Yucca Mountain Road up Highway Ridge, about 1000 ft northwest of borehole USW UZ-N66, and about 0.6 mi. east of the intersection of the road with the Yucca Crest Road. Located at the southeastern extent of the repository block, just outside of the Conceptual Controlled Area Boundary.

Access to Location: Access is by Yucca Mountain Road on Highway Ridge.

Rationale for Location: Half-grid location modified by topography, drift configuration, and proximity to holes UZ-2, -3 -7 (Ref. 2). This borehole is essentially the only deep borehole that is located on a ridge crest and at a distance from the Solitario Canyon scarp. This borehole will encounter close to the entire thickness of the Tiva Canyon Member tuff before drilling into the nonwelded interval above the Topopah Spring Member. This configuration is essential to testing certain hypotheses regarding infiltration into Yucca Mountain, lateral flow at stratigraphic unit contacts and consequent flux through the repository host rock itself. Hydrologic variables, such as saturation, measured in this configuration may be critical to understanding the initial amounts of water available to participate in convection cells induced by the thermal load of the repository. A ridge-top location was also selected to examine the hydrologic properties of a deep borehole that is not located in a wash (Ref. 4).

Borehole Dimensions

Planned Borehole Depth:	About 2450 ft (325 ft below water table at elevation 2400 ft in boreholes USW H-3 and USW W-2 [Ref. 3]).
Elevation at Total Depth (above sea level):	2075 ft (628 m)
Planned Borehole Diameter:	$\geq 5 \frac{1}{2}$ "; preferably $12 \frac{1}{4}$ " to accommodate the standard UZ <i>in situ</i> monitoring package.
Planned Core Size:	2.4 inches (HQ core)

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry; dual-wall reverse circulation is preferred.
Recommended Drill Rig:	The LM-300 drill rig is preferred to allow instrumentation with the standard UZ <i>in situ</i> monitoring package. The Stratmaster drill rig could potentially be used; it would create a borehole that requires instrumenting with a smaller monitoring package.
Drilling Fluids:	Air
Tracers:	Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	Vertical seismic profiling and seismic tomography between boreholes; continuous core.
Testing & Sampling to be Conducted as Listed in Study Plan:	Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling Currently Planned:	Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, <i>in situ</i> long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL); stratigraphy and rock mass properties (M&O).
Borehole Instrumentation:	Instrumented to measure potentiometric surface.
Borehole Construction Requirements:	See introductory section for SD boreholes.

Environmental Prerequisites

Land Ownership:	BLM
Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated, unless perched water zone is encountered.
Required Surface Preparation:	Construction of a drill pad and short road access is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

- (1) The location of the SD-7 borehole given in Refs. 1 and 5 was about 350 ft to the south of the present location, on a hillslope on the south side of the Yucca Mountain Road on Highway Ridge, at NVSPC coordinates N758,605/E561,060.
- (2) In June '93 the locations of three of the planned SD boreholes (SD-10, -11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The adjustment in the location of these three boreholes caused a shift in the

locations of other SD boreholes in order to maintain a grid spacing for obtaining systematic data. As a result, the SD-7 borehole was moved northwest to about N759,855/E560,585 (Ref. 2) to maintain equal spacing between boreholes SD-11 and SD-12.

(3) The location of SD-7 was shifted again in September '93 from that shown in Ref. 2 to its present location for (a) ease of access, and (b) to obtain hydrologic data from the unsaturated zone from a ridgetop location.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 SD#8

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N762,800/E564,600
UTM: N4,077,675/E 549,404

Ground Elevation of Borehole (above sea level): About 4100 ft

Location Description: The planned borehole location is on the south slope of a small drainage that is parallel to and about 800 ft south of Split Wash. It is about 1000 ft west of seismic hole US-25 #1, and 800 ft west of borehole UE-25 UZN #29.

Access to Location: There are no trails or roads shown to this location on the EG&G topographic maps (scale 1:6000). The closest road access is the road up Split Wash.

Rationale for Location: Grid location modified by topography, drift configuration (Ref. 2). Located at the downdip margin of the repository block to provide structural and stratigraphic control. Aligned with SD-6 and -12 boreholes, and at an intermediate location between UZ-7 and SD-5 (Ref. 4).

Borehole Dimensions

Planned Borehole Depth: About 2025 ft (325 ft below water table at an elevation of 2400 ft [Ref. 3])

Elevation at Total Depth (above sea level): 2075 ft (628 m)

Planned Borehole Diameter: > 5 1/2"

Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry

Recommended Drill Rig: Stratmaster or LM-300

Drilling Fluids: Air

Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core.

Testing & Sampling to be Conducted as Listed in Study Plan: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); unsaturated and saturated zone hydrochemistry, measurement of potentiometric surface, geologic framework-geologic model for repository block (USGS); mineralogy and petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).

Borehole Instrumentation: Instrumented to measure potentiometric surface.

Borehole Construction Requirements: See introductory section for SD boreholes

Environmental Prerequisites

Land Ownership: NTS

Access: Field Work

Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated, unless perched water zone is encountered.
Required Surface Preparation:	Construction of a drill pad and road access of about 1200 ft length are required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air, and (2) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

- (1) In the SCP, borehole SD-8 was part of a cluster of SD and UZ boreholes located in the vicinity of the UZ-16/UZ-9 complex, to test small-scale lateral variability for the geostatistical analysis (Ref. 5). This location was about 200 east of borehole USW H-4, directly outside of the Conceptual Perimeter Drift Boundary, at NVSPC coordinates N761,415/E564,010.
- (2) The borehole was moved to N762,487/E564,537, close to its present location, in the study plan (Ref. 1 and 2) where the approach to data collection was shifted from the borehole cluster that resulted in a spatial bias of the SD/UZ programs, outside of the repository area, to a more areal coverage represented by a grid layout (Ref. 4).
- (3) The location of SD-2 was shifted about 300 ft downslope in September '93 to its present location that is more accessible for a drilling rig (Ref. 6).

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-9

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL, M&O

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N767,950/E561,800
UTM: N4,079,241/E548,545

Ground Elevation of Borehole (above sea level): About 4260 ft.

Location Description: The planned location of the borehole is in Wren Wash, about 0.4 mi west of the intersection of the Wren Wash road with the Drill Hole Wash. It is about 300 ft west of neutron boreholes USW UZN-48 and -49.

Access to Location: The location is accessible by the road up Wren Wash.

Rationale for Location: Grid location modified by topography, drift configuration, and locations of adjacent boreholes (Ref. 2). Located at the northern portion of the potential repository block to provide stratigraphic control south of the Drill Hole Wash fault zone, which isolates a series of borehole in the wash from the repository block proper. The borehole is spaced relative to borehole NRG-7, which is also south of the main trace of the fault interpreted in the wash. The borehole is expected to confirm that tuffs of the Calico Hills are entirely zeolitic, as suggested by the G-4/G-1 borehole data (Ref. 4). The borehole was moved closer to the ESF drift alignment from its previous location in order to acquire engineering design data.

Borehole Dimensions

Planned Borehole Depth: About 2175 ft (325 ft below water table at an elevation of 2400 ft [Ref. 3]).

Elevation at Total Depth (above sea level): 2085 ft (631 m)

Planned Borehole Diameter: > 5 1/2"; preferably 12 1/4 " to accommodate the standard UZ *in situ* monitoring package.

Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry; dual-wall reverse circulation preferred

Recommended Drill Rig: The LM-300 is preferred to allow instrumentation with the standard UZ *in situ* monitoring package. The Stratmaster drilling rig could potentially be used; it would create a borehole that requires instrumenting with a smaller monitoring package.

Drilling Fluids: Air

Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core.

Testing & Sampling to be Conducted as Listed in Study Plan: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of the potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, *in situ* long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology,

fracture mineralogy and alteration history, chlorine-36 analyses (LANL); stratigraphy and rock quality data (M&O).

Borehole Instrumentation: Instrumented to measure potentiometric surface.

Borehole Construction Requirements: See introductory section for SD boreholes.

Environmental Prerequisites

Land Ownership: Air Force

Access: Field Work

Required Pre-Activity Surveys: See Appendix B

Estimated Amt. of Discharged Water: Construction of a drill pad and improvement of the road in Wren Wash is required.

Required Surface Preparation: None anticipated, unless perched water zone is encountered.

Anticipated Area of Surface Disturbance: TBD

Required Permits: (1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration

Borehole Closure Requirements: TBD

Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

(1) In the SCP, borehole SD-9 was part of a cluster of SD and UZ boreholes located in the vicinity of the UZ-16/UZ-9 complex, to test small-scale lateral variability for the geostatistical analysis (Ref. 5). This location was about 800 southeast of borehole USW H-4, outside of the Conceptual Perimeter Drift Boundary, at NVSPC coordinates N761,160/E564,625.

(2) The borehole was moved north (close to its present location), to be spatially located between the ESF shafts and SD-2 and -3, in the study plan (Ref. 1). At that time, the approach to data collection was shifted from the borehole cluster that resulted in a spatial bias of the SD/UZ programs, outside of the repository area, to a more areal coverage represented by a grid layout (Ref. 4).

(3) The borehole location was moved again to about coordinates N768,000/E561,750 in June 1993 when the locations of three of the planned SD boreholes (SD-10, -11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes had been relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The adjustment in the location of these three boreholes caused a shift in the locations of other SD boreholes in order to maintain a grid spacing for obtaining systematic data (Ref. 2).

(4) The location of SD-9 was shifted again in August 1993 from that shown in Ref. 2 to its present location in order to move it (a) downslope to a more accessible location for a drilling rig, and (b) closer to the main north-south drift of the enhanced ESF design.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-10

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL, M&O

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N765,500/E561,800
UTM: N4,078,591/E548,549

Ground Elevation of Borehole (above sea level): About 4250 ft.

Location Description: In the northern tributary to Split Wash, about 1300 ft or existing neutron boreholes USW UZN-48, and -49, and 1.1 miles from the Met Tower Road.

Access to Location: Access is via a road up Split Wash to the neutron boreholes. An overgrown trail continues from the neutron boreholes to the planned SD-10 location.

Rationale for Location: Grid location modified by topography, drift configuration; also located and paired with SD-4 to provide stratigraphic and structural control along the main drift alignment and offset across the Ghost Dance fault (Ref. 2). Located to evaluate a structural low in the TSw1/TSw2 contact generated by the three-dimensional computer model of Ortiz et al. (Ref.4).

Borehole Dimensions

Planned Borehole Depth: About 2175 ft (325 ft below water table at 2400 ft elevation [Ref. 3]).

Elevation at Total Depth (above sea level): 2075 ft (628 m)

Planned Borehole Diameter: > 5 1/2"; preferably 12 1/4 " to accommodate the standard UZ *in situ* monitoring package.

Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry, dual-wall reverse circulation preferred.

Recommended Drill Rig: The LM-300 is preferred to allow instrumentation with the standard UZ *in situ* monitoring package. The Stratmaster drilling rig could potentially be used; it would create a borehole that requires instrumenting with a smaller monitoring package.

Drilling Fluids: Air

Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Vertical seismic profiling and seismic tomography between holes; continuous core.

Testing & Sampling to be Conducted as Listed in Study Plan: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of the potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, *in situ* long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL); stratigraphy and rock quality data (M&O).

Borehole Instrumentation: Instrumented to measure potentiometric surface.

Borehole Construction Requirements: See introductory section for SD boreholes

Environmental Prerequisites

Land Ownership:	Air Force
Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated, unless perched water zone is encountered.
Required Surface Preparation:	Construction of a drill pad and an access road about 1000 ft long, and improvement of existing road in Split Wash will be required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

(1) In the SCP (Ref. 5) and Ref. 1, borehole SD-10 was part of a cluster of SD and UZ boreholes located in the vicinity of the UZ-16/UZ-9 complex, to test small-scale lateral variability for the geostatistical analysis. This location was about 1200 ft west of borehole USW UZ-16, at NVSPC coordinates N760,781/E563,610, outside of the Conceptual Perimeter Drift Boundary.

(2) The borehole was moved in June 1993 (Ref. 2) when the location of SD-10 and two other of the planned SD boreholes (SD-11, and -12) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design. The coordinates for the new location shown in Ref. 2 were about N764,387/E561,493.

(3) The location of SD-10 was shifted 500 ft to the northeast from that shown in Ref. 2 to its present location in July 1993 in order to move it from a narrow ridgetop location to a location that is (a) more accessible for a drilling rig and (b) within 500 ft of the enhanced ESF main drift alignment.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.

3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SRG-5/SD-11

Type of Investigation: ESF Ramps / Systematic Drilling

WBS No.: 1.2.3.2.6.2.1 / 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.14.2.1 / 8.3.1.4.3.1

Study Plan Title: Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities / Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Dave Kessel / Chris Rautman

Other Participant Organizations: USGS, LANL, M&O

Purpose of Activity: To provide soil and rock information for design and construction of the ESF Ramps and Main Test Level; and to acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N758,175/E558,315
UTM: N4,076,259/E547,493

Ground Elevation of Borehole (above sea level): About 4880 ft. (1478 m)

Location Description: On the South Yucca Crest Road, about 0.4 mi south of the intersection of the Yucca Mountain Crest Road on Highway Ridge with the South Yucca Crest Road.

Access to Location: Access is by the existing South Yucca Crest Road.

Rationale for Location: For SRG-5: Originally, the borehole was located to constrain transition from south ramp to main drift alignments by providing stratigraphic and structural information at the juncture of the two drifts and near the highest absolute elevation to be encountered in the conceptual repository block (Ref. 1). In the enhanced ESF design, the borehole provides stratigraphic control at the western end of the south ramp extension.
For SD-11: The borehole is situated at a half-grid location modified by topography, drift configuration (Ref. 1). Also, the borehole will provide critical information regarding the vitric/zeolitic transition in the tuffs of Calico Hills and the respective thicknesses of each. There is currently no data on this transition between boreholes G-4 and GU-3 (Ref. 2).

Borehole Dimensions

Planned Borehole Depth:	About 2665 ft to 2800 ft (812 m to 853 m): either 325 ft below water table at an elevation of (1) 2540 ft. in borehole USW H-5, <u>or</u> (2) 2400 ft. in boreholes USW H-3 and USW W-2 (Ref.3).
Elevation at Total Depth (above sea level):	2080 to 2215 ft (630 to 670 m)
Planned Borehole Diameter:	> 5 1/2"
Planned Core Size:	2.4 inches (HQ core)

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry
Recommended Drill Rig:	Stratmaster, or the LM-300
Drilling Fluids:	Air
Tracers:	Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	<u>For SD-11:</u> vertical seismic profiling and seismic tomography between holes; continuous core. There was no entry for borehole USW SRG-5 in the SBIP.
Testing & Sampling to be Conducted as Listed in Study Plan:	<u>For SRG-5:</u> Collect core for stratigraphic and structural data and laboratory analyses, preliminary evaluation of physical, mechanical, and dynamic soil and rock properties; and collect geophysical logs of borehole. <u>For SD-11:</u> Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling

	interval may change depending on rock properties.
Testing & Sampling Currently Planned:	<u>SRG-5:</u> Continuous core, description and laboratory analysis of physical, mechanical, and thermal properties of the stratigraphic interval of interest to ESF/repository design (SNL/M&O); matrix hydrologic properties and hydrochemistry of the unsaturated zone (USGS). <u>SD-11:</u> Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of the potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, <i>in situ</i> long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL).
Borehole Instrumentation:	Instrumented to measure potentiometric surface.
Borehole Construction Requirements:	See introductory sections on SD boreholes.
<u>Environmental Prerequisites</u>	
Land Ownership:	BLM
Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated, unless perched water zone is encountered.
Required Surface Preparation:	Construction of a drill pad is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air, and (2) intersection of water table.
<u>Restoration</u>	
Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD
<u>Comments:</u>	

(1) In the SCP (Ref. 5) and Ref. 1, borehole SD-11 was part of a cluster of SD and UZ boreholes located in the vicinity of the UZ-16/UZ-9 complex, to test small-scale lateral variability for the geostatistical analysis. This location was about

700 ft west of borehole USW UZ-16, at NVSPC coordinates N760,670/E564,132, outside of the Conceptual Perimeter Drift Boundary.

(2) During the drilling prioritization meetings in Las Vegas in October and December 1992, there was discussion of combining an SD borehole with the SRG-5 ramp borehole located at the intersection of the main ESF drift and the south ramp.

(3) A work scope consolidation meeting was held in February, 1993 in Las Vegas for a combined SRG-5/SD-11 borehole at the present SD-11 location (Ref. 2).

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SD-12

Type of Investigation: Systematic Drilling

WBS No.: 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.4.3.1

Study Plan Title: Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL

Principal Investigators: Chris Rautman

Other Participant Organizations: USGS, LANL, M&O

Purpose of Activity: To acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N761,950/E561,587
UTM: N4,077,413/E548,487

Ground Elevation of Borehole (above sea level): About 4330 ft.

Location Description: The planned borehole is located in the drainage directly north of Whaleback Ridge, about 700 ft west-southwest of borehole USW UZN-35, and 3400 ft west-northwest of the USW UZ-16 borehole.

Access to Location: There is road access to the N-35 borehole location via the Met Tower Road to UZ-16, and the road to the south of Antler Ridge. Access to the SD-12 borehole will need to be constructed west from borehole N-35.

Rationale for Location: Half-grid location modified by topography, drift configuration; borehole is located to provide geologic and engineering data along the main drift alignment (Ref. 2). Aligned with boreholes SD-6 and -8, parallel to the stratigraphic dip across the repository block. Location allows development of pre-drift monitoring of *in situ* conditions and the monitoring of changes in those conditions as the drift is excavated (Ref. 4).

Borehole Dimensions

Planned Borehole Depth: About 2260 ft (689 m); at 325 ft below water table at 2400 ft elevation in borehole USW WT-2 [Ref. 3].

Elevation at Total Depth (above sea level): 2070 ft (627 m)

Planned Borehole Diameter: 12 1/4"
Planned Core Size: 2.4 inches (HQ core)

Schedule

Scheduled Start Date: FY'94
Scheduled Completion Date: FY'94

Drilling and Construction

Drilling Method: Dry, with dual-wall reverse circulation
Recommended Drill Rig: LM-300
Drilling Fluids: Air
Tracers: Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.

