Hydrogeologic Characterization of the U-3at Collapse Zone

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Prepared for
U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Las Vegas, Nevada

August 2005

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DOE/NV/11718--199-REV.1

Preface

The Special Projects Section of Reynolds Electrical & Engineering Co., Inc. (REECo) and REECo's successor, Bechtel Nevada (BN) (among other entities), were responsible for characterizing the subsurface hydrogeology of the Area 3 Radioactive Waste Management Site (RWMS) at the Nevada Test Site for the U.S. Department of Energy, Nevada Operations Office in the early to mid-1990s. This work was documented in a series of limited-distribution data reports. As part of BN's current scope for closure planning for the Area 3 RWMS, some of these older data reports are being updated and submitted for approval for public release so they will be accessible for public review and for citation in future documents.

A document titled "Hydrogeologic Characterization of the Unsaturated Zone at the Area 3 Radioactive Waste Management Site" was prepared by BN in February 1998 and assigned the document number DOE/NV/11718--210. This document included several reports that address various portions of the Area 3 RWMS, some of which were assigned separate document numbers. None of the included documents or the larger comprehensive document were approved for public release. To permit public access to these data and to relieve confusion caused by this arrangement of nested documents, four reports within the larger document are being updated and released separately.

This document was originally prepared by BN under the same title in February 1998, and is one of the four documents that were included in the larger report. This report has been updated by revising it to conform to current editorial standards of BN and the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

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Hydrogeologic Characterization of the U-3at Collapse Zone

DOE/NV/11718--199-REV.1

Abstract

Hydrogeologic characteristics and properties of the U-3at collapse zone were determined from cores obtained from two angled boreholes drilled in 1996 under the subsidence crater formed by an underground nuclear test in 1963. This crater, used for disposal of bulk low-level radioactive waste since 1988, is located within the Area 3 Radioactive Waste Management Site in Yucca Flat on the Nevada Test Site in Nye County, Nevada. The purpose of this characterization effort was to provide data required to develop a conceptual hydrogeologic model and to complete flow and transport modeling required for the Area 3 performance assessment and composite analysis.

To minimize disturbance of the core samples, drilling was done by a method that used only air as the drilling fluid. No evidence of preferential pathways for water flow was detected via visual geologic descriptions of the core samples. Laboratory analyses showed physical and hydraulic properties that are typical of alluvial valleys at the Nevada Test Site. Water content values ranged from 0.05 to 0.33 cubic meters per cubic meter, with water content tending to increase with depth. Water potential values ranged from -10.7 MegaPascals at a depth of 15.3 meters to greater than -0.40 MegaPascals at 78.9 meters. Tritium concentrations in pore water extracted from the cores were below the detection limits from the surface to a depth of 118.9 meters. Below this depth, concentrations generally increased to a maximum of 2,200 picoCuries per liter in the deepest sample at 146.9 meters.

Unusually wet alluvium recovered from the drill bit during drilling between 50.9 and 71.6 meters in the first borehole raised concerns that water condensed in the compressed air system or excess oil introduced into the borehole may have penetrated core segments intended for analyses. The drilling process was modified to preclude introduction of fluids and the borehole was completed without further evidence of excess water. Using the same drilling method, the second borehole adjacent to the first was drilled and sampled over the interval from 47.5 to 78.3 meters. Analyses of samples from the second borehole showed water content values, water potential values, and stable isotope concentrations consistent with those of samples from the first borehole. This demonstrated that fluids had not been introduced into core segments intended for analyses during drilling of the first borehole, and thus the elevated water values are considered to be natural.

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List of Acronyms and Abbreviations

‰	parts per thousand
°C	degrees Celsius
°F	degrees Fahrenheit
¹⁸ O	oxygen-18
BN	Bechtel Nevada
CAU	casing-advance under-reaming
cm	centimeter
D	deuterium
DOE	U.S. Department of Energy
ft	foot (feet)
I.D.	inner diameter
in.	inch(es)
kg/m ³	kilograms per cubic meter
LANL	Los Alamos National Laboratory
LMWL	local meteoric water line
m	meter(s)
m ³ /m ³	cubic meters per cubic meter
mm	millimeter(s)
MPa	MegaPascals
NNSA/NSO	National Nuclear Security Administration Nevada Site Office
NTS	Nevada Test Site
O.D.	outer diameter
pCi/L	picoCuries per liter
REEC _o	Reynolds Engineering and Electrical Company, Inc.
RWMS	Radioactive Waste Management Site
SMOW	standard mean ocean water

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1.0 Introduction

The work described in this document was conducted by personnel of the Bechtel Nevada (BN) Environmental Management Program at the Nevada Test Site (NTS). The work was conducted for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO; formerly U.S. Department of Energy [DOE], Nevada Operations Office) Waste Management Division.

A document titled “Hydrogeologic Characterization of the Unsaturated Zone at the Area 3 Radioactive Waste Management Site” was prepared by BN in February 1998, and assigned the document number DOE/NV/11718--210. This document included several data reports that addressed various portions of the Area 3 Radioactive Waste Management Site (RWMS), some of which were assigned separate document numbers. To permit public access to these data and to relieve confusion caused by this arrangement of nested documents, four reports within the larger document, of which this is one, are being updated and released separately.

This document was originally prepared by BN under the same title in February 1998, and was assigned the document number DOE/NV/11718--199. This report has been updated to conform to current editorial standards of BN and the NNSA/NSO, and to facilitate public distribution of the data contained herein. No new data have been added to this report, though additional relevant studies of the area have been conducted in the intervening years.

1.1 Project Description

This report provides qualitative analyses and preliminary interpretations of hydrogeologic data obtained from two boreholes drilled at an angle to penetrate the disturbed alluvial materials beneath the U-3at subsidence crater in the Area 3 RWMS. The U-3at crater was being used as a disposal site for low-level bulk radioactive waste, and the borehole angles were selected so that the waste disposed in the crater would not be disturbed. Borehole U-3at-D1 was drilled to a slant depth of 182.6 meters (m) (599 feet [ft]), which equates to a vertical depth of approximately 147.3 m (483.3 ft). Borehole U-3at-D2 was drilled nearby to a slant depth of 91.1 m (298.8 ft), which equates to a vertical depth of 78.3 m (256.9 ft). The second borehole was drilled to verify data from the first. Throughout this report, boreholes U-3at-D1 and U-3at-D2 will be referred to as boreholes D1 and D2, respectively. Figure 1-1 shows the location of the Area 3 RWMS within the NTS. Figure 1-2 shows the locations of the subsidence craters and exploratory boreholes in the Area 3 RWMS facility.

1.2 Purpose and Justification

The Area 3 RWMS includes seven subsidence craters, five of which have been used for the disposal of low-level bulk radioactive waste (U-3ah, U-3at, U-3ax, U-3bh, and U-3bl). A waste cell was formed from the U-3at and U-3ah craters by excavating soil between the two adjacent subsidence craters to form a single cell. Disposal in the combined U-3ah/at unit began in 1988.

Figure 1-1
Location of the Area 3 Radioactive Waste Management Site
at the Nevada Test Site

Figure 1-2
Map of Area 3 Radioactive Waste Management Site Showing Locations of
Characterization Boreholes

Waste forms consist primarily of contaminated soil, concrete, scrap metal, cables, construction debris, and containerized waste. Disposal cell U-3ah/at is currently being used for disposal of bulk, low-level radioactive waste from the NTS and approved offsite generators (DOE, 1996a).

A performance assessment is required by DOE Order 435.1, "Radioactive Waste Management" (DOE, 2001), for radioactive wastes disposed on or after September 26, 1988. The requirement for a composite analysis, which evaluates radionuclide inventories from all sources interacting with a given disposal site, is set out in DOE (1996b). The characterization data from this site were used in the performance assessment and in the composite analysis (Shott et al., 1997) for development of a conceptual hydrogeologic model, and provided estimates of the physical and hydraulic characteristics for flow and transport simulations. In addition, characterization data from the Area 3 RWMS site will be used in future closure design activities.

Site characterization at disposal units within the Area 3 RWMS must address the possibility that subsidence craters and their respective alluvial chimneys (regions of alluvium lying between the collapsed subsurface cavity created by the detonation of a nuclear device and the corresponding subsidence crater) act as pathways for contaminant migration. Researchers have suggested that chimneys might provide enhanced pathways for the migration of water into the uppermost aquifer (Borg et al., 1976; Tyler et al., 1992). Boreholes D1 and D2 were drilled and sampled to obtain data on the hydrogeologic conditions of alluvium beneath the waste disposal crater, within the U-3at chimney, to help address this issue

1.3 Data Objectives of the Project

The data objectives listed below were identified to ensure that the appropriate data were collected during drilling to support site characterization.

- Obtain core samples on which to measure physical and hydrogeologic properties of alluvial materials from the chimney in the upper vadose zone.
- Measure concentrations of environmental tracers and hydrogeologic parameters in the core samples to estimate soil water fluxes in the upper vadose zone.
- Determine if contaminants, whether from the disposal unit itself or from nuclear testing, are present below the U-3ah/at waste disposal unit.

In addition, Los Alamos National Laboratory (LANL) conducted a review of data related to the construction and execution of the underground nuclear test that produced the U-3at subsidence crater, to determine if anything related to the test could produce preferential pathways for contaminant transport from the disposal unit (Plannerer, 1996).

1.4 Scope of Report

This report includes the following information:

- Summary of the LANL underground test review.
- Descriptions of the drilling, sampling, and laboratory testing methods
- Preliminary interpretations of hydrogeologic data
- Appendices containing data obtained from the boreholes and sample laboratory tests.

1.5 Site Description

The Area 3 RWMS is located in Yucca Flat on the NTS in Nye County, Nevada (Figure 1-3). The topography of the region is distinguished by north-south trending mountain ranges separated by alluvial valleys. The geology of Yucca Flat in the vicinity of the RWMS is characterized by thick sections of sedimentary rocks overlain by volcanic rocks and deposits of alluvium consisting of post-volcanic sands and gravels (DOE, 1996a). At the Area 3 RWMS, the alluvium is over 304.8 m (1,000 ft) thick, and the depth to groundwater is about 487.7 m (1,600 ft). Precipitation at this site averages 159 millimeters per year (6.3 inches per year) and monthly average temperatures range from 2 degrees Celsius (°C) [36 degrees Fahrenheit (°F)] in January to 25°C (77°F) in July (SORD website).

Figure 1-2 shows the location of U-3at, one of seven subsidence craters within the boundaries of the Area 3 RWMS (see Section 2.1). Five of the craters, including two pairs of conjoined craters, have been used for the disposal of low-level bulk radioactive waste.

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Figure 1-3
Location of the Area 3 Radioactive Waste Management Site in Yucca Flat

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2.0 Test Review and Borehole Construction

Included in this data report are a summary of information compiled regarding the nuclear test that led to the formation of subsidence crater U-3at (Section 2.1) and data from U-3at-D1 and U-3at-D2 samples. These data comprise field descriptions and results of laboratory analyses of 56 cores obtained from Borehole U-3at-D1 and 13 cores obtained from Borehole U-3at-D2 (Section 2.2). These data were used in the Area 3 performance assessment and the composite analysis (Shott et al., 1997) to develop the conceptual hydrogeologic model and provide physical and hydraulic characteristics for flow and transport simulations.

2.1 Review of the U-3at Underground Nuclear Test

2.1.1 General Information on Subsidence Craters

Craters within the Area 3 RWMS were formed by testing of nuclear devices in the early 1960s. These tests were conducted hundreds of meters below the ground surface in shafts bored vertically into the alluvium. Upon detonation of a nuclear device underground, extremely high pressures and temperatures produce a cavity in the alluvium. When the gas pressure dissipates to a point at which it can no longer support the overburden, the top of the cavity collapses and the void region propagates upward to the surface, forming a saucer-like subsidence crater on the surface (U.S. Congress, 1989). The region through which the void propagates is referred to as the collapse zone or chimney. At the time of formation, the seven craters within the Area 3 RWMS ranged from 121.9 to 176.8 m (400 to 580 ft) in diameter and from 14.0 to 32.0 m (46 to 105 ft) in depth (Plannerer, 1996).

2.1.2 Test Construction Information

A review of available data describing U-3at site construction, diagnostics hardware, stemming, explosion phenomenology, and post-shot activities was prepared by Plannerer (1996). For brevity, only the principal findings of this review are summarized here.

The U-3at emplacement hole, initially a small-diameter pilot hole, was begun on January 10, 1962. After reaming of the pilot hole, the borehole diameter was 1.524 m (60 inches [in.]) to a depth of 30.5 m (100 ft), 1.067 m (42 in.) to a depth of 307.8 m (1,010 ft), and 0.661 m (26 in.) to a depth of 309.4 m (1,015 ft). Surface casing of 1.372-m (54-in.) outside diameter (O.D.) extended to a depth of 30.5 m (100 ft). Casing of 0.737-m (29-in.) inside diameter (I.D.) extended from 24.5 m (80.4 ft) to a depth of 306.3 m (1,005 ft). Casing sections were connected by welding. The emplacement hole was subsequently modified by extending the 0.737-m (29-in.) I.D. casing to the surface. This casing joint was not welded.

Four satellite boreholes intended for instrumentation associated with the nuclear test were drilled along a radial extending north from the emplacement hole. The closest borehole, U-3at-1, was located 7.53 m (24.7 ft) from the U-3at emplacement hole. It was drilled to a depth of 322.5 m (1,058 ft) and 0.273-m (10¾-in.) I.D. casing was installed to 217.9 m (715 ft). Borehole U-3at-2

was drilled to a depth of 325.5 m (1,068 ft) and 0.273-m (10¾-in.) I.D. casing was installed to 243.5 m (799 ft). Borehole U-3at-3 was drilled to a depth of 189.9 m (623 ft) and 0.273-m (10¾-in.) I.D. casing was installed to 106.7 m (350 ft). This hole was subsequently plugged with cement from the bottom of the casing to the surface and abandoned. The distal borehole, U-3at-3s, was located 20.2 m (66.3 ft) north of the emplacement hole. It was drilled to a depth of 320.0 m (1,050 ft) and 0.273-m (10¾-in.) I.D. casing was installed to 243.8 m (800 ft).

The device was located in a canister and inserted, along with a rack of instruments above it, into the emplacement hole to the depth of 301.1 m (988 ft). The canister and rack were surrounded by 2.29 cubic meters (80.9 cubic feet) of magnetite sand. Above the magnetite were emplaced alternating layers of coarse and fine sand. Layers of coarse sand were 30.5 m (100 ft) thick, and the layers of fine sand were 1.8 m (6 ft) thick. The satellite holes were stemmed by backfilling them with sand until a thickness of 30.7 m (100.6 ft) accumulated above the instrumentation, then filling with cement from the top of the sand to the surface.

2.1.3 Post-Test Information

The JERBOA device was detonated in Emplacement Hole U-3at on March 1, 1963. Cavity collapse occurred 35.3 minutes later, forming a collapse zone (rubble chimney) and a surface subsidence crater. No additional subsidence has been reported. The crater was generally symmetrical, with an average radius of 84.4 m (277 ft), a depth of 32.3 m (106 ft), and an estimated volume of 246,040 cubic meters (8,694,010 cubic feet). The crater diameter along the east-west axis was approximately 1.2 times that along the north-south axis. This slight asymmetry was attributed to differences in the subsidence along the western edges of the crater. A contour map of the crater and an average crater profile can be found in Plannerer (1996). An analysis of the subsidence indicated that the overburden response to the JERBOA explosion was typical. There was no evidence of any release of radioactivity resulting from the test.

Two vertical post-shot boreholes, U-3at-PS#1 and U-3at-PS#2, were drilled from the crater floor near the emplacement hole, starting within 10.3 hours of the detonation. At completion, Borehole U-3at-PS#1 extended to a depth of 335.6 m (1,101 ft), and 0.349-m (13¾-in.) I.D. casing was installed in the upper 12.2 m (40 ft). Post-shot Borehole U-3at-PS#2 extended to a depth of 302.4 m (992 ft) and 0.273-m (10¾-in.) I.D. casing was installed in the upper 18.3 m (60 ft). Post-shot Borehole U-3at-PS#3 was drilled at an angle from a point outside the crater rim toward the explosion point. This borehole extended to a slant depth of 382.8 m (1,256 ft), which corresponds to a vertical depth of 352.0 m (1,155 ft). Casing (0.178-m [7-in.] O.D.) in Borehole U-3at-PS#1 extended from the surface to a slant depth of 38.4 m (126 ft).

Plannerer (1996) noted that the post-shot drilling records indicate a loss of drilling fluid circulation occurred in all three post-shot boreholes at similar depths. Loss of circulation in Borehole U-3at-PS#1 was first reported at 231.6 m (760 ft), in Borehole U-3at-PS#2 at 234.7 m (770 ft), and in Borehole U-3at PS#3 at a vertical depth of 246.9 m (810 ft). Plannerer (1996) suggested that the reported loss of circulation was attributable to characteristics of the geologic

medium in that depth interval (231.6 to 246.9 m [760 to 810 ft]), such as a zone of higher porosity or permeability.

2.1.4 Potential for Preferential Pathways

In his review of aspects of JERBOA construction and execution that could lead to preferential pathways in the collapse zone, Plannerer (1996) raised a particular concern with an unwelded casing joint in Emplacement Hole U-3at. During the construction of the emplacement hole, a decision was made to extend the 0.737-m (29-in.) inner casing from the disconnect collar at 24.4 m (80 ft) to the surface. This extension consisted of stabbing a smaller diameter casing into the disconnect collar and sealing it with gypsum cement. A worst-case scenario is suggested by Plannerer (1996) in which the shock wave separated the metal casing and fractured the cement, providing a pathway between the inner casing and the surface casing.

Test instrumentation for JERBOA required 37 down-hole cables. Plannerer (1996) noted that cables were known pathways for preferential transport of radioactive gases, and gas blocks were installed at the surface between the well head and the recording trailer. No records documenting the use of down-hole gas blocks in cables or cable fan-outs were found. Whether a pathway available for high-pressure gases would also be a preferential pathway for the movement of water is uncertain.

No records documenting the abandonment of the post-shot boreholes were recovered. The common practice at the time was to leave the boreholes unplugged, but with some type of closure at the top of the short surface casing (Hawkins, 1994).

