RAI Volume 2, Chapter 2.1.1.1, First Set, Number 1: Justify the shear strength and compressibility of alluvium and underlying materials within the zones of influence of proposed surface facility structures that are based on few shallow test data (SAR Section 1.1.5.3.2.6.2.1.1). In particular, describe: (a) the strength and compressibility of alluvium as they vary laterally or with depth; (b) the spatial relationships or relative amounts and mechanical properties of cemented and un-cemented alluvium; (c) the strength and compressibility of tuffs that underlie the alluvium; and (d) justify the assumption that the subsurface materials supporting the foundations (including the tuffs that underlie the alluvium) will be stable and undergo only elastic deformations when subjected to static and seismic loading (SAR Section 1.2.2.5, BSC 2007j. section 6.2.3, page 16).

The applicant estimated the shear strength of alluvium using *in situ* measurements of relative density in a few test pits (4–19 ft deep), and concluded that shear strength of the alluvium (30 ft to 200 ft thick) does not vary laterally or with depth (Attachment I, section I.2.2 pages I-19 to I-29, BSC 2002c of SAR Section 1.1.10). SAR Section 1.1.5.3.2.6.2.1.1 did not include compressibility or strength of the underlying tuff. Furthermore, the applicant indicates the occurrence of cemented and un-cemented zones of alluvium and low-density tuff (SAR Section 1.1.5.3.2.6.3), but has not provided information about the spatial relationships or relative amounts and mechanical properties of these materials. Additionally, the applicant, in assessing the performance of surface-facility structures, assumes that the subsurface materials supporting the foundations (including the tuffs that underlie the alluvium) will be stable and undergo only elastic deformations when subjected to static and seismic loading (SAR Section 1.2.2.5, BSC 2007j, section 6.2.3, page 16). However, the applicant has not provided supporting technical basis to justify this assumption. Staff needs the information to verify compliance with 10 CFR 63.21(c)(1)(ii) and 63.112(c).

1. RESPONSE

The information provided below justifies the selection of shear strength and compressibility of the alluvium and underlying materials within the zones of influence of the surface facility structures.

(A) The shear strength and compressibility of the alluvium were determined using the following methodology.

The alluvial soils are dense, with varying amounts of cementation, and contain large granular material that is not conducive to standard test procedures (such as triaxial, direct shear, or consolidation tests) for evaluating strength and compressibility. Therefore, more indirect means are used as is standard in the industry for these types of materials.

As described in Section I.2.2 of *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002c in SAR Section 1.1.10),[1] the strength of the alluvium can be evaluated using two approaches: (1) correlations between measured shear-wave

velocity and standard penetration test blow count, with the blow counts then correlated to shear strength, and (2) correlations between relative density and shear strength. The second approach was used since it provided a lower, more conservative shear strength.

Initially, 22 in-place densities were measured using the water-replacement method on 6-ft-diameter rings and 20-in. sand cone density tests at depths varying between 4 ft and 20 ft within four test pits (test pits TP-WHB-1 through 4 as noted in *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project*[2]). Associated laboratory tests were performed to determine the maximum and minimum densities of the material and the relative densities were determined for each ring test. Calculated relative densities of the in situ alluvium varied between 25% and 120%, with a mean of 68% and standard deviation of 21%. Five different correlations between relative density and internal friction angle (friction angle is a measure of the shear strength) were used to arrive at the recommended design friction angle of 39° for the alluvium which is stated in SAR Section 1.1.5.3.2.4. This value is midway between the mean and lower bound values. This approach neglects any cohesion in the alluvium, which would tend to provide additional strength, and therefore the selected friction angle is considered to be conservative, especially for the large mat foundations that are used for the surface facilities.

Test results from three later test pits, designated TP-WHB-5 through TP-WHB-7, each with three 6-ft ring densities and associated laboratory relative-density tests conducted within them, are summarized in SAR Section 1.1.5.3.2.3. These relative-density test results ranged between 60% and 102%, thereby confirming the design internal friction angle of 39° used for the alluvium.

Additional material classifications from the 2005 through 2007 drilling results are provided in the geologic logs included in the RAI 2.2.1.1.1-004 response. A comparison of the various logged soil types shows that vertically, material types show little preference to depth, with a relatively equal distribution between material types at depths from 0 ft to almost 200 ft; specifically, the distribution of soil classifications does not change perceptibly with depth.

Material classification results from the drilling are comparable to those of the test pits. Although the soil material is disturbed in the sonic drilling process, there is no indication that the drilled gradations differ enough to prevent a direct comparison with test pit classifications. When soil classification results from drilling and test pits are compared, there are no indications of significant differences in material type or property. Therefore, the 2005 through 2007 drilling results capture the lateral variability of material properties conveyed in the SAR. Soils throughout the north-south and east-west extent of the investigated area yielded nearly identical soil classifications, exhibiting no lateral changes in classification with areal extent.