Geophysical Logging: Geophysical logs identified for Group II bore holes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core.

Testing & Sampling to be Conducted as Listed in Study Plan: Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.

Testing & Sampling Currently Planned: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of the potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, *in situ* long-term monitoring), geologic framework-geologic model for repository block (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL); stratigraphy and rock quality data (M&O).

Borehole Instrumentation: Instrumented to measure potentiometric surface.

Borehole Construction Requirements: See introductory section for SD boreholes.

Environmental Prerequisites

Land Ownership:	Air Force
Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated, unless perched water zone is encountered.
Required Surface Preparation:	Construction of a drill pad and an access road about 700 ft long is required. The road west of the UZ-16 borehole will also need to be upgraded.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracers added to drilling air, (2) additional tracers if air permeability and water injection tests are conducted; and (3) intersection of water table.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

- (1) In the SCP (Ref. 5), borehole SD-12 was part of a cluster of SD and UZ boreholes located in the vicinity of the UZ-16/UZ-9 complex, to test small-scale lateral variability for the geostatistical analysis. This location was about 800 ft southwest of borehole USW UZ-16, about at NVSPC coordinates N760,030/E564,260, outside of the Conceptual Perimeter Drift Boundary.
- (2) In Ref. 1, the borehole was moved to the northwest and aligned between boreholes SD-6 and -8, not far from its present location.
- (3) The borehole was moved in June '93 to about N762,350/E560,250 (Ref. 2) when the location of SD-12 and two other of the planned SD boreholes (SD-10, and -11) were adjusted to be coincident with the main ESF drift. These boreholes were relocated to become dual-purpose boreholes and to be used to acquire engineering data for ramp/drift design.
- (4) The location of SD-12 was shifted 1500 ft to the east from that shown in Ref. 2 to its present location in July 1993 in order to move it from a narrow ridgetop to (a) a location more accessible for a drilling rig and (b) within 500 ft of the enhanced ESF main drift alignment.

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev. 0, December 2, 1992.
2. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information," Rev.1, effective date, June 14, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
5. Department of Energy, 1988, Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada, DOE/RW-0199, Vol. IV, Part B, Section 8.3.1.4.3.1.1

REQUIREMENTS FOR DRILLING/TESTING

ESF RAMP (NRG/SRG) BOREHOLES

Requirements of Primary User:

Overall Objectives:¹ - To obtain geologic and rock properties data of the planned Exploratory Studies Facility (ESF) and repository horizon(s) along the ramps and drifts of the (ESF) to assist engineers in designing the ramp, rock supports, and anticipated Tunnel Boring Machine (TBM) performance.

Location Requirement:¹ - The boreholes are planned along the surface projection of the underground ESF ramps and drifts.
- The boreholes must be located at least 15 m (50 ft) laterally from the underground alignment,²
- Borehole SRG-1, at the portal location, will be drilled directly on the ramp alignment.³
- If possible, the boreholes are to be situated on the same side of the ESF tunnel as the muck conveyor belt. Therefore, for the north and south ramps, the boreholes will be located at the inside of the curve, i.e., south of the north ramp and north of the south ramp.⁴

Schedule Requirement: Engineering Design Packages:⁵
- Acquisition of stratigraphic and rock quality data (visual field inspection as well as laboratory analyses) from the ramp and drift horizons in:
- Borehole NRG-7 for ESF Design Package 2c for the North Ramp; current due date for data input to the 90% design review package is February 28, 1994.
- Borehole SRG-4 for ESF Design Package 8A for the Main Drift; current due date for data input for the 50% design package is October 17, 1994; the 90% design review package is due March 14, 1995.
- Boreholes SRG-1, -2, -3, and -4 for ESF Design Package 4 for the South Ramp; current due date for data input for the 50% design package is May, 1995; the 90% design review package is due October, 1995.
- The laboratory analyses of drill core samples are available about 3 to 4 months after the core comes out of the ground.

Site Characterization Goals:

- These boreholes are scheduled for completion in early FY'95, prior to the development of the Preliminary Stratigraphic, Structural, and Geologic Models/Reports.

Depth Requirement:¹ - Minimum depth requirement is for drilling to continue to at least one recognizable stratigraphic contact below the expected ramp or drift interval.
- For the deeper ramp and the main drift boreholes, minimum depth requirement is penetration of the TSw2/TSw3 contact or another recognizable stratigraphic contact.

Geologic Data Requirements:¹ - Stratigraphic information along the ramps and drifts.
- Rock quality sampling and testing for every geologic unit through which the ESF ramp/drift will be excavated, including the interval from at least 30 ft above the highest possible rock crown to at least 30 ft below the lowest possible ramp invert.
- Stratigraphic information and contacts for the TSw1, TSw2, and TSw3 thermal mechanical units at the junctions of the ramps with the main drift to define the stratigraphic limits of the ESF and repository.
- A continuous measure of rock mass classification through the entire thickness of TSw1, TSw2, and TSw3 at the junctions of the ramps with the main drift.

- Geologic and rock structure logs that include:³
 - core run intervals
 - percent recovery
 - run RQD
 - RQD per 10-ft sections
 - fracture descriptions
 - fractures per 10-ft sections
 - hardness estimate
 - weathering description
 - percent lithophysae
 - graphic lithology log
 - lithologic description and stratigraphy
- Continuous geophysical logs from the ground surface to TD are recommended.
- Laboratory measurement of:
 - uniaxial compression
 - triaxial compression
 - Brazilian tensile
 - physical properties (density, moisture content, porosity)
 - thermal properties (thermal conductivity, heat capacity, coefficient of thermal expansion)

Drilling Method:	Utilization of a method that permits collection of core at specified depths.
Minimum Borehole Size:	Of sufficient diameter to run the geophysical logs selected by YMPO for ramp boreholes.
Minimum Core Size:	NQ core (1 7/8"). ³ PQ core (3 11/32") is preferred in order to standardize the size of the ramp boreholes, facilitate the collection of geophysical logs, and maximize potential future use of the borehole for instrumentation. ⁶
Cored Interval: ^{3, 7, 8}	<ul style="list-style-type: none"> - For the shallow ramp boreholes: from ground surface to TD. - For those boreholes of intermediate depth along the ramp alignments: from about 25 ft above an anticipated, recognizable, stratigraphic contact that is at least 25 ft above the ramp interval, to about 25 ft below an anticipated, recognizable stratigraphic contact below the ramp interval. - For boreholes providing design data for tunnel intervals within or approaching the targeted Topopah Springs tunnel intervals: from 50 ft above the estimated TSw1/TSw2 contact to about 100 ft below the TSw2/TSw3 contact - If the decision is made to construct the Calico Hills drift of the ESF, the desired cored interval is from about 10 ft above the estimated TSw2/TSw3 contact through the entire Calico Hills stratigraphic unit, to 25 ft below the Calico Hills/Prow Pass contact.⁸ - If the PI judges that geologic data from nearby holes are sufficient, more select portions than the intervals stated above for the boreholes may be cored.
Testing/Sampling Requirements: ³	- The sampling interval for the tests listed above is determined by SNL in coordination with the M&O/M-K ESF design engineers.
Special Sample Handling Requirements:	None
Equipment Requirements: (to be supplied by SNL)	Standard geologic logging supplies and equipment.
Equipment Requirements: (to be supplied by contractor)	<ul style="list-style-type: none"> - Drill rig and materials for borehole construction - the tracer input and sampling system
Study Plan:	8.3.1.14.2 Studies to Provide Soil and Rock Properties of Potential Locations of Surface Facilities and Subsurface Access Facilities

Principal Investigator: David Kessel, SNL

Principal User: Kal Bhattacharyya, for ESF design; M&O/ M-K

Requirements/Requests of Secondary Users:

Hydrochemical Characterization of the UZ:^{9,10}

- Monitor the input of tracer-tagged drilling air
- Dry-core for samples
- Core samples from:
 - regularly spaced intervals of the core,
 - calcite-filled fractures and vugs containing calcite crystals,
 - lithologic contacts,
 - wet or moist zones,
- Wrap samples in saran wrap, weigh sample, cap and seal in a lexan liner, seal in ProtecCore, weigh sample again, refrigerate the package.

Matrix Hydrologic Properties of UZ:¹¹

- Collect samples from regularly spaced intervals of the core.
- Place core sample in a lexan liner, with spacers at each end of the sample, then cap and seal the lexan liner and place it in ProtecCore.

Mineralogy/Petrology:¹²

- Collect continuous core.
- In the non-welded to partially welded zones, with the exception of the thoroughly zeolitized Calico Hills unit, collect about a one-inch sample for every foot of sample taken for the UZ hydrochemistry study.

Alteration History and Transport Pathways:¹²

- A portion of the selected fractures or contacts in the moderately to densely welded zones should not be packaged in saran wrap (lexan and ProtecCore is acceptable) so that the samples can be viewed.
- A portion of the calcite fractures, wet fractures, or cross-cutting fractures should not be packaged in saran wrap (lexan and ProtecCore is acceptable) so that the samples can be viewed.

Water Movement Tracer Tests (Chlorine-36):¹³

- Dry drilling
- No tracers, fluids, or other materials, other than those specified in planning documents, can be introduced downhole prior to sample collection.
- Collect ream-bit cuttings from the same stratigraphic intervals from which core samples are specified for hydrochemical testing.
- If no hydrochemical samples are collected, collect cutting samples from the prescribed interval.
- Collect cuttings from a 0.5 to 1-ft-interval of ream-down; expected sample weight is 50 -130 lbs.
- Collect additional cuttings from selected weathered fractures or fracture zones, as evidenced by iron staining in core, and determined by the drillsite geologist.

Geologic Model:¹⁴

- Continue coring through next major stratigraphic contact if within 50 to 100 ft.

If the ramp borehole is to be instrumented for gaseous phase studies in the unsaturated zone:

- The borehole is to be drilled with air, preferably with a drill rig having dual-wall, reverse circulation capabilities.
- The unsaturated zone tests require that the borehole walls be kept dry and clear, (i.e., protected from water and mudcake contamination).
- *If perched water is encountered:*⁹
 - A low capacity (i.e., 0.5 to 2 liters/min) submersible pump for small perched water sampling operations will be needed.
 - Temporary casing will be needed to protect the borehole walls during any water-pumping and drilling operations when water is present.
 - Upon completion of any water-pumping operations, care must be taken to prevent water in the discharge pipe from splashing out of the pipe and cascading downhole or onto the drill pad when the pipe is being disconnected.

- If an encountered perched water zone continues to seep water into the borehole after completion of water pumping from the zone, it must be sealed off with a grout mixture, while taking care not to contaminate the borehole walls, in order to maintain dry borehole walls when drilling continues.
- Air Permeability Testing needs:⁹
 - Clean sides of borehole, with minimal clogging of fractures and the formation.
 - Removal of drilling air from borehole prior to testing.
 - A tracer gas injection and monitoring setup.
 - Injection of gas in selected stratigraphic intervals at a constant rate while monitoring transient pressure response.
 - Tracer(s), different from that used in the drilling air, to be added to injected air.
 - A generator or electrical power to support the air permeability trailer.
 - A dry, filtered compressed air supply.
- UZ instrumentation needs:^{9,15}
 - Protection of UZ when drilling into water table
 - Installation of long-term *in situ* monitoring equipment
 - Installation of Hydrologic Data Acquisition System (HDAS) with protective shelters for monitoring down-hole sensors.
 - Stemming material (i.e., grout) for *in situ* instrumentation,
 - An electrical power line to the insulated instrument shelter (IIS).
 - Communication hookups, including data transmission and telephone facilities for the IIS facility.
 - A sand-bag perimeter seal around the base of the IIS.
- Hydrochemical Characterization of the UZ needs:⁹
 - A tracer input and sampling system
 - A vacuum unit for evacuating air from the borehole.
 - Equipment for lowering and raising a packer string into and out of borehole.
 - A compressor (50 CFM) to inflate packers or packer inflation gas.
 - A generator or electrical power.
 - A gas sampling packer system, and associated equipment to sample and analyze downhole gases.
 - Removal of tracer-tagged drilling air from borehole following drilling, using a vacuum unit; and sampling of formation gases and water vapor:
 - Installation of packer system to collect gas and water vapor samples from selected intervals, both before and after air permeability testing:
 - Isolation of selected intervals by the *in situ* instrumentation, and collection of gas samples about twice a year from these intervals.

ENVIRONMENTAL CONCERNS

Use of Tracers:	<ul style="list-style-type: none"> - Tracer will be added to drilling medium. - Additional gas tracer(s) may be required for air permeability test, and water injection testing, if it is conducted.
Emissions/Effluent:	
Water Discharge:	None anticipated
Amount	
Rate	
Chemistry	
Discharge Point	
Will Study Intersect the Water Table?	Not anticipated
Extent and Location of Ground Disturbance:	
Road Access	Dependent on specific borehole location.
Pad Construction:	Of sufficient dimension to position and drill with a Joy or comparable drilling rig.

BOREHOLE PRIORITIZATION BY PRINCIPAL INVESTIGATOR

(as of September 24, 1993)

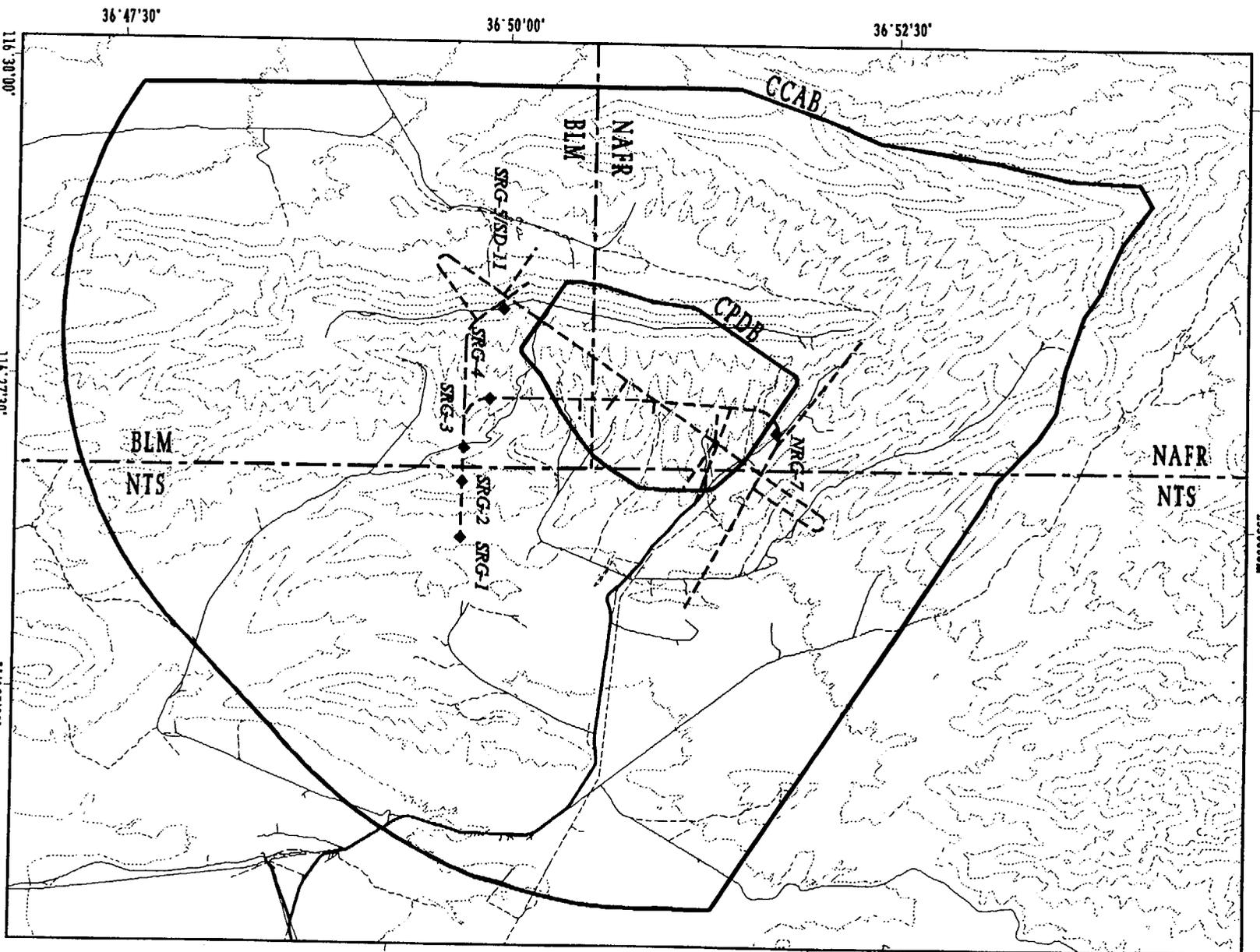
USW NRG-7
USW SRG-4
USW SRG-3
UE-25 SRG#1
UE-25 SRG#2

Primary Sources of Information:

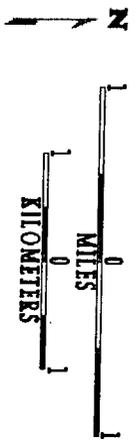
1. Study Plan 8.3.1.14.2, "Studies to Provide Soil and Rock Properties of Potential Locations of Surface Facilities and Subsurface Access Facilities."
2. U.S. Department of Energy, 1993, Exploratory Studies Facility Design Requirements, Yucca Mountain Site Characterization Project, YMP/CM-0019.
3. Written communication from Robert Elayer (M&O/M-K): "Recommended Drilling Program for Proposed Enhanced ESF South Ramp Design," July 22, 1993.
4. Work scope consolidation meeting for SRG-4, June 9, 1993, Las Vegas.
5. Oral communication, Jack Nesbitt and Jim Beyer (M&O) with Norma Biggar (M&O/WCFS), September 24, 1993.
6. Oral communication, Tim Sullivan (DOE/RSED) with Norma Biggar (M&O/WCFS), September 3, 1993.
7. Written communication from Robert Elayer (M&O/M-K): "Recommended Drilling Program for Proposed Enhanced ESF Topopah Spring Main Drift Design," July 22, 1993.
8. Work scope consolidation meeting for SRG-5/SD-11, February 2, 1993, Las Vegas.
9. USGS Criteria Letter dated July 22, 1992 (USGS-YMP-3343G-01-C4, R0) for drilling, testing, and instrumenting of UZ-14.
10. Letter from Robert Craig (USGS) to Heidi Lohn (SAIC), "Request for Input for Test Planning Package T-93-09," August 9, 1993.
11. Letter to Deborah Edwards (USGS) from Alan Flint (USGS), "Core Collection for SRG-5/SD-11," May 20, 1993.
12. Memorandum from R. Oliver (LANL) to Russ Dyer (DOE-RSED), "Los Alamos National Laboratories Design and Test Related Input for Test Planning Package (TPP) T-93-09, USW SD-12," August 18, 1993.
13. Criteria Letter for "Collection of Ream-Bit Cuttings from Deep Dry-Drilled Surface-Based Boreholes, Yucca Mountain, Nevada," June Fabryka-Martin, TWS-INC-9-02-93-07.
14. Drilling prioritization meetings, October and December, 1993, Las Vegas.
15. Personnel communication, Mike Chornack (USGS) to Norma Biggar (M&O/WCFS), August 30, 1993.