2.2 Chimney Characterization Boreholes

Drilling of Borehole U-3at-D1 began on June 18, 1996, adjacent to the crater formed by the JERBOA test in Emplacement Hole U-3at. The borehole was drilled at an angle of approximately 35 degrees to pass under the waste cell and into the collapse zone below the crater. To minimize disturbance of the core samples, drilling was done by a method that used only air as the drilling fluid. Only small amounts of oil were used to lubricate the drill string. A second borehole, U-3at-D2, was drilled and sampled over a shorter interval to confirm that core samples from Borehole D1 had not been affected by water condensed in the compressed air system or by excess lubrication oil, after indications of excess water had been observed in the interval 50.9 to 71.6 m (167 to 235 ft) in Borehole D1. The locations of boreholes D1 and D2 are shown in Figure 1-2, and coordinates, land surface elevations, and depths are provided in Table 2-1. These boreholes are two of seven characterization boreholes shown in Figure 1-2 that were drilled and sampled in the Area 3 RWMS. Characterization data from these other boreholes are provided in BN (1998a, 1998b, 2005).

Table 2-1
Location and Depth of Characterization Boreholes U-3at and U-3at-D2

Borehole	Total Vertical Depth meters (feet)	Land Surface Elevation Above Sea Level meters (feet)	Nevada State Central Zone Coordinates (NAD 27)	
			North meters (feet)	East meters (feet)
U-3at-D1	147.3 (483.3)	1,222.6 (4,011)	254,647.95 (835,457.48)	209,333.82 (686,789.39)
U-3at-D2	78.3 (256.9)	1,222.6 (4,011)	254,648.11 (835,458.00)	209,327.85 (686,769.80)

2.2.1 Drilling and Sampling Methods for Borehole U-3at-D1

Drilling of the characterization Borehole D1 was initiated by setting 30.5-centimeter (cm) (12-in.) diameter surface casing at a 30-degree angle in a 2.9-m (9.5-ft) deep trench located near the southern edge of the U-3at crater rim. Surface casing was used to reduce dust and help guide the drill casing. From this depth, the borehole was drilled with an Ingersol-Rand T-4 rig using a casing-advance under-reaming (CAU) system. The method consisted of attaching an air percussion hammer to a drill rod within a 27.0-cm (10.63-in.) diameter casing. A drive shoe was attached to the bottom of the casing. The air percussion hammer drilled a hole slightly larger than the casing and advanced the casing by impacting on the shoe. Drill cuttings were forced to the surface through the casing using only air as the drilling fluid. The casing was advanced until a coring depth was reached. The major advantage of a CAU system is that it prevents the borehole from collapsing during drilling. Therefore, CAU systems are well suited for use in unconsolidated alluvium, where borehole collapse is a constant risk.

Core samples were obtained at approximately 3.05-m (10-ft) intervals in a 0.76-m (2.5-ft) long by 11.43-cm (4.5-in.) O.D. solid tube core barrel containing ten clear polycarbonate liner segments 7.62 cm (3-in.) long by 8.89-cm (3.5-in.) O.D. The core barrel was driven into the bottom of the hole using the air percussion hammer. After retrieving the core barrel, the liner segments were removed using a pneumatic core extruder. This method was chosen because it provides good core recovery and reduces the disturbance of hydrogeologic conditions and properties of relatively dry, coarse-grained, unconsolidated alluvial samples (Hammermeister et al., 1986).

A geologic description of the core was made by examining the open ends of each liner segment. Geologic description consisted of noting visual indications of moisture content, particle size distribution, lithology, sorting, grain shape, and any anomalies including indications of preferential pathways. The liner segments were then capped, taped, labeled with sample identification numbers, and sealed in tubular plastic laminate for shipping to laboratories for analyses. Sampling in Borehole D1 began on June 18, 1996, at a borehole length of 6.4 m (21 ft), which corresponds to a vertical depth of 5.2 m (17 ft). At a vertical depth of 46.3 m

(152 ft), the drive casing was switched to 21.9-cm (8.63-in.) O.D., and drilling proceeded with this size casing to a final vertical depth of 147.3 m (483.3 ft).

During drilling of Borehole D1, unusually wet alluvium was observed on the drill bit when it was returned to the surface from a vertical depth of approximately 50.9 m (167 ft). Wet alluvium was observed on the drill bit at subsequent sampling intervals to a vertical depth of 71.6 m (235 ft). The borehole was then logged with a neutron moisture meter; however, no zones of anomalously high water content were observed. Because the usual practice was to take a drive core sample from the point at which drilling stopped, observations of wet alluvium on the drill bit raised concerns that water condensed from the compressed air or excess lubrication oil from drilling may have infiltrated as far as the sample segments. Air dryers were restored, air compressor separators were drained, and the amount of lubricant oil used was reduced for drilling of the remainder of the borehole.

2.2.2 Drilling and Sampling of Borehole U-3at-D2

To ensure that representative characterization samples were obtained between vertical depths of 50.9 and 73.8 m (167 and 242 ft), a second borehole was drilled to obtain duplicate samples over this depth interval. Borehole D2 was begun by placing a 2.1-m (7.0-ft) length of 27.3-cm (10.75-in.) O.D. surface casing in a trench located 6.0 m (19.8 ft) west of Borehole D1. Drilling of Borehole D2 began on August 13, 1996, using 21.9-cm (8.63-in.) O.D. casing. The same drilling and sampling methods were used for this borehole as for Borehole D1. Samples were collected from a vertical depth of 47.5 m (156 ft) to the final depth of 78.3 m (257 ft).

Figure 2-1 is a schematic representation depicting the locations of boreholes D1 and D2 with respect to U-3at crater and the estimated margins of the collapse zone and cavity.

2.3 Laboratory Tests

Drillers completed 56 core runs in Borehole D1, and 13 core runs in Borehole D2. Although core recovery was generally less than 100 percent, recovery was sufficient in all runs to meet minimum sample requirements of the analytical laboratories. The analytical method, source of the method, and the laboratory performing the analysis are shown in Table 2-2 for each of the characterized properties. Volumetric water content and bulk density were measured on two cores from each core run to provide better knowledge of the variation of these properties with depth. BN audited and approved the quality assurance programs for the two laboratories, Huffman Laboratories and Northwest Environmental Services, Testing and Training.

Figure 2-1
Schematic Showing Locations of Boreholes U-3at-D1 and U-3at-D2 with Respect to the U-3at Crater and Estimated Margins of the Collapse Zone and Cavity

**Table 2-2
Methods of Analysis**

Characteristic or Property	Method	Reference	Laboratory
Geologic Description	Visual / Manual	ASTM, 1990. "Standard Recommended Practice for the Description of Soils-visual Manual Procedure." D 2488-90. In: 1990 Annual Book of ASTM Standards. Vol. 04.08. American Society for Testing and Materials, Philadelphia, Pennsylvania.	BN ^a
Particle Density	Liquid Pycnometer	Snyder, K. E., G. E. Byers, and R. D. van Remortel, 1996. <i>Handbook of Laboratory Methods of Soil Analysis</i> . U. S. Department of Energy Report DOE/NV 11718-074, Las Vegas, Nevada.	HL ^b
Bulk Density	Core	Blake, G. R. and K. H. Hartge, 1986. "Bulk Density." In: Klute, A. L. (ed), <i>Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods</i> . 2 nd Ed. American Society of Agronomy, Madison, Wisconsin.	NESTT ^c / BN
Water Retention	Centrifugation	Hoffman, R. N. A., 1963. "A Technique for the Determination of Capillary Pressure Curves Using a Constantly Accelerated Centrifuge." <i>Society of Petroleum Engineering Journal</i> , vol. 3, pp. 227-235.	NESTT
Hydraulic Conductivity Saturated	Constant Head	ASTM, 1974. "Test Method for Permeability of Granular Soils (Constant Head)." D2434-68. In: 1987 Annual Book of ASTM Standards. Vol. 04.08. American Society for Testing and Materials, Philadelphia, Pennsylvania.	NESTT
Hydraulic Conductivity Unsaturated	Centrifugation	Conca, J. L., and J. V. Wright, 1992. "Diffusion and Flow in Gravel, Soil and Whole Rock." <i>Applied Hydrology</i> , vol. 1, pp. 5-24	NESTT
Water Content	Volumetric	Snyder, K. E., G. E. Byers, and R. D. van Remortel, 1996. <i>Handbook of Laboratory Methods of Soil Analysis</i> . U. S. Department of Energy Report DOE/NV 11718-074, Las Vegas, Nevada.	NESTT/BN
Water Potential	Water Activity Meter	Snyder, K. E., G. E. Byers, and R. D. van Remortel, 1996. <i>Handbook of Laboratory Methods of Soil Analysis</i> . U. S. Department of Energy Report DOE/NV 11718-074, Las Vegas, Nevada.	BN
Chloride	Ion Chromatography	Snyder, K. E., G. E. Byers, and R. D. van Remortel, 1996. <i>Handbook of Laboratory Methods of Soil Analysis</i> . U. S. Department of Energy Report DOE/NV 11718-074, Las Vegas, Nevada.	HL
Carbonate	Pressure Calcimeter	Snyder, K. E., G. E. Byers, and R. D. van Remortel, 1996. <i>Handbook of Laboratory Methods of Soil Analysis</i> . U. S. Department of Energy Report DOE/NV 11718-074, Las Vegas, Nevada.	HL
Tritium	Liquid Scintillation	Burg, W. P. 1994. "Liquid Scintillation Instrumentation Method." In: DOE Methods for Evaluating Environmental and Waste Management Samples. DOE/EM-089T, Rev. 2.	DRI ^d

a Bechtel Nevada

b Huffman Laboratories Inc.

c Northwest Environmental Services, Testing and Training

d Desert Research Institute

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3.0 Results

Visual geologic descriptions of the core obtained from the characterization borehole were recorded on borehole log sheets, which are presented in Appendix A. No visual evidence of preferential pathways for water was observed in the cores. The results of laboratory tests on cores are presented in graphic form as figures in this section and are provided in tabular form in Appendix B. All results are presented in terms of the vertical depth of the sample calculated from the slant (drilled) depth.

3.1 *Geologic Properties of Borehole U-3at-D1*

The variation of particle density with depth for Borehole D1 is shown in Figure 3-1. Particle density values range from 2,180 to 2,540 kilograms per cubic meter (kg/m^3). Values show no trends with depth and, on average, are slightly lower than particle densities previously observed for shallower sediments within the RWMS (BN, 1998a). Percentages of sand, silt, and clay for the fine-earth (less than 2 millimeter [mm]) fraction of the samples from Borehole D1 are shown in Figure 3-2. Results from this borehole are similar to others from the RWMS (BN, 1998a, 1998b, 2005), with particle size distribution being dominated by the 0.05- to 2.0-mm size sand fraction. In general, the sand fraction ranges from approximately 61 to 94 percent, with an average of 81 percent. The silt and clay fractions range from approximately 2 to 28 percent, with the means of both fractions being 9 percent. These percentages are typical of a loamy sand to sandy loam texture (USDA, 1993). Dry bulk density for Borehole D1, shown in Figure 3-3, ranges from 1,330 to 2,055 kg/m^3 , with no obvious trend with depth. The mean bulk density is 1,602 kg/m^3 .

3.2 *Hydrogeologic Properties of Borehole U-3at-D1*

Water retention relations for samples from Borehole D1 are shown in Figures 3-4 through 3-9. This property, while variable, is relatively consistent for the cores tested and is typical of water retention relations for the other soils of similar texture.

The relationship between hydraulic conductivity and water content for Borehole D1 samples is shown in Figures 3-10 through 3-15. These hydraulic conductivity water-content relations were measured directly on samples and thus are not dependent on fitting model parameters to the water retention relations. The results are typical of sandy soil, with hydraulic conductivity decreasing rapidly as the soil dries. While variable, these relations show no trend with depth. These results reflect subtle, yet distinct, differences in hydraulic properties of the alluvium layers.

The variation of volumetric water content with depth for Borehole D1 is shown in Figure 3-16. The reported value of 0.005 cubic meters per cubic meter (m^3/m^3) at a depth of 7.74 m (25.4 ft) is much lower than any water content value observed in near-surface soil and is probably the result of a laboratory error. Excluding this point, volumetric water content values range from 0.05 to 0.33 m^3/m^3 and tend to increase with depth. The trend in volumetric water content with depth is, on average, an increase of 0.065 m^3/m^3 per 100 m (328 ft) of depth.

Figure 3-1
Particle Density versus Depth for U-3at-D1
(In kilograms per cubic meter)

Figure 3-2
Sand, Silt and Clay Fractions versus Depth for U-3at-D1

Figure 3-3
Dry Bulk Density versus Depth for U-3at-D1
 (In kilograms per cubic meter)

Figure 3-4
Water Retention Relations for U-3at-D1 Samples from 8 Depths
from 5.4 to 22.9 Meters
 (Depths as indicated by symbols; matrix potential given in MegaPascals;
 water content given in cubic meters per cubic meter)

Figure 3-5
Water Retention Relations for U-3at-D1 samples at 10 Depths
from 25.4 to 49.3 Meters
 (Depths as indicated by symbols; matric potential given in MegaPascals;
 water content given in cubic meters per cubic meter)

Figure 3-6
Water Retention Relations for U-3at-D1 Samples at 10 Depths
from 52.0 to 74.0 Meters
 (Depths as indicated by symbols; matric potential given in MegaPascals;
 water content given in cubic meters per cubic meter)

Figure 3-7
Water Retention Relations for U-3at-D1 Samples at 10 Depths
from 76.3 to 97.9 Meters

(Depths as indicated by symbols; matric potential given in MegaPascals;
 water content given in cubic meters per cubic meter)

Figure 3-8
Water Retention Relations for U-3at-D1 Samples at 10 Depths
from 100.1 to 124.2 Meters
 (Depths as indicated by symbols; matric potential given in MegaPascals;
 water content given in cubic meters per cubic meter)

Figure 3-9
Water Retention Relations for U-3at-D1 Samples at 10 Depths
from 126.5 to 147.2 Meters

(Depths as indicated by symbols; matric potential given in MegaPascals; water content given in cubic meters per cubic meter)

Figure 3-10
Hydraulic Conductivity / Water Content Relations for U-3at-D1 Samples at
8 Depths from 5.4 to 22.9 Meters

(Depths as indicated by symbols; hydraulic conductivity given in meters per second;
 water content given in cubic meters per cubic meter)

Figure 3-11
Hydraulic Conductivity / Water Content Relations for U-at-D1 Samples at
10 Depths from 25.4 to 49.3 Meters

(Depths as indicated by symbols; hydraulic conductivity given in meters per second;
water content given in cubic meters per cubic meter)

Figure 3-12
Hydraulic Conductivity / Water Content Relations for U-3at-D1 Samples at
10 Depths from 52.0 to 74.0 Meters

(Depths as indicated by symbols; hydraulic conductivity given in meters per second;
water content given in cubic meters per cubic meter)

Figure 3-13
Hydraulic Conductivity / Water Content Relations for U-3at-D1 Samples at
10 Depths from 76.3 to 97.9 Meters

(Depths as indicated by symbols; hydraulic conductivity given in meters per second;
water content given in cubic meters per cubic meter)

Figure 3-14
Hydraulic Conductivity / Water Content Relations for U-3at-D1 Samples at
10 Depths from 100.1 to 124.2 Meters

(Depths as indicated by symbols; hydraulic conductivity given in meters per second;
water content given in cubic meters per cubic meter)

Figure 3-15
Hydraulic Conductivity / Water Content Relations for U-3at-D1 Samples at
10 Depths from 126.5 to 147.2 Meters

(Depths as indicated by symbols; hydraulic conductivity given in meters per second;
 water content given in cubic meters per cubic meter)

Figure 3-16
Volumetric Water Content versus Depth for U-3at-D1
 (Water content given in cubic meters per cubic meter)

The water potential values of samples taken from Borehole D1 range from -10.7 MegaPascals (MPa) at 15.3 m (50.2 ft) to greater than -0.40 MPa at 78.9 m (259 ft) as shown in Figure 3-17. Although variable, water potential tends to increase with depth. The upper limit of water potential measurable with the water activity meter is -0.40 MPa (Gee et al., 1992). Below a depth of 120.1 m (394 ft), water potential values are consistently greater than this limit.

3.3 Environmental Tracers at Borehole U-3at-D1

3.3.1 Stable Isotopes

Concentrations of stable isotopes of oxygen (oxygen-18 [^{18}O]) and of hydrogen (deuterium [D]) in water provide indications of past and current water fluxes in the vadose zone. Concentrations of deuterium and ^{18}O in the pore water of samples obtained from Borehole D1 are shown in Figures 3-18 and 3-19. Concentrations are reported in standard delta (δ) notation in reference to standard mean ocean water (SMOW). Reproducibility of the values is ± 1 part per thousand (‰). In general, enrichment in the heavy isotopes (less negative values) is shown near the land surface. This enrichment in the upper portion of the profile is caused by evaporation.

A comparison of stable isotope concentrations in pore water from Borehole D1 samples and precipitation is shown in Figure 3-20. The local meteoric water line (LMWL) represents the ratio of stable isotopes in precipitation and has been described by Tyler et al. (1996) for the NTS as:

$$\delta\text{D} = 6.26 \cdot \delta^{18}\text{O} - 15.3$$

Isotopic compositions of the majority of Borehole D1 samples fall below the LMWL. This deviation from the LMWL is typical of systems with significant evaporation.

Figures 3-18 and 3-19 show that below 29.9 m (98 ft), isotope concentrations vary little and display no trend with depth. Average concentrations are -14.2 ‰ for $\delta^{18}\text{O}$, and -111 ‰ for δD . Weighted mean isotope concentrations for winter precipitation at the NTS have been estimated to be -12.5 ‰ and -93 ‰ for $\delta^{18}\text{O}$ and δD , respectively (Tyler et al., 1996). Winter concentrations represent precipitation under cooler temperatures. Comparing the winter mean concentrations with the average concentrations of the profiles in Figures 3-18 and 3-19 shows that isotopic compositions of samples from Borehole D1 were more depleted than weighted mean values for winter precipitation. These results indicate that the pore water found in the samples from the collapse zone below 30 m (98 ft) must have infiltrated under cooler, past climate conditions.