Compressibility of the alluvium was determined indirectly from shear-wave velocity measurements made in the field and correlations presented in the literature, as discussed in Section I.2.3 of BSC 2002c and Appendix B of *Supplemental Soils*

Report.[3] Settlement beneath foundation mats was determined for a range of foundation dimensions and loadings in Appendix B of *Supplemental Soils Report*.[4] These were equivalent spring analyses, in which modulus values were reduced to account for the soil strains during loading. In this way, the modulus reduction for dynamic conditions is accounted for by the associated strain level for the magnitude of the applied load.

On the basis of the items discussed above, the strength and compressibility of the alluvium do not vary significantly laterally or with depth and it is concluded that the alluvium provides an excellent, stable support for the planned structures.

(B) With regard to the spatial relationships or relative amounts and mechanical properties of cemented and un-cemented alluvium, cementation in the alluvium is conservatively neglected for strength considerations, and included in the field measurements of shear-wave velocity used in estimating foundation settlement.

Test pit logs included in *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project*[5] and *Technical Report: Geotechnical Data for a Geologic Repository at Yucca Mountain, Nevada*[6] make note of cementation of materials, and although no attempt has been made to quantify cementation it is inherently accounted for in water-replacement, ring-density testing conducted in seven test pits (test pits TP-WHB 1 through 7). In addition, comparisons of material types in the ground motion analyses demonstrate that the material recovered as a result of drilling at depth is not materially different than the material tested in the test pits. The analysis of the mechanical properties of uncemented alluvium is presented in the ground motion analyses.

(C) There are no directly measured values of strength and compressibility in the tuffs (or bedrock) beneath the alluvium in Midway Valley; however, approximated and comparable properties have been developed from shear-wave velocity and density data (ground motion analyses and BSC 2002c). Subsequent to the geotechnical and soils report (BSC 2002c; ground motion analyses) there has been additional collection of (1) shear-wave velocity data and (2) density data derived from borehole geophysical logs. For the 2007 density data, the "Long Spaced Density" data are the same type of density data collected in the 2000 boreholes; therefore, these are comparable types of data. These more recently collected data are included in the geotechnical data technical report[7] and in the geologic and geophysical logs included in the response to RAI 2.2.1.1.1-004. These data continue to indicate the tuffaceous bedrock has greater strength than the overlying alluvium.

For bearing capacity and settlement considerations, the tuff underlying the alluvium is stronger and less compressible than the alluvium, and, due to its presence at a minimum of 35 ft beneath the structures, was not considered further.

(D) Subsurface materials supporting the foundations (including the tuffs that underlie the alluvium) are stable and undergo only equivalent elastic deformations under the design static and seismic loads.

Calculated bearing capacity of the mat foundations, analyzed in Appendix B of *Supplemental Soils Report*,[8] indicated very high values, as would be expected for a large foundation on dense granular material. For these conditions and soils, settlement is typically of more concern for foundation design. In addition, dense granular soils do not exhibit strength loss and remain stable during shaking and therefore can be treated as an equivalent elastic material using reduced material stiffness to account for strain under the design loads.

Compressibility of the alluvium was determined indirectly from shear-wave velocity measurements made in the field and correlations presented in the literature as discussed in Section I.2.3 of BSC 2002c and Appendix B of *Supplemental Soils Report*.[9] Settlement beneath foundation mats was determined for a range of foundation dimensions and loadings, including loads matching design seismic levels, in Appendix B of *Supplemental Soils Report*.[10] These were equivalent spring analyses, in which modulus values were reduced to account for the soil strains during loading. In this way, the modulus reduction for dynamic conditions is accounted for by the associated strain level for the magnitude of the applied load. This type of analysis is considered appropriate whether the loads are of static or seismic origin.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2002. *Soils Report for North Portal Area, Yucca Mountain Project.* 100-00C-WRP0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021015.0323; ENG.20050823.0018.

[2] BSC 2002. *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project*. ANL-MGR-GE-000003 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021004.0078.

[3] BSC 2008. *Supplemental Soils Report*. 100-S0C-Cy00-00100-066-00E CACN 001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080828.0016; ENG.20081117.0004.

[4] Ibid.

[5] BSC 2002, *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project*.

[6] SNL (Sandia National Laboratories) *Technical Report: Geotechnical Data for a Geologic Repository at Yucca Mountain, Nevada.* TDR-MGR-GE-000010 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080206.0001.

[7] Ibid.

[8] BSC 2008. *Supplemental Soils Report*.

[9] Ibid.

[10] Ibid.