E550245H
E545000M

E566660H
E550000M



LEGEND
◆ Planned Borehole



• Dashed line represents preliminary ESF layout Design

Contour Interval 200 Feet

YUCCA MOUNTAIN
SITE CHARACTERIZATION PROJECT
PLANNED ESF DESIGN
SUPPORT BOREHOLES

EG&G WMP-93-147A

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW NRG-7

Type of Investigation: ESF Ramps

WBS No.: 1.2.3.2.6.2.1

Study Plan No.: 8.3.1.14.2.1

Study Plan Title: Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities

Principal Organization: SNL

Principal Investigators: D. Kessel

Other Participant Organizations: M&O, USGS, LANL

Purpose of Activity: To provide soil and rock information for design and construction of the ESF ramps and main test level.

Location

Coordinates: NVSPC: N768,846/E563,005
UTM: N4,079,516/E548,911

Ground Elevation of Borehole (above sea level): 4209 ft (1283 m) (Ref. 1)

Location Description: At the western end of the surface projection of the North Ramp of the ESF, adjacent to and west of Drill Hole Wash Road, at the base of the hillslope, 2000 ft northwest of NRG-5, and 2400 ft north-northwest of NRG-6.

Access to Location: Access is by Drill Hole Wash Road; the borehole is sited about 0.6 mi northwest of the turn-off to Coyote Wash.

Rationale for Location: To acquire stratigraphic and rock properties data to be used in the design of the north ramp of the ESF.

Borehole Dimensions

Planned Borehole Depth: About 1450 ft (25 ft below the base of TSw3, the vitrophyre of the Topopah Spring Member) (Ref. 2)

Elevation at Total Depth (above sea level): 2759 ft (835 m)

Planned Borehole Diameter: Approximately 5 1/2 "

Planned Core Size: 3 11/32" (PQ size core)

Schedule

Scheduled Start Date: At the beginning of FY '94

Scheduled Completion Date: FY'94

Drilling and Construction

Drilling Method:	Dry drilling, using reverse circulation with ODEX system
Recommended Drill Rig:	Joy-type rig
Drilling Fluids:	Air
Tracers:	Tracer is to be added to the drilling air.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core
Geophysical Logging:	Geophysical logs identified for ramp boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	This borehole was not included in the SBIP.
Testing & Sampling to be Conducted as Listed in Study Plan:	Collect core for stratigraphic and structural data and laboratory analyses, preliminary evaluation of physical, mechanical, and dynamic soil and rock properties; and collect geophysical logs of borehole.
Testing & Sampling Currently Planned:	Continuous core, laboratory analyses to determine physical, mechanical and thermal properties (SNL/M&O); matrix hydrologic properties, hydrochemistry of the unsaturated zone (USGS); fracture mineralogy, chlorine-36 (LANL).
Borehole Instrumentation:	None anticipated
Borehole Construction Requirements:	See introductory summary sheet for ESF ramp boreholes.

Environmental Prerequisites

Land Ownership:	Air Force
Access:	Field work (not casual)
Required Pre-Activity Surveys:	See Introduction to Borehole Catalog and Appendix B.
Estimated Amt. of Discharged Water:	None anticipated
Required Surface Preparation:	Construction of a drill pad is required.
Anticipated Area of Surface Disturbance:	Approx. 150 ft x 150 ft for pad and construction area, and an add'l. 75 ft x 77 ft for the topsoil storage area (Ref. 1).
Required Permits:	Gas tracers added to drilling air

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

References:

1. Preliminary layout and surveyed location for the NRG-7 borehole site, supplied by Arch Girdley, RSED Field Test Coordinator.
2. Consolidated Work Scope for USW NRG-7 Borehole, prepared by M&O/WCFS for DOE/RSED, August 5, 1993.
3. Study Plan 8.3.1.14.2.1, "Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities."

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 SRG#1

Type of Investigation: ESF Ramps

WBS No.: 1.2.3.2.6.2.1

Study Plan No.: 8.3.1.14.2.1

Study Plan Title: Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities

Principal Organization: SNL

Principal Investigators: D. Kessel

Other Participant Organizations: M&O, USGS, LANL

Purpose of Activity: To provide soil and rock information for design and construction of the ESF ramps and main test level.

Location

Coordinates: Tentative location is NVSPC: N756,600/E567,200 (Ref. 1)
UTM: N4,075,789/E550,203

Ground Elevation of Borehole (above sea level): About 3880 ft at the above location.

Location Description: Situated at the south ramp portal of the Exploratory Studies Facility. The location of the south portal has not been finalized; it may be moved to the west, farther up the ridge, pending development of the south ramp design package (Ref. 1). The intent is to drill the borehole directly on the ramp alignment, then excavate it out in the process of construction of the south ramp portal (Ref. 2).

Access to Location: Construction of a new access road and pad is required.

Rationale for Location: To study the near-surface rock properties in the vicinity of the proposed location of the south ramp portal of the Exploratory Studies Facility.

Borehole Dimensions

Planned Borehole Depth: Approximately 150 ft (Ref. 1).

Elevation at Total Depth (above sea level): 3730 ft (1129 m)

Planned Borehole Diameter: Approximately 5 1/2 "

Planned Core Size: 3- 11/32" (PQ size core)

Schedule

Scheduled Start Date: FY '94

Scheduled Completion Date: FY'94

Drilling and Construction

Drilling Method:	Dry drilling, using reverse circulation with ODEX system
Recommended Drill Rig:	CME-850 -type rig
Drilling Fluids:	Air
Tracers:	Tracer is to be added to the drilling air.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core
Geophysical Logging:	Geophysical logs identified for Group III boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	This borehole was not included in the SBIP.
Testing & Sampling to be Conducted as Listed in Study Plan:	Collect core for stratigraphic and structural data and laboratory analyses, preliminary evaluation of physical, mechanical, and dynamic soil and rock properties; and collect geophysical logs of borehole.
Testing & Sampling Currently Planned:	Continuous core, laboratory analyses to determine physical, mechanical and thermal properties (SNL/M&O); matrix hydrologic properties, hydrochemistry of the unsaturated zone (USGS); fracture mineralogy, chlorine-36 (LANL).
Borehole Instrumentation:	None anticipated
Borehole Construction Requirements:	See introductory summary sheet for ESF ramp boreholes.

Environmental Prerequisites

Land Ownership:	NTS
Access:	Field work (not casual access)
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	None anticipated
Required Surface Preparation:	Construction of an access road and drill pad is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	Gas tracers added to drilling air

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

References:

1. Oral communication: ESF Design Engineer, Bill Kennedy (M&O/M-K), with Norma Biggar (M&O/WCFS), September 16, 1993.
2. Written communication from Bob Elayer (M&O/M-K): "Recommended Drilling Program for Proposed Enhanced ESF south ramp design; July 22, 1993."

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 SRG#2

Type of Investigation: ESF Ramps

WBS No.: 1.2.3.2.6.2.1

Study Plan No.: 8.3.1.14.2.1

Study Plan Title: Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities

Principal Organization: SNL

Principal Investigators: D. Kessel

Other Participant Organizations: USGS, M&O, LANL

Purpose of Activity: To provide soil and rock information for design and construction of the ESF South Ramp

Location

Coordinates: NVSPC: N756,650/E565,000 (Ref. 1)
UTM: N4,075,802/E549,532

Ground Elevation of Borehole (above sea level): About 4060 ft (1230 m)

Location Description: At the head of a small tributary wash to Ghost Dance Wash, and west of Boundary Ridge. Located about 50 ft north of the surface projection of the proposed south ramp alignment, and about 1800 ft (0.35 mi.) north of the Yucca Mountain Crest Road.

Access to Location: Access is by the Yucca Mountain Crest Road, about 1/2 mi. south of "Jessie's Curve".

Rationale for Location: To acquire stratigraphic and rock properties data to be used in the design of the south ramp of the ESF.

Borehole Dimensions

Planned Borehole Depth: About 400 ft (120 m) (Ref.1).

Elevation at Total Depth (above sea level): 3660 ft (1108 m)

Planned Borehole Diameter: Approximately 5 1/2 "

Planned Core Size: 3 11/32" (PQ size core)

Schedule

Scheduled Start Date: FY'95

Scheduled Completion Date: FY'95

Drilling and Construction

Drilling Method:	Dry drilling, using reverse circulation with ODEX system
Recommended Drill Rig:	Joy-type rig
Drilling Fluids:	Air
Tracers:	Tracer is to be added to the drilling air.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core
Geophysical Logging:	Geophysical logs identified for Group III boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	This borehole was not included in the SBIP.
Testing & Sampling to be Conducted as Listed in Study Plan:	Collect core for stratigraphic and structural data and laboratory analyses, preliminary evaluation of physical, mechanical, and dynamic soil and rock properties; and collect geophysical logs of borehole.
Testing & Sampling Currently Planned:	Continuous core, laboratory analyses to determine physical, mechanical and thermal properties (SNL/M&O); matrix hydrologic properties, hydrochemistry of the unsaturated zone (USGS); fracture mineralogy, chlorine-36 (LANL).
Borehole Instrumentation:	None anticipated
Borehole Construction Requirements:	See introductory summary sheet for ESF ramp boreholes.

Environmental Prerequisites

Land Ownership:	NTS
Access:	Field work (not casual)
Required Pre-Activity Surveys:	See Appendix B.
Estimated Amt. of Discharged Water:	None anticipated
Required Surface Preparation:	Construction of a drill pad and an access road about 1800 ft long is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	Gas tracer added to drilling air

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

References:

1. Written communication from Bob Elayer (M&O/M-K): "Recommended Drilling Program for Proposed Enhanced ESF south ramp design; July 22, 1993."

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SRG-3

Type of Investigation: ESF Ramps

WBS No.: 1.2.3.2.6.2.1

Study Plan No.: 8.3.1.14.2.1

Study Plan Title: Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities

Principal Organization: SNL

Principal Investigators: D. Kessel

Other Participant Organizations: USGS, M&O, LANL

Purpose of Activity: To provide soil and rock information for design and construction of the ESF Ramps and Main Test Level.

Location

Coordinates: NVSPC: N756,000/E563,700 (Ref. 1)
UTM: N4,075,816/E549,136

Ground Elevation of Borehole (above sea level): About 4100 ft (1240 m.) (Ref. 1)

Location Description: Along the eastern margin of Ghost Dance Wash, about 1/4 mi south of "Jessie's Curve", and 200 ft (60 m) east of the Yucca Mountain Crest Road. Borehole location is located about 100 ft north of the surface projection of the South Ramp Alignment.

Access to Location: Access is by the Yucca Mountain Crest Road; a short (200 ft) access road will be need to be constructed eastward from the Yucca Mountain Crest Road.

Rationale for Location: To acquire stratigraphic and rock properties data to be used in the design of the south ramp of the ESF.

Borehole Dimensions

Planned Borehole Depth: About 500 ft (151 m), to penetrate through all possible ramp intervals and at least penetrate the TSw1/TSw2 contact or other recognizable stratigraphic contact (Ref.1).

Elevation at Total Depth (above sea level): 3600 ft (1090 m)

Planned Borehole Diameter: Approximately 5 1/2"

Planned Core Size: 3 11/32" (PQ size core)

Schedule

Scheduled Start Date: FY'94
Scheduled Completion Date: FY'94

Drilling and Construction

Drilling Method: Dry drilling, using reverse circulation with ODEX system
Recommended Drill Rig: Joy-type rig
Drilling Fluids: Air
Tracers: Tracer is to be added to the drilling air.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: Standard core sampling equipment, standard geologic core logging equipment.

Sample Collection & Interval (cores/cuttings): Continuous core

Geophysical Logging: Geophysical logs identified for Group I or III boreholes will be run, depending on the depth of the borehole (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:
This borehole was not included in the SBIP.

Testing & Sampling to be Conducted as Listed in Study Plan:
Collect core for stratigraphic and structural data and laboratory analyses, preliminary evaluation of physical, mechanical, and dynamic soil and rock properties; and collect geophysical logs of borehole.

Testing & Sampling Currently Planned: Continuous core, laboratory analyses to determine physical, mechanical and thermal properties (SNL/M&O); matrix hydrologic properties, hydrochemistry of the unsaturated zone (USGS); fracture mineralogy, chlorine-36 (LANL).

Borehole Instrumentation: None anticipated

Borehole Construction Requirements: See introductory summary sheet for ESF ramp boreholes.

Environmental Prerequisites

Land Ownership: NTS

Access: Field work (not casual)

Required Pre-Activity Surveys: See Appendix B.

Estimated Amt. of Discharged Water: None anticipated

Required Surface Preparation:	Construction of a drill pad and an access road about 200 ft long is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	Gas tracer added to drilling air

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

References:

1. Written communication from Bob Elayer (M&O/M-K): "Recommended Drilling Program for Proposed Enhanced ESF South Ramp Design," July 22, 1993.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SRG-4
Type of Investigation: ESF Ramps
WBS No.: 1.2.3.2.6.2.1
Study Plan No.: 8.3.1.14.2.1
Study Plan Title: Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities
Principal Organization: SNL
Principal Investigators: D. Kessel
Other Participant Organizations: USGS, M&O, LANL
Purpose of Activity: To provide soil and rock information for design and construction of the ESF Ramps and Main Test Level.

Location

Coordinates: NVSPC: N757,675/E561,800
UTM: N4,075,111/E548,556

Ground Elevation of Borehole (above sea level): About 4230 ft (1280 m)

Location Description: In Ghost Dance Wash, about 100 ft east of the surface projection of the ESF main drift, about 1500 west of and up the wash from the Yucca Mountain Crest Road.

Access to Location: Access is by Yucca Mountain Crest Road, and an access road that will need to be constructed from the Yucca Mountain Crest Road to the drill site, intersecting the Yucca Mountain Crest Road about 500 ft south of Jessie's Curve".

Rationale for Location: To acquire stratigraphic and rock properties data to be used in the design of the main drift and south ramp of the ESF.

Borehole Dimensions

Planned Borehole Depth: About 1100 ft (333 m), coring through all possible ramp intervals, and through the TSw1, TSw2, and TSw3 units (Ref.1).

Elevation at Total Depth (above sea level): 3130 ft (948 m)

Planned Borehole Diameter: Approximately 5 1/2"

Planned Core Size: 3 11/32" (PQ size core)

Schedule

Scheduled Start Date: FY'94

Scheduled Completion Date: FY'94

Drilling and Construction

Drilling Method:	Dry drilling, using reverse circulation with ODEX system
Recommended Drill Rig:	Joy-type rig
Drilling Fluids:	Air
Tracers:	Tracer is to be added to the drilling air.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core
Geophysical Logging:	Geophysical logs identified for Group I boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	This borehole was not included in the SBIP.
Testing & Sampling to be Conducted as Listed in Study Plan:	Collect core for stratigraphic and structural data and laboratory analyses, preliminary evaluation of physical, mechanical, and dynamic soil and rock properties; and collect geophysical logs of borehole.
Testing & Sampling Currently Planned:	Continuous core, laboratory analyses to determine physical, mechanical and thermal properties (SNL/M&O); matrix hydrologic properties, hydrochemistry of the unsaturated zone (USGS); fracture mineralogy, chlorine-36 (LANL).
Borehole Instrumentation:	None anticipated
Borehole Construction Requirements:	See introductory summary sheet for ESF ramp boreholes.

Environmental Prerequisites

Land Ownership:	NTS
Access:	Field work (not casual)
Required Pre-Activity Surveys:	See Appendix B.
Estimated Amt. of Discharged Water:	None anticipated
Required Surface Preparation:	Construction of a drill pad and an access road about 1800 ft long is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	Gas tracer added to drilling air

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:

References:

1. Written communication from Bob Elayer (M&O/M-K): "Recommended Drilling Program for Proposed Enhanced ESF south ramp design; July 22, 1993."

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW SRG-5/SD-11

Type of Investigation: Surface Facilities

WBS No.: 1.2.3.2.6.2.1 / 1.2.3.2.2.2.1

Study Plan No.: 8.3.1.14.2.1 / 8.3.1.4.3.1

Study Plan Title: Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities / Systematic Acquisition of Site-Specific Subsurface Information

Principal Organization: SNL / SNL

Principal Investigators: D. Kessel / Chris Rautman

Other Participant Organizations: USGS, M&O, LANL

Purpose of Activity: To provide soil and rock information for design and construction of the ESF Ramps and Main Test Level; and to acquire physical rock samples, analytic data, and basic description of the subsurface geology of the proposed repository site on a systematic basis.

Location

Coordinates: NVSPC: N758,175/E558,315
UTM: N4,076,259 / E547,493

Ground Elevation of Borehole (above sea level): About 4880 ft. (1478 m)

Location Description: On the South Yucca Crest Road, about 0.4 mi south of the intersection of the Yucca Mountain Crest Road on Highway Ridge with the Yucca Crest Road.

Access to Location: Access is by the existing Yucca Crest Road.