3.3.2 Chloride and Calcium Carbonate Profiles

The soil chloride profile shown for Borehole D1 in Figure 3-21 indicates an accumulation of chloride in the near-surface sediments, which is typical of arid regions. Below 14.9 m (49 ft), chloride concentrations are negligible to a depth of 135.9 m (446 ft), where concentrations

Figure 3-17
Water Potential versus Depth for U-3at-D1
(The dashed line at -0.4 MegaPascals indicates the upper limit of water potential measurable with the water activity meter)

Figure 3-18
Deuterium Concentrations in Pore Water from U-3at-D1 versus Depth
 (Expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

Figure 3-19
Oxygen-18 Concentrations in Pore Water from U-3at-D1 versus Depth
 (Expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

Figure 3-20
Stable Isotope Concentrations in Pore Water from U-3at-D1 and
Local Meteoric Water Line (LMWL)
 (Expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

Figure 3-21
Soil Chloride Concentrations versus Depth for U-3at-D1
(In milligrams per kilogram)

increase and reach a maximum of 20.7 milligrams/kilogram at 140.8 m (462 ft). From this depth, concentrations again decrease, reaching negligible levels at a depth of 146.9 m (482 ft). Three samples (from depths 140.8, 143.0, and 145.4 m [462, 469, and 477 ft]) have elevated concentrations of chloride. An inspection of these and adjacent samples under a binocular microscope and in hand sample found no obvious lithologic, diagenetic, or pedogenic explanation for the differences in chloride.

Calcium carbonate equivalent for Borehole D1 is shown with depth in Figure 3-22. Calcium carbonate equivalent concentrations at 30.5 and 119.2 m (100 and 391 ft) below the surface are approximately 12 percent, substantially greater than concentrations from most other samples analyzed. An inspection of these and adjacent samples, using a binocular microscope and in hand sample, found no significant difference in clast lithology, but the matrix of the two samples in question was cemented by calcium carbonate and contained weathered fragments of caliche.

3.3.3 Tritium Profiles

A plot of tritium concentration versus vertical depth for the Borehole D1 samples, is shown in Figure 3-23. Concentrations are below the detection limits (226 to 312 picoCuries per liter [pCi/L]) from the surface to a depth of 119 m (390 ft). Below this depth, concentrations generally increase to a maximum of 2,200 pCi/L in the deepest sample at 146.9 m (482 ft). This tritium most likely originated as a product of the nuclear test.

3.4 Results of Verification Testing at Borehole U-3at-D2

The purpose of drilling and sampling Borehole D2 was to confirm that core samples taken from Borehole D1 over the interval of 50.9 to 71.6 m (167 to 235 ft) had not been altered by the addition of fluids during drilling. Thirteen samples were taken from Borehole D2 over the interval 47.5 to 78.3 m (156 to 257 ft) and tested for the same characteristics and properties as samples from Borehole D1. These results are shown in Figures 3-24 to 3-36.

Particle density values (Figure 3-24) are similar to those observed for the same depth interval in Borehole D1. Particle size distributions shown in Figure 3-25 are similar, except for a high-silt zone at 63.7 m (209 ft), which was not seen in Borehole D1. Bulk density; water-retention relations; hydraulic conductivity water-content relations; and chloride, carbonate, and tritium concentrations (Figures 3-26 to 3-31) are similar to those observed in the same depth interval in Borehole D1.

The variation of volumetric water content with depth for Borehole D2 is shown in Figure 3-32. Volumetric water content values over similar depths from Borehole D1 are also plotted for comparison. Volumetric water content in the vertical depth interval 46.9 to 78.9 m (154 to 259 ft) in Borehole D1 ranges from 0.076 to 0.215 m³/m³, with a mean of 0.123 m³/m³. In Borehole D2, volumetric water content in the depth interval 47.9 to 78.3 m (157 to 257 ft) is more variable, ranging from 0.067 to 0.254 m³/m³, with a mean of 0.145 m³/m³. These differences in the range and mean are small enough to be attributed to spatial variability.

Figure 3-22
Calcium Carbonate Equivalent within the Fine-Earth Fraction
(less than 2 millimeters) versus Depth for U-3at-D1
 (Oven-dry weight percent)

Figure 3-23
Tritium Concentrations versus Depth for U-3at-D1
(Bars indicate counting error)

Figure 3-24
Particle Density versus Depth for U-3at-D2
(In kilograms per cubic meter)

Figure 3-25
Sand, Silt, and Clay Fractions versus Depth for U-3at-D2

Figure 3-26
Dry Bulk Density versus Depth for U-3at-D2
(In kilograms per cubic meter)

Figure 3-27
Water Retention Relations for U-3at-D2 Samples at 14 Depths
from 48.0 to 78.3 Meters
 (Depths as indicated by symbols; matric potential given in MegaPascals;
 water content given in cubic meters per cubic meter)

Figure 3-28
Hydraulic Conductivity / Water Content Relations for U-3at-D2 Samples at
14 Depths from 48.0 to 78.3 Meters

(Depths as indicated by symbols; hydraulic conductivity given in meters per second;
water content given in cubic meters per cubic meter)

Figure 3-29
Soil Chloride Concentration versus Depth for U-3at-D2
(In milligrams per kilogram)

Figure 3-30
Calcium Carbonate Equivalent within the Fine-Earth Fraction
(less than 2 millimeters) versus Depth for U-3at-D2
(Oven-dry weight percent)

Figure 3-31
Tritium Concentration versus Depth for U-3at-D2
(Bars indicate counting error)

Figure 3-32
Comparison of Volumetric Water Content from 40 to 80 Meters Depth in
U-3at-D1 and U-3at-D2
 (In cubic meters per cubic meter)

Water potential plotted versus depth for Borehole D2 is shown in Figure 3-33. Water potential values for a similar depth interval from Borehole D1 are also plotted for comparison. Over the interval sampled, the water potential values from Borehole D2 samples are generally greater than those from Borehole D1, indicating slightly wetter conditions over a portion of the interval.

Stable isotope concentrations in the interval 46.9 to 78.0 m (154 to 256 ft) in both boreholes are compared in Figures 3-34 and 3-35. Stable isotope concentrations of pore water from Borehole D2 are compared to the LMWL in Figure 3-36 (see Figure 3-20 for Borehole D1). The results in these figures show that stable isotope concentrations are nearly identical between boreholes.

The above comparisons of water content, water potential, and stable isotope concentrations confirm that water condensed in the compressed air system and excess lubrication oil introduced into the borehole while drilling a portion of Borehole D1 were not sufficient to penetrate core segments used for samples.

Figure 3-33
Comparison of Water Potential for 40 to 80 Meters Depth in U-3at-D1 and U-3at-D2
 (The dashed line at -0.4 MegaPascals indicates the upper limit of water potential measurable with water activity meter)

Figure 3-34
Comparison of Deuterium Concentrations in Pore Water
from 46 to 78 Meters Depth in U-3at-D1 and U-3at-D2
 (Expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

Figure 3-35
Comparison of Oxygen-18 Concentrations in Pore Water
from 46 to 78 Meters Depth in U-3at-D1 and U-3at-D2
 (Expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

Figure 3-36
Comparison of Stable Isotope Concentrations in Pore Water from U-3at-D2 and
Local Meteoric Water Line (LMWL)
 (Expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

4.0 Summary

Two angled boreholes were drilled in 1996 to intercept the disturbed alluvium of the collapse zone (rubble chimney) beneath the U-3at subsidence crater. This subsidence crater, produced by the underground nuclear test JERBOA in 1963, is located in the Area 3 RWMS. The crater has served as a waste disposal unit for low-level bulk radioactive waste since 1988. Borehole U-3at-D1 was drilled to an equivalent vertical depth of 147.3 m (484.4 ft). Borehole U-3at-D2 was drilled nearby to a vertical depth of 78.3 m (256.9 ft) to verify the results from the first borehole.

Geologic and hydrologic observations and measurements were made on core samples from the two boreholes to obtain hydrogeologic characterization in support of modeling and closure planning for the waste disposal site. These data may also be used to address the issue of whether preferential pathways for the movement of contaminants in fluids from the waste disposal site might exist as a result of activities related to the U-3at JERBOA underground nuclear test.

A review of activities related to construction and execution of the U-3at JERBOA test indicated that an un-welded casing joint, the presence of instrumentation cables for which gas-blocks were not installed within the emplacement hole, and the unknown status of post-shot drill holes may be potential pathways for high-pressure gases produced by the explosion. However, it is uncertain whether these potential pathways could also be preferential pathways for the downward movement of water.

Particle density and dry bulk density values show no trends with depth. Water retention relations and hydraulic conductivity values, while variable, are relatively consistent for the cores tested, are typical for the other soils of similar texture, and show no trend with depth. Water content and water potential values tend to increase with depth.

In general, enrichment in heavy isotopes of hydrogen and oxygen in pore water is seen near the land surface, and is caused by evaporation. Accumulation of chloride is also seen in the near-surface sediments, which is typical of arid regions. Tritium concentrations in pore water are below the detection limits from the surface to a depth of 119 m (390 ft). Below this depth, concentrations generally increase to a maximum of 2,200 pCi/L in the deepest sample at 146.9 m (482 ft). This tritium most likely originated as a product of the nuclear test.

A comparison of water content, water potential, and stable isotope concentrations for the two boreholes confirmed that water condensed in the compressed air system and excess lubrication oil introduced into the borehole while drilling a portion of Borehole D1 were not sufficient to penetrate core segments used for samples.

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U3at Collapse Zone

Appendix A

Borehole Log Sheets for Exploratory Boreholes U-3at-D1 and U-3at-D2

Legend for Borehole Log Sheets

ARCH	Archive sample
BN	Bechtel Nevada sample
C	Common: although not dominant, prevalent throughout the sample
COLOR	Refer to Munsell Soil Color Chart that defines hue, value (brilliance), and chroma (purity)
D	Dominant: primary constituent of sample
DRI	Desert Research Institute sample
HF	Huffman Laboratories, Inc. sample
LL	Lawrence Livermore National Laboratory sample
NW	Northwest Laboratory sample
P	Present: occurs regularly throughout the sample
R	Rare: occurs infrequently in the sample
USCS	Unified Soil Classification System; refer to American Society of Testing and Materials (1984) for a listing of appropriate group symbols.

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13. LOGGED BY:	Parsons
14. REVIEWED BY & DATE:	Julianne Hudson 6/24/97

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13. LOGGED BY:	Parsons
14. REVIEWED BY & DATE:	Judanne Butler 6/20/93

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Parsons

13. LOGGED BY:

14. REVIEWED BY & DATE: Julianne Under 60 JAN 97

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Shannon M. Parsons 11/6/97

BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

1. BOREHOLE DATA			DESIGNATION: U-3at-D1			RIG: Tonto Rig 12; Ingersoll Rand T-4 DRILL METHOD: ODEX Casing Advance Underreaming			Inclination 30 degrees																							
2. CORE DATA			RUN No.	5	DATE & TIME: 6/21/96, 1546	INTERVAL: 57.0-59.5 ft	PENETRATION RATE: 1.25 ft/min	RECOVERY: 100%	11. SAMPLE DESIGNATION																							
3. DEPTH (ft)	4. COLOR (MUNSELL CHART)	5. MOISTURE CONTENT			6. PARTICLE SIZE DISTRIBUTION				7. LITHOLOGY				8. SORTING			9. GRAIN SHAPE				10. USCS GROUP SYMBOL												
		DRY	MOIST	WET	COBBLES	GRAVEL	SAND	SILT-CLAY	BASALT	TUFF	CARBONATES	SILICICLASTICS	OTHER	WELL	MODERATE	POOR	ANGULAR	SUBANGULAR	SUBROUNDED		ROUNDED											
57.0-57.25	7.5YR6/6	X				R	D	P		D	P	R			X	X		X			SM	NW1	NW2	BN	HF1	HF2	DR1	DR2	ARCH	ARCH	X	
57.25-57.5	7.5YR6/6	X				R	D	P		D	P	R			X	X		X			SM									X		
57.5-57.75	7.5YR7/3	X						P		D	P				X			X			SM							X				
57.75-58.0	7.5YR7/3	X				R	D	P		D	P				X	X		X			SM						X					
58.0-58.25	7.5YR7/3	X					D	P		D	P				X	X		X			SM											
58.25-58.5	7.5YR7/3	X				R	D	P		D	P				X	X		X			SM				X							
58.5-58.75	7.5YR7/3	X					D	P		D	P				X	X		X			SM				X							
58.75-59.0	7.5YR7/3	X					D	P		D	P				X	X		X			SM			X								
59.0-59.25	7.5YR7/3	X					D	P		D	P				X	X		X			SM											
59.25-59.5	7.5YR7/3	X					D	P		D	P				X	X		X			SM	X										
12. COMMENTS:			Bedding obvious in cores from alternating fine sands to coarse sand. Segments 57.0-57.5 are weakly cemented; other segments are uncemented. Gravels are subrounded.																													
13. LOGGED BY:			Miller			14. REVIEWED BY & DATE:			Shannon M. Furman 11/6/97																							

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14. REVIEWED BY & DATE:

Shannon M. Parsons 11/6/97

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13. LOGGED BY:	Parsons
14. REVIEWED BY & DATE:	W. J. Turner 6/24/97

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but none under 60 AN97

Parsons

13. LOGGED BY:

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Parsons

13. LOGGED BY:

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Julianne Bates 6/24/97

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1. BOREHOLE DATA		DESIGNATION: U-3al-D1		RIG: Tonto Rig 12; Ingersoll Rand T-4		DRILL METHOD: ODEX Casing Advance Underreaming		Inclination 30 degrees																								
2. CORE DATA		RUN No.	11	DATE & TIME: 6/29/96, 0952		INTERVAL: 115.75-118.25 ft		PENETRATION RATE: INVALID		RECOVERY: 100%																						
		5. MOISTURE CONTENT		6. PARTICLE SIZE DISTRIBUTION				7. LITHOLOGY				8. SORTING		9. GRAIN SHAPE				10. USCS GROUP SYMBOL		11. SAMPLE DESIGNATION												
3. DEPTH (ft)	4. COLOR (MUNSELL CHART)	DRY	MOIST	WET	COBBLES	GRAVEL	SAND	SILT-CLAY	BASALT	TUFF	CARBONATES	SILICICLASTICS	OTHER	WELL	MODERATE	POOR	ANGULAR	SUBANGULAR	SUBROUNDED	ROUNDED		NW1	NW2	BN	HF1	HF2	DR11	DR12	ARCH	ARCH	ARCH	
115.75-116.0	7.5YR6/3	X					P	D	P	D	P				X			X				SM										X
116.0-116.25	7.5YR6/3	X				P	D	P		D	P				X		X				SM										X	
116.25-116.5	7.5YR6/3	X				P	D	P		D	P				X		X				SM								X			
116.5-116.75	7.5YR6/3	X				P	D	P		D	P				X		X				SM							X				
116.75-117.0	7.5YR6/4	X				P	D	P		D	P				X		X				SM							X				
117.0-117.25	7.5YR6/4	X					D	P		D	P				X		X				SM							X				
117.25-117.5	7.5YR6/4	X					D	P		D	P				X		X				SM											
117.5-117.75	7.5YR6/4	X					D	P		D	P				X		X				SM											
117.75-118.0	7.5YR6/4	X					D	P		D	P				X		X				SM											
118.0-118.25	7.5YR6/4	X					D	P		D	P				X		X				SM											
12. COMMENTS:																																
Coring time of 5 minutes is believed to be invalid because core barrel was partially filled when time began. Core overcompacted. Top four segments (115.75-116.75) may be fill. Thin carbonate wisps in lower cores. Segment 117.25-117.5 contains possible small root structures. Near vesicular structure in lower core segments.																																
13. LOGGED BY: Parsons																																
14. REVIEWED BY & DATE: Julianne Waters 10 JAN 97																																

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Miller

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Tobiason

BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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1. BOREHOLE DATA		DESIGNATION: U-3atD1		RIG: Tonto Rig 12; Ingersoll Rand T-4		DRILL METHOD: ODEX Casing Advance Underreaming		Inclination 30 degrees																											
2. CORE DATA		RUN No.	21	DATE & TIME:	7/11/96, 1227	INTERVAL:	220.0-222.5 ft	PENETRATION RATE:	2.5 ft/min	RECOVERY:	90%																								
3. DEPTH (ft)	4. COLOR (MUNSELL CHART)	5. MOISTURE CONTENT			6. PARTICLE SIZE DISTRIBUTION			7. LITHOLOGY			8. SORTING			9. GRAIN SHAPE				10. USCS GROUP SYMBOL		11. SAMPLE DESIGNATION															
		DRY	MOIST	WET	COBBLES	GRAVEL	SAND	SILT-CLAY	BASALT	TUFF	CARBONATES	SILICICLASTICS	OTHER	WELL	MODERATE	POOR	ANGULAR	SUBANGULAR	SUBROUNDED	ROUNDED			NW1	NW2	BN	HF1	HF2	DR11	DR12	ARCH	ARCH	ARCH	ARCH		
220.0-220.25	No Recovery																																		
220.25-220.5	7.5YR7/6		X			P	D	P		D	P				X			X																	
220.5-220.75	7.5YR4/3		X			P	D	P		D	P				X			X																	
220.75-221.0	7.5YR7/6					P	D	P		D	P				X			X																	
221.0-221.25	7.5YR7/4	X				P	D	P		D	P				X			X																	
221.25-221.5	7.5YR7/4	X				P	D	P		D	P				X			X																	
221.5-221.75	7.5YR7/4	X				P	D	P		D	P				X			X																	
221.75-222.0	7.5YR7/4	X				P	D	P		D	P				X			X																	
222.0-222.25	7.5YR7/4	X				P	D	P		D	P				X			X																	
222.25-222.5	7.5YR7/4	X				P	D	P		D	P				X			X																	
222.5-222.75	7.5YR7/4	X				R	D	P-C		D	P				X			X																	
12. COMMENTS:		Entire core fairly loose, possibly underdriven. Segments 220.0-220.5 probably fill. Segment 220.0-220.25 has a dark "soil" that appears almost organic.																																	
		The segment has no apparent hydrocarbon odor to indicate contamination. Wide range of gravel sizes throughout the entire core except for the last segment (222.25-222.5). This segment has a near absence of gravels and an increase in silt.																																	
13. LOGGED BY:		Tobiason											14. REVIEWED BY & DATE: Shannon M. Tobiason 1/6/97																						

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structure.