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 2: Provide information on the stability of subsurface materials underlying the surface-facility structures and any cut or fill slopes near the aging pads or on transportation routes to and from the aging pads, during a full range of potential seismic events in the hazard curve (SAR Section 1.2.2.1).

The applicant's assessment of the performance of surface-facility structures assumes the subsurface materials supporting the foundations will be stable and undergo only elastic deformations when subjected to static and seismic loading (SAR Section 1.2.2.5, BSC 2007j, Section 6.2.3, page 16). However, the applicant has not provided a basis to support the stability assumption. Furthermore, SAR Figure 1.1-129 indicates excavation for a proposed aging pad could expose the alluvium in a cut slope of up to 60 ft high. In addition, transportation routes that link the aging pads to other surface-facility structures (SAR Figure 1.2.7-2) could involve cut and fill slopes. In addition, the applicant has not provided information on stability analysis of slopes adjoining the aging pads or transportation routes. This information is required to verify compliance with 10 CFR 63.21(c)(1)(ii), and 10 CFR 63.112(c), (e)(8).

1. RESPONSE

During the RAI Clarification Meeting conducted on December 4, 2008, the NRC clarified that RAI 2.2.1.1.1-002 consists of two parts: (1) assessment of the stability of subsurface materials and (2) assessment of the stability of slopes under both static and seismic loading. It was further confirmed that the response to RAI 2.2.1.1.1-001 would provide the information for the assessment of the stability of subsurface materials for RAI 2.2.1.1.1-002. Therefore, response to RAI 2.2.1.1.1-002 is limited to assessment of the stability of slopes under both static and seismic loading.

The cut and fill slopes near the aging pads and on transportation routes (access road) to and from the aging pads will be designed to ensure stability under static and design basis ground motion loading.

The aging pads are nominally 3-ft-thick reinforced concrete slabs on grade that provide a stable support surface for the vertical aging overpacks and the horizontal aging modules. There is a perimeter pathway of compacted aggregate around each concrete slab to allow access for equipment. The concrete slabs and pathways have a slight grade in the direction of the natural topography to allow for drainage. Within aging pad area 17P, the elevation of each of the seven concrete slabs decreases from north to south, producing a terraced layout. There is a similar terraced layout for the concrete slabs in aging pad area 17R. This terraced layout minimizes the cut and fill required. Also, the elevations of the concrete slabs are set to approximately balance the amount of cut and fill. It is expected that the maximum cut and fill within the aging pad area will be less than 35 ft. Beyond the perimeter pathway around each of the aging pad areas, there will be a shallow slope to existing grade.

The nuclear handling facilities are connected to the aging pad areas by an access road. The grade for the access road will be within the design parameters of the site transporter. Beyond the shoulders of the access road, there will be a shallow slope to existing grade.

The permanent slopes will be no steeper than 2H:1V.[1] Stability of the cut and fill slopes near the aging pads and on the transportation routes (access road) to and from the aging pads will be evaluated during detailed design by performing a pseudostatic analysis on a simple wedge considering the site transporter load and the design basis ground motion-2 (DBGM-2) seismic loads to demonstrate adequate factors of safety.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2008. *Supplemental Soils Report.* 100-S0C-CY00-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080828.0016; ENG.20081117.0004, Table 2-2.

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 3: Justify the adequacy of information on subsurface geotechnical properties from site borings used in the analysis, design and performance of surface facilities. The justification should include discussion on plans, if any, for the number and location of future borings or field tests (SAR General Information Section 5.1.6.4; BSC 2007b, section 7.3.2).

In SAR General Information Section 5.1.6.4, the applicant refers to a soils report BSC 2007b (SAR Section 5.3 General References), supporting geotechnical properties. In Section 7.3.2 of the report, the applicant states that there are very few borings within the borders of the planned buildings and that "another 29 borings will be required to provide sufficient coverage of the planned facilities." The additional information is needed to verify compliance with 10 CFR 63.21(c)(1)(ii) and 10 CFR 63.112(c).

1. RESPONSE

The full set of site borings and test pits used to develop the geology and subsurface geotechnical properties for the analysis, design, and performance of the surface facilities is shown on SAR Figures 1.1-129 and 1.1-145. There are no plans for future borings or test pits.

RAI 2.2.1.1.1-003 refers to a statement in Revision D of the *Supplemental Soils Report* (BSC 2007b from General Information 5.1.6.4)[1] that estimates that 29 more borings are needed. This statement is not made in the license application. It was initially made in the *Supplemental Soils Report,* Revision A, which was issued in November of 2004.[2] Two phases of drilling for repository facilities at the surface GROA have been conducted since November of 2004. More than 29 holes have been drilled and other geotechnical data have been gathered, as discussed in SAR Sections 1.1.5.2 and 1.1.5.3. In August 2008, Revision E of the *Supplemental Soils Report* was issued[3] and the statement that "another 29 borings will be required to provide sufficient coverage of the planned facilities" was removed.