Rationale for Location: For the ESF Ramp Program: Originally, the borehole was located to constrain transition from south ramp to main drift alignments by providing stratigraphic and structural information at the juncture of the two drifts and near the highest absolute elevation to be encountered in the conceptual repository block (Ref. 1). In the enhanced ESF design, the borehole provides stratigraphic control at the western end of the south ramp extension. For the SD Program, the borehole is situated at a half-grid location modified by topography, drift configuration (Ref. 1). Also, the borehole will provide critical information regarding the vitric/zeolitic transition within the tuffs of Calico Hills and the respective thicknesses of each. There is currently no data on this transition between boreholes G-4 and GU-3 (Ref. 2).

Borehole Dimensions

Planned Borehole Depth:	About 2665 ft (325 ft below water table at an elevation of 2540 ft. in borehole USW H-5 [Ref. 3]) to 2800 ft (325 ft below water table at an elevation of 2400 ft. in boreholes USW H-3 and USW W-2 [Ref.3]).
Elevation at Total Depth (above sea level):	2215 ft (671 m)
Planned Borehole Diameter:	> 5 1/2 in
Planned Core Size:	2.4 inches (HQ core)

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry
Recommended Drill Rig:	Stratmaster, or the LM-300
Drilling Fluids:	Air
Tracers:	Tracer(s) are to be added to drilling air and any tracer/fluid injected during testing.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	Standard core sampling equipment, standard geologic core logging equipment.
Sample Collection & Interval (cores/cuttings):	Continuous core, unless PI determines that previously obtained core from adjacent boreholes is sufficient except for select stratigraphic intervals.
Geophysical Logging:	Geophysical logs identified for Group II bore holes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	<u>For SD-11:</u> vertical seismic profiling and seismic tomography between holes; continuous core. There was not a SRG-5 in the SBIP.
Testing & Sampling to be Conducted as Listed in Study Plan:	Continuous core; one sample collected at 5 ft (1.5 m) intervals from core for laboratory testing. Sampling interval may change depending on rock properties.
Testing & Sampling Currently Planned:	<u>SRG-5:</u> Description and analysis of physical properties and strengths of the stratigraphic interval of interest to

ESF/repository design (SNL); matrix hydrologic properties and hydrochemistry of the unsaturated zone (USGS).
SD-11: Geostatistical analysis of geologic and engineering properties of repository block; matrix hydrologic properties, thermomechanical and sealing related lithologies (SNL); measurement of the potentiometric surface, unsaturated and saturated zone hydrochemistry, unsaturated zone studies (gas chemistry, air permeability testing, shut-in pressure tests, *in situ* long-term monitoring) (USGS); mineralogy/petrology, fracture mineralogy and alteration history, chlorine-36 analyses (LANL); geologic framework-geologic model for repository block (USGS).

Borehole Instrumentation:

Instrumented to measure potentiometric surface.

Borehole Construction Requirements:

See introductory sections on ESF Ramp boreholes and SD boreholes.

Environmental Prerequisites**Land Ownership:**

BLM

Access:

Field Work

Required Pre-Activity Surveys:

See Appendix B

Estimated Amt. of Discharged Water:

None anticipated, unless perched water zone is encountered.

Required Surface Preparation:

Construction of a drill pad is required.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling air, and (2) intersection of water table.

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

(1) During the drilling prioritization meetings in Las Vegas in October and December 1992, there was discussion of combining an SD borehole with the SRG-5 ramp borehole located at the intersection of the main ESF drift and the south ramp.

(2) A work scope consolidation meeting was held in February, 1993 in Las Vegas for a combined SRG-5/SD-11 borehole at the present SD-11 location (Ref. 1).

References:

1. Study Plan 8.3.1.4.3.1: "Systematic Acquisition of Site-Specific Subsurface Information", Rev.1, effective date, June 14, 1993.
2. Rautman, C. A., 1993, written communication: Summary Description of Systematic Drilling Program, Facsimile transmission to Norma Biggar, YMP M&O, Las Vegas, September 8, 1993.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada", Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.

Requirements/Requests of Secondary Users:

Hydrochemistry:

- Water sample of any perched water encountered, and of the saturated zone in the Tertiary rocks, and in the Paleozoic section.
- Drilling of the boreholes several hundred feet into the Paleozoic, for those boreholes that penetrate the Tertiary/Paleozoic contact.

Mineralogy/Petrology, Alteration History and Transport Pathways

- Selectively core intervals from Calico Hills to TD; this may result in one-half to two-thirds core of that interval.

Potentiometric Surface

- Obtain water table measurement

Natural Resource Potential:

- Collect gas samples.

Other comments:

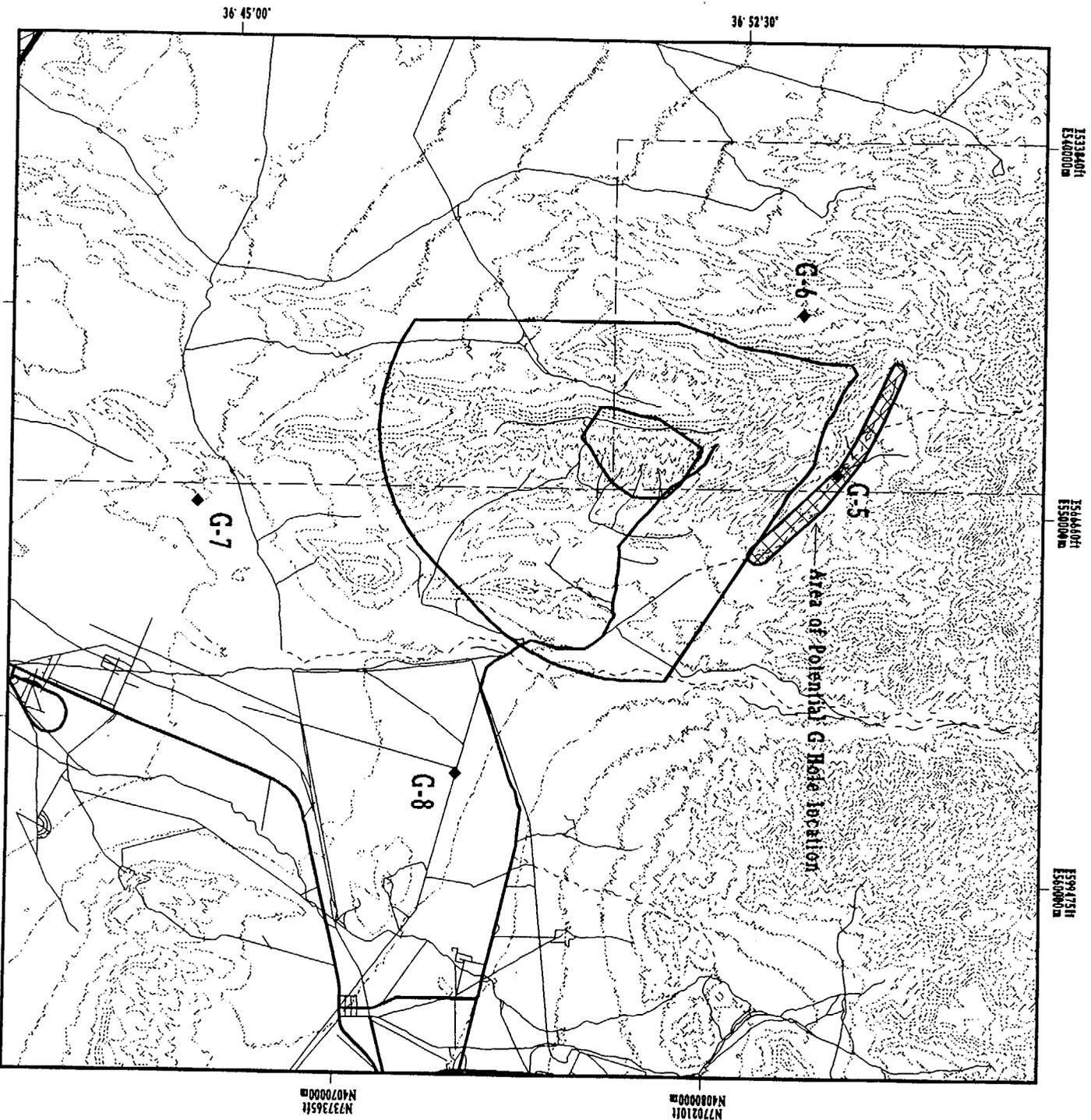
- The potential presence of hydrocarbons may require a blow-out preventor as per state regulations.
- ACNW wants to go 10,000 feet to intersect low-angle fault. Where? Basis??

ENVIRONMENTAL CONCERNS

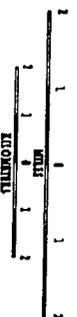
Use of Tracers:	Tracer will be added to drilling medium
Emissions/Effluent:	
Water Discharge:	No significant amount anticipated
Amount	
Rate	
Chemistry	
Discharge Point	
Will Study Intersect the Water Table?	Yes
Extent and Location of Ground Disturbance:	
Road Access	Dependent on specific borehole location.
Pad Construction:	Of sufficiently dimension to accommodate a Stratmaster or equivalent drill rig.

**BOREHOLE PRIORITIZATION BY PRINCIPAL INVESTIGATOR
(as of April 23, 1993)**

USW G-5
USW G-6
UE-25 G#7
UE-25 G#8, combined with UE-25 WT#19



LEGEND
 ◆ Planned Borehole



Contour Interval 200 Feet

**YUCCA MOUNTAIN
 SITE CHARACTERIZATION PROJECT
 PLANNED GEOLOGIC BOREHOLES**

EG&G YMP-92-041.4

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW G-5

Type of Investigation: Geologic

WBS No.: 1.2.3.2.2.1.1

Study Plan No.: 8.3.1.4.2.1

Study Plan Title: Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area

Principal Organization: USGS

Principal Investigators: Rick Spengler

Other Participant Organizations: LANL

Purpose of Activity: To gather pertinent geologic data, develop lithologic correlations, and describe the stratigraphy of the site area; to penetrate a representative section of the Paleozoic sequence beneath the volcanic tuffs; to assess the nature of the Tertiary/pre-Tertiary boundary; and to assess the natural resource potential of the Paleozoic rocks (Ref. 1).

Location

Coordinates: NVSPC: N781,930/E563,008
UTM: N4,083,503/E548,898

Ground Elevation of Borehole (above sea level): TBD

Location Description: In Yucca Wash along the northeast flank of Yucca Mountain. Acquisition of geophysical data in Yucca Wash may result in the moving the borehole to another location within the shaded area shown in the vicinity of G-5 on the Geologic Borehole Map (Ref. 2).

Access to Location: The primary access is the Midway Valley Road up Yucca Wash. Some road construction or improvement of existing roads or trails may be identified when a more definite location for the borehole is selected.

Rationale for Location: To determine the structural character and facies changes in the Topopah Springs and Calico Hills Members across Yucca Wash, and whether lithological or structural causes are responsible for the steeper gradient in the potentiometric surface north of drillhole G-1 (Refs. 1 and 2)

Borehole Dimensions

Planned Borehole Depth: Anticipated to be on the order of 7000 ft. Target TD is several hundred feet into the Paleozoic section (Ref. 2). See Comment 1, below.

Elevation at Total Depth (above sea level):	TBD
Planned Borehole Diameter:	Of sufficient diameter at the tops of the saturated zone and the Paleozoic section to accommodate a pump for collecting water samples (depends on drilling medium; see below); if cased to 4000 ft, the ID of the casing should be $\geq 4 \frac{1}{2}$ "; ≥ 4 in at TD to accommodate geophysical logging tool and borehole video camera (Ref. 3).
Planned Core Size:	1.87 or 2.44 in (NQ or HQ core) at TD (Ref. 3).

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Wireline rotary with conventional rotary reaming. State regulations may require that the drill rig is equipped with a blow-out preventor if there is a potential for hydrocarbons to be present (Ref. 3).
Recommended Drill Rig:	Stratmaster, or equivalent.
Drilling Fluids:	Polymer mud.
Tracers:	Tracer added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory summary sheet for the geologic boreholes.
Sample Collection & Interval (cores/cuttings):	Core top and bottom of Calico Hills and other predicted, selected contacts: collect representative (spot) core from about 50 to 66% of the section, particularly in the lower part of the borehole and at the boundary between welded and non-welded tuffs; collect continuous core 100 ft above to 100 ft below Tertiary/Paleozoic contact.
Geophysical Logging:	The geophysical logging suite for a Group I borehole (see Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	Continuous wire-line core with split barrel. In situ stress measurement by hydrofracturing; 1) borehole TV (dry hole) or acoustic televiewer (water-filled hole) will be used to locate suitable intervals for testing; 2) straddle packers will be set in hole and water will be pumped into the isolated interval until the fm. is fractured; 3) injection procedure may be repeated at the discretion of the USGS site geologist; 4) packers will be reset at different intervals until five good

quality measurements have been made. Estimate 5,000 gallons clean water will be needed for the test.

Testing & Sampling to be Conducted as Listed in Study Plan:

Geologic logging of cuttings and core; borehole logging with video camera and geophysical tools; collection of core samples for petrographic, geochemical, and isotopic analyses.

Testing & Sampling Currently Planned:

Geologic framework of Calico Hills section and Tertiary/Paleozoic contact; geologic discontinuities; mineral and hydrocarbon potential; hydrochemistry; matrix properties in unsaturated zone/saturated zone contact; isotopic and noble-gas sampling; potentiometric surfaces of the different flow systems encountered (USGS); alteration history of Calico Hills to TD, mineralogy and petrology, including distribution and history of zeolites (LANL) (Ref. 3).

Borehole Instrumentation:

TBD; perhaps instrumented for potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for geologic boreholes.

Environmental Prerequisites

Land Ownership:

USAF (i.e., at location given above) or NTS, depending on selected borehole location.

Access:

Field work (not casual).

Required Pre-Activity Surveys:

See Introduction to Borehole Catalog and Appendix B.

Estimated Amt. of Discharged Water:

A minimal amount is anticipated.

Required Surface Preparation:

Construction of drill pad with mud (if used) and cuttings pit is required. Depending on selected location, construction of an access road or improvement of existing roads may be necessary.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration

Borehole Closure Requirements:

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

(1) The ACNW has expressed an interest in this borehole going to 10,000 ft depth to intersect a hypothesized low-angle fault (Ref. 3).

References:

1. Study Plan 8.3.1.4.2.1, "Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area", Revision 3, Effective Date: September 2, 1993.
2. Workscope Consolidation Meeting for planned FY'94 boreholes, June 17, 1993, Las Vegas.
3. Drilling Prioritization Meetings, October and December, 1992, Las Vegas.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW G-6

Type of Investigation: Geologic

WBS No.: 1.2.3.2.2.1.1

Study Plan No.: 8.3.1.4.2.1

Study Plan Title: Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area

Principal Organization: USGS

Principal Investigators: Rick Spengler

Other Participant Organizations: LANL

Purpose of Activity: To gather pertinent geologic data, develop lithologic correlations, and describe the stratigraphy of the site area; to collect stratigraphic information on the older volcanic units underlying the Calico Hills.

Location

Coordinates: NVSPC: N778,722/E548,922
UTM: N4,082,511/E544,610

Ground Elevation of Borehole (above sea level): TBD

Location Description: Along the northwest flank of Yucca Mountain in the upper Windy Wash area.

Access to Location: No road access is shown on topographic maps; if these maps are correct, 3 miles or more of road may need to be constructed to access the site from an existing road/trail.

Rationale for Location: To provide representative stratigraphic data for the western margin of the site, and for correlation of units across the repository site area.

Borehole Dimensions

Planned Borehole Depth: Anticipated to be on the order of 5000 ft.

Elevation at Total Depth (above sea level): TBD

Planned Borehole Diameter: Of sufficient diameter at the tops of the saturated zone to accommodate a pump for collecting water samples (depends on drilling medium; see below); if cased to 4000 ft, the ID of the casing should be $\geq 4 \frac{1}{2}$ "; ≥ 4 in at TD to accommodate geophysical logging tool and borehole video camera (Ref. 3).

Planned Core Size: 1.87 or 2.44 in (NQ or HQ core) at TD (Ref. 3).

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Wireline rotary with conventional rotary reaming. State regulations may require that the drill rig is equipped with a blow-out preventor if there is a potential for hydrocarbons to be present (Ref. 3); however, if this borehole is not planned to intersect the Paleozoic section, this may not be necessary on this borehole.

Recommended Drill Rig: Stratmaster or equivalent.

Drilling Fluids: Polymer mud.

Tracers: Tracer added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for the geologic boreholes.

Sample Collection & Interval (cores/cuttings): Core top and bottom of Calico Hills and other predicted, selected contacts: collect representative (spot) core from about 50 to 66% of the section, particularly in the lower part of the borehole and at the boundary between welded and non-welded tuffs.

Geophysical Logging: The geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

Continuous wire-line core with split barrel. In situ stress measurement by hydrofracturing; 1) borehole TV (dry hole) or acoustic televiewer (water-filled hole) will be used to locate suitable intervals for testing; 2) straddle packers will be set in hole and water will be pumped into the isolated interval until the fm. is fractured; 3) injection procedure may be repeated at the discretion of the USGS site geologist; 4) packers will be reset at different intervals until five good quality measurements have been made. Estimate 5,000 gallons clean water will be needed for the test.

Testing & Sampling to be Conducted as Listed in Study Plan:

Geologic logging of cuttings and core; borehole logging with video camera and geophysical tools; collection of core samples for petrographic, geochemical, and isotopic analyses.

Testing & Sampling Currently Planned:

Geologic framework of Calico Hills section; geologic discontinuities; mineral potential; hydrochemistry; matrix

properties in unsaturated zone/saturated zone contact; isotopic and noble-gas sampling (USGS); alteration history of Calico Hills to TD, mineralogy and petrology, including distribution and history of zeolites (LANL) (Ref. 3).

Borehole Instrumentation: TBD; perhaps instrumented for potentiometric surface.

Borehole Construction Requirements: See introductory summary sheet for geologic boreholes.

Environmental Prerequisites

Land Ownership: USAF

Access: Field work (not casual).

Required Pre-Activity Surveys: See Appendix B.

Estimated Amt. of Discharged Water: A minimal amount is anticipated.

Required Surface Preparation: Construction of drill pad with mud (if used) and cuttings pit is required. For the location given above, construction of an access road, and possibly improvement of existing roads may be necessary.