Parsons

13. LOGGED BY:

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13. LOGGED BY: Parsons

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Parsons

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1. BOREHOLE DATA		DESIGNATION: U-3at-D1		RIG: Tonto Rig 12; Ingersoll Rand T-4 DRILL METHOD: ODEX Casing Advance Underreaming		Inclination 30 degrees																											
2. CORE DATA		RUN No.	26	DATE & TIME: 7/15/96, 1108	INTERVAL: 269.0-271.5 ft	PENETRATION RATE: 0.8 ft/min	RECOVERY: 100%																										
		5. MOISTURE CONTENT			6. PARTICLE SIZE DISTRIBUTION			7. LITHOLOGY				8. SORTING			9. GRAIN SHAPE				11. SAMPLE DESIGNATION														
3. DEPTH (ft)	4. COLOR (MUNSELL CHART)	DRY	MOIST	WET	COBBLES	GRAVEL	SAND	SILT-CLAY	BASALT	TUFF	CARBONATES	SILICICLASTICS	OTHER	WELL	Moderate	POOR	ANGULAR	SUBANGULAR	SUBROUNDED	ROUNDED	10. USCS GROUP SYMBOL	NW1	NW2	BN	HF1	HF2	DR11	DR12	ARCH	ARCH	X		
																							SM										
269.0-269.25	7.5YR3/4			X			D	P		D	C			X				X			SM												
269.25-269.5	7.5YR3/4			X		R	D	P		D	C			X			X				SM											X	
269.5-269.75	7.5YR4/4			X		P	D	P		D	C				X		X				SM-GM									X			
269.75-270.0	7.5YR5/3			X		P	D	P		D	C				X		X				SM-GM							X					
270.0-270.25	7.5YR5/6			X		R	D	P		D	C				X		X				SM-GM			X									
270.25-270.5	7.5YR4/6			X		R	D	P		D	C				X		X				SM-GM		X										
270.5-270.75	7.5YR5/6			X		R	D	P		D	C				X		X				SM		X										
270.75-271.0	7.5YR5/6		X			R	D	P		D	C				X		X				SM				X								
271.0-271.25	7.5YR5/6		X			R	D	P		D	C				X		X				SM												
271.25-271.5	7.5YR5/6		X			R	D	P		D	C				X		X				SM												
12. COMMENTS:												Top segments (269.0-top half of 269.75) contain brown fill. Carbonate coatings are present on grains. Thin carbonate lenses are present in some segments. The entire core is wetter than core 262.25-264.75.																					
13. LOGGED BY:												Parsons										14. REVIEWED BY & DATE: <i>[Signature]</i> 10/10/97											

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Parsons

14. REVIEWED BY & DATE:

Julianne Kader 6 Jan 97

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14. REVIEWED BY & DATE:

11/6/97

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Miller

13. LOGGED BY:

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Baron M. Lauma 11/6/97

Segments 329.75-33.75 partial recovery. Segments 331.0-331.75 contains carbonate vels. Gravels are subrounded

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13. LOGGED BY:	Miller	14. REVIEWED BY & DATE:	<i>Sharon McFarlane</i> 11/6/97
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Shannon M. Parsons 1/6/97

14. REVIEWED BY & DATE:

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BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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Miller

13. LOGGED BY:

14. REVIEWED BY & DATE:

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Only sections 3 and 7 were archived because entire core is fill from within the casing. Core only driven 21" and not past drive shoe. Core is moist throughout. Very rare gravels are present; it is mostly medium sand. Color is 7.5YR7/4.

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Shannon H. Ladd 11/6/97

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13. LOGGED BY:	Miller
14. REVIEWED BY & DATE:	<i>Symon M. Lerner</i> 11/6/97

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Tobiason

14. REVIEWED BY & DATE:

Shannon M. Parsons 11/6/97

BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

[illegible]

BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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1. BOREHOLE DATA		DESIGNATION: U-3at-D1		RIG: Tonto Rig 12; Ingersoll Rand T-4		DRILL METHOD: ODEX Casing Advance Underreaming		Inclination 30 degrees																										
2. CORE DATA		RUN No. 47		DATE & TIME: 7/30/96, 0716		INTERVAL: 479.75-482.25 ft		PENETRATION RATE: 1.25 ft/min		RECOVERY: 90+%																								
3. DEPTH (ft)	4. COLOR (MUNSELL CHART)	5. MOISTURE CONTENT				6. PARTICLE SIZE DISTRIBUTION				7. LITHOLOGY				8. SORTING			9. GRAIN SHAPE				10. USCS GROUP SYMBOL	11. SAMPLE DESIGNATION												
		DRY	MOIST	WET		COBBLES	GRAVEL	SAND	SILT-CLAY	BASALT	TUFF	CARBONATES	SILICICLASTICS	OTHER	WELL	MODERATE	POOR	ANGULAR	SUBANGULAR	SUBROUNDED		ROUNDED	NW1	NW2	BN	HF1	HF2	DR1	DR2	ARCH	ARCH	ARCH		
479.75-480.0	7.5YR5/6		X				D	P		D	P				X				X			SM											X	
480.0-480.25	7.5YR5/6		X				D	P		D	P				X				X			SM											X	
480.25-480.5	7.5YR5/6		X				D	P		D	P				X				X			SM											X	
480.5-480.75	7.5YR5/6		X				D	P		D	P								X			SM					X							
480.75-481.0	7.5YR5/6		X				D	P		D	P				X							SM					X							
481.0-481.25	7.5YR6/6		X				D	P		D	P				X							SM												
481.25-481.5	7.5YR6/6		X				D	P		D	P				X							SM					X							
481.5-481.75	7.5YR6/6		X				D	P		D	P				X							SM												
481.75-482.0	7.5YR6/6		X				D	P		D	P											SM												
482.0-482.25	7.5YR5/6		X				D	P		D	P				X							SM												
482.0-482.25	7.5YR5/6		X				D	P		D	P				X							SM												
12. COMMENTS:		Coarse sand is dominant in segments 479.75-480.5. Lighter soil is intermixed in segments 480.75-481.75. Segment 479.75-480.0 is a partial segment.																																
13. LOGGED BY:		Miller																																
14. REVIEWED BY & DATE:		Shannon M. Taylor 11/6/97																																

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James M. Evans 11/6/97

Miller

14. REVIEWED BY & DATE:

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BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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Shannon M. Lyons 11/6/97

BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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James M. Evans - 11/6/97

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BOREHOLE LOG SHEET FOR ALLUVIAL CORE SAMPLES

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1. BOREHOLE DATA		DESIGNATION: U-3at-D2		RIG: Tonto Rig 12; Ingersoll Rand T-4		DRILL METHOD: ODEX Casing Advance Underreaming		Inclination 30 degrees																											
2. CORE DATA		RUN No.	7	DATE & TIME: 8/17/96, 1436	INTERVAL: 240.75-243.25 ft	PENETRATION RATE: 1.25 ft/min	RECOVERY: 100%																												
3. DEPTH (ft)	4. COLOR (MUNSELL CHART)	5. MOISTURE CONTENT				6. PARTICLE SIZE DISTRIBUTION				7. LITHOLOGY				8. SORTING			9. GRAIN SHAPE				10. USCS GROUP SYMBOL	11. SAMPLE DESIGNATION													
		DRY	MOIST	WET		COBBLES	GRAVEL	SAND	SILT-CLAY	BASALT	TUFF	CARBONATES	SILICICLASTICS	OTHER	WELL	MODERATE	POOR	ANGULAR	SUBANGULAR	SUBROUNDED		ROUNDED	NW1	NW2	BN	HF1	HF2	DR11	DR12	ARCH	ARCH	ARCH			
240.75-241.0	7.5YR6/4		X				D	P		D	P				X			X				SM											X		
241.0-241.25	7.5YR6/4		X				D	P		D	P				X			X				SM											X		
241.25-241.5	7.5YR7/4		X				D	P		D	P				X			X				SM											X		
241.5-241.75	7.5YR7/4		X				D	P		D	P				X			X				SM					X								
241.75-242.0	7.5YR7/4		X				D	P		D	P				X			X				SM						X							
242.0-242.25	7.5YR7/4		X				D	P		D	P				X			X				SM							X						
242.25-242.5	7.5YR7/4		X				D	P		D	P				X			X				SM													
242.5-242.75	7.5YR6/3		X				D	P		D	P				X			X				SM							X						
242.75-243.0	7.5YR6/3		X				D	P		D	P				X			X				SM													
243.0-243.25	7.5YR6/4		X				D	P		D	P				X			X				SM													
12. COMMENTS:		Vesicular soil visible in segments 242.5-243.0. Segments 240.75-241.25 are dominated by medium sand. Segments 241.25-243.25 contain very fine sand and silt. This core is substantially drier than the last core.																																	
13. LOGGED BY:		Miller																																	
14. REVIEWED BY & DATE:		Shannon McFarlane 11/6/97																																	

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13. LOGGED BY:	Parsons
14. REVIEWED BY & DATE:	Julianne Miller 6/29/97

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U3at Collapse Zone

Appendix B

Characterization Data Tables

Table B-1
Particle Density for U-3at-D1 Characterization Samples
 (Depth in meters; density in kilograms per cubic meters)

Location: U-3at-D1		Analysis: Particle Density	
Depth (m)	Density (kg/m ³)	Depth (m)	Density (kg/m ³)
5.32	2470	78.81	2410
7.65	2440	81.10	2490
10.69	2430	83.40	2450
13.05	2380	85.84	2490
15.15	2420	88.28	2420
17.93	2380	90.66	2400
20.42	2380	93.22	2430
22.94	2350	95.48	2410
25.23	2220	97.68	2360
27.99	2310	100.33	2340
30.47	2240	104.97	2410
32.90	2390	107.35	2440
35.16	2320	109.88	2410
40.14	2470	112.17	2320
42.85	2480	114.55	2370
46.68	2310	116.87	2470
49.10	2290	119.19	2500
51.74	2240	121.69	2400
54.19	2360	124.07	2480
56.82	2290	126.41	2440
58.73	2260	128.74	2400
61.39	2390	131.28	2430
66.72	2280	135.97	2370
67.27	2410	138.36	2320
68.94	2320	140.78	2380
71.23	2480	142.96	2180
74.14	2470	145.53	2390
76.52	2540	147.08	2450

Table B-2
Particle Size Distribution for the Fine Earth (<2 millimeters) Fraction
for U-at-D1 Characterization Samples
 (Depth in meters; particle sizes [weight percent] in millimeters)

Location: U-3at-D1 Analysis: Particle Size										
Depth (m)	Sand (0.05 - 2 mm) (wt %)						Silt (2 - 50 mm) (wt %)			Clay (< 2 mm) (wt %)
	1 - 2 mm	0.5 - 1 mm	0.25 - 0.5 mm	0.1 - 0.25 mm	0.05 - 0.1 mm	Total Sand	20 - 50 mm	2 - 20 mm	Total Silt	Total Clay
5.32	30.3	25.2	17.1	11.2	5.1	88.9	2.9	2.2	5.1	6.0
7.65	18.0	30.7	28.6	14.1	2.5	93.9	1.3	1.1	2.4	3.7
10.69	4.6	7.4	17.2	35.9	19.4	84.5	4.4	3.2	7.6	7.9
13.05	11.3	13.2	17.7	25.5	12.7	80.5	6.1	3.5	9.6	9.9
15.15	12.8	18.1	29.9	26.2	6.0	92.9	1.5	1.4	2.9	4.2
17.93	11.5	14.1	17.4	20.8	10.2	74.0	9.9	3.6	13.5	12.5
20.42	23.2	19.1	15.7	11.8	5.7	75.5	6.6	1.5	8.1	16.4
22.94	25.8	24.9	19.6	11.9	3.6	85.8	3.2	1.3	4.5	9.7
25.23	27.6	17.6	10.6	9.2	7.1	72.0	10.6	4.1	14.7	13.3
27.99	25.6	20.8	22.0	16.4	5.3	90.1	3.2	1.8	5.0	4.9
30.47	11.9	20.0	23.4	11.0	4.7	71.0	7.7	1.3	9.0	20.0
32.90	27.5	31.1	15.4	8.0	3.1	85.2	2.0	0.7	2.7	12.1
35.16	14.3	19.6	25.7	21.5	5.6	86.8	4.0	1.6	5.6	7.6
40.14	40.3	32.3	9.9	8.0	3.1	93.6	1.2	1.1	2.3	4.1
42.85	48.2	24.4	11.3	5.3	1.9	91.2	3.2	1.4	4.6	4.2
46.68	11.1	12.0	17.9	22.2	10.6	73.8	10.2	2.4	12.6	13.6
49.10	5.2	7.2	19.1	36.5	14.8	82.9	5.1	1.5	6.6	10.5
51.74	2.3	5.0	13.4	29.0	18.3	67.9	12.3	5.0	17.3	14.8
54.19	12.7	13.8	23.0	25.1	8.4	83.0	6.7	2.9	9.6	7.4
56.82	8.6	10.0	12.0	17.0	15.9	63.4	15.0	7.2	22.2	14.4
58.73	22.9	17.4	16.0	14.8	5.4	76.5	7.3	2.3	9.6	13.9
61.39	17.1	22.3	30.4	15.9	3.8	89.5	2.7	1.4	4.1	6.4
66.72	4.7	6.4	13.7	28.9	20.3	74.0	11.1	4.5	15.6	10.4
67.27	8.1	13.3	25.2	29.0	10.1	85.7	5.2	2.8	8.0	6.3
68.94	3.7	6.2	14.9	28.3	16.3	69.3	10.8	4.2	15.0	15.7
71.23	7.4	7.6	13.8	25.0	12.6	66.5	10.8	4.0	14.8	18.7
74.14	5.9	16.6	31.8	28.4	7.0	89.7	1.5	3.6	5.1	5.2
76.52	14.4	16.5	18.7	16.9	8.7	75.1	8.5	2.6	11.1	13.8
78.81	5.4	6.4	11.4	22.6	22.3	68.2	13.5	7.4	20.9	10.9
81.10	15.8	17.8	22.5	18.3	6.5	80.9	6.5	3.1	9.6	9.5
83.40	19.9	17.9	13.1	9.4	4.9	65.1	5.9	1.4	7.3	27.6
85.84	9.1	14.6	21.9	30.1	11.9	87.5	3.8	1.4	5.2	7.3
88.28	4.8	8.4	16.9	32.7	15.8	78.7	8.1	5.2	13.3	8.0
90.66	8.0	11.5	20.7	29.6	14.9	84.7	4.6	2.8	7.4	7.9
93.22	3.9	7.3	16.4	32.9	17.9	78.6	9.4	4.0	13.4	8.0
95.48	5.3	10.0	21.5	31.6	14.4	82.8	6.2	2.9	9.1	8.1
97.68	11.9	13.6	20.5	28.0	12.2	86.2	5.2	2.7	7.9	5.9
100.33	19.0	24.2	29.4	17.1	4.7	94.4	2.6	0.5	3.1	2.5
104.97	17.4	21.7	23.3	13.8	6.2	82.4	6.4	0.8	7.2	10.4
107.35	1.6	2.8	9.7	30.5	20.4	65.0	18.1	10.2	28.3	6.7
109.88	2.0	3.1	8.0	23.5	24.1	60.7	21.4	6.8	28.2	11.1
112.17	9.6	16.0	27.6	28.4	9.0	90.6	3.3	1.8	5.1	4.3
114.55	4.1	8.7	21.6	29.7	15.8	79.8	6.1	3.8	9.9	10.3
116.87	17.3	21.5	22.6	16.5	5.7	83.7	3.3	1.1	4.4	11.9
119.19	4.2	6.5	15.1	24.5	15.2	65.5	11.2	3.3	14.5	20.0
121.69	3.7	6.3	18.1	31.9	12.9	72.9	10.7	2.5	13.2	13.9
124.07	26.0	23.8	22.9	13.9	3.5	90.0	3.0	0.6	3.6	6.4
126.41	8.1	13.4	21.0	25.3	14.6	82.5	5.6	4.6	10.2	7.3
128.74	7.9	10.8	17.9	28.6	17.3	82.5	5.8	4.1	9.9	7.6
131.28	6.9	31.4	40.8	11.3	2.4	92.9	2.6	0.6	3.2	3.9
135.97	18.0	20.3	25.8	19.1	5.8	88.9	4.4	2.0	6.4	4.7
138.36	10.5	17.8	31.1	23.5	7.7	90.6	2.7	1.4	4.1	5.3
140.78	9.1	14.8	26.7	29.7	9.7	89.9	3.3	2.7	6.0	4.1
142.96	14.3	15.3	20.7	22.6	10.5	83.5	6.3	3.1	9.4	7.1
145.53	4.3	8.5	22.5	38.6	15.3	89.2	3.0	1.9	4.9	5.9
147.08	35.0	28.3	18.8	7.5	1.8	91.5	2.1	1.0	3.1	5.4

Table B-3
Bulk Density for U-3at-D1 Characterization Samples
 (Depth in meters; density in kilograms per cubic meter)

Location: U-3at-D1		Analysis: Dry Bulk Density			
Depth (m)	Bulk Density (kg/m ³)	Depth (m)	Bulk Density (kg/m ³)	Depth (m)	Bulk Density (kg/m ³)
5.42	1550	56.60	1707	105.18	1580
5.55	1545	56.78	1540	107.44	1557
7.75	1783	58.52	1700	107.56	1530
7.81	1580	58.64	1641	109.82	1413
10.40	1622	61.36	1540	109.88	1450
10.53	1420	61.43	1566	112.26	1569
13.18	1650	66.56	1400	112.38	1650
13.31	1530	66.62	1552	114.64	1497
15.25	1508	67.06	1360	114.76	1460
15.37	1590	67.12	1480	116.96	1836
17.90	1420	68.73	1773	117.08	1780
17.96	1454	68.85	1450	119.28	1748
20.35	1588	71.33	1797	119.40	1560
20.48	1450	71.39	1860	121.78	1520
22.94	1510	73.99	1640	121.89	1550
23.00	1792	74.05	1718	124.16	1721
25.40	1560	76.34	1490	124.28	1640
25.46	1727	76.52	1877	126.49	1774
28.08	2055	78.78	1509	126.61	1670
28.15	1750	78.84	1560	128.83	1857
30.25	1480	81.04	1850	128.95	1610
30.31	1330	81.10	1730	131.34	1592
32.67	1701	83.48	1442	131.46	1400
32.74	1610	83.60	1550	133.55	1922
35.16	1604	86.04	1757	133.61	1410
35.42	1530	86.10	1630	136.06	1796
40.14	1856	88.37	1501	136.18	1790
40.26	1660	88.49	1410	138.45	1578
42.62	1783	90.75	1702	138.57	1560
42.92	1640	90.87	1600	140.90	1465
42.96	1750	93.31	1475	141.02	1550
46.77	1830	93.37	1430	143.05	1449
46.83	1490	95.33	1620	143.29	1500
49.20	1671	95.45	1364	145.62	1591
49.32	1530	97.74	1560	145.74	1490
51.83	1446	97.89	1586	147.17	1825
51.96	1540	100.12	1750	147.29	1520
54.19	1685	100.18	1410		
54.37	1480	105.06	1585		