The number and location of the existing borings and test pits adequately capture the variability of the geology and geotechnical properties across the surface geologic repository operations area (GROA) and the variation in the contact elevations among the underlying rock units. As discussed in SAR Section 1.1.5.2.7.2, drilling results through 2000 show the base of the alluvium in Midway Valley as relatively flat. Results from the 2005 through 2007 drilling not only confirm this but also extend the interpretation of a smooth, relatively flat, top-of-bedrock contact across two-thirds of Midway Valley from west to east. Alluvium thickness is zero at the base of Exile Hill and increases in thickness to almost 200 ft about halfway across the valley, and then begins to thin eastward towards Alice Point (SAR Figure 1.1-130).

As shown in the borehole logs and the mapping and logging of test pits, the alluvium at the surface GROA has consistent engineering properties. The major variability with respect to foundation design for the surface facilities is the thickness of the alluvium that overlies bedrock. The local geologic setting, the relative proximity of the numerous surface facilities, and the consistency of the alluvium encountered in the various boreholes were considered in determining

the number and location of the boreholes in the 2005 through 2007 drilling program. The locations and spacings of the boreholes sufficiently capture the site variability across the surface GROA and the variation in the contact elevations among the underlying rock units. Each ITS surface facility has a deep borehole penetrating, at a minimum, into the Tiva Canyon Tuff crystal-poor member (Tpcp) near the center of the building with additional, shallower boreholes near the building corners penetrating through the alluvium. Several boreholes have been drilled in the areas where the concrete slabs for the aging pads will be constructed. Given the uniform nature of the alluvium across the surface GROA, the borings and test pits shown on SAR Figures 1.1-129 and 1.1-145 in conjunction with the additional geotechnical data discussed in SAR Section 1.1.5 are sufficient to develop the subsurface geotechnical properties for use in the analysis, design and performance of surface facilities.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2007. *Supplemental Soils Report*. 100-S0C-CY00-00100-000-00D CACN 002. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080102.0045; ENG.20080220.0002; ENG.20080324.0006.

[2] BSC 2004. *Supplemental Soils Report*. 100-S0C-CY00-00100-000-00A ECN 1. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041108.0006; ENG.20050823.0021.

[3] BSC 2008. *Supplemental Soils Report*. 100-S0C-CY00-00100-000-00E CACN 001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080828.0016; ENG.20081117.0004.

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 4: Provide the geotechnical information and supporting geophysical analyses from the additional boreholes drilled during 2006 and 2007 (Buesch and Lung 2008, SNL 2008a – SAR Section 1.1-10 [1.1.10]) to justify that seismic site response analysis for the Geologic Repository Operations Area described in SAR Section 1.1.5.2.5.2 adequately reflects site conditions.

In SAR Section 1.1.5.2.5.2 (pages 1.1-95-1.1-96), the applicant states that geotechnical data from 43 boreholes drilled during 2006 and 2007 were still being processed at the time the License Application was submitted to the NRC. The applicant provided a summary assessment of a subset of the geotechnical information from the 2006 and 2007 site characterization activities based on the alluvium depths observed in 12 of the 43 boreholes (Buesch and Lung 2008, SNL 2008a – SAR Section 1.1-10 [1.1.10]). The applicant's preliminary conclusion, based on observations from these 12 boreholes, was that the new information was consistent with interpretations based on geotechnical data collected from site characterization activities carried out prior to 2006. However, no data or analysis is provided in the SAR, or in Buesch and Lung 2008, to support this conclusion. The information is needed to complete the review of the DOE site response analysis, and verify compliance with 63.21(c)(1)(ii) and 10 CFR 63.112(c).

1. RESPONSE

This RAI response provides the geotechnical information from boreholes drilled in 2006 and 2007 that are identified in *Technical Report: Geotechnical Data for a Geologic Repository at Yucca Mountain, Nevada* (SNL 2008a in SAR Section 1.1.10)[1] and *Update of Geotechnical Boreholes and Test Pit Program through 2007 in Midway Valley, Nevada*[2] that was not provided in the SAR. There are 43 repository facility boreholes in the 2006–2007 drilling program. Geologic logs are provided for the 23 boreholes from the 2006–2007 drilling program that support the alluvium thickness interpretation presented in SAR Figure 1.1-130. Also, geologic and geophysical logs for the additional boreholes used in the geologic observations in *Update of Geotechnical Boreholes and Test Pit Program through 2007 in Midway Valley, Nevada*[2] are provided.