Anticipated Area of Surface Disturbance: TBD

Required Permits: (1) Tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration

Borehole Closure Requirements: TBD

Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

References:

1. Study Plan 8.3.1.4.2.1, "Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area", Revision 3, Effective Date: September 2, 1993.
2. Workscope Consolidation Meeting for planned FY'94 boreholes, June 17, 1993, Las Vegas.
3. Drilling Prioritization Meetings, October and December, 1992, Las Vegas.

Activity I.D.: UE-25 G#7

Type of Investigation: Geologic

WBS No.: 1.2.3.2.2.1.1

Study Plan No.: 8.3.1.4.2.1

Study Plan Title: Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area

Principal Organization: USGS

Principal Investigators: Rick Spengler

Other Participant Organizations: LANL

Purpose of Activity: To gather pertinent geologic data, develop lithologic correlations, and describe the stratigraphy of the site area; to penetrate a representative section of the Paleozoic sequence beneath the volcanic tuffs; to assess the nature of the Tertiary/pre-Tertiary boundary; and to assess the natural resource potential of the Paleozoic rocks (Ref. 1).

Location

Coordinates: NVSPC: N724,586/E566,090
UTM: N4,066,033/E549,898

Ground Elevation of Borehole (above sea level): TBD

Location Description: The tentative location given above is on the southern part of Yucca Mountain.

Access to Location: No road access is shown on topographic maps; if these maps are correct, about 3/4 mi of road may need to be constructed to access the site from an existing road/trail.

Rationale for Location: To test the hypothesis of a pre-existing paleotopographic high and its effects on the deposition of the Paintbrush Tuff, as well as to provide important geological constraints on hydrogeological properties, ground water travel times, and potential flow paths to the south of the repository for saturated zone flow modeling.

Borehole Dimensions

Planned Borehole Depth: Anticipated to be on the order of 7000 ft. Target TD is several hundred feet into the Paleozoic section (Ref. 2).

Elevation at Total Depth (above sea level): TBD

Planned Borehole Diameter: Of sufficient diameter at the tops of the saturated zone and the Paleozoic section to accommodate a pump for collecting water samples (depends on drilling medium; see below); if cased to 4000 ft, the ID of the casing should be $\geq 4 \frac{1}{2}$ "; ≥ 4 in at TD to accommodate geophysical logging tool and borehole video camera (Ref. 3).

Planned Core Size: 1.87 or 2.44 in (NQ or HQ core) at TD (Ref. 3).

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Wireline rotary with conventional rotary reaming. State regulations may require that the drill rig is equipped with a blow-out preventor if there is a potential for hydrocarbons to be present (Ref. 3).

Recommended Drill Rig: Stratmaster or equivalent.

Drilling Fluids: Polymer mud.

Tracers: Tracer added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheet for the geologic boreholes.

Sample Collection & Interval (cores/cuttings): Core top and bottom of Calico Hills and other predicted, selected contacts; collect representative (spot) core from about 50 to 66% of the section, particularly in the lower part of the borehole and at the boundary between welded and non-welded tuffs; collect continuous core 100 ft above to 100 ft below Tertiary/Paleozoic contact.

Geophysical Logging: The geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

Continuous wire-line core with split barrel. In-situ stress measurement by hydrofracturing; 1) borehole TV (dry hole) or acoustic televiewer (water-filled hole) will be used to locate suitable intervals for testing; 2) straddle packers will be set in hole and water will be pumped into the isolated interval until the fm. is fractured; 3) injection procedure may be repeated at the discretion of the USGS site geologist; 4) packers will be reset at different intervals until five good quality measurements have been made. Estimate 5,000 gallons clean water will be needed for the test.

Testing & Sampling to be Conducted as Listed in Study Plan:

Geologic logging of cuttings and core; borehole logging with video camera and geophysical tools; collection of core samples for petrographic, geochemical, and isotopic analyses.

Testing & Sampling Currently Planned:

Geologic framework of Calico Hills section and Tertiary/Paleozoic contact; geologic discontinuities; mineral and hydrocarbon potential; hydrochemistry; matrix properties of unsaturated zone/saturated zone contact; isotopic and noble-gas sampling (USGS); alteration history of Calico Hills to TD, mineralogy and petrology, including distribution and history of zeolites, and mineralogy of transport pathways (LANL) (Ref. 3).

Borehole Instrumentation:

TBD; perhaps instrumented for potentiometric surface.

Borehole Construction Requirements:

See introductory summary sheet for geologic boreholes.

Environmental Prerequisites**Land Ownership:**

NTS, for the location given above.

Access:

Field work (not casual).

Required Pre-Activity Surveys:

See Appendix B.

Estimated Amt. of Discharged Water:

A minimal amount is anticipated.

Required Surface Preparation:

Construction of drill pad with mud (if used) and cuttings pit is required. For the location given above, construction of an access road, and possibly improvement of existing roads may be necessary.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

References:

1. Study Plan 8.3.1.4.2.1, "Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area," Revision 3, Effective Date: September 2, 1993.
2. Workslope Consolidation Meeting for planned FY'94 boreholes, June 17, 1993, Las Vegas.
3. Drilling Prioritization Meetings, October and December, 1992, Las Vegas.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 G#8/WT#19

Type of Investigation: Geologic/ Water Table

WBS No.: 1.2.3.2.1.1.1 / 1.2.3.2.2.1.1

Study Plan No.: 8.3.1.3.2.1 / 8.3.1.4.2.1

Study Plan Title: Mineralogy, Petrology, and Chemistry of Transport Pathways / Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area

Principal Organization: LANL / USGS

Principal Investigators: Barbara Carlos / Pat Tucci

Other Participant Organizations: USGS

Purpose of Activity: To evaluate the lateral changes in mineralogy, chemistry, and petrography at Yucca Mountain; to define the potentiometric surface and the fluctuations of this surface with time, and to obtain hydrochemical data of the saturated zone (Refs. 1, 2, 7).

Location

Coordinates: NVSPC: N747,978/E589,973
UTM: N4,073,186/E557,151

Ground Elevation of Borehole (above sea level): Approximately 3350 ft (1021 m)

Location Description: At the intersection of two access roads, to the south of the main road from the FOC to the site, about 2 miles east of Well J-13.

Access to Location: Existing access is adequate.

Rationale for Location: To better define the potentiometric surface in the presumed flow path south and southeast from the repository block, and to obtain information on the mineralogic and chemical variability along saturated flow paths and on the Topopah Spring Member, which occurs in the unsaturated zone in the repository block, under saturated conditions (Refs. 1, 2).

Borehole Dimensions

Planned Borehole Depth: About 1350 to 1400 ft (400 ft below WT at elevation of 2390 ft in well J-13 [Ref. 4]).

Elevation at Total Depth (above sea level): About 2000 ft (610 m)

Planned Borehole Diameter: Greater than or equal to 9 7/8 in; maintain constant diameter from about 75 ft above WT to TD to accommodate packers (Ref. 3).

Planned Core Size: 2.44 in (HQ core) at TD (Ref. 3).

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25G#8/WT#19

Type of Investigation: Geologic/ Water Table

WBS No.: 1.2.3.2.1.1.1 / 1.2.3.2.2.1.1

Study Plan No.: 8.3.1.3.2.1 / 8.3.1.4.2.1

Study Plan Title: Mineralogy, Petrology, and Chemistry of Transport Pathways / Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area

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Rationale for Location: To better define the potentiometric surface in the presumed flow path south and southeast from the repository block, and to obtain information on the mineralogic and chemical variability along saturated flow paths and on the Topopah Spring Member, which occurs in the unsaturated zone in the repository block, under saturated conditions (Refs. 1, 2).

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Elevation at Total Depth (above sea level): About 2000 ft (610 m)

Planned Borehole Diameter: Greater than or equal to 9 7/8 in; maintain constant diameter from about 75 ft above WT to TD to accommodate packers (Ref. 3).

Planned Core Size: 2.44 in (HQ core) at TD (Ref. 3).

Schedule

Scheduled Start Date: TBD; see Comment 1, below.

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry

Recommended Drill Rig: Stratmaster or LM-300, or a another rig having a comparable depth capacity.

Drilling Fluids: Air

Tracers: Tracer added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheets for the geologic and hydrologic boreholes.

Sample Collection & Interval (cores/cuttings): Core predicted, selected contacts in the upper approximately 700 ft; collect continuous core from 200 ft above to 400 ft below WT (Ref. 2, 3).

Geophysical Logging: The geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

For G-8: Continuous core from minimum of 200 ft above water table to TD.

For WT-19: 1) After logging, a small down-hole pump will be hung in 2.875 in OD 8 rd tubing, with a 12 ft well screen at total depth; 2) pump will be run for 1 week to obtain water samples for chemical analyses; 3) after testing, pump will be removed and tubing will be reinstalled for long-term monitoring of potentiometric surface. Cuttings to total depth; core from ~50 ft above water table to 20 ft below water table; water samples from completed hole.

Testing & Sampling to be Conducted as Listed in Study Plan:

For G-8: Geologic logging of cuttings and core; borehole logging with video camera and geophysical tools; collection of core samples for petrographic, geochemical, and isotopic analyses.

For WT-19: Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, and barometric and earth tidal analysis (Refs. 1 and 2).

Testing & Sampling Currently Planned: Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; static water

level and temperature measurements; barometric and earth tidal analysis; cuttings collected for stratigraphic model (USGS); fracture mineralogy of Topopah and Calico Hills near and below water table; chlorine-36 analysis, water sample collected for radionuclide transport study (LANL) (Ref. 3).

Borehole Instrumentation:

Three strings of tubing, with a transducer in one string of tubing (Ref. 1).

Borehole Construction Requirements:

Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table (Refs. 1, 3).

Environmental Prerequisites**Land Ownership:**

NTS

Access:

Field work (not casual).

Required Pre-Activity Surveys:

See Appendix B.

Estimated Amt. of Discharged Water:

The potential amount of water discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min (Ref. 5, 6).

Required Surface Preparation:

Construction of drill pad is required. At the location given above, construction of an access road would not be needed, but improvement of existing roads/trails may be necessary.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

(1) This borehole should be drilled after any adjacent holes are completed, and the stratigraphy of well JF3 is obtained, in order to better understand the local stratigraphy before starting this borehole (Ref. 3).

References:

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.
3. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
4. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
5. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
6. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
7. Study Plan 8.3.1.4.2.1, "Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area," Revision 3, Effective Date: September 2, 1993.

REQUIREMENTS FOR DRILLING/TESTING

VOLCANIC BOREHOLES

Requirements of Primary User:

- Overall Objectives: - To investigate the origin of four aeromagnetic anomalies in Crater Flat and Amargosa Valley, and the ages of subsurface basaltic units under Crater Flat
- Location Requirement: - All locations are outside of the exploratory block and controlled area of Yucca Mountain, in Crater Flat and the Amargosa Valley.
- One drill hole will be drilled at each of the anomaly sites. The exact location of the drill hole will be determined from modeling and analysis of ground-based gravity and magnetic data for each anomaly site.
- Schedule Requirement: - TBD
- Depth Requirement: - Approximately 1000 ft, through both the upper and lower contact of any volcanic or intrusive rocks, so that the nature of the contact relationships can be determined.
- Data Requirements: - Continuous rock core through volcanic or subvolcanic rock.
- Geologic logs.
- Master suite of geophysical logs for borings more than 500 ft deep (Group I).
- stratigraphy of any volcanic or intrusive rocks present in the drill holes.
- Petrologic description of Pliocene and Quaternary volcanic rocks in this series of boreholes.
- Determination of the nature of contact relationships of both the upper and lower contact of any volcanic or intrusive rocks.
- Age assessment of volcanic units.
- Paleomagnetic analyses.
- Drilling Method¹: Conventional rotary with polymer mud
- Minimum Borehole Size¹: 6"
- Minimum Core Size¹: 1.87-2.44 in (NQ-HQ)
- Cored Interval^{1, 2}: - Cored continuously through both the upper and lower contact of any volcanic or intrusive rocks, estimated total of 100 ft of core.
- Sample/Testing Requirements²: - Representative core samples to be used for laboratory studies of magnetic polarity, petrographic, major element chemistry, and selected trace element and isotopic chemistry.
- K-Ar ages to be obtained for a minimum of two samples of the drill core per drill hole.
- If rocks are younger than 100,000 years old, alternative geochronology measurements will be obtained.
- Whole rock, major element, and selected trace element (strontium, rubidium, and zirconium) chemistry of core samples to be determined by XRF for at least six samples per drill hole.
- Additional selected trace element chemistry to be determined by INAA for at least three samples per drill hole.

- Strontium and neodymium isotopic compositions of one sample selected from each drill hole to be determined by solid-source mass spectroscopy.
- Representative samples will be selected for laboratory studies, based on visual and binocular examination.
- Thin sections of core samples to be cut into doubly polished mounts. Petrographic characteristics of the volcanic rocks to be determined from the thin section mounts using transmitted, polarized, and reflected microscopy.

Special Sample Handling Requirements:

- Core samples will be logged and stored at the Sample Management Facility.
- Magnetic polarity measurements require only preserving identified top and bottom segments of the drill core. (Oriented samples are not needed for core from this series of drill holes.)

Equipment Required:

- Drill rig and materials for borehole construction.
- Equipment and materials for downhole geophysical logging.

Study Plan: 8.3.1.8.5.1 "Characterization of Volcanic Features"
 WBS No.: 1.2.3.2.5.5.1
 Principal Investigator (/User): B. M. Crowe, LANL

Requirements/Requests of Secondary Users:

Other comments:

ENVIRONMENTAL CONCERNS

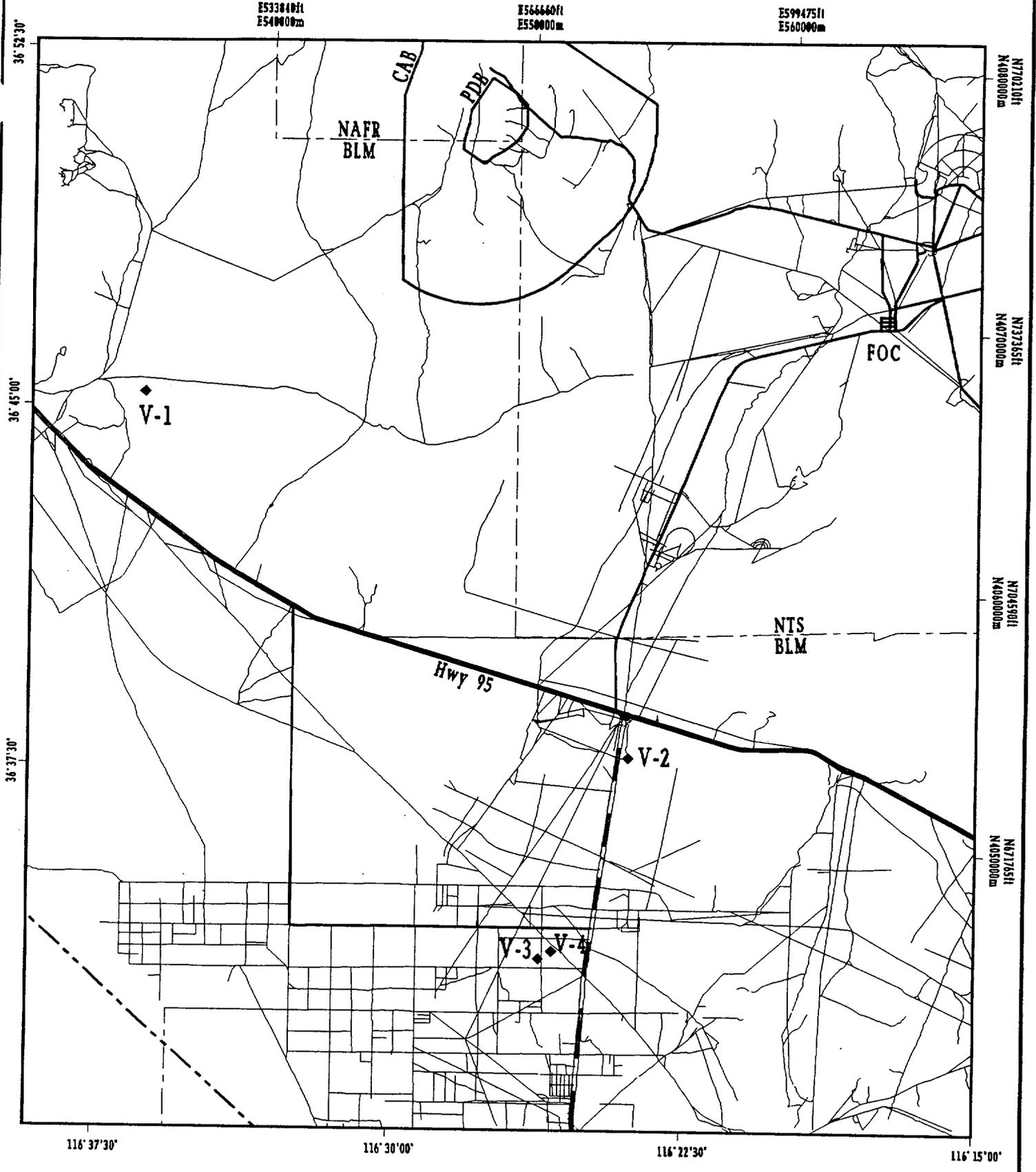
Use of Tracers: TBD
 Emissions/Effluent: Anticipated to be N/A.
 Water Discharge: None anticipated.
 Amount
 Rate
 Chemistry
 Discharge Point
 Will Study Intersect the Water Table? No
 Extent and Location of Ground Disturbance:
 Road Access Depends on location.
 Pad Construction:

**BOREHOLE PRIORITIZATION BY PRINCIPAL INVESTIGATOR
 (as of April 23, 1993)¹**

USW V-1
 USW V-3
 USW V-4
 USW V-2

Primary Sources of Information:

1. Drilling prioritization meetings, October and December, 1992, Las Vegas.
2. Study Plan 8.3.1.8.5.1, "Characterization of Volcanic Features."



LEGEND
 ◆ Volcanic Borehole



**YUCCA MOUNTAIN
 SITE CHARACTERIZATION PROJECT
 PLANNED VOLCANIC BOREHOLES**

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW V-1
Type of Investigation: Volcanic
WBS No.: 1.2.3.2.5.5.1
Study Plan No.: 8.3.1.8.5.1.1
Study Plan Title: Characterization of Volcanic Features
Principal Organization: LANL
Principal Investigators: B. M. Crowe
Other Participant Organizations: None
Purpose of Activity: To investigate the origin of the four aeromagnetic anomalies in Crater Flat and Amargosa Valley and the ages of subsurface basaltic beds under Crater Flat.