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples
 (Depth in meters; volumetric water content θ in cubic meters per cubic meter;
 matric potential h MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	5.4		7.8		10.5	
	θ (m ³ m ⁻³)	h (MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.391	0.004	0.386	0.004	0.394	0.004
	0.364	0.017	0.366	0.017	0.284	0.017
	0.320	0.030	0.327	0.030	0.233	0.030
	0.179	0.047	0.270	0.047	0.211	0.047
	0.167	0.068	0.216	0.068	0.196	0.068
	0.160	0.106	0.195	0.106	0.180	0.106
	0.157	0.153	0.188	0.153	0.170	0.153
	0.153	0.208	0.182	0.208	0.164	0.208
	0.148	0.295	0.181	0.295	0.156	0.295
	0.142	0.425	0.176	0.425	0.150	0.425
	0.138	0.579	0.171	0.579	0.145	0.579
	0.134	0.756	0.167	0.756	0.132	0.756
	0.129	1.182	0.160	1.182	0.119	1.182
	0.125	1.702	0.154	1.702	0.109	1.702
	0.120	2.316	0.148	2.316	0.096	2.316
	0.116	3.025	0.143	3.025	0.086	3.025
	0.112	3.829	0.139	3.829	0.077	3.829
	0.109	4.727	0.136	4.727	0.070	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	13.3		15.4		17.9	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.372	0.004	0.379	0.004	0.413	0.004
	0.348	0.017	0.350	0.017	0.390	0.017
	0.307	0.030	0.296	0.030	0.347	0.030
	0.228	0.047	0.215	0.047	0.285	0.047
	0.204	0.068	0.138	0.068	0.232	0.068
	0.193	0.106	0.125	0.106	0.214	0.106
	0.185	0.153	0.121	0.153	0.206	0.153
	0.179	0.208	0.118	0.208	0.200	0.208
	0.172	0.295	0.113	0.295	0.194	0.295
	0.162	0.425	0.107	0.425	0.188	0.425
	0.157	0.579	0.103	0.579	0.180	0.579
	0.151	0.756	0.099	0.756	0.174	0.756
	0.143	1.182	0.095	1.182	0.164	1.182
	0.135	1.702	0.090	1.702	0.155	1.702
	0.128	2.316	0.087	2.316	0.146	2.316
	0.122	3.025	0.083	3.025	0.140	3.025
	0.117	3.829	0.081	3.829	0.134	3.829
	0.113	4.727	0.078	4.727	0.130	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content $[\theta]$ in cubic meters per cubic meter;
 matric potential $[h]$ MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	20.5		22.9		25.4	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.366	0.004	0.313	0.004	0.404	0.004
	0.302	0.017	0.232	0.017	0.385	0.017
	0.285	0.030	0.213	0.030	0.355	0.030
	0.276	0.047	0.202	0.047	0.312	0.047
	0.269	0.068	0.194	0.068	0.270	0.068
	0.260	0.106	0.186	0.106	0.249	0.106
	0.254	0.153	0.179	0.153	0.235	0.153
	0.249	0.208	0.174	0.208	0.214	0.295
	0.243	0.295	0.168	0.295	0.203	0.425
	0.238	0.425	0.162	0.425	0.195	0.579
	0.233	0.579	0.158	0.579	0.187	0.756
	0.228	0.756	0.153	0.756	0.174	1.182
	0.219	1.182	0.144	1.182	0.162	1.702
	0.210	1.702	0.136	1.702	0.151	2.316
	0.201	2.316	0.128	2.316	0.143	3.025
	0.195	3.025	0.122	3.025	0.137	3.829
	0.190	3.829	0.119	3.829	0.132	4.727
	0.185	4.727	0.113	4.727		

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	28.1		30.3		32.7	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.211	0.004	0.481	0.004	0.343	0.004
	0.180	0.017	0.464	0.017	0.232	0.017
	0.135	0.030	0.427	0.030	0.179	0.030
	0.128	0.047	0.303	0.047	0.173	0.047
	0.125	0.068	0.263	0.068	0.167	0.068
	0.120	0.106	0.246	0.106	0.159	0.106
	0.116	0.153	0.235	0.153	0.155	0.153
	0.114	0.208	0.228	0.208	0.151	0.208
	0.111	0.295	0.217	0.295	0.147	0.295
	0.107	0.425	0.213	0.425	0.143	0.425
	0.104	0.579	0.202	0.579	0.138	0.579
	0.102	0.756	0.195	0.756	0.135	0.756
	0.098	1.182	0.186	1.182	0.130	1.182
	0.094	1.702	0.176	1.702	0.126	1.702
	0.092	2.316	0.164	2.316	0.121	2.316
	0.089	3.025	0.156	3.025	0.117	3.025
	0.086	3.829	0.149	3.829	0.114	3.829
	0.084	4.727	0.143	4.727	0.111	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content θ in cubic meters per cubic meter;
 matric potential h MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	35.4		40.3		42.9	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.302	0.004	0.239	0.004	0.277	0.004
	0.182	0.017	0.130	0.017	0.254	0.017
	0.163	0.030	0.121	0.030	0.245	0.030
	0.153	0.047	0.117	0.047	0.239	0.047
	0.147	0.068	0.115	0.068	0.234	0.068
	0.141	0.106	0.111	0.106	0.226	0.106
	0.136	0.153	0.109	0.153	0.219	0.153
	0.131	0.208	0.106	0.208	0.213	0.208
	0.127	0.295	0.103	0.295	0.206	0.295
	0.122	0.425	0.099	0.425	0.196	0.425
	0.118	0.579	0.096	0.579	0.186	0.579
	0.114	0.756	0.094	0.756	0.179	0.756
	0.109	1.182	0.090	1.182	0.168	1.182
	0.105	1.702	0.086	1.702	0.159	1.702
	0.100	2.316	0.083	2.316	0.152	2.316
	0.096	3.025	0.080	3.025	0.145	3.025
	0.093	3.829	0.078	3.829	0.140	3.829
	0.090	4.727	0.075	4.727	0.135	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	43.0		46.8		49.3	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.285	0.004	0.289	0.004	0.407	0.004
	0.225	0.017	0.240	0.017	0.392	0.017
	0.128	0.030	0.199	0.030	0.353	0.030
	0.120	0.047	0.190	0.047	0.286	0.047
	0.116	0.068	0.187	0.068	0.219	0.068
	0.112	0.106	0.179	0.106	0.195	0.106
	0.108	0.153	0.172	0.153	0.186	0.153
	0.104	0.208	0.167	0.208	0.180	0.208
	0.101	0.295	0.162	0.295	0.175	0.295
	0.098	0.425	0.156	0.425	0.170	0.425
	0.095	0.579	0.150	0.579	0.163	0.579
	0.093	0.756	0.145	0.756	0.157	0.756
	0.090	1.182	0.138	1.182	0.151	1.182
	0.087	1.702	0.132	1.702	0.145	1.702
	0.085	2.316	0.125	2.316	0.138	2.316
	0.082	3.025	0.120	3.025	0.131	3.025
	0.080	3.829	0.116	3.829	0.126	3.829
	0.078	4.727	0.112	4.727	0.121	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content θ in cubic meters per cubic meter;
 matric potential h in MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	52.0		54.4		56.8	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.381	0.004	0.395	0.004	0.246	0.004
	0.376	0.017	0.373	0.017	0.193	0.017
	0.360	0.030	0.325	0.030	0.181	0.030
	0.335	0.047	0.188	0.047	0.173	0.047
	0.318	0.068	0.174	0.068	0.168	0.068
	0.299	0.106	0.165	0.106	0.161	0.106
	0.279	0.153	0.158	0.153	0.155	0.153
	0.263	0.208	0.152	0.208	0.151	0.208
	0.245	0.295	0.146	0.295	0.147	0.295
	0.235	0.425	0.141	0.425	0.141	0.425
	0.215	0.579	0.134	0.579	0.137	0.579
	0.203	0.756	0.129	0.756	0.133	0.756
	0.188	1.182	0.125	1.182	0.128	1.182
	0.175	1.702	0.119	1.702	0.123	1.702
	0.162	2.316	0.113	2.316	0.119	2.316
	0.154	3.025	0.108	3.025	0.115	3.025
	0.147	3.829	0.104	3.829	0.112	3.829
	0.141	4.727	0.100	4.727	0.109	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	58.5		61.4		66.6	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.271	0.004	0.354	0.004	0.387	0.004
	0.177	0.017	0.233	0.017	0.332	0.017
	0.149	0.030	0.190	0.030	0.269	0.030
	0.143	0.047	0.178	0.047	0.245	0.047
	0.140	0.068	0.172	0.068	0.231	0.068
	0.135	0.106	0.165	0.106	0.213	0.106
	0.130	0.153	0.161	0.153	0.200	0.153
	0.127	0.208	0.156	0.208	0.190	0.208
	0.123	0.295	0.150	0.295	0.180	0.295
	0.119	0.425	0.145	0.425	0.171	0.425
	0.115	0.579	0.141	0.579	0.163	0.579
	0.110	0.756	0.137	0.756	0.157	0.756
	0.103	1.182	0.130	1.182	0.147	1.182
	0.097	1.702	0.125	1.702	0.139	1.702
	0.092	2.316	0.119	2.316	0.131	2.316
	0.088	3.025	0.114	3.025	0.124	3.025
	0.085	3.829	0.110	3.829	0.119	3.829
	0.081	4.727	0.107	4.727	0.113	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content $[\theta]$ in cubic meters per cubic meter;
 matric potential $[h]$ MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	67.1		68.9		71.4	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.468	0.004	0.362	0.004	0.247	0.004
	0.462	0.017	0.311	0.017	0.211	0.017
	0.458	0.030	0.275	0.030	0.197	0.030
	0.256	0.047	0.262	0.047	0.187	0.047
	0.242	0.068	0.251	0.068	0.180	0.068
	0.230	0.106	0.238	0.106	0.172	0.106
	0.219	0.153	0.228	0.153	0.166	0.153
	0.210	0.208	0.222	0.208	0.161	0.208
	0.201	0.295	0.214	0.295	0.157	0.295
	0.194	0.425	0.208	0.425	0.153	0.425
	0.187	0.579	0.201	0.579	0.148	0.579
	0.180	0.756	0.196	0.756	0.145	0.756
	0.170	1.182	0.187	1.182	0.142	1.182
	0.161	1.702	0.181	1.702	0.138	1.702
	0.151	2.316	0.173	2.316	0.134	2.316
	0.143	3.025	0.167	3.025	0.131	3.025
	0.136	3.829	0.163	3.829	0.128	3.829
	0.131	4.727	0.158	4.727	0.125	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	74.0		76.3		78.8	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.314	0.004	0.373	0.004	0.380	0.004
	0.235	0.017	0.325	0.017	0.360	0.017
	0.203	0.030	0.242	0.030	0.321	0.030
	0.188	0.047	0.225	0.047	0.272	0.047
	0.180	0.068	0.219	0.068	0.229	0.068
	0.170	0.106	0.210	0.106	0.211	0.106
	0.160	0.153	0.204	0.153	0.201	0.153
	0.156	0.208	0.198	0.208	0.193	0.208
	0.150	0.295	0.193	0.295	0.184	0.295
	0.144	0.425	0.187	0.425	0.176	0.425
	0.138	0.579	0.182	0.579	0.169	0.579
	0.132	0.756	0.178	0.756	0.162	0.756
	0.124	1.182	0.172	1.182	0.150	1.182
	0.118	1.702	0.167	1.702	0.140	1.702
	0.113	2.316	0.160	2.316	0.131	2.316
	0.109	3.025	0.156	3.025	0.124	3.025
	0.105	3.829	0.151	3.829	0.118	3.829
	0.101	4.727	0.147	4.727	0.113	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content θ in cubic meters per cubic meter;
 matric potential h MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	81.1		83.5		86.0	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.345	0.004	0.308	0.004	0.403	0.004
	0.324	0.017	0.244	0.017	0.386	0.017
	0.286	0.030	0.214	0.030	0.345	0.030
	0.228	0.047	0.203	0.047	0.208	0.047
	0.171	0.068	0.194	0.068	0.201	0.068
	0.157	0.106	0.184	0.106	0.190	0.106
	0.150	0.153	0.176	0.153	0.182	0.153
	0.144	0.208	0.171	0.208	0.176	0.208
	0.138	0.295	0.166	0.295	0.170	0.295
	0.131	0.425	0.160	0.425	0.164	0.425
	0.125	0.579	0.156	0.579	0.158	0.579
	0.120	0.756	0.152	0.756	0.154	0.756
	0.115	1.182	0.147	1.182	0.147	1.182
	0.110	1.702	0.119	3.025	0.142	1.702
	0.105	2.316	0.114	3.829	0.136	2.316
	0.101	3.025	0.110	4.727	0.131	3.025
	0.098	3.829			0.128	3.829
	0.096	4.727			0.124	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	88.4		90.7		93.3	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.452	0.004	0.435	0.004	0.451	0.004
	0.436	0.017	0.410	0.017	0.451	0.017
	0.394	0.030	0.365	0.030	0.444	0.030
	0.267	0.047	0.300	0.047	0.360	0.047
	0.220	0.068	0.230	0.068	0.282	0.068
	0.196	0.106	0.209	0.106	0.233	0.106
	0.185	0.153	0.200	0.153	0.221	0.153
	0.176	0.208	0.193	0.208	0.212	0.208
	0.169	0.295	0.184	0.295	0.205	0.295
	0.161	0.425	0.176	0.425	0.194	0.425
	0.154	0.579	0.168	0.579	0.175	0.579
	0.148	0.756	0.162	0.756	0.169	0.756
	0.140	1.182	0.152	1.182	0.157	1.182
	0.133	1.702	0.145	1.702	0.146	1.702
	0.125	2.316	0.135	2.316	0.138	2.316
	0.119	3.025	0.129	3.025	0.131	3.025
	0.115	3.829	0.124	3.829	0.125	3.829
	0.111	4.727	0.119	4.727	0.120	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content θ in cubic meters per cubic meter;
 matric potential h in MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	95.5		97.9		100.1	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.411	0.004	0.436	0.004	0.366	0.004
	0.398	0.017	0.426	0.017	0.338	0.017
	0.365	0.030	0.401	0.030	0.208	0.030
	0.211	0.047	0.346	0.047	0.182	0.047
	0.177	0.068	0.271	0.068	0.176	0.068
	0.168	0.106	0.213	0.106	0.168	0.106
	0.159	0.153	0.208	0.153	0.162	0.153
	0.153	0.208	0.201	0.208	0.157	0.208
	0.147	0.295	0.193	0.295	0.151	0.295
	0.141	0.425	0.186	0.425	0.145	0.425
	0.135	0.579	0.180	0.579	0.140	0.579
	0.131	0.756	0.174	0.756	0.136	0.756
	0.125	1.182	0.163	1.182	0.129	1.182
	0.120	1.702	0.154	1.702	0.124	1.702
	0.114	2.316	0.146	2.316	0.118	2.316
	0.109	3.025	0.138	3.025	0.113	3.025
	0.105	3.829	0.131	3.829	0.108	3.829
	0.102	4.727	0.125	4.727	0.104	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	105.1		107.4		109.8	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.411	0.004	0.418	0.004	0.449	0.004
	0.404	0.017	0.408	0.017	0.439	0.017
	0.383	0.030	0.367	0.030	0.418	0.030
	0.343	0.047	0.268	0.047	0.371	0.047
	0.333	0.068	0.231	0.068	0.350	0.068
	0.317	0.106	0.210	0.106	0.323	0.106
	0.304	0.153	0.195	0.153	0.299	0.153
	0.294	0.208	0.185	0.208	0.282	0.208
	0.282	0.295	0.175	0.295	0.264	0.295
	0.259	0.579	0.165	0.425	0.248	0.425
	0.249	0.756	0.159	0.579	0.235	0.579
	0.234	1.182	0.153	0.756	0.226	0.756
	0.220	1.702	0.143	1.182	0.205	1.182
	0.208	2.316	0.136	1.702	0.190	1.702
	0.199	3.025	0.130	2.316	0.178	2.316
	0.192	3.829	0.124	3.025	0.169	3.025
	0.185	4.727	0.119	3.829	0.160	3.829
			0.115	4.727	0.153	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content θ in cubic meters per cubic meter;
 matric potential h MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	112.3		114.6		117.0	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.342	0.004	0.368	0.004	0.327	0.004
	0.329	0.017	0.355	0.017	0.310	0.017
	0.298	0.030	0.312	0.030	0.275	0.030
	0.238	0.047	0.272	0.047	0.166	0.047
	0.221	0.068	0.261	0.068	0.161	0.068
	0.207	0.106	0.246	0.106	0.151	0.106
	0.198	0.153	0.235	0.153	0.147	0.153
	0.189	0.208	0.227	0.208	0.145	0.208
	0.178	0.295	0.218	0.295	0.138	0.295
	0.169	0.425	0.209	0.425	0.132	0.425
	0.160	0.579	0.199	0.579	0.128	0.579
	0.154	0.756	0.192	0.756	0.125	0.756
	0.145	1.182	0.178	1.182	0.120	1.182
	0.138	1.702	0.164	1.702	0.117	1.702
	0.130	2.316	0.150	2.316	0.112	2.316
	0.124	3.025	0.140	3.025	0.109	3.025
	0.119	3.829	0.131	3.829	0.106	3.829
	0.115	4.727	0.124	4.727	0.103	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	119.3		121.8		124.2	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.450	0.004	0.396	0.004	0.273	0.004
	0.441	0.017	0.386	0.017	0.229	0.017
	0.422	0.030	0.361	0.030	0.125	0.030
	0.317	0.047	0.338	0.047	0.112	0.068
	0.285	0.068	0.312	0.068	0.105	0.106
	0.272	0.106	0.292	0.106	0.099	0.153
	0.259	0.153	0.278	0.153	0.094	0.208
	0.249	0.208	0.268	0.208	0.090	0.295
	0.239	0.295	0.256	0.295	0.082	0.425
	0.230	0.425	0.244	0.425	0.076	0.579
	0.221	0.579	0.232	0.579	0.071	0.756
	0.215	0.756	0.221	0.756	0.063	1.182
	0.202	1.182	0.204	1.182	0.056	1.702
	0.190	1.702	0.188	1.702	0.050	2.316
	0.178	2.316	0.172	2.316	0.045	3.025
	0.168	3.025	0.162	3.025	0.042	3.829
	0.160	3.829	0.153	3.829	0.038	4.727
	0.152	4.727	0.146	4.727		