Table 6.2-2 of *Technical Report: Geotechnical Data for a Geologic Repository at Yucca Mountain, Nevada*[1] provides a listing of the boreholes that provided data used to develop the alluvium thickness contour map of Midway Valley (SAR Figure 1.1-130). Graphical geologic logs of the boreholes drilled prior to 2006 used in the development of the SAR Figure 1.1-130 that are currently provided in the license application are listed in Table RAI 2.2.1.1.1-004-1. Data from the geologic logs of boreholes UE-25 RF#3 and UE-25 RF#64 were also used in the development of the Alluvium Thickness Contour Map of Midway Valley. A descriptive geologic log for UE-25 RF#3 is provided currently in Table 1.1-72 of the license application. UE-25 RF#64 was drilled in 2005 at a location to the northwest of Exile Hill that was being considered for the site of an aging pad. A Sample Management Facility geologic log was completed for this borehole.[3] Because this location was abandoned as the potential site of an aging pad, a detailed

geologic log was not completed for UE-25 RF#64. The Sample Management Facility geologic log is provided as Figure RAI 2.2.1.1.1-004-1.

Data from 23 boreholes drilled in 2006 and 2007 were used in the development of SAR Figure 1.1-130. Graphical geologic logs of these 23 boreholes are provided in the corresponding figures identified in Table RAI 2.2.1.1.1-004-2.[4, 5]

Buesch and Lung[2] examined data from 12 boreholes drilled during 2006 and 2007, including:

- An angled borehole that was designed to penetrate the Exile Hill Fault splay (UE-25 RF#40)
- Boreholes within or near the boundaries of planned important to safety facilities (UE-25 RF#30, UE-25 RF#81, UE-25 RF#82, UE-25 RF#85, UE-25 RF#86, and UE-25 RF#92)
- Boreholes within or near the boundaries of the aging pads (UE-25 RF#67, UE-25 RF#69, UE-25 RF#71, UE-25 RF#94, and UE-25 RF#102).

Graphical geologic logs of these 12 boreholes are provided in the corresponding figures identified in Table RAI 2.2.1.1.1-004-3.[4, 5]

Downhole geophysical logging was performed in a subset of the boreholes drilled in 2006 and 2007 and was examined by Buesch and Lung[2]. Table RAI 2.2.1.1.1-004-4[6] identifies the boreholes and the corresponding figures for the geophysical logs.

SAR Figure 1.1-129 shows the boreholes used in the geotechnical investigation of the geologic repository operations area for the design and analysis of the surface facility structures. The data and logs for the 2006–2007 boreholes both support and confirm the previous investigations addressing alluvium thickness contours, geologic and geophysical data, and uniformity of the site conditions.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1]SNL (Sandia National Laboratories) 2008. *Technical Report: Geotechnical Data for a Geologic Repository at Yucca Mountain, Nevada.* TDR-MGR-GE-000010 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080206.0001.

[2]Buesch, D.C. and Lung, R.C. 2008. *Update of Geotechnical Boreholes and Test Pit Program through 2007 in Midway Valley, Nevada.* Denver, Colorado: U.S. Geological Survey. ACC: LLR.20080121.0080.

[3]MO0612SMFGLGIB.000. Sample Management Facility Geologic Logs for the Repository Facilities Geotechnical Investigations Boreholes. Submittal date: 12/18/2006.

[4]GS080983114233.008. December 2008, Revised Geotechnical Borehole Logs of 20 Repository Facilities Geotechnical Investigations Boreholes for the Yucca Mountain Waste Handling Building, 4/27/2007 through 4/21/2008. Submittal date: 11/22/2008.

[5]GS081083114233.009. December 2008, Revised Geotechnical Borehole Logs of 21 Repository Facilities Geotechnical Investigations Boreholes for the Yucca Mountain Waste Handling Building, 04/27/2007 through 04/21/2008. Submittal date: 11/04/2008.

[6]MO0801RFGEOLOG.002. Output Data from the Forensic Evaluation of Geophysical Log Data Collected in Support of the Repository Facilities Geotechnical Investigations. Submittal date: 01/25/2008.