Location

Coordinates: NVSPC: N729,600/E518,000
UTM: N4,067,509/E535,239
Ground Elevation of Borehole (above sea level): TBD
Location Description: TBD
Access to Location: Proposed site may be accessible by existing road.
Rationale for Location: TBD

Borehole Dimensions

Planned Borehole Depth: Approx. 1000 ft
Elevation at Total Depth (above sea level): TBD
Planned Borehole Diameter: 6 in
Planned Core Size: 1.87-2.44 in (NQ-HQ)

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Conventional rotary

Recommended Drill Rig: CME-850
Drilling Fluids: Polymer mud
Tracers: TBD

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: TBD
Sample Collection & Interval (cores/cuttings): 100 ft total core, through basalt layers; cuttings from upper part of hole
Geophysical Logging: Geophysical logs identified for Group I boreholes will be run (Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core
Testing & Sampling to be Conducted as Listed in Study Plan: TBD
Testing & Sampling Currently Planned: Evaluate aeromagnetic anomalies associated with volcanic features in Crater Flat (LANL); age-dating of basalt layers (LANL)
Borehole Instrumentation: TBD
Borehole Construction Requirements: 9-5/8 in. casing set at 40 ft.

Environmental Prerequisites

Land Ownership: BLM
Access: TBD
Required Pre-Activity Surveys: TBD
Estimated Amt. of Discharged Water: TBD
Required Surface Preparation: TBD
Anticipated Area of Surface Disturbance: TBD
Required Permits: TBD

Restoration

Borehole Closure Requirements: TBD
Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

Primary Reference:

U.S. Department of Energy, 1988, Surface-Based Testing Investigations Plan, Yucca Mountain Project, YMP/88-25.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW V-2
Type of Investigation: Volcanic
WBS No.: 1.2.3.2.5.5.1
Study Plan No.: 8.3.1.8.5.1.1
Study Plan Title: Characterization of Volcanic Features
Principal Organization: LANL
Principal Investigators: B. Crowe
Other Participant Organizations: None
Purpose of Activity: To investigate the origin of the four aeromagnetic anomalies in Crater Flat and Amargosa Valley and the ages of subsurface basaltic beds under Crater Flat.

Location

Coordinates: NVSPC: N683,721/E578,907
UTM: N4,053,594/E553,847
Ground Elevation of Borehole (above sea level): TBD
Location Description: TBD
Access to Location: Proposed site may be accessible by existing road.
Rationale for Location: TBD

Borehole Dimensions

Planned Borehole Depth: Approx. 1000 ft
Elevation at Total Depth (above sea level): TBD
Planned Borehole Diameter: 6 in
Planned Core Size: 1.87-2.44 in (NQ-HQ)

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Conventional rotary

Recommended Drill Rig: CME-850
Drilling Fluids: Polymer mud
Tracers: TBD

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: TBD
Sample Collection & Interval (cores/cuttings): 100 ft total core, through basalt layers; cuttings from upper part of hole
Geophysical Logging: Geophysical logs identified for Group I boreholes will be run (Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core
Testing & Sampling to be Conducted as Listed in Study Plan: TBD
Testing & Sampling Currently Planned: Evaluate aeromagnetic anomalies associated with volcanic features in Crater Flat (LANL); age-dating of basalt layers (LANL)
Borehole Instrumentation: TBD
Borehole Construction Requirements: 9-5/8 in. casing set at 40 ft.

Environmental Prerequisites

Land Ownership: TBD
Access: TBD
Required Pre-Activity Surveys: TBD
Estimated Amt. of Discharged Water: TBD
Required Surface Preparation: TBD
Anticipated Area of Surface Disturbance: TBD
Required Permits: TBD

Restoration

Borehole Closure Requirements: TBD
Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

Primary Reference:

U.S. Department of Energy, 1988, Surface-Based Testing Investigations Plan, Yucca Mountain Project, YMP/88-25.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW V-3
Type of Investigation: Volcanic
WBS No.: 1.2.3.2.5.5.1
Study Plan No.: 8.3.1.8.5.1.1
Study Plan Title: Characterization of Volcanic Features
Principal Organization: LANL
Principal Investigators: B. Crowe
Other Participant Organizations: None
Purpose of Activity: To investigate the origin of the four aeromagnetic anomalies in Crater Flat and Amargosa Valley and the ages of subsurface basaltic beds under Crater Flat.

Location

Coordinates: NVSPC: N658,100/E567,848
UTM: N4,045,775/E550,504
Ground Elevation of Borehole (above sea level): TBD
Location Description: TBD
Access to Location: Depends on location.
Rationale for Location: TBD

Borehole Dimensions

Planned Borehole Depth: Approx. 1000 ft
Elevation at Total Depth (above sea level): TBD
Planned Borehole Diameter: 6 in
Planned Core Size: 1.87-2.44 in (NQ-HQ)

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Conventional rotary

Recommended Drill Rig: CME-850
Drilling Fluids: Polymer mud
Tracers: TBD

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: TBD
Sample Collection & Interval (cores/cuttings): 100 ft total core, through basalt layers; cuttings from upper part of hole
Geophysical Logging: Geophysical logs identified for Group I boreholes will be run (Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core
Testing & Sampling to be Conducted as Listed in Study Plan: TBD
Testing & Sampling Currently Planned: Evaluate aeromagnetic anomalies associated with volcanic features in Crater Flat (LANL); age-dating of basalt layers (LANL)
Borehole Instrumentation: TBD
Borehole Construction Requirements: 9-5/8 in. casing set at 40 ft.

Environmental Prerequisites

Land Ownership: TBD
Access: TBD
Required Pre-Activity Surveys: TBD
Estimated Amt. of Discharged Water: TBD
Required Surface Preparation: TBD
Anticipated Area of Surface Disturbance: TBD
Required Permits: TBD

Restoration

Borehole Closure Requirements: TBD
Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

Primary Reference:

U.S. Department of Energy, 1988, Surface-Based Testing Investigations Plan, Yucca Mountain Project, YMP/88-25.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW V-4
Type of Investigation: Volcanic
WBS No.: 1.2.3.2.5.5.1
Study Plan No.: 8.3.1.8.5.1.1
Study Plan Title: Characterization of Volcanic Features
Principal Organization: LANL
Principal Investigators: B. Crowe
Other Participant Organizations: None
Purpose of Activity: To investigate the origin of the four aeromagnetic anomalies in Crater Flat and Amargosa Valley and the ages of subsurface basaltic beds under Crater Flat.

Location

Coordinates: NVSPC: N659,056/E569,502
UTM: N4,046,068/E551,007
Ground Elevation of Borehole (above sea level): TBD
Location Description: TBD
Access to Location: Depends on location.
Rationale for Location: TBD

Borehole Dimensions

Planned Borehole Depth: 400-1000 ft
Elevation at Total Depth (above sea level): TBD
Planned Borehole Diameter: 6 in
Planned Core Size: 1.87-2.44 in (NQ-HQ)

Schedule

Scheduled Start Date: TBD
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Conventional rotary

Recommended Drill Rig: CME-850
Drilling Fluids: Polymer mud
Tracers: TBD

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: TBD
Sample Collection & Interval (cores/cuttings): 100 ft total core, through basalt layers; cuttings from upper part of hole
Geophysical Logging: Geophysical logs identified for Group I boreholes will be run (Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan: Continuous core
Testing & Sampling to be Conducted as Listed in Study Plan: TBD
Testing & Sampling Currently Planned: Evaluate aeromagnetic anomalies associated with volcanic features in Crater Flat (LANL); age-dating of basalt layers (LANL)
Borehole Instrumentation: TBD
Borehole Construction Requirements: 9-5/8 in. casing set at 40 ft.

Environmental Prerequisites

Land Ownership: TBD
Access: TBD
Required Pre-Activity Surveys: TBD
Estimated Amt. of Discharged Water: TBD
Required Surface Preparation: TBD
Anticipated Area of Surface Disturbance: TBD
Required Permits: TBD

Restoration

Borehole Closure Requirements: TBD
Borehole Closure Date: TBD

Site Restoration Requirements: TBD

Site Restoration Date: TBD

Comments:

Primary Reference:

U.S. Department of Energy, 1988, Surface-Based Testing Investigations Plan, Yucca Mountain Project, YMP/88-25.

REQUIREMENTS FOR DRILLING/TESTING

WATER TABLE BOREHOLES

Requirements of Primary User:

- Overall Objectives:¹
- To define potentiometric surfaces, particularly the uppermost surface, and calculate average levels and hydraulic gradients within and in the vicinity of the repository block.
 - To determine the character and magnitude of potentiometric-level fluctuations with time and depth to determine cause, and estimate system parameters, such as transmissive and storage properties.
 - To determine well/formation properties such as barometric efficiency, dilational efficiency, and correlate water-level variations with earth crustal strain changes.
 - To determine to frequency response function of the well/formation to barometric and earth-tide induced strains, and the frequencies at which a static-confined response can be inferred.
 - To assess the significance of fault-related features on water movement.
 - To collect gas samples from the lowermost unsaturated zone
- Location Requirements:¹
- Boreholes are planned at locations that provided spatial geographical coverage and where additional data can refine the present understanding of the hydraulic gradient¹.
- Schedule Requirement:²
- Completion of one to two boreholes to incorporate preliminary description/analysis of the large hydraulic gradient into the Preliminary Saturated Zone Model.
 - Completion of additional WT borehole to provide an integrated regional/site potentiometric map for the Interim Saturated Zone Model.
 - All WT boreholes completed for the Final Saturated Zone Model.
- Depth Requirement:
- The boreholes are to be drilled a short distance, probably less than 100 m into the saturated zone¹. Boreholes WT-23 and WT-24 are to be drilled to 150 ft below the base of the Calico Hills unit³. (Note TD request of secondary user, Mineralogy and Petrology.)
- Hydrologic Data Requirements:¹
- The accurate measurement of the potentiometric surface during borehole development and long-term monitoring.
 - Prevention of communication between the saturated zone and the unsaturated zone to measure barometrically driven changes in water levels.
 - The periodic measurement of temperature in the borehole.
 - Geophysical logs and downhole video logs showing stratigraphic units and structural features penetrated during drilling.
- Drilling Method:
- Most boreholes are to be drilled with air; although another drilling medium may be considered for some that are a distance from the repository block. However, dry drilling is required for core collected in the lower unsaturated zone, within about 100 ft of the water table.
 - Tracers are to be added to the drilling medium.
 - Casing needs to extend to about 20 to 30 feet below the water table; gas samples need to be collected from the lowermost unsaturated zone prior to the setting of casing.³
- Minimum Borehole Size:
- Borehole needs to be of sufficient diameter to accommodate pump capable of pumping at a rate of 100 gal/min and lifting water 2000 ft.³
 - The borehole diameter within the saturated zone needs to be constant in order that packers can be used.³

Minimum Core Size:	HQ (2.4 in) - requirement is set by laboratory equipment used in UZ hydrochemistry analyses.
Cored Interval:	From about 75 ft (25 m) above the water table to about 75 ft (25 m) below the water table ⁵ .
Special Sample Handling Requirements: ⁶	<ul style="list-style-type: none"> - Collect one sample, 20 cm long, for about every 10 m of core. - From 15 m (45 ft) above the water table to 15 m (45 ft) below the water table, collect one sample, 20 cm long, for about every 2 m of core. - Samples are to be an intact section whenever possible. - Isolate samples from the atmosphere as soon as possible in the following manner: <ul style="list-style-type: none"> - Place each sample in separate, acid-rinsed, lexan-type liner, not exceeding 30 cm in length; - Cap liner at both ends, tape caps, and place in ProtecCore.
Sample/Testing Requirements: ^{1,3,4,6}	<ul style="list-style-type: none"> - Dry drilling in the unsaturated zone. - Tracer is to be added to the drilling medium when coring in the unsaturated zone, and while drilling/coring in the saturated zone. - The measurement and analysis of gas squeezed from rock core at 4 to 5 intervals within 75 ft (25 m) above the water table.⁴ - The evacuation of the borehole of drilling air, and the collection of gas samples from the lowermost unsaturated zone, within about 10 ft of the water table, prior to the installation of casing across this zone. - The collection of geophysical logs in both the unsaturated and saturated zones; the unsaturated zone should be logged prior to setting casing. - The development and pumping of the borehole after the completion of drilling to remove cuttings and traces of drilling medium, prior to collection of water chemistry samples from the unsaturated zone directly above the water table or from identified intervals within the saturated zone. - The accurate measurement of water level: <ul style="list-style-type: none"> - during drilling, as determined by the PI - following completion of drilling - on a periodic basis following installation of water level monitoring equipment. - The prevention of communication between the saturated zone and the unsaturated zone, in order to measure barometrically driven changes in water levels. Either <ul style="list-style-type: none"> - 'tack cement' around the base of the casing, - grout casing in borehole, or - utilize another method to be determined. - The installation of three access tubes: two are for water-level measurements, the third is for temperature measurement of the unsaturated zone¹.
Equipment Required - to be Supplied by Participant:	<ul style="list-style-type: none"> - Water level monitoring equipment - Gas sampling equipment and containers - Water sampling equipment and containers - Packers for collection of either gas or water samples (may be supplied by contractor) - Mobile laboratory equipment required by participant
Equipment Required - to be Supplied by Contractor:	<ul style="list-style-type: none"> - Drill rig and borehole construction materials - Tracer gas and tracer monitoring equipment - Vacuum for pumping drilling air from borehole - Submersible pump - Access tubing and screens - Generator to operate the submersible pump - Discharge line, or tank or truck to remove pumped water from the immediate vicinity of the borehole. - Packers for gas and water sampling, of not supplied by participant.

Study Plans: (a) 8.3.1.2.3.1 "Characterization of the Site Saturated-Zone Ground-Water Flow System"
 (b) 8.3.1.2.3.2 "Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry"

WBS No. (a) 1.2.3.3.1.3.1
 (b) 1.2.3.3.1.3.2

Principal Investigators/Users: (a) Pat Tucci, USGS
 (b) Bill Steinkampf, USGS

Requirements/Requests of Secondary Users:

Mineral and Alteration History (LANL):^{7,8}

- TD below top of Tram
- core from 50 feet above to 50 ft below the top of the saturated zone
- drill dry in the unsaturated zone
- collect a drum (55 gal) of water at the same time as the water chemistry samples are collected.

Systematic Drilling (at selected WT boreholes, only) (SNL):³

- HQ core or larger, or sidewall core
- core shardy base, Calico Hills, base of Topopah
- wet or dry drilling

Chlorine-36 (LANL):³

- Cuttings are requested from the unsaturated zone if the hole is drilled dry.

Geologic Model (USGS):³

- Stratigraphic contacts
- Cuttings are OK

Matrix Properties of UZ (USGS):

- Core samples from the unsaturated zone are requested from some of the WT boreholes

Heat Flow Measurements:

- The regular monitoring of borehole temperatures in the unsaturated zone.

ENVIRONMENTAL CONCERNS

Use of Tracers:	Tracer will be added to drilling medium
Emissions/Effluent:	Anticipated to be N/A
Water Discharge: ⁹	
Amount	10,000 to 2,000,000 gal
Rate	20 gal/min for up to 14 days (approximate); variable pumping rate of about 10 to 100 gal/min.
Chemistry	TBD
Discharge Point	TBD for each borehole
Will Study Intersect the Water Table?	Yes
Extent and Location of Ground Disturbance:	
Road Access	Dependent on specific borehole location
Pad Construction:	Of sufficient dimension to position and drill with a Stratmaster or comparable drilling rig.