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content θ in cubic meters per cubic meter;
 matric potential h in MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	126.5		128.8		131.3	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.383	0.004	0.372	0.004	0.490	0.004
	0.372	0.017	0.348	0.017	0.476	0.017
	0.346	0.030	0.299	0.030	0.446	0.030
	0.262	0.047	0.211	0.047	0.382	0.047
	0.251	0.068	0.150	0.068	0.298	0.068
	0.238	0.106	0.140	0.106	0.233	0.106
	0.229	0.153	0.134	0.153	0.222	0.153
	0.221	0.208	0.129	0.208	0.213	0.208
	0.214	0.295	0.124	0.295	0.205	0.295
	0.206	0.425	0.118	0.425	0.196	0.425
	0.199	0.579	0.114	0.579	0.189	0.579
	0.194	0.756	0.110	0.756	0.182	0.756
	0.186	1.182	0.103	1.182	0.170	1.182
	0.177	1.702	0.098	1.702	0.159	1.702
	0.170	2.316	0.093	2.316	0.148	2.316
	0.164	3.025	0.089	3.025	0.140	3.025
	0.159	3.829	0.086	3.829	0.133	3.829
	0.155	4.727	0.082	4.727	0.127	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	133.5		136.1		138.4	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.447	0.004	0.315	0.004	0.406	0.004
	0.427	0.017	0.304	0.017	0.390	0.017
	0.387	0.030	0.286	0.030	0.351	0.030
	0.310	0.047	0.255	0.047	0.294	0.047
	0.192	0.068	0.232	0.068	0.193	0.068
	0.176	0.106	0.218	0.106	0.148	0.106
	0.168	0.153	0.206	0.153	0.143	0.153
	0.160	0.208	0.199	0.208	0.139	0.208
	0.153	0.295	0.190	0.295	0.134	0.295
	0.145	0.425	0.181	0.425	0.129	0.425
	0.138	0.579	0.171	0.579	0.125	0.579
	0.132	0.756	0.164	0.756	0.122	0.756
	0.124	1.182	0.153	1.182	0.112	1.182
	0.117	1.702	0.142	1.702	0.106	1.702
	0.108	2.316	0.131	2.316	0.100	2.316
	0.103	3.025	0.125	3.025	0.095	3.025
	0.098	3.829	0.119	3.829	0.091	3.829
	0.094	4.727	0.115	4.727	0.088	4.727

Table B-4
Water Retention Relations for U-3at-D1 Characterization Samples (continued)
 (Depth in meters; volumetric water content $[\theta]$ in cubic meters per cubic meter;
 matric potential $[h]$ MegaPascals)

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	140.9		143.0		145.6	
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)
	0.363	0.004	0.402	0.004	0.389	0.004
	0.344	0.017	0.380	0.017	0.370	0.017
	0.306	0.030	0.335	0.030	0.328	0.030
	0.260	0.047	0.259	0.047	0.269	0.047
	0.218	0.068	0.177	0.068	0.217	0.068
	0.198	0.106	0.144	0.106	0.193	0.106
	0.190	0.153	0.136	0.153	0.181	0.153
	0.183	0.208	0.129	0.208	0.173	0.208
	0.176	0.295	0.124	0.295	0.165	0.295
	0.168	0.425	0.117	0.425	0.157	0.425
	0.161	0.579	0.113	0.579	0.149	0.579
	0.154	0.756	0.108	0.756	0.143	0.756
	0.143	1.182	0.102	1.182	0.134	1.182
	0.134	1.702	0.096	1.702	0.126	1.702
	0.127	2.316	0.090	2.316	0.116	2.316
	0.120	3.025	0.086	3.025	0.109	3.025
	0.116	3.829	0.081	3.829	0.103	3.829
	0.111	4.727	0.078	4.727	0.098	4.727

Location: U-3at-D1 Analysis: Water Retention						
Depth (m)	147.2					
	θ (m ³ m ⁻³)	h(MPa)				
	0.335	0.004				
	0.279	0.017				
	0.258	0.030				
	0.253	0.068				
	0.246	0.106				
	0.240	0.153				
	0.236	0.208				
	0.233	0.295				
	0.226	0.425				
	0.221	0.579				
	0.216	0.756				
	0.210	1.182				
	0.205	1.702				
	0.200	2.316				
	0.196	3.025				
	0.193	3.829				
	0.190	4.727				

Table B-5
Hydraulic Conductivity / Water Content Relations for U-3at-D1
Characterization Samples

(Depth in meters; volumetric water content $[\theta]$ in cubic meters per cubic meter;
hydraulic conductivity $[K]$ in meters per second)

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	5.4		7.8		10.5	
	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)
	0.328	1.29E-05	0.397	1.94E-05	0.443	2.67E-05
	0.320	9.61E-06	0.383	6.16E-06	0.425	7.10E-06
	0.292	1.58E-06	0.375	1.58E-06	0.415	1.58E-06
	0.285	3.96E-07	0.356	3.96E-07	0.337	3.96E-07
	0.234	1.43E-07	0.274	1.43E-07	0.285	1.43E-07
	0.208	6.33E-08	0.253	6.33E-08	0.241	6.33E-08
	0.196	2.85E-08	0.234	2.85E-08	0.226	2.85E-08
	0.188	1.07E-08	0.229	1.07E-08	0.208	1.07E-08
	0.183	3.56E-09	0.222	3.56E-09	0.195	3.56E-09
	0.174	7.13E-10	0.209	7.13E-10	0.188	7.13E-10
	0.167	2.69E-10	0.202	2.69E-10	0.178	2.69E-10
	0.158	4.56E-11	0.190	4.56E-11	0.164	5.39E-11
	0.143	2.50E-12	0.178	3.60E-12	0.153	3.60E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	13.3		15.4		17.9	
	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)
	0.420	3.38E-06	0.335	3.46E-06	0.428	1.68E-05
	0.393	1.58E-06	0.308	3.96E-07	0.386	1.58E-06
	0.372	3.96E-07	0.217	1.43E-07	0.354	3.96E-07
	0.296	1.43E-07	0.191	6.33E-08	0.287	1.43E-07
	0.263	6.33E-08	0.168	2.85E-08	0.269	6.33E-08
	0.239	2.85E-08	0.164	1.07E-08	0.248	2.85E-08
	0.231	1.07E-08	0.145	3.56E-09	0.237	1.07E-08
	0.223	3.56E-09	0.140	7.13E-10	0.226	3.56E-09
	0.206	7.13E-10	0.116	2.69E-10	0.219	7.13E-10
	0.194	2.69E-10	0.112	4.56E-11	0.208	2.69E-10
	0.175	4.56E-11	0.107	3.17E-12	0.196	4.56E-11
	0.170	3.60E-12			0.185	4.56E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	20.5		22.9		25.4	
	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K(m/s)
	0.470	1.68E-05	0.363	3.55E-06	0.462	1.97E-06
	0.418	1.58E-06	0.333	1.58E-06	0.450	5.28E-07
	0.391	3.96E-07	0.327	9.92E-07	0.406	3.96E-07
	0.333	1.43E-07	0.273	1.43E-07	0.377	1.43E-07
	0.314	6.33E-08	0.252	6.33E-08	0.335	6.33E-08
	0.300	2.85E-08	0.234	2.85E-08	0.306	2.85E-08
	0.290	1.07E-08	0.220	1.07E-08	0.284	1.07E-08
	0.282	3.56E-09	0.211	3.56E-09	0.270	3.56E-09
	0.269	7.13E-10	0.197	7.13E-10	0.247	7.13E-10
	0.259	2.69E-10	0.185	2.69E-10	0.232	2.69E-10
	0.247	4.56E-11	0.171	4.56E-11	0.216	4.56E-11
	0.237	2.50E-12	0.161	2.50E-12	0.200	2.50E-12

Table B-5
Hydraulic Conductivity / Water Content Relations for U-3at-D1
Characterization Samples (continued)

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	28.1		30.3		32.7	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.343	1.79E-04	0.462	7.54E-06	0.348	3.27E-05
	0.306	1.00E-06	0.438	1.58E-06	0.324	1.58E-06
	0.225	2.50E-07	0.397	3.96E-07	0.307	3.96E-07
	0.189	9.00E-08	0.361	1.43E-07	0.233	1.43E-07
	0.172	4.00E-08	0.334	6.33E-08	0.207	6.33E-08
	0.154	1.80E-08	0.306	2.85E-08	0.195	2.85E-08
	0.148	6.75E-09	0.295	1.07E-08	0.179	1.07E-08
	0.139	2.25E-09	0.287	3.56E-09	0.173	3.56E-09
	0.131	4.50E-10	0.263	7.13E-10	0.173	7.13E-10
	0.128	1.70E-10	0.251	2.69E-10	0.166	2.69E-10
	0.121	2.88E-11	0.228	4.56E-11	0.155	4.56E-11
	0.114	2.28E-12	0.211	2.50E-12	0.150	3.60E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	35.4		40.3		42.9	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.361	8.05E-06	0.333	3.66E-05	0.386	1.09E-06
	0.327	1.58E-06	0.163	9.00E-08	0.357	1.00E-06
	0.283	3.96E-07	0.144	1.80E-08	0.334	2.50E-07
	0.210	1.43E-07	0.139	6.75E-09	0.304	9.00E-08
	0.190	6.33E-08	0.131	2.25E-09	0.282	4.00E-08
	0.183	2.85E-08	0.122	4.50E-10	0.276	1.80E-08
	0.174	1.07E-08	0.118	1.70E-10	0.266	6.75E-09
	0.168	3.56E-09	0.110	2.88E-11	0.255	2.25E-09
	0.156	7.13E-10	0.103	2.28E-12	0.236	4.50E-10
	0.150	2.69E-10			0.223	1.70E-10
	0.136	4.56E-11			0.213	2.88E-11
	0.126	3.60E-12			0.208	2.28E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	43.0		46.8		49.3	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.292	1.10E-05	0.341	2.15E-05	0.415	7.43E-06
	0.167	9.00E-08	0.305	1.58E-06	0.365	1.58E-06
	0.148	4.00E-08	0.268	3.96E-07	0.354	3.96E-07
	0.136	6.75E-09	0.244	1.43E-07	0.294	1.43E-07
	0.130	2.25E-09	0.228	6.33E-08	0.272	6.33E-08
	0.123	4.50E-10	0.206	2.85E-08	0.255	2.85E-08
	0.118	1.70E-10	0.203	1.07E-08	0.243	1.07E-08
	0.110	2.88E-11	0.201	3.56E-09	0.229	3.56E-09
	0.104	2.28E-12	0.190	7.13E-10	0.214	7.13E-10
			0.183	2.69E-10	0.203	2.69E-10
			0.169	4.56E-11	0.186	4.56E-11
			0.158	2.50E-12	0.170	3.60E-12

Table B-5
Hydraulic Conductivity / Water Content Relations for U-3at-D1
Characterization Samples (continued)

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	52.0		54.4		56.8	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.446	3.96E-07	0.454	1.76E-05	0.340	4.40E-05
	0.402	3.64E-07	0.408	9.40E-06	0.333	1.00E-06
	0.387	1.43E-07	0.379	1.58E-06	0.281	2.50E-07
	0.357	6.33E-08	0.353	3.96E-07	0.237	9.00E-08
	0.344	2.85E-08	0.274	1.43E-07	0.223	4.00E-08
	0.329	1.07E-08	0.221	6.33E-08	0.201	1.80E-08
	0.311	3.56E-09	0.213	2.85E-08	0.194	6.75E-09
	0.283	7.13E-10	0.204	1.07E-08	0.188	2.25E-09
	0.262	2.69E-10	0.196	3.56E-09	0.169	4.50E-10
	0.248	4.56E-11	0.192	7.13E-10	0.168	1.70E-10
	0.229	2.50E-12	0.174	2.69E-10	0.150	2.88E-11
			0.159	4.56E-11	0.147	2.28E-12
			0.149	4.56E-12		

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	58.5		61.4		66.6	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.306	1.16E-04	0.387	7.41E-06	0.490	2.83E-06
	0.265	1.58E-06	0.385	3.56E-06	0.453	1.58E-06
	0.253	3.96E-07	0.351	1.58E-06	0.430	3.96E-07
	0.218	1.43E-07	0.334	3.96E-07	0.380	1.43E-07
	0.197	6.33E-08	0.265	1.43E-07	0.340	6.33E-08
	0.181	2.85E-08	0.226	6.33E-08	0.318	2.85E-08
	0.173	1.07E-08	0.216	2.85E-08	0.297	1.07E-08
	0.165	3.56E-09	0.207	1.07E-08	0.290	3.56E-09
	0.153	7.13E-10	0.202	3.56E-09	0.262	7.13E-10
	0.142	2.69E-10	0.186	7.13E-10	0.248	2.69E-10
	0.122	4.56E-11	0.180	2.69E-10	0.230	5.39E-11
	0.118	2.50E-12	0.166	4.56E-11	0.222	3.60E-12
			0.156	4.56E-12		

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	67.1		68.9		71.4	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.464	4.01E-06	0.425	9.35E-06	0.341	2.12E-05
	0.422	2.77E-07	0.386	3.50E-06	0.297	1.00E-06
	0.347	9.98E-08	0.372	1.58E-06	0.288	2.50E-07
	0.306	4.43E-08	0.355	3.96E-07	0.263	9.00E-08
	0.283	2.49E-08	0.321	1.43E-07	0.232	4.00E-08
	0.268	1.07E-08	0.292	6.33E-08	0.218	1.80E-08
	0.262	3.56E-09	0.256	3.56E-09	0.216	6.75E-09
	0.243	7.13E-10	0.245	7.13E-10	0.207	2.25E-09
	0.228	2.69E-10	0.233	2.69E-10	0.183	4.50E-10
	0.208	4.56E-11	0.217	5.39E-11	0.175	1.70E-10
	0.193	2.50E-12	0.210	3.60E-12	0.167	2.88E-11
					0.161	2.28E-12

Table B-5
Hydraulic Conductivity / Water Content Relations for U-3at-D1
Characterization Samples (continued)

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	74.0		76.3		78.8	
	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)
	0.344	3.69E-06	0.408	2.77E-05	0.434	3.89E-05
	0.312	1.58E-06	0.378	1.12E-05	0.411	1.82E-06
	0.292	3.96E-07	0.365	1.58E-06	0.383	1.58E-06
	0.258	1.43E-07	0.335	3.96E-07	0.369	3.96E-07
	0.230	6.33E-08	0.298	1.43E-07	0.328	1.43E-07
	0.213	2.85E-08	0.281	6.33E-08	0.284	6.33E-08
	0.196	1.07E-08	0.263	2.85E-08	0.272	2.85E-08
	0.192	3.56E-09	0.257	1.07E-08	0.252	1.07E-08
	0.174	7.13E-10	0.231	7.13E-10	0.236	3.56E-09
	0.167	2.69E-10	0.219	2.69E-10	0.219	7.13E-10
	0.155	4.56E-11	0.196	4.56E-11	0.199	2.69E-10
	0.143	2.50E-12	0.188	2.50E-12	0.186	5.39E-11
					0.182	6.84E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	81.1		83.5		86.0	
	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)
	0.355	2.86E-06	0.427	1.78E-05	0.389	4.41E-06
	0.308	1.08E-06	0.398	1.58E-06	0.348	1.58E-06
	0.288	2.77E-07	0.373	3.96E-07	0.329	3.96E-07
	0.265	9.98E-08	0.277	1.43E-07	0.270	1.43E-07
	0.228	4.43E-08	0.254	6.33E-08	0.251	6.33E-08
	0.197	1.07E-08	0.235	2.85E-08	0.237	2.85E-08
	0.174	3.56E-09	0.225	1.07E-08	0.226	1.07E-08
	0.162	7.13E-10	0.215	3.56E-09	0.216	3.56E-09
	0.157	2.69E-10	0.204	7.13E-10	0.200	7.13E-10
	0.139	4.56E-11	0.194	2.69E-10	0.181	2.69E-10
	0.134	3.60E-12	0.179	4.56E-11	0.177	4.56E-11
			0.164	2.50E-12	0.163	2.50E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	88.4		90.7		93.3	
	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)	θ ($\text{m}^3 \text{m}^{-3}$)	K (m/s)
	0.479	3.02E-06	0.459	1.60E-05	0.411	5.44E-06
	0.434	1.58E-06	0.403	1.58E-06	0.396	4.02E-07
	0.377	3.96E-07	0.376	3.96E-07	0.364	3.96E-07
	0.334	1.43E-07	0.301	1.43E-07	0.333	1.43E-07
	0.307	6.33E-08	0.277	6.33E-08	0.301	6.33E-08
	0.285	2.85E-08	0.258	2.85E-08	0.278	2.85E-08
	0.274	1.07E-08	0.247	1.07E-08	0.275	1.07E-08
	0.261	3.56E-09	0.231	3.56E-09	0.266	3.56E-09
	0.240	7.13E-10	0.217	7.13E-10	0.234	7.13E-10
	0.228	2.69E-10	0.205	2.69E-10	0.223	2.69E-10
	0.211	4.56E-11	0.188	4.56E-11	0.203	4.60E-11
	0.194	2.50E-12	0.181	3.60E-12	0.199	3.81E-12