Table RAI 2.2.1.1.1-004-1. Geologic Logs of Boreholes Drilled Prior to 2006 and Included in the SAR

Borehole Identifier	LA SAR Figure
UE-25 RF#13	1.1-95
UE-25 RF#14	1.1-96
UE-25 RF#15	1.1-97
UE-25 RF#16	1.1-98
UE-25 RF#17	1.1-99
UE-25 RF#18	1.1-100
UE-25 RF#19	1.1-101
UE-25 RF#20	1.1-102
UE-25 RF#21	1.1-103
UE-25 RF#22	1.1-104
UE-25 RF#23	1.1-105
UE-25 RF#24	1.1-106
UE-25 RF#25	1.1-107
UE-25 RF#26	1.1-108
UE-25 RF#28	1.1-109
UE-25 RF#29	1.1-110
UE-25 RF#42	1.1-111
UE-25 RF#43	1.1-112
UE-25 RF#44	1.1-113
UE-25 RF#45	1.1-114
UE-25 RF#46	1.1-115
UE-25 RF#47	1.1-116
UE-25 RF#48	1.1-117
UE-25 RF#49	1.1-118
UE-25 RF#50	1.1-119
UE-25 RF#51	1.1-120
UE-25 RF#52	1.1-121
UE-25 RF#53	1.1-122
UE-25 RF#54	1.1-123
UE-25 RF#55	1.1-124
UE-25 RF#56	1.1-125
UE-25 RF#58	1.1-126
UE-25 RF#59	1.1-127
UE-25 RF#60	1.1-128

Table RAI 2.2.1.1.1-004-2. Geologic Logs for 2006-2007 Boreholes Used in Development of SAR Figure 1.1-130

Borehole Identifier	Figure RAI 2.2.1.1.1-004
UE25 RF-31	2
UE25 RF-33	3
UE25 RF-34	4
UE25 RF-35	5
UE25 RF-36	6
UE25 RF-37	7
UE25 RF-38	8
UE25 RF-39	9
UE25 RF-41	10
UE25 RF-57	11
UE25 RF-75	12
UE25 RF-76	13
UE25 RF-78	14
UE25 RF-79	15
UE25 RF-80	16
UE25 RF-83	17
UE25 RF-95	18
UE25 RF-97	19
UE25 RF-104	20
UE25 RF-105	21
UE25 RF-106	22
UE25 RF-107	23
UE25 RF-112	24

Source: GS080983114233.008 and GS081083114233.009.

Table RAI 2.2.1.1.1-004-3. Geologic Logs for Boreholes Examined by Buesch and Lung

Borehole Identifier	Figure RAI 2.2.1.1.1-004
UE25 RF-30	25
UE25 RF-40	26
UE25 RF-67	27
UE25 RF-69	28
UE25 RF-71	29
UE25 RF-81	30
UE25 RF-82	31
UE25 RF-85	32
UE25 RF-86	33
UE25 RF-92	34
UE25 RF-94	35
UE25 RF-102	36

Source: GS080983114233.008 and GS081083114233.009.

Table RAI 2.2.1.1.1-004-4. Geophysical Logs for Boreholes Examined by Buesch and Lung

Borehole Identifier	Figure RAI 2.2.1.1.1-004
UE-25 RF#30	37
UE-25 RF#35	38
UE-25 RF#37	39
UE-25 RF#39	40
UE-25 RF#41	41
UE-25 RF#69	42
UE-25 RF#71	43
UE-25 RF#75	44
UE-25 RF#82	45
UE-25 RF#85	46
UE-25 RF#90	47
UE-25 RF#94	48
UE-25 RF#95	49
UE-25 RF#97	50
UE-25 RF#106	51
UE-25 RF#112	52

Source: MO0801RFGEOLOG.002.

Borehole Name: UE-25 RF #64	SMF ID: 1259	SAMPLE MANAGEMENT FACILITY GEOLOGIC LOG	Cuttings ☐ QA:QA; Core ☒
Location (approximate): N 767879.63', E 568919.29'			
Elevation: 3787.8' approx.	Inclination: 90°	Core Size: 4.91"	Revision # /Date: Rev. 0, 12-5-06
Bearing: N/A	Rig: GP 24 RS		From: 0.0' To: 16.0'
Scale: 1 division = 1 ft	TD: 105.0'	Logged By: Hopkins	Date: 11-2-05
		Verified by (Printed Name/Signature): Michael Pitterle Michael Pitterle	Date: 10-23-06

GRAPHIC: Rubble, Unrecovered, Breccia

ROCK TYPE: VOLCANIC: Ignimbrite, Lithophysal, Vitrophyre, Bedded; SEDIMENTARY: Carbonate, Alluvium, Conglomerate, Claystone, Siltstone, Sandstone; OTHER: Fracture Fill