BOREHOLE PRIORITIZATION BY PRINCIPAL INVESTIGATOR
(as of April 23, 1993)⁸

USW WT-23
UE-25 WT#24
USW WT-8
SW WT-9
USW WT-21
USW WT-22
UE-25WT#20
UE-25 WT#19/G#8

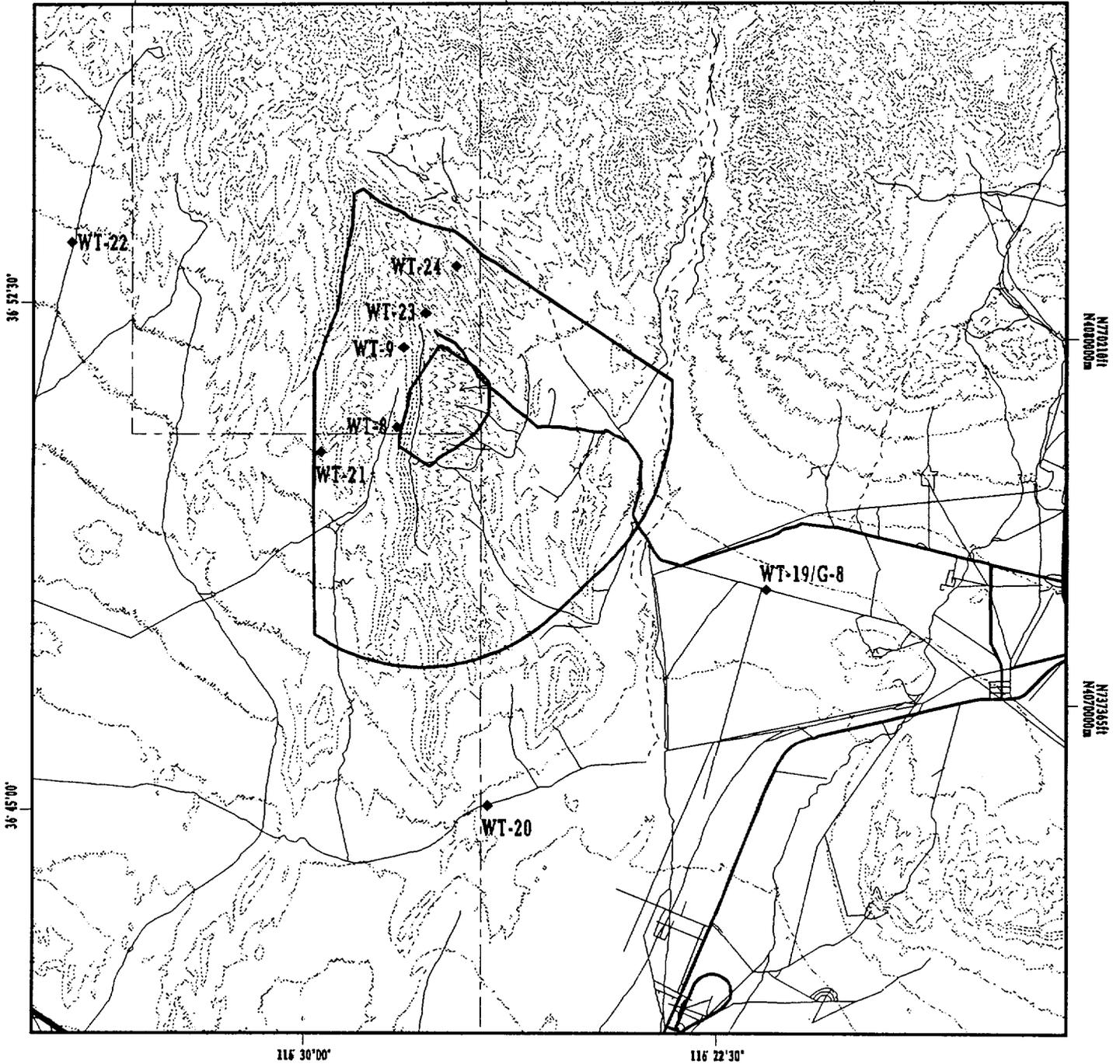
Primary Sources of Information:

1. Study Plan 8.3.1.2.3.1: "Characterization of the Site Saturated Ground-Water Flow System," Rev. 0, approved February 26, 1991.
2. FY 1994 Draft Annual Plan, Site Characterization , Yucca Mountain Project, Appendix D, Preliminary Compilation of Level 2 and 3 Integrated Milestones for the Site Investigations Long-Range Plan, April, 1993.
3. Consolidated work scope meeting for planned FY'94 boreholes, 17 June, 1993.
4. Study Plan 8.3.1.2.3.2: "Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0, dated November 11, 1991.
5. Letter from Robert Craig (USGS) to Heidi Lohn (SAIC), "Request for Input for Test Planning Package T-93-09," August 9, 1993. Modified to accommodate requested cored interval.
6. Oral communication, Dick Luckey (USGS) with Norma Biggar (M&O/WCFS), August 30, 1993.
7. Memorandum from R. Oliver (LANL) to Russ Dyer (DOE-RSED), "Los Alamos National Laboratories Design and Test Related Input for Test Planning Package (TPP) T-93-09, USW SD-12," August 18, 1993.
8. Drilling prioritization meetings, October and December, 1992, Las Vegas.
9. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.

E533840ft
E540000m

E566640ft
E550000m

E599475ft
E560000m



LEGEND

◆ Planned Borehole



Contour Interval 200 Feet

**YUCCA MOUNTAIN
SITE CHARACTERIZATION PROJECT
PLANNED WATER TABLE BOREHOLES**



YMP-92-039.5

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW WT-8

Type of Investigation: Water Table

WBS No.: 1.2.3.3.1.3.1

Study Plan No.: 8.3.1.2.3.1

Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System

Principal Organization: USGS

Principal Investigators: Pat Tucci / W. Steinkampf

Other Participant Organizations: LANL

Purpose of Activity: To define water table surface and obtain hydrochemical data of the saturated zone.

Location

Coordinates: NVSPC: N772,550/E559,600
UTM: N4,080,641/E547,870

Ground Elevation of Borehole (above sea level): About 4250 ft (1287 m)

Location Description: On the east side of Solitario Canyon, about 100 ft above the canyon floor, and west of the Solitario Canyon fault; and about 1.5 miles north of the turnoff of the Solitario Canyon road to well USW H-6.

Access to Location: Access is by the road in Solitario Canyon. There is no trail or road shown on the topographic map to the planned borehole location on the eastern slope of the canyon. An access road \geq 1000 ft long will need to be constructed from the Solitario Canyon road, from in the vicinity of where the road to well H-7 turns westward from the canyon.

Rationale for Location: The WT-8 location is in an alignment with well H-6 to the west and planned well H-7/SD-6 to the east, on Yucca Crest (Ref. 1).

Borehole Dimensions

Planned Borehole Depth: About 2025 ft (613 m) to 2300 ft (700 m). A borehole depth of about 2025 would be 325 ft below the water table at an elevation of 2545 ft in well H-6 [Ref. 2], approximately 3100 ft to the west-northwest). However, an addition 300 ft (100 m) of drilling may be necessary to meet the LANL request of a TD below the top of the Tram Member (Refs. 1, 4)

Elevation at Total Depth (above sea level): 1950 ft (594 m) to 2200 ft (671 m)

Planned Borehole Diameter: > 9 7/8 in. (Refs. 1 and 4); maintain constant diameter throughout the portion of the borehole in which packers will be emplaced (Ref. 4).

Planned Core Size: 2.44 in (HQ) is preferred

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry drilling above the water table.

Recommended Drill Rig: Stratmaster or LM-300

Drilling Fluids: Air

Tracers: A tracer(s) is to be added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory section for WT boreholes.

Sample Collection & Interval (cores/cuttings): Collect continuous core for 66 to 100 percent of the borehole, particularly from about 200 ft above the anticipated water table (WT) to 75 ft below WT; collect dry cuttings above WT for chlorine-36 analysis, and cuttings from both the UZ and SZ for stratigraphic analysis (Ref. 1, 4).

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

1) Core for 75 ft above WT; 2) land removable packer and access tubing ~10 ft above hole bottom; 3) collect gas sample with vacuum and peristaltic pumps; 4) core ~25 ft; 5) drill to total depth; 6) collect geophysical logs; 7) collect water samples using packers and submersible pump; 8) collect water samples using bridge plug, small-diameter tubing, and small-capacity pump; 9) bridge plug and tubing remain in hole for long-term monitoring of potentiometric surface and vertical thermal profile. Cuttings to total depth; continuous core from 75 ft above water table to 30 ft below water table; interstitial gas samples; water samples.

Testing & Sampling to be Conducted as Listed in Study Plan:

Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, barometric and earth tidal analysis, and possible installation of a strain meter to monitor for correlations between water

level fluctuations and changes in crustal strain near the Solitario Canyon fault (Refs. 1 and 7).

Testing & Sampling Currently Planned:

Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; monitoring of potentiometric surface and borehole temperatures, analysis of matrix hydrologic properties, collect cuttings for stratigraphic model, conduct hydraulic tests for Solitario Canyon hydrologic studies (USGS); evaluate alteration history and fracture mineralogy; examine mineralogy and petrology; collect water sample for radionuclide transport study; collect cuttings of UZ for chlorine-36 analysis (LANL)

Borehole Instrumentation:

Three strings of tubing, with a transducer in one string of tubing; possible installation of a strain meter to monitor for correlations between water level fluctuations and changes in crustal strain near the Solitario Canyon fault (Ref. 1).

Borehole Construction Requirements:

Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table.

Environmental Prerequisites

Land Ownership:

USAF

Access:

Field Work

Required Pre-Activity Surveys:

See Appendix B.

Estimated Amt. of Discharged Water:

The potential amount of water that may be discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min. (Ref. 5, 6).

Required Surface Preparation:

Construction of a drill pad and an access road \leq 1000 ft long is required.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration

Borehole Closure Requirements:

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:**References:**

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
3. Craig, R.W., and Reed, R.L., 1991, Geohydrology of Rocks Penetrated by Test Well USW H-6, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey, Water Resources Investigations Report 89-4025, 40 p.
4. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
5. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
6. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
7. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW WT-9
Type of Investigation: Water Table
WBS No.: 1.2.3.3.1.3.1
Study Plan No.: 8.3.1.2.3.1
Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System
Principal Organization: USGS
Principal Investigators: Pat Tucci / W. Steinkampf
Other Participant Organizations: LANL
Purpose of Activity: To define water table surface and obtain hydrochemical data of the saturated zone.

Location

Coordinates: NVSPC: N769,477/E557,642
UTM: N4,079,703/E547,276.4

Ground Elevation of Borehole (above sea level): 4450 ft (1347 m)

Location Description: At the north end of Solitario Canyon, west-southwest of the juncture of Diablos Ridge with Yucca Crest, and about 1.5 miles north of the turnoff of the Solitario Canyon road to well USW H-6. The borehole is approximately 3100 ft north-northwest of well USW H-5 and 3500 ft south-southwest of planned borehole USW WT-23.

Access to Location: Proposed site is accessible by existing road/trail. Some improvements may be necessary.

Rationale for Location: The borehole is located to define the potentiometric surface at the northern part of the Solitario fault; and, with boreholes WT-7 and WT-8 to the south, to better describe flow across the fault. The borehole is located on the west side of the fault as an observation well to assess if changes are noted in water level when pumping is occurring in well H-7/SD-6 on the east side of the fault. Water levels measured in borehole WT-9, along with that in planned borehole WT-23, will better define the transition between the potentiometric surfaces measured in (1) the Solitario Canyon area (water levels at 2530 ft (775 m) elevation) and (2) to the north of the repository area, in the vicinity of borehole USW G-2 and USW WT-6, where the water level is at elevation of 3395 ft (1035 m).

Borehole Dimensions

Planned Borehole Depth:	About 2235 ft (680 m) to 2560 ft (775 m). A borehole depth of about 2230 would be about 325 ft (100 m) below WT at an elevation of 2540 [775 m] in wells H-5 and H-6 [Ref. 1]). However, an addition 325 ft (100 m) of drilling may be necessary to meet the LANL request of a TD below the top of the Tram Member (Ref. 2).
Elevation at Total Depth (above sea level):	1890 ft (576 m) to 2215 ft (675 m)
Planned Borehole Diameter:	> 9 7/8 in. (Refs. 2 and 3); maintain constant diameter throughout the portion of the borehole in which packers will be emplaced (Ref. 2).
Planned Core Size:	2.44 in (HQ) is preferred

Schedule

Scheduled Start Date:	TBD
Scheduled Completion Date:	TBD

Drilling and Construction

Drilling Method:	Dry drilling above the water table.
Recommended Drill Rig:	Stratmaster or LM-300 or an equivalent rig having a comparable depth capacity.
Drilling Fluids:	Air
Tracers:	A tracer(s) is to be added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory section for WT boreholes.
Sample Collection & Interval (cores/cuttings):	Collect continuous core for 66 to 100 percent of the borehole, particularly from about 200 ft above the anticipated water table (WT) to 75 ft below WT; collect dry cuttings above WT for chlorine-36 analysis, and cuttings from both the UZ and SZ for stratigraphic analysis (Refs. 1, 2).
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	1) Drill to WT, collect ~30 ft of saturated core, drill to total depth; 2) collect geophysical logs; 3) collect water samples using packers and submersible pump; 4) collect water samples using bridge plug, small-diameter tubing, and small-capacity pump; 5) bridge plug and tubing remain in

hole for long-term monitoring of potentiometric surface and vertical thermal profile. Cuttings to TD and core from WT to ~30 ft below WT; water samples.

Testing & Sampling to be Conducted as Listed in Study Plan:

Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, barometric and earth tidal analysis, and possibly the installation of a strain meter to monitor for correlations between water level fluctuations and changes in crustal strain near the Solitario Canyon fault (Refs. 1 and 7).

Testing & Sampling Currently Planned:

Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; monitoring of potentiometric surface and borehole temperatures, analysis of matrix hydrologic properties, collect cuttings for stratigraphic model, conduct hydraulic tests for Solitario Canyon hydrologic studies (USGS); evaluate alteration history and fracture mineralogy; examine mineralogy and petrology; collect water sample for radionuclide transport study; collect cuttings of UZ for chlorine-36 analysis (LANL)

Borehole Instrumentation:

Three strings of tubing, with a transducer in one string of tubing; possible installation of a strain meter to monitor for correlations between water level fluctuations and changes in crustal strain near the Solitario Canyon fault (Ref. 1).

Borehole Construction Requirements:

Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table.

Environmental Prerequisites

Land Ownership:	USAF
Access:	TBD
Required Pre-Activity Surveys:	TBD
Estimated Amt. of Discharged Water:	The potential amount of water that may be discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min. (Refs. 5, 6).
Required Surface Preparation:	Construction of a drill pad is required, as well as probable improvement of access road.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

RELEASE OF EMISSIONS (BATCH & SCREENING PLANTS, DRILLRIG > 500 hp)

- o Location of surface facilities
 - Plot plan
 - USGS 7.5 or 15' map
- o Description of surface facilities
 - Proposed uses for disturbed areas
 - Acres per disturbed area
 - Sand/gravel sources
 - Material storage
 - Haul roads
- o Description of stationary emission sources
 - Type of equipment
 - Manufacturer, model, date built, date purchased
 - Design capacity, operating rate/time
 - Primary material consumed, fuels used
 - Quantity, rate, duration of emissions
 - Type & efficiency of pollution control equipment
- o Operation
 - Methods of dust control
 - Expected activity/construction startup dates

DISCHARGE OF EFFLUENT/WASTEWATER/STORMWATER

- o Location of discharge system
 - Facility
 - Discharge structures
 - Wastewater storage areas
- o Description of discharge system
 - Detailed design drawings
 - Number of discharge points
 - Schematic water flow
 - Discharge destinations (sewer, well, tank, lagoon)
 - Pond and pond liner specifications
- o Description of effluent
 - Chemical & physical composition
 - Potential for change in composition in five years
 - Amount (daily average, daily maximum, total)
 - Months during which discharge occurs
 - Days of week during which discharge occurs
- o Operation
 - Principal activity
 - Number of employees operating facility
 - Wastewater treatment method
 - Oil recovery handling procedures

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:**References:**

1. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
2. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
3. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
4. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.
5. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
6. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 WT#19/G#8

Type of Investigation: Water Table / Geologic

WBS No.: 1.2.3.3.1.3.1 / 1.2.3.2.1.1.1

Study Plan No.: 8.3.1.2.3.1 / 8.3.1.3.2.1

Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System / Mineralogy, Petrology, and Chemistry of Transport Pathways

Principal Organization: USGS / LANL

Principal Investigators: Pat Tucci and W. Steinkampf / Barbara Carlos

Other Participant Organizations: None identified

Purpose of Activity: To define the potentiometric surface and the fluctuations of this surface with time, to obtain hydrochemical data of the saturated zone, and to evaluate the lateral changes in mineralogy, chemistry, and petrography at Yucca Mountain (Refs. 1, 2, 7).

Location

Coordinates: NVSPC: N747,978/E589,973
UTM: N4,073,186/E557,151

Ground Elevation of Borehole (above sea level): Approximately 3350 ft (1021 m)

Location Description: At the intersection of two access roads, to the south of the main road from the FOC to the site, about 2 miles east of Well J-13.

Access to Location: Proposed site is accessible by existing road.

Rationale for Location: To better define the potentiometric surface in the presumed flow path south and southeast from the repository block, and to obtain information on the mineralogic and chemical variability along saturated flow paths and on the Topopah Spring Member, which occurs in the unsaturated zone in the repository block, under saturated conditions (Refs. 1, 2).

Borehole Dimensions

Planned Borehole Depth: About 1350 to 1400 ft (400 ft below WT at elevation of 2390 ft in well J-13 [Ref. 3]).

Elevation at Total Depth (above sea level): About 2000 ft (610 m)

Planned Borehole Diameter: Greater than or equal to 9 7/8 in; maintain constant diameter from about 75 ft above WT to TD to accommodate packers (Ref. 4)

Planned Core Size: 2.44 in (HQ core)

Schedule

Scheduled Start Date: TBD; see Comment 1, below
Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry
Recommended Drill Rig: Stratmaster, or LM-300, or a another rig having a comparable depth capacity
Drilling Fluids: Air
Tracers: Tracer to be added to drilling medium

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory summary sheets for hydrologic and geologic boreholes.

Sample Collection & Interval (cores/cuttings): Core predicted, selected contacts in the upper approximately 700 ft; collect continuous core from 200 ft above to 400 ft below WT (Refs. 2, 3).

Geophysical Logging: The geophysical logging suite for a Group I borehole (see Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:
For WT-19: 1) After logging, a small down-hole pump will be hung in 2.875 in OD 8 rd tubing, with a 12 ft well screen at total depth; 2) pump will be run for 1 week to obtain water samples for chemical analyses; 3) after testing, pump will be removed and tubing will be reinstalled for long-term monitoring of potentiometric surface. Cuttings to total depth; core from ~50 ft above water table to 20 ft below water table; water samples from completed hole.
For G-8: Continuous core from minimum of 200 ft above water table to TD.

Testing & Sampling to be Conducted as Listed in Study Plan:
For WT-19: Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, and barometric and earth tidal analysis (Refs. 1 and 2).
For G-8: Geologic logging of cuttings and core; borehole logging with video camera and geophysical tools; collection of core samples for petrographic, geochemical, and isotopic analyses (Ref. 7).

Testing & Sampling Currently Planned: Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; static water

level and temperature measurements; barometric and earth tidal analysis; cuttings collected for stratigraphic model (USGS); fracture mineralogy of Topopah and Calico Hills near and below water table; chlorine-36 analysis, water sample collected for radionuclide transport study (LANL) (Ref. 3).

Borehole Instrumentation:

Three strings of tubing, with a transducer in one string of tubing.

Borehole Construction Requirements:

Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table.

Environmental Prerequisites**Land Ownership:**

NTS - Area 25

Access:

Field Work

Required Pre-Activity Surveys:

See Appendix B

Estimated Amt. of Discharged Water:

The potential amount of water discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min (Refs. 5, 6).

Required Surface Preparation:

Construction of drill pad is required. At the location given above, construction of an access road would not be needed, but improvement of existing roads/trails may be necessary.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:

(1) This borehole should be drilled after any adjacent holes are completed and the stratigraphy of well JF3 is obtained, in order to better understand the local stratigraphy before starting this borehole (Ref. 3).