Table B-5
Hydraulic Conductivity / Water Content Relations for U-3at-D1
Characterization Samples (continued)

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	95.5		97.9		100.1	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.362	2.46E-06	0.425	4.31E-07	0.431	1.11E-05
	0.340	1.58E-06	0.390	3.80E-07	0.357	1.58E-06
	0.321	3.96E-07	0.381	9.50E-08	0.272	3.96E-07
	0.271	1.43E-07	0.305	3.42E-08	0.243	1.43E-07
	0.252	6.33E-08	0.281	1.52E-08	0.227	6.33E-08
	0.220	2.85E-08	0.263	8.55E-09	0.214	2.85E-08
	0.211	1.07E-08	0.249	3.56E-09	0.208	1.07E-08
	0.201	3.56E-09	0.228	7.13E-10	0.197	3.56E-09
	0.185	7.13E-10	0.217	2.69E-10	0.184	7.13E-10
	0.174	2.69E-10	0.200	4.56E-11	0.179	2.69E-10
	0.157	4.56E-11	0.194	3.60E-12	0.161	4.56E-11
	0.142	2.50E-12			0.148	3.60E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	105.1		107.4		109.8	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.430	8.44E-08	0.439	2.56E-06	0.481	7.21E-07
	0.402	1.98E-08	0.385	3.96E-07	0.503	7.55E-07
	0.363	7.13E-09	0.334	1.43E-07	0.453	3.96E-07
	0.332	3.17E-09	0.299	6.33E-08	0.436	1.43E-07
	0.318	7.13E-10	0.269	2.85E-08	0.408	6.33E-08
	0.299	2.69E-10	0.257	1.07E-08	0.383	2.85E-08
	0.284	4.56E-11	0.243	3.56E-09	0.350	1.07E-08
	0.270	2.50E-12	0.217	7.13E-10	0.332	3.56E-09
			0.201	2.69E-10	0.307	7.13E-10
			0.184	4.56E-11	0.287	2.69E-10
			0.164	2.50E-12	0.269	4.56E-11
					0.249	2.50E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	112.3		114.6		117.0	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.380	1.16E-06	0.398	2.89E-06	0.318	1.02E-06
	0.354	9.23E-07	0.380	3.80E-07	0.288	9.50E-07
	0.338	2.38E-07	0.373	9.50E-08	0.280	2.38E-07
	0.304	8.55E-08	0.341	3.42E-08	0.234	8.55E-08
	0.282	3.80E-08	0.317	1.52E-08	0.213	3.80E-08
	0.264	2.14E-08	0.305	8.55E-09	0.202	2.14E-08
	0.249	1.07E-08	0.290	3.56E-09	0.190	1.07E-08
	0.226	3.56E-09	0.258	7.13E-10	0.179	3.56E-09
	0.215	7.13E-10	0.242	2.69E-10	0.171	7.13E-10
	0.199	2.69E-10	0.218	4.56E-11	0.163	2.69E-10
	0.182	4.56E-11	0.214	3.60E-12	0.150	4.56E-11
	0.168	2.50E-12			0.135	2.50E-12

Table B-5
Hydraulic Conductivity / Water Content Relations for U-3at-D1
Characterization Samples (continued)

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	119.3		121.8		124.2	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.384	1.77E-06	0.403	3.96E-07	0.347	3.62E-06
	0.379	2.02E-07	0.393	1.43E-07	0.230	1.00E-06
	0.369	7.92E-08	0.361	6.33E-08	0.205	2.50E-07
	0.365	1.98E-08	0.341	2.85E-08	0.184	9.00E-08
	0.348	7.13E-09	0.315	3.56E-09	0.173	4.00E-08
	0.319	3.17E-09	0.298	7.13E-10	0.149	1.80E-08
	0.279	7.13E-10	0.291	2.69E-10	0.146	6.75E-09
	0.265	2.69E-10	0.267	4.56E-11	0.134	2.25E-09
	0.247	4.56E-11	0.249	2.50E-12	0.107	4.50E-10
	0.229	2.50E-12			0.102	1.70E-10
					0.091	3.00E-11
					0.087	2.29E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	126.5		128.8		131.3	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.382	1.06E-06	0.389	1.04E-05	0.445	6.11E-06
	0.345	3.96E-07	0.336	1.58E-06	0.421	1.58E-06
	0.327	1.43E-07	0.308	3.96E-07	0.397	3.96E-07
	0.297	6.33E-08	0.257	1.43E-07	0.341	1.43E-07
	0.263	2.85E-08	0.213	6.33E-08	0.315	6.33E-08
	0.260	1.07E-08	0.192	2.85E-08	0.295	2.85E-08
	0.260	3.56E-09	0.172	1.07E-08	0.284	1.07E-08
	0.238	7.13E-10	0.171	3.56E-09	0.267	3.56E-09
	0.224	2.69E-10	0.158	7.13E-10	0.252	7.13E-10
	0.206	4.56E-11	0.150	2.69E-10	0.235	2.69E-10
	0.190	2.50E-12	0.135	4.56E-11	0.209	4.56E-11
			0.119	2.50E-12	0.194	2.50E-12

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	133.5		136.1		138.4	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.424	1.71E-05	0.325	1.04E-06	0.396	1.11E-05
	0.386	1.58E-06	0.298	7.92E-08	0.336	1.58E-06
	0.346	3.96E-07	0.291	2.85E-08	0.275	3.96E-07
	0.277	1.43E-07	0.280	1.27E-08	0.241	1.43E-07
	0.253	6.33E-08	0.262	7.13E-09	0.219	6.33E-08
	0.236	2.85E-08	0.239	3.56E-09	0.203	2.85E-08
	0.226	1.07E-08	0.220	7.13E-10	0.194	1.07E-08
	0.218	3.56E-09	0.214	2.69E-10	0.185	3.56E-09
	0.201	7.13E-10	0.195	4.56E-11	0.169	7.13E-10
	0.183	2.69E-10	0.182	2.50E-12	0.157	2.69E-10
	0.161	4.56E-11			0.144	4.56E-11
	0.146	2.50E-12			0.130	2.50E-12

Table B-5
Hydraulic Conductivity / Water Content Relations for U-3at-D1
Characterization Samples (continued)

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	140.9		143.0		145.6	
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$
	0.353	9.36E-06	0.376	1.25E-05	0.433	4.89E-06
	0.349	1.58E-06	0.402	2.25E-05	0.390	1.58E-06
	0.345	3.96E-07	0.368	1.58E-06	0.377	3.96E-07
	0.302	1.43E-07	0.334	3.96E-07	0.304	1.43E-07
	0.280	6.33E-08	0.250	1.43E-07	0.284	6.33E-08
	0.264	2.85E-08	0.225	6.33E-08	0.260	2.85E-08
	0.245	1.07E-08	0.207	2.85E-08	0.249	1.07E-08
	0.233	3.56E-09	0.197	1.07E-08	0.231	3.56E-09
	0.217	7.13E-10	0.185	3.56E-09	0.209	7.13E-10
	0.203	2.69E-10	0.167	7.13E-10	0.188	2.69E-10
	0.183	4.56E-11	0.158	2.69E-10	0.170	4.56E-11
	0.168	2.50E-12	0.140	4.56E-11	0.155	2.50E-12
			0.120	2.50E-12		

Location: U-3at-D1 Analysis: Hydraulic Conductivity						
Depth (m)	147.2					
	θ ($\text{m}^3 \text{m}^{-3}$)	$K(\text{m/s})$				
	0.311	9.00E-08				
	0.310	4.00E-08				
	0.288	1.80E-08				
	0.284	6.75E-09				
	0.272	2.25E-09				
	0.258	4.50E-10				
	0.253	1.70E-10				
	0.242	3.00E-11				
	0.232	2.29E-12				

Table B-6
Volumetric Water Content for U-3at-D1 Characterization Samples
 (Depth in meters; water content in cubic meters per cubic meter)

Location: U-3at-D1		Analysis: Volumetric Water Content			
Depth (m)		Water Content (m ³ /m ³)		Depth (m)	
5.42		0.065		105.18	
5.55		0.099		107.44	
7.75		0.005		107.56	
7.81		0.082		109.82	
10.40		0.169		109.88	
10.53		0.083		112.26	
13.18		0.096		112.38	
13.31		0.086		114.64	
15.25		0.059		114.76	
15.37		0.048		116.96	
17.90		0.080		117.08	
17.96		0.162		119.28	
20.35		0.120		119.40	
20.48		0.084		121.78	
22.94		0.078		121.89	
23.00		0.094		124.16	
25.40		0.118		124.28	
25.46		0.130		126.49	
28.08		0.087		126.61	
28.15		0.071		128.83	
30.25		0.170		128.95	
30.31		0.161		131.34	
32.67		0.127		131.46	
32.74		0.096		133.55	
35.16		0.122		133.61	
35.42		0.096		136.06	
40.14		0.075		136.18	
40.26		0.054		138.45	
42.62		0.090		138.57	
42.92		0.059		140.90	
42.96		0.063		141.02	
46.77		0.119		143.05	
46.83		0.112		143.29	
49.20		0.160		145.62	
49.32		0.123		145.74	
51.83		0.164		147.17	
51.96		0.154		147.29	
54.19		0.126			
54.37		0.088			

Table B-7
Water Potential for U-3at-D1 Characterization Samples
 (Depth in meters; water potential in MegaPascals)

Location: U-3at-D1 Analysis: Water Potential			
Depth (m)	Potential (MPa)	Depth (m)	Potential (MPa)
5.55	-7.729	81.04	-2.645
7.75	-8.792	83.48	-1.147
10.40	-5.345	86.04	-0.824
13.18	-4.732	88.37	-0.963
15.25	-10.670	90.75	-0.917
17.96	-2.439	93.31	-0.780
20.35	-2.765	95.45	-0.733
23.00	-8.083	97.89	-0.733
25.46	-2.070	100.12	-0.458
28.08	-2.210	105.06	-0.596
30.25	-1.420	107.44	-0.504
32.67	-1.515	109.82	> -0.400
35.16	-1.886	112.26	-0.730
40.14	-2.582	114.64	-0.548
42.62	-1.655	116.96	-1.192
46.77	-1.193	119.28	> -0.400
49.20	-0.917	121.78	> -0.400
51.83	-1.056	124.16	> -0.400
54.19	-1.195	126.49	> -0.400
56.60	-1.287	128.83	> -0.400
58.64	-0.642	131.34	> -0.400
61.43	-1.197	133.55	> -0.400
66.62	-1.661	136.06	> -0.400
67.06	-0.921	138.45	> -0.400
68.73	-1.060	140.90	> -0.400
71.33	-1.801	143.05	> -0.400
74.05	-0.644	145.62	> -0.400
76.52	-1.060	147.17	> -0.400
78.78	> -0.400		

Table B-8
Stable Isotope Concentrations for U-3at-D1 Characterization Samples
 (Depth in meters; oxygen-18 [^{18}O] and deuterium [D] concentrations expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

Location: U-3at-D1			Analysis: Stable Isotopes		
Depth (m)	$\delta^{18}\text{O}$ (‰)	δD (‰)	Depth (m)	$\delta^{18}\text{O}$ (‰)	δD (‰)
5.61	-8.5	-90	80.86	-13.6	-108
7.55	-8.2	-87	83.31	-13.7	-106
10.78	-10.6	-99	85.75	-13.3	-106
12.85	-11.1	-102	88.19	-14.4	-113
15.05	-11.2	-100	90.57	-13.8	-111
17.77	-11.8	-99	93.13	-14.8	-114
20.09	-11.6	-99	95.27	-14.3	-116
22.75	-12.6	-102	97.59	-14.7	-112
25.53	-13.6	-109	100.06	-14.7	-112
28.27	-13.7	-109	104.88	-14.4	-111
30.19	-13.3	-111	107.26	-14.7	-114
32.61	-14.0	-107	109.70	-13.7	-115
35.29	-14.2	-111	112.08	-14.7	-113
40.01	-14.2	-109	114.46	-14.3	-111
42.75	-13.7	-108	116.78	-14.1	-111
46.58	-14.1	-112	119.10	-14.4	-111
49.00	-13.7	-112	121.60	-14.9	-116
51.65	-14.7	-112	123.98	-14.4	-109
54.43	-13.8	-110	126.32	-14.4	-113
56.66	-14.5	-112	128.65	-14.5	-112
58.83	-15.0	-114	131.16	-14.3	-113
61.61	-14.1	-111	135.88	-14.2	-110
66.44	-14.2	-111	138.27	-14.4	-109
66.99	-14.2	-110	140.78	-14.2	-109
69.04	-14.5	-114	142.87	-14.4	-105
71.14	-14.3	-110	145.44	-13.6	-106
73.86	-13.9	-111	146.99	-14.0	-110
76.28	-14.4	-112			
78.66	-13.6	-109			

Table B-9
Soil Chloride Concentrations for U-3at-D1 Characterization Samples
 (Depth in meters; chloride in milligrams per kilogram)

Location: U-3at-D1 Analysis: Soil Chloride			
Depth (m)	Chloride (mg/kg)	Depth (m)	Chloride (mg/kg)
5.32	74.2	78.81	1.3
7.65	27.5	81.10	3.3
10.69	7.2	83.40	1.4
13.05	3.4	85.84	1.3
15.15	1.9	88.28	0.8
17.93	3.9	90.66	0.7
20.42	3.6	93.22	0.7
22.94	2.0	95.48	0.6
25.23	2.3	97.68	0.9
27.99	1.5	100.33	0.6
30.47	2.6	104.97	0.8
32.90	1.6	107.35	1
35.16	1.4	109.88	1
40.14	0.8	112.17	0.6
42.85	0.7	114.55	1
46.68	1.5	116.87	0.9
49.10	2.0	119.19	2.1
51.74	2.3	121.69	1.5
54.19	1.4	124.07	0.8
56.82	1.7	126.41	1
58.73	1.9	128.74	1.4
61.39	0.9	131.28	2.2
66.72	1.9	135.97	4.2
67.27	0.7	138.36	7.3
68.94	1.2	140.78	20.7
71.23	1.8	142.96	11.3
74.14	0.7	145.53	13.5
76.52	1.3	147.08	1.7

Table B-10
Soil Carbonate Concentrations for U-3at-D1 Characterization Samples
 (Depth in meters; calcium carbonate equivalent in [oven-dry] weight percent)

Location: U-3at-D1 Analysis: Soil Carbonate			
Depth (m)	CaCO ₃ l	Depth (m)	CaCO ₃ Eq. (wt %)
5.32	0.38	78.81	4.89
7.65	0.33	81.10	2.10
10.69	1.76	83.40	6.67
13.05	3.60	85.84	1.75
15.15	2.50	88.28	4.12
17.93	4.32	90.66	6.74
20.42	3.96	93.22	6.42
22.94	0.47	95.48	1.11
25.23	2.51	97.68	4.6
27.99	4.49	100.33	2.39
30.47	12.06	104.97	0.84
32.90	0.60	107.35	2.07
35.16	4.43	109.88	3.13
40.14	1.08	112.17	3.31
42.85	1.52	114.55	4.64
46.68	0.74	116.87	3.29
49.10	2.61	119.19	12.55
51.74	7.54	121.69	2.89
54.19	3.70	124.07	2.52
56.82	1.10	126.41	1.57
58.73	1.68	128.74	4.47
61.39	1.52	131.28	0.92
66.72	0.83	135.97	2.53
67.27	4.47	138.36	1.56
68.94	6.55	140.78	2.46
71.23	4.42	142.96	4.65
74.14	1.97	145.53	2.38
76.52	4.36	147.08	0.92

Table B-11
Tritium Concentrations for U-3at-D1 Characterization Samples
 (Depth in meters; tritium and counting error [1 standard deviation] in picoCuries per liter)

Location: U-3at-D1			Analysis: Tritium		
Depth (m)	Tritium (pCi/L)	Error (1σ) (pCi/L)	Depth (m)	Tritium (pCi/L)	Error (1σ) (pCi/L)
7.94	0	283	80.92	15	228
10.46	0	275	83.25	9	247
12.92	78	274	85.69	85	234
14.08	11	300	88.13	0	282
17.70	0	312	90.51	0	230
20.16	108	290	93.07	64	269
22.68	0	282	95.21	179	248
25.59	0	228	97.95	0	247
28.34	0	255	100.00	109	263
30.12	0	305	104.82	125	297
32.55	0	250	107.20	285	293
35.35	212	251	109.64	72	288
39.95	0	304	112.02	157	268
42.56	0	294	114.40	34	218
46.52	0	255	116.72	153	254
48.94	70	300	119.04	273	229
51.59	0	246	121.54	348	461
54.06	132	279	123.92	291	256
56.54	7	235	126.26	302	293
58.83	31	259	128.59	306	265
61.24	41	257	131.10	391	330
66.38	0	226	135.82	867	280
66.93	45	268	138.21	1330	299
68.66	0	300	140.66	1710	309
71.45	33	248	142.81	1660	310
73.80	57	261	145.38	1520	314
76.22	25	278	146.93	2200	277
78.60	145	257			

Table B-12
Particle Density for U-3at-D2 Characterization Samples
 (Depth in meters; density in kilograms per cubic meter)

Location: U-3at-D2 Analysis: Particle Density	
Depth (m)	Density (kg/m ³)
47.81	2360
50.56	2260
53.19	2390
55.68	2520
58.43	2390
61.05	2440
63.67	2370
66.23	2420
68.72	2470
71.53	2410
74.28	2370
76.64	2420
78.08	2430

Table B-13
Particle Size Distribution for Fine-Earth (<2millimeters) Fraction
for Characterization Samples
 (Depth in meters; particle sizes [weight percent] in millimeters)