WELDING: Non, Partial, Moderate to Dense

Date Drilled	Depth	Fracture Description/Remarks: Piece Length	Frequency	Graphic	Origin: Natural, Coring, Handling, Indeterminant. Dip: Angle between plane parallel to axis of core and plane of feature expressed in degrees. Fracture Line: Planar, Irregular, Curved, Stepped. Surface Characteristics: Smoothness, roughness, coatings, and fillings.	Lithology Description/Remarks: Welding	Rock Type	Unit	Lithology: Unit, Member, Zone, Subzone. Matrix: Welding, alteration, color, other distinctive features. Pumice: %, color, alteration, size, aspect ratio. Lithophysae: %, rounding, size, alteration. Lithic clasts: %, color, size. Crystal Fragments: %, type or mineral (felsics, mafics).
1	2	3	4	5	6	7	8	9	10
5/19/05	1.9/2.6, 2.6	N/A	N/A		Sonic Core Note: Due to the sonic drilling process, material that has fallen out of the core barrel (unrecovered) becomes mixed with caved material from the borehole walls and is not representative of the material being drilled. This material, if recovered on the subsequent core run, is discarded or labeled as fill.			Qta	0.0'-69.5' Alluvium: The alluvium consists of a mixture of gravel (30-50%), sand (20-40%), silt and clay (10-30%), and cobbles (<5-30%). The larger fragments, sand to cobble, are densely welded tuff, reddish-gray (10R5/1), weak red (7.5R5/2), light gray (N7), and gray (5R5/1). The finer alluvium, silt and very fine to medium sand size fragments, consist of welded tuff fragments as above and lesser felsics. The gravel and cobbles have caliche coatings. The caliche is white (N9) and (10YR8/1) and is highly reactive with HCL. They
5/23/05	2.3/4.2, 6.8	N/A	N/A						
	2.2/2.2, 9.0	N/A	N/A						
	3.5/3.5, 12.5	N/A	N/A						
	4.8/4.8	N/A	N/A						

LP-SMF-002Q-BSC Note: All Blanks Are Intentional FORM NO. LSMF2-1 (Rev. 11/21/2005)

Figure RAI 2.2.1.1.1-004-1 (Sheet 1 of 7)

INSTRUCTIONS FOR THE GEOLOGIC LOG

HEADER INFORMATION

Borehole Name:	Unique designation for borehole.
SMF ID:	Unique identification number assigned by the SMF.
Location (approximate)	Approximate location (geographic feature, Exploratory Studies Facility stationing, alcove number, etc.); North and East State Plane, if known.
Elevation:	Elevation of borehole collar, if known.
Inclination:	Inclination of borehole, if known (Horizontal = 0°).
Bearing:	Bearing of borehole, if known.
Rig:	Drill rig type or model.
Scale:	Identify the scale used for the Depth column.
TD (Total Depth):	Depth of borehole at its completion.
Core Size:	Size designation of core drilled (NQ/HQ/PQ, etc).
Revision and Date:	Revision number of log upon completion of a Technical Review, and effective date of revision.
Logged by and Date:	Name of the SMF Geologist logging the core/cuttings, and the date logged.
Cuttings/Core:	Check appropriate box to indicate type of samples produced by drilling activity.
From and To:	Depth Interval represented by each page of the Geologic Log.
Verified by and Date:	Signature of the SMF Geologist who checked for accuracy and completeness and date verified.

COLUMN INFORMATION

1. Date(s) Drilled:	Date(s) that the interval noted on the Geologic Log was drilled.
2. Depth:	Depth notation of core runs (from borehole collar). Rotary borehole depths may be recorded as appropriate for the scale used.
3. Piece Length:	Cumulative total of intact core pieces ≥ 0.33 foot, on a per run basis.
4. Frequency:	Note fracture frequency (including natural and mechanical breaks) using the following letter descriptors: **U**nfractured — No fractures in core run **V**ery slightly — Most pieces longer than 3 feet **S**lightly — Core mostly in 1 to 3 feet lengths **M**oderately — Core mostly in 4 inch to 1 foot lengths **I**ntensely — Pieces average 1 to 4 inches **E**xtremely — Recovery mostly chips and fragments
5. Graphic:	Graphical representation of faults, fractures, broken core, and other structural features. Attitude of features should be sketched relative to the core axis at the appropriate depth. Use patterns provided in header to show breccia, rubble zones and unrecovered intervals.
6. Fracture Description/ Remarks:	Brief description of faults, fractures and other structural characteristics including planarity, roughness, brecciation, and fill/coatings with approximate thickness.
7. Welding:	Degree of welding. Use patterns provided in header.
8. Rock Type:	Type of lithology encountered. Use patterns provided in header. "Other" patterns may be used for lithologies/rock types encountered which are not listed in the header.
9. Unit:	*Indicate YMP lithostratigraphic unit.
10. Lithology Description/ Remarks:	Includes contact depths, lithologic descriptions, and other observations related to geology/stratigraphy. Use the following format for lithologic descriptions: For footage intervals use the following format where X indicates depth, for example: XX.X' – XX.X' for complete descriptions of a member, unit, zone, or subzone. From XX.X' – XX.X' to describe changes or unique lithologies within units, zones or subzones of limited length. @ or Below XX.X' to describe local features or changes within units, zones or subzones. For the Descriptive Format (primarily for volcanic lithologies) use the following: *Unit Name (Formation/Member/Unit/Zone/Subzone), (if known) Lithology/type of deposit (ignimbrite, tephra, reworked, etc.): **Matrix/groundmass** welding, crystalization, alteration, color (use Munsell Soil Color Charts), foliation, bedding (thickness), sorting, grading and other distinctive features; % **pumice**, color, crystalization, alteration, aspect ratio, size; % **lithophysae**, shape, alteration, mineralization (vapor-phase), size; % **lithics**, color, lithology, rounding, size; % **felsic crystal fragments**, minerals; % **mafic crystal fragments**, minerals. List any other unique characteristics, such as the nature of contacts; (i.e., sharp, or gradational over XX feet).