References:

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.
3. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
4. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
5. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
6. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
7. Study Plan 8.3.1.4.2.1, "Characterization of the Vertical and Lateral Distribution of Stratigraphic Units in the Site Area," Revision 3, Effective Date: September 2, 1993.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 WT#20

Type of Investigation: Water Table

WBS No.: 1.2.3.3.1.3.1

Study Plan No.: 8.3.1.2.3.1

Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System

Principal Organization: USGS

Principal Investigators: Pat Tucci / W. Steinkampf

Other Participant Organizations: LANL

Purpose of Activity: To define water table surface and obtain hydrochemical data of the saturated zone.

Location

Coordinates: NVSPC: N728,303/E565,143
UTM: N4,067,164/E549,606

Ground Elevation of Borehole (above sea level): 3190 ft (972 m) (estimated from Ref. 1)

Location Description: 3.1 mi southwest of J-12 (Ref. 1)

Access to Location: Proposed site is accessible by existing road.

Rationale for Location: Located to better define the presumed flow path south from repository block (Ref. 1)

Borehole Dimensions

Planned Borehole Depth: < 1115 ft (340 m) (325 ft [100 m] below the water table at a elevation of 2400 ft [730 m], projected from wells USW WT-11 and UE-25 WT#12, about 2 mi to the north [Ref. 3]). A TD of 980 ft (300 m) is given in Ref. 1.

Elevation at Total Depth (above sea level): TBD

Planned Borehole Diameter: > 9 7/8 in; maintain constant diameter from about 100 ft above WT to TD to accommodate packers

Planned Core Size: 2.44 in (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method:	Dry
Recommended Drill Rig:	Joy, CME-850, Failing, or other rig of comparable depth capability
Drilling Fluids:	Air
Tracers:	A tracer(s) is to be added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory section for WT boreholes.
Sample Collection & Interval (cores/cuttings):	Continuous core from about 75 ft (25 m) above to 75 ft (25 m) below the WT (Ref. .
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	1) After logging, a small down-hole pump will be hung in 2.875 in OD 8 rd tubing, with a 12 ft well screen at total depth; 2) pump will be run for 1 week to obtain water samples for chemical analyses; 3) after testing, pump will be removed and tubing will be reinstalled for long-term monitoring of potentiometric surface. Cuttings to total depth; core from ~50 ft above water table to 20 ft below water table; water samples from completed hole.
Testing & Sampling to be Conducted as Listed in Study Plan:	Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, and barometric and earth tidal analysis (Refs. 1 and 6).
Testing & Sampling Currently Planned:	Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; static water level and temperature measurements; barometric and earth tidal analysis; cuttings collected for stratigraphic model (USGS); water sample collected for radionuclide transport study (LANL).
Borehole Instrumentation:	Three strings of tubing, with a transducer in one string of tubing
Borehole Construction Requirements:	Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table.

Environmental Prerequisites

Land Ownership:	NTS - Area 25
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Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	The potential amount of water discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal , pumped at a rate of up to 100 gal/min (Refs. 4, 5).
Required Surface Preparation:	Construction of a drill pad is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:**References:**

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
5. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
6. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW WT-21

Type of Investigation: Water Table

WBS No.: 1.2.3.3.1.3.1

Study Plan No.: 8.3.1.2.3.1

Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System

Principal Organization: USGS

Principal Investigators: Pat Tucci / W. Steinkampf

Other Participant Organizations: LANL

Purpose of Activity: To define water table surface and obtain hydrochemical data of the saturated zone.

Location

Coordinates: NVSPC: N760,086/E550,328
UTM: N4,076,833/E545,058

Ground Elevation of Borehole (above sea level): About 4080 ft (1244 m)

Location Description: At the southwestern end of Jet Ridge, which is west of Solitario Canyon, about one mile north of the Solitario Canyon Road.

Access to Location: Access is by the Solitario Canyon Road; no close approach by road or trail is shown on the topographic map. Slightly more than one mile of access road may need to be constructed to reach the above location.

Rationale for Location: The borehole is located to better define the potentiometric surface to the west of the repository block (Ref. 1). It is about 5500 ft northwest of well USW WT-17, and about 5000 ft southwest of well USW H-6.

Borehole Dimensions

Planned Borehole Depth: 1640 ft (500 m, Ref. 1) to \leq 1865 ft (568 m) (\leq 325 ft [100 m] below WT at elevation 2540 ft [775 m] in wells USW WT-7 and USW H-6 [Ref. 3]).

Elevation at Total Depth (above sea level): 2215 to 2440 ft (675 to 744 m)

Planned Borehole Diameter: $>$ 9 7/8 in; maintain constant diameter throughout borehole to accommodate packers

Planned Core Size: 2.44 in (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry drilling above the water table (Ref. 2).

Recommended Drill Rig: Stratmaster or a rig with a comparable depth capability

Drilling Fluids: Air

Tracers: A tracer(s) is to be added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory section for WT boreholes.

Sample Collection & Interval (cores/cuttings): Continuous core from about 75 ft (25 m) above to 75 ft (25 m) below the WT (Ref. 6).

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

1) After logging, a small down-hole pump will be hung in 2.875 in OD 8 rd tubing, with a 12 ft well screen at total depth; 2) pump will be run for 1 week to obtain water samples for chemical analyses; 3) after testing, pump will be removed and tubing will be reinstalled for long-term monitoring of potentiometric surface. Cuttings to total depth; core from ~50 ft above water table to 20 ft below water table; water samples from completed hole.

Testing & Sampling to be Conducted as Listed in Study Plan:

Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, and barometric and earth tidal analysis (Refs. 1 and 6).

Testing & Sampling Currently Planned:

Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; static water level and temperature measurements; barometric and earth tidal analysis; cuttings collected for stratigraphic model (USGS); water sample collected for radionuclide transport study (LANL).

Borehole Instrumentation:

3 strings of tubing, with a transducer in one string of tubing

Borehole Construction Requirements:

Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table.

Environmental Prerequisites

Land Ownership:	BLM
Access:	Field work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	The potential amount of water discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min (Refs. 4, 5).
Required Surface Preparation:	Construction of a drill pad and an access road \leq 1 mile long is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:**References:**

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
5. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
6. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry,"Rev. 0.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW WT-22

Type of Investigation: Water Table

WBS No.: 1.2.3.3.1.3.1

Study Plan No.: 8.3.1.2.3.1

Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System

Principal Organization: USGS

Principal Investigators: Pat Tucci / W. Steinkampf

Other Participant Organizations: LANL

Purpose of Activity: To define water table surface and obtain hydrochemical data of the saturated zone.

Location

Coordinates: NVSPC: N778,858/E528,373
UTM: N4,082,530/E538,347

Ground Elevation of Borehole (above sea level): About 3700 ft (1128 m)

Location Description: In the northeastern edge of Crater Flat, on a northerly trending road; the borehole is approximately 5 1/2 miles northwest of planned borehole USW WT-21, and 5.6 mi north of existing well USW VH-2 (Ref. 1)

Access to Location: Access is by existing road.

Rationale for Location: The borehole is located to better define the potentiometric surface to the northwest of the repository block (Ref. 1).

Borehole Dimensions

Planned Borehole Depth: 1310 ft (400 m) (Ref. 1)

Elevation at Total Depth (above sea level): About 1390 ft (424 m)

Planned Borehole Diameter: > 9 7/8 in; maintain constant diameter from about 100 above the WT to TD to accommodate packers.

Planned Core Size: 2.44 in (HQ core) (Ref. 2)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method:	Dry drilling above the water table (Ref. 2)
Recommended Drill Rig:	Stratmaster, or a rig with a comparable depth capability
Drilling Fluids:	Air
Tracers:	A tracer(s) is to be added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory section for WT boreholes.
Sample Collection & Interval (cores/cuttings):	Continuous core from about 75 ft (25 m) above to 75 ft (25 m) below the WT (Ref. 6).
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	1) After logging, a small down-hole pump will be hung in 2.875 in OD 8 rd tubing, with a 12 ft well screen at total depth; 2) pump will be run for 1 week to obtain water samples for chemical analyses; 3) after testing, pump will be removed and tubing will be reinstalled for long-term monitoring of potentiometric surface. Bottom-hole core; cuttings to total depth; water samples from completed hole.
Testing & Sampling to be Conducted as Listed in Study Plan:	Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, and barometric and earth tidal analysis (Refs. 1 and 5).
Testing & Sampling Currently Planned:	Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; static water level and temperature measurements; barometric and earth tidal analysis; cuttings collected for stratigraphic model (USGS); water sample collected for radionuclide transport study (LANL).
Borehole Instrumentation:	Three strings of tubing, with a transducer in one string of tubing
Borehole Construction Requirements:	Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table.

Environmental Prerequisites

Land Ownership:	BLM
Access:	Field work

Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	The potential amount of water discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min (Refs. 3, 4).
Required Surface Preparation:	Construction of a drill pad is required.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:**References:**

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
3. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
4. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
5. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: USW WT-23

Type of Investigation: Water Table

WBS No.: 1.2.3.3.1.3.1

Study Plan No.: 8.3.1.2.3.1

Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System

Principal Organization: USGS

Principal Investigators: Pat Tucci / W. Steinkampf

Other Participant Organizations: LANL

Purpose of Activity: To define water table surface and obtain hydrochemical data of the saturated zone.

Location

Coordinates: NVSPC: ~N772,550/E559,600
UTM: N4,080641/E547,870

Ground Elevation of Borehole (above sea level): About 4540 ft (1384 m)

Location Description: In Drill Hole Wash, about 1400 ft northwest of USW UZ-1 and UZ-14.

Access to Location: Drill Hole Wash Road.

Rationale for Location: To assess the cause and nature of the apparent change in hydraulic gradient to the north of the repository block, between boreholes USW G-2 and USW H-1.

Borehole Dimensions

Planned Borehole Depth: About 2200 ft (670 m). TD is to be about 150 ft below the base of the Calico Hills.

Elevation at Total Depth (above sea level): 2340 ft (713 m)

Planned Borehole Diameter: > 9 7/8 in; maintain constant diameter from about 100 above the WT to TD to accommodate packers (Ref. 2).

Planned Core Size: 2.44 in (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method:	Dry
Recommended Drill Rig:	Stratmaster, LM-300, or other rig of comparable depth capability
Drilling Fluids:	Air
Tracers:	A tracer(s) is to be added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed:	See introductory section for WT boreholes.
Sample Collection & Interval (cores/cuttings):	Collect continuous core for 66 to 100 percent of the borehole, particularly from about 200 ft above the anticipated water table (WT) to 75 ft below WT; collect dry cuttings above WT for chlorine-36 analysis, and cuttings from both the UZ and SZ for stratigraphic analysis (Refs. 1, 2).
Geophysical Logging:	Geophysical logs identified for Group II boreholes will be run (See Appendix A).
Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:	1) After logging, a small down-hole pump will be hung in 2.875 in OD 8 rd tubing, with a 12 ft well screen at total depth; 2) pump will be run for 1 week to obtain water samples for chemical analyses; 3) after testing, pump will be removed and tubing will be reinstalled for long-term monitoring of potentiometric surface. Bottom-hole core; cuttings to total depth; water samples from completed hole.
Testing & Sampling to be Conducted as Listed in Study Plan:	Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, and barometric and earth tidal analysis (Refs. 1 and 6).
Testing & Sampling Currently Planned:	Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; monitoring of potentiometric surface and borehole temperatures, analysis of matrix hydrologic properties, collect cuttings for stratigraphic model, conduct hydraulic tests for Solitario Canyon hydrologic studies (USGS); evaluate alteration history and fracture mineralogy; examine mineralogy and petrology; collect water sample for radionuclide transport study; collect cuttings of UZ for chlorine-36 analysis (LANL) (Ref. 2)
Borehole Instrumentation:	Three strings of tubing, with a transducer in one string of tubing (Ref. 1)

Borehole Construction Requirements:

Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table (Ref. 2).

Environmental Prerequisites**Land Ownership:**

USAF

Access:

Field Work

Required Pre-Activity Surveys:

See Appendix B

Estimated Amt. of Discharged Water:

The potential amount of water discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min (Refs. 4, 5).

Required Surface Preparation:

Construction of a drill pad is required; about 1400 ft of road improvement may be necessary west of UZ-14.

Anticipated Area of Surface Disturbance:

TBD

Required Permits:

(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration**Borehole Closure Requirements:**

TBD

Borehole Closure Date:

TBD

Site Restoration Requirements:

TBD

Site Restoration Date:

TBD

Comments:**References:**

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
5. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
6. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.

BOREHOLE CATALOG DATA SHEET

Activity I.D.: UE-25 WT#24

Type of Investigation: Water Table

WBS No.: 1.2.3.3.1.3.1

Study Plan No.: 8.3.1.2.3.1

Study Plan Title: Characterization of the Site Saturated-Zone Ground-Water Flow System

Principal Organization: USGS

Principal Investigators: Pat Tucci / W. Steinkampf

Other Participant Organizations: LANL

Purpose of Activity: To define water table surface and obtain hydrochemical data of the saturated zone.

Location

Coordinates: NVSPC: N776,670/E562,300
UTM: N4,081,900/E548,688

Ground Elevation of Borehole (above sea level): 4900 ft (1494 m)

Location Description: About 150 ft west of the road (Castle Point Road) to borehole USW G-2; about 1.1 mi up the road from well UE-25 WT#18.

Access to Location: Access is by Castle Point Road. Some road improvements may be necessary.

Rationale for Location: To assess the cause and nature of the apparent change in hydraulic gradient to the north of the repository block, between boreholes USW G-2 and USW H-1.

Borehole Dimensions

Planned Borehole Depth: About 2850 (150 ft below base of Calico Hills, extrapolated to be at a depth of 2700 ft [Ref. 8]). A TD of 2200 ft (670 m) is estimated in Ref. 1.

Elevation at Total Depth (above sea level): 2050 ft (625 m)

Planned Borehole Diameter: > 9 7/8 in; maintain constant diameter from about 100 above the WT to TD to accommodate packers (Ref. 2).

Planned Core Size: 2.44 in (HQ core)

Schedule

Scheduled Start Date: TBD

Scheduled Completion Date: TBD

Drilling and Construction

Drilling Method: Dry

Recommended Drill Rig: Stratmaster or other rig of comparable depth capacity

Drilling Fluids: Air

Tracers: A tracer(s) is to be added to drilling medium.

Logging, Sampling, and Testing

Testing & Support Eqpt. Needed: See introductory section for WT boreholes.

Sample Collection & Interval (cores/cuttings): Collect continuous core for 66 to 100 percent of the borehole, particularly from about 200 ft above the anticipated water table (WT) to 75 ft below WT; collect dry cuttings above WT for chlorine-36 analysis, and cuttings from both the UZ and SZ for stratigraphic analysis (Refs. 1, 2).

Geophysical Logging: Geophysical logs identified for Group II boreholes will be run (See Appendix A).

Testing & Sampling to be Conducted as Listed in Surface-Based Investigations Plan:

1) After logging, a small down-hole pump will be hung in 2.875 in OD 8 rd tubing, with a 12 ft well screen at total depth; 2) pump will be run for 1 week to obtain water samples for chemical analyses; 3) after testing, pump will be removed and tubing will be reinstalled for long-term monitoring of potentiometric surface. Bottom-hole core; cuttings to total depth; water samples from completed hole.

Testing & Sampling to be Conducted as Listed in Study Plan:

Geophysical logging, water sampling for hydrochemical and isotopic analyses, hydraulic tests, water-level measurements, and barometric and earth tidal analysis (Refs. 1 and 6).

Testing & Sampling Currently Planned:

Geophysical logging, hydrochemical analysis of interstitial water and gas samples collected directly above the water table, and of water from the saturated zone; monitoring of potentiometric surface and borehole temperatures, analysis of matrix hydrologic properties, collect cuttings for stratigraphic model, conduct hydraulic tests for Solitario Canyon hydrologic studies (USGS); evaluate alteration history and fracture mineralogy; examine mineralogy and petrology; collect water sample for radionuclide transport study; collect cuttings of UZ for chlorine-36 analysis (LANL) (Ref. 2)

Borehole Instrumentation:	Three strings of tubing, with a transducer in one string of tubing (Ref. 1)
Borehole Construction Requirements:	Casing set and 'tacked' at ~25 ft below water table; three small-diameter tubing (two not less than 2.4 in ID and one not less than 1.8 in ID) installed to water table (Ref. 2).
<u>Environmental Prerequisites</u>	
Land Ownership:	USAF
Access:	Field Work
Required Pre-Activity Surveys:	See Appendix B
Estimated Amt. of Discharged Water:	The potential amount of water discharged from the borehole in order to clean it for collection of a hydrochemical sample could be between 10,000 to 2,000,000 gal, pumped at a rate of up to 100 gal/min (Refs. 4, 5).
Required Surface Preparation:	Construction of a drill pad is required; about 1400 ft of road improvement may be necessary west of UZ-14.
Anticipated Area of Surface Disturbance:	TBD
Required Permits:	(1) Gas tracer added to drilling medium, (2) intersection of water table, and (3) an NPDES discharge permit.

Restoration

Borehole Closure Requirements:	TBD
Borehole Closure Date:	TBD
Site Restoration Requirements:	TBD
Site Restoration Date:	TBD

Comments:**References:**

1. Study Plan 8.3.1.2.3.1, "Characterize Site Saturated Zone Ground Water Flow System."
2. Drilling prioritization meeting, October 28-29, 1992, Las Vegas, NV.
3. Ervin, E.M., Luckey, R.R., and Burkhardt, D. J., 1993, "Summary of Revised Potentiometric-Surface Map for Yucca Mountain and Vicinity, Nevada," Proceedings, Fourth Annual International Conference, High Level Radioactive Waste Management, Vol. 2, pp. 1554-1558.
4. Consolidated Work Scope for the Pumping and Cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17: Prepared by M&O/WCFS for DOE/RSED, Las Vegas, May 21, 1993.
5. Written communication from Bill Steinkampf and Dick Luckey (USGS) to Norma Biggar: comments on the consolidated work scope for the pumping and cleaning of USW WT-1, UE-25 WT#12, and UE-25 WT#17, August 13, 1993.
6. Study Plan 8.3.1.2.3.2, " Characterization of the Yucca Mountain Saturated-Zone Hydrochemistry," Rev. 0.
7. Stratigraphic Prognosis for borehole USW WT-24, prepared by the Sample Management Facility (Drilling Support, T&MSS), Yucca Mountain Project, Las Vegas.