Location: U-3at-D2 Analysis: Particle Size											
Depth (m)	Sand (0.05 - 2 mm) (wt %)						Silt (2 - 50 mm) (wt %)			Clay (< 2 mm) (wt %)	
	1 - 2 mm	0.5 - 1 mm	0.25 - 0.5 mm	0.1 - 0.25 mm	0.05 - 0.1 mm	Total Sand	20 - 50 mm	2 - 20 mm	Total Silt	Total Clay	
42.17	15.1	15.9	22.6	25.9	9.1	88.6	0.5	4.8	5.3	6.1	
44.30	7.8	8.9	17.8	30.1	17.2	81.8	4.9	6.4	11.3	6.9	
45.88	9.4	11.8	13.9	17.9	17.3	70.4	8.3	14.6	22.9	6.7	
47.96	10.3	15.4	26.6	21.9	8.0	82.2	0.6	4.4	5.0	12.8	
49.92	22.3	21.6	25.4	18.5	3.5	91.7	0.0	2.3	1.5	6.8	
51.79	6.8	9.8	18.4	24.0	10.7	69.7	3.1	14.2	17.3	13.0	
53.75	6.5	8.1	16.1	30.9	18.8	80.4	3.1	7.4	10.5	9.1	
55.69	7.1	7.4	16.6	27.0	12.2	70.4	2.4	13.1	15.5	14.1	
57.68	1.0	2.3	9.5	29.8	31.2	73.8	12.5	10.1	22.6	3.6	
59.76	5.1	6.3	15.3	30.9	14.8	72.3	1.3	14.9	16.2	11.5	
61.60	6.9	9.6	19.8	29.9	13.8	80.1	2.7	7.4	10.1	9.8	
63.52	3.4	3.4	9.3	25.1	19.6	60.8	6.6	22.4	29.0	10.2	
65.41	29.2	33.0	18.2	4.7	1.7	87.4	0.0	1.9	0.7	11.9	

Table B-14
Bulk Density for U-3at-D2 Characterization Samples
 (Depth in meters; density in kilograms per cubic meter)

Location: U-3at-D2		Analysis: Dry Bulk Density	
Depth (m)	Bulk Density (kg/m ³)	Depth (m)	Bulk Density (kg/m ³)
47.90	1652	63.77	1544
48.04	1450	66.33	1283
50.66	1680	66.46	1510
50.78	1560	68.81	1522
50.81	1340	68.95	1620
53.29	1458	71.63	1354
53.42	1430	71.76	1420
55.78	1766	74.12	1410
55.91	1690	74.18	1335
58.53	1515	76.77	1560
58.66	1570	76.87	1636
61.15	1685	78.25	1835
61.28	1390	78.31	1410
63.90	1600		

Table B-15
Water Retention Relations for U-3at-D2 Characterization Samples
 (Depth in meters; volumetric water content $[\theta]$ in cubic meters per cubic meter;
 matric potential $[h]$ MegaPascals)

Location: U-3at-D2		Analysis: Water Retention					
Depth (m)	48.0		50.8		50.8		
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	
	0.270	0.004	0.251	0.004	0.462	0.004	
	0.196	0.017	0.181	0.017	0.418	0.017	
	0.178	0.030	0.166	0.030	0.398	0.030	
	0.170	0.047	0.158	0.047	0.381	0.047	
	0.163	0.068	0.156	0.068	0.362	0.068	
	0.155	0.106	0.147	0.106	0.340	0.106	
	0.149	0.153	0.141	0.153	0.320	0.153	
	0.145	0.208	0.136	0.208	0.304	0.208	
	0.139	0.295	0.131	0.295	0.285	0.295	
	0.135	0.425	0.127	0.425	0.265	0.425	
	0.130	0.579	0.123	0.579	0.251	0.579	
	0.126	0.756	0.119	0.756	0.238	0.756	
	0.121	1.182	0.115	1.182	0.218	1.182	
	0.115	1.702	0.111	1.702	0.205	1.702	
	0.111	2.316	0.108	2.316	0.195	2.316	
	0.106	3.025	0.105	3.025	0.187	3.025	
	0.101	3.829	0.103	3.829	0.179	3.829	
	0.098	4.727	0.100	4.727	0.172	4.727	

Location: U-3at-D2		Analysis: Water Retention					
Depth (m)	53.4		55.9		58.7		
	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	θ (m ³ m ⁻³)	h(MPa)	
	0.439	0.004	0.212	0.004	0.402	0.004	
	0.318	0.017	0.148	0.017	0.327	0.017	
	0.276	0.030	0.136	0.030	0.284	0.030	
	0.254	0.047	0.129	0.047	0.262	0.047	
	0.241	0.068	0.126	0.068	0.244	0.068	
	0.228	0.106	0.121	0.106	0.227	0.106	
	0.218	0.153	0.117	0.153	0.215	0.153	
	0.210	0.208	0.114	0.208	0.206	0.208	
	0.202	0.295	0.111	0.295	0.196	0.295	
	0.194	0.425	0.108	0.425	0.186	0.425	
	0.188	0.579	0.105	0.579	0.177	0.579	
	0.182	0.756	0.102	0.756	0.170	0.756	
	0.171	1.182	0.099	1.182	0.159	1.182	
	0.163	1.702	0.096	1.702	0.150	1.702	
	0.155	2.316	0.094	2.316	0.143	2.316	
	0.149	3.025	0.091	3.025	0.137	3.025	
	0.142	3.829	0.089	3.829	0.131	3.829	
	0.137	4.727	0.087	4.727	0.127	4.727	

Table B-15
Water Retention Relations for U-3at-D2 Characterization Samples (continued)
 (Depth in meters; volumetric water content $[\theta]$ in cubic meters per cubic meter;
 matric potential $[h]$ MegaPascals)

Location: U-3at-D2 Analysis: Water Retention						
Depth (m)	61.3		63.9		66.5	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.450	0.004	0.448	0.004	0.310	0.004
	0.336	0.017	0.431	0.017	0.279	0.017
	0.262	0.030	0.401	0.030	0.254	0.030
	0.243	0.047	0.310	0.047	0.238	0.047
	0.227	0.068	0.300	0.068	0.228	0.068
	0.212	0.106	0.286	0.106	0.216	0.106
	0.207	0.153	0.276	0.153	0.205	0.153
	0.200	0.208	0.265	0.208	0.198	0.208
	0.192	0.295	0.254	0.295	0.190	0.295
	0.182	0.425	0.240	0.425	0.182	0.425
	0.174	0.579	0.227	0.579	0.174	0.579
	0.168	0.756	0.216	0.756	0.167	0.756
	0.158	1.182	0.198	1.182	0.158	1.182
	0.149	1.702	0.183	1.702	0.148	1.702
	0.143	2.316	0.171	2.316	0.141	2.316
	0.138	3.025	0.162	3.025	0.133	3.025
	0.133	3.829	0.155	3.829	0.127	3.829
	0.128	4.727	0.149	4.727	0.122	4.727

Location: U-3at-D2 Analysis: Water Retention						
Depth (m)	68.9		71.8		74.1	
	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)	θ ($\text{m}^3 \text{m}^{-3}$)	h (MPa)
	0.338	0.004	0.347	0.004	0.459	0.004
	0.256	0.017	0.319	0.017	0.446	0.017
	0.227	0.030	0.289	0.030	0.410	0.030
	0.216	0.047	0.270	0.047	0.273	0.047
	0.205	0.068	0.251	0.068	0.227	0.068
	0.194	0.106	0.231	0.106	0.208	0.106
	0.187	0.153	0.216	0.153	0.196	0.153
	0.181	0.208	0.206	0.208	0.186	0.208
	0.177	0.295	0.197	0.295	0.178	0.295
	0.170	0.425	0.188	0.425	0.168	0.425
	0.164	0.579	0.180	0.579	0.161	0.579
	0.160	0.756	0.172	0.756	0.155	0.756
	0.156	1.182	0.161	1.182	0.145	1.182
	0.152	1.702	0.149	1.702	0.135	1.702
	0.148	2.316	0.142	2.316	0.121	2.316
	0.145	3.025	0.133	3.025	0.111	3.025
	0.141	3.829	0.126	3.829	0.102	3.829
	0.138	4.727	0.121	4.727	0.095	4.727

Table B-15
Water Retention Relations for U-3at-D2 Characterization Samples (continued)
 (Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
 matric potential [h] MegaPascals)

Location: U-3at-D2		Analysis: Water Retention			
Depth (m)	76.8		78.3		
	θ (m ³ m ⁻³)	h (MPa)	θ (m ³ m ⁻³)	h (MPa)	
	0.316	0.004	0.404	0.004	
	0.211	0.017	0.386	0.017	
	0.192	0.030	0.353	0.030	
	0.180	0.047	0.308	0.047	
	0.172	0.068	0.271	0.068	
	0.164	0.106	0.255	0.106	
	0.158	0.153	0.243	0.153	
	0.153	0.208	0.233	0.208	
	0.150	0.295	0.224	0.295	
	0.143	0.425	0.215	0.425	
	0.139	0.579	0.209	0.579	
	0.135	0.756	0.202	0.756	
	0.130	1.182	0.191	1.182	
	0.126	1.702	0.182	1.702	
	0.121	2.316	0.174	2.316	
	0.117	3.025	0.166	3.025	
	0.114	3.829	0.160	3.829	
	0.110	4.727	0.154	4.727	

Table B-16
Hydraulic Conductivity / Water Content Relations for U-3at-D2
Characterization Samples

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D2 Analysis: Hydraulic Conductivity						
Depth (m)	48.0		50.8		50.8	
	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$
	0.404	4.28E-05	0.388	1.89E-04	0.529	2.49E-06
	0.392	1.58E-06	0.244	2.50E-07	0.524	1.58E-06
	0.354	3.96E-07	0.218	9.00E-08	0.507	3.96E-07
	0.227	1.43E-07	0.212	4.00E-08	0.473	1.43E-07
	0.210	6.33E-08	0.197	1.80E-08	0.440	6.33E-08
	0.198	2.85E-08	0.176	6.75E-09	0.397	2.85E-08
	0.190	1.07E-08	0.160	4.50E-10	0.375	1.07E-08
	0.182	3.56E-09	0.150	1.70E-10	0.362	3.56E-09
	0.173	7.13E-10	0.136	2.95E-11	0.328	7.13E-10
	0.163	2.69E-10	0.131	2.28E-12	0.309	2.69E-10
	0.149	4.56E-11			0.289	4.56E-11
	0.135	2.50E-12			0.266	2.50E-12

Location: U-3at-D2 Analysis: Hydraulic Conductivity						
Depth (m)	53.4		55.9		58.7	
	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$
	0.491	3.04E-06	0.320	3.84E-05	0.385	4.80E-07
	0.454	1.58E-06	0.221	2.50E-07	0.503	7.37E-06
	0.404	3.96E-07	0.191	9.00E-08	0.445	1.58E-06
	0.350	1.43E-07	0.169	4.00E-08	0.335	1.43E-07
	0.314	6.33E-08	0.161	1.80E-08	0.308	6.33E-08
	0.285	2.85E-08	0.148	6.75E-09	0.281	2.85E-08
	0.275	1.07E-08	0.134	4.50E-10	0.264	1.07E-08
	0.264	3.56E-09	0.127	1.70E-10	0.250	3.56E-09
	0.247	7.13E-10	0.120	2.95E-11	0.233	7.13E-10
	0.233	2.69E-10	0.113	2.28E-12	0.221	3.23E-10
	0.213	4.56E-11			0.203	5.30E-11
	0.196	2.50E-12			0.198	4.26E-12

Location: U-3at-D2 Analysis: Hydraulic Conductivity						
Depth (m)	61.3		63.9		66.5	
	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$
	0.440	5.94E-06	0.399	1.94E-07	0.404	8.41E-07
	0.425	1.58E-06	0.380	1.43E-07	0.360	3.96E-07
	0.396	3.96E-07	0.360	6.33E-08	0.319	1.43E-07
	0.322	1.43E-07	0.329	2.85E-08	0.285	6.33E-08
	0.300	6.33E-08	0.313	1.07E-08	0.256	2.85E-08
	0.275	2.85E-08	0.300	3.56E-09	0.253	1.07E-08
	0.262	1.07E-08	0.279	7.13E-10	0.243	3.56E-09
	0.238	3.56E-09	0.265	2.69E-10	0.221	7.13E-10
	0.228	7.13E-10	0.254	4.60E-11	0.207	2.69E-10
	0.219	3.23E-10	0.252	3.81E-12	0.192	4.56E-11
	0.198	5.30E-11			0.189	3.60E-12
	0.192	4.26E-12				

Table B-16
Hydraulic Conductivity-Water Content Relations for U-3at-D2
Characterization Samples (continued)

(Depth in meters; volumetric water content [θ] in cubic meters per cubic meter;
hydraulic conductivity [K] in meters per second)

Location: U-3at-D2 Analysis: Hydraulic Conductivity						
Depth (m)	68.9		71.8		74.1	
	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$
	0.516	3.51E-06	0.456	1.40E-06	0.381	7.89E-07
	0.354	2.50E-07	0.444	7.28E-07	0.430	2.76E-06
	0.307	9.00E-08	0.414	3.96E-07	0.411	1.58E-06
	0.283	4.00E-08	0.387	1.43E-07	0.364	1.43E-07
	0.250	1.80E-08	0.353	6.33E-08	0.314	6.33E-08
	0.239	6.75E-09	0.314	2.85E-08	0.286	2.85E-08
	0.225	2.25E-09	0.295	1.07E-08	0.274	1.07E-08
	0.210	4.50E-10	0.278	3.56E-09	0.257	3.56E-09
	0.200	1.70E-10	0.255	7.13E-10	0.234	7.13E-10
	0.185	2.88E-11	0.239	2.69E-10	0.219	2.69E-10
	0.178	2.28E-12	0.219	4.56E-11	0.200	4.56E-11
			0.213	3.60E-12	0.183	2.50E-12

Location: U-3at-D2 Analysis: Hydraulic Conductivity						
Depth (m)	76.8		78.3			
	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$	θ ($\text{m}^3 \text{ m}^{-3}$)	$K(\text{m/s})$		
	0.374	2.50E-07	0.468	3.77E-06		
	0.266	9.00E-08	0.442	1.58E-06		
	0.240	4.00E-08	0.408	3.96E-07		
	0.213	1.80E-08	0.356	1.43E-07		
	0.208	6.75E-09	0.333	6.33E-08		
	0.196	2.25E-09	0.312	2.85E-08		
	0.182	4.50E-10	0.294	1.07E-08		
	0.172	1.70E-10	0.284	3.56E-09		
	0.158	2.88E-11	0.263	7.13E-10		
	0.104	2.28E-12	0.249	2.69E-10		
			0.232	4.56E-11		
			0.216	2.50E-12		

Table B-17
Volumetric Water Content for U-3at-D2 Characterization Samples
 (Depth in meters; water content in cubic meters per cubic meter)

Location: U-3at-D2		Analysis: Volumetric Water Content	
Depth (m)	Water Content (m ³ /m ³)	Depth (m)	Water Content (m ³ /m ³)
47.90	0.121	63.77	0.145
48.04	0.067	66.33	0.148
50.66	0.118	66.46	0.156
50.78	0.091	68.81	0.147
50.81	0.189	68.95	0.117
53.29	0.176	71.63	0.187
53.42	0.153	71.76	0.151
55.78	0.117	74.12	0.140
55.91	0.078	74.18	0.149
58.53	0.145	76.77	0.106
58.66	0.142	76.87	0.180
61.15	0.171	78.25	0.254
61.28	0.162	78.31	0.174
63.90	0.144		

Table B-18
Water Potential for U-3at-D2 Characterization Samples
 (Depth in meters; water potential in MegaPascals)

Location: U-3at-D2		Analysis: Water Potential	
Depth (m)	Potential (MPa)	Depth (m)	Potential (MPa)
47.90	-2.163	66.33	-0.595
50.66	-0.687	68.81	> -0.400
53.29	-0.412	71.63	> -0.400
55.78	-1.239	74.18	> -0.400
58.53	-0.595	76.87	> -0.400
61.15	> -0.400	78.25	> -0.400
63.77	-0.549		

Table B-19
Stable Isotope Concentrations for U-3at-D2 Characterization Samples
 (Depth in meters; oxygen-18 [^{18}O] and deuterium [D] concentrations expressed in standard delta notation relative to standard mean ocean water in parts per thousand)

Location: U-3at-D2		Analysis: Stable Isotopes	
Depth (m)	$\delta^{18}\text{O}$ (‰)	δD (‰)	
47.71	-13.0	-101	
50.46	-14.2	-107	
53.10	-14.5	-106	
55.59	-14.3	-108	
58.34	-14.2	-108	
60.96	-14.3	-108	
63.58	-14.6	-109	
66.13	-14.3	-112	
68.49	-13.5	-104	
71.43	-15.0	-111	
74.38	-14.2	-107	
76.94	-14.5	-111	
78.18	-14.4	-108	

Table B-20
Soil Chloride Concentrations for U-3at-D2 Characterizations Samples
 (Depth in meters; chloride in milligrams per kilogram)

Location: U-3at-D2		Analysis: Soil Chloride	
Depth (m)	Chloride (mg/kg)	Depth (m)	Chloride (mg/kg)
47.81	3.2	66.23	1.4
50.56	1.7	68.72	1.2
53.19	1.4	71.53	1.1
55.68	1.0	74.28	0.7
58.43	0.8	76.64	0.5
61.05	0.7	78.08	1.2
63.67	1.0		

Table B-21
Soil Carbonate Concentrations for U-3at-D2 Characterization Samples
 (Depth in meters; calcium carbonate equivalent in [oven-dry] weight percent)

Location: U-3at-D2		Analysis: Soil Carbonate	
Depth (m)	CaCO ₃ Eq. (wt %)	Depth (m)	CaCO ₃ Eq. (wt %)
47.81	2.95	66.23	2.87
50.56	1.76	68.72	7.76
53.19	7.52	71.53	9.18
55.68	3.40	74.28	3.94
58.43	1.99	76.64	4.52
61.05	2.63	78.08	1.86
63.67	6.21		

Table B-22
Tritium Concentration for U-3at-D2 Characterization Samples
 (Depth in meters; tritium and counting error [1 standard deviation] in picoCuries per liter)

Location: U-3at-D2			Analysis: Tritium		
Depth (m)	Tritium (pCi/L)	Error (1s) (pCi/L)	Depth (m)	Tritium (pCi/L)	Error (1s) (pCi/L)
47.64	47	270	66.06	34	286
50.40	25	299	68.42	99	286
53.03	27	289	71.37	0	260
55.52	89	275	73.99	0	335
58.27	0	307	77.00	20	281
60.89	0	325	77.98	0	337
63.51	0	339			