* per Buesch, D. C., et al, "Proposed Stratigraphic Nomenclature and Macroscopic Identification of Lithostratigraphic Units of the Paintbrush Group Exposed at Yucca Mountain, Nevada," USGS OFR 94-469, 1996.

11/21/2005

Figure RAI 2.2.1.1.1-004-1 (Sheet 2 of 7)

Borehole Name: UE-25 RF #64

SMF ID: 1259

Scale: 1 division = 1 ft TD: 105.0'

SAMPLE MANAGEMENT FACILITY

GEOLOGIC LOG (Continuation Page)

Cuttings ☐ Core ☒ QA:QA

From: 16.0' To: 40.0'

Logged By: Hopkins Date: 11-2-05

Verified By (Printed Name/Signature): Michael Pitterle Date: 10-23-06

Date Drilled	Depth	Piece Length	Frequency	Graphic	Fracture Description/Remarks	Welding	Rock Type	Unit	Lithologic Description/Remarks
1	2	3	4	5	6	7	8	9	10
					Sonic Core				Alluvium as above are also subrounded to subangular.
5/23/05	17.3							Qta	from 0.0'-0.3' Poorly developed soil, light brownish-gray (10YR6/3) and grayish-brown (10YR5/3).
	6.3/6.3	N/A	N/A						consists of 60% fines (silt and clay), 20% gravel, 20% sand. Scattered organics (roots, leaves, stems/twigs). Weakly reactive with HCL.
	23.6				23.6'-24.9' Fill				from 1.2'-2.7' 30% cobbles, densely welded tuff.
	4.3/5.4	N/A	N/A						from 4.9'-8.4' 30% cobbles, densely welded tuff.
	29.0								from 29.0'-29.2' cored cobble greater than the core diameter, crystal-rich light gray (N6) with dark gray (N4) mottling.
	3.3/3.3	N/A	N/A						from 30.5'-30.8' cored cobble greater than the core diameter, crystal-rich densely welded tuff, light gray (N7).
	32.3				34.0'-34.6' Fill				
	0.4/0.4	N/A	N/A						
	32.7								
	0.9/1.3	N/A	N/A						
	34.0								
	5.8/6.0	N/A	N/A						
	40.0								

Note: All Blanks Are Intentional

LP-SMF-002Q-BSC

FORM NO. LSMF2-1 (Rev. 11/21/2005)

Figure RAI 2.2.1.1.1-004-1 (Sheet 3 of 7)

SAMPLE MANAGEMENT FACILITY
GEOLOGIC LOG (Continuation Page)

Borehole Name: UE-25 RF #64
SMF ID: 1259
Scale: 1 division = 1 ft TD: 105.0'
Logged By: Hopkins Date: 11-3-05
Verified By (Printed Name/Signature): Michael Pitterle Michael Pitterle Date: 10-23-06
Cuttings ☐ Core ☒ QA:QA
From: 40.0' To: 64.0'

Date Drilled	Depth	Piece Length	Frequency	Graphic	Fracture Description/Remarks	Welding	Rock Type	Unit	Lithologic Description/Remarks
1	2	3	4	5	6	7	8	9	10
5/23/05	41.2/41.2	N/A	N/A		Sonic Core			Qta	Alluvium as above
	8.2/8.2	N/A	N/A						from 32.3'-33.1' cored cobble greater than the core diameter, crystal-poor densely welded tuff, dark gray (N4) with light gray (N7) spherulites.
	49.4								from 34.0'-34.1' cored cobble greater than the core diameter, crystal-poor densely welded tuff, light gray (N7).
	4.5/5.7	N/A	N/A						
	55.1								
	4.8/5.0	N/A	N/A						
	60.1								
	4.9/4.9	N/A	N/A						

Note: All Blanks Are Intentional

LP-SMF-002Q-BSC FORM NO. LSMF2-1 (Rev. 11/21/2005)

Figure RAI 2.2.1.1.1-004-1 (Sheet 4 of 7)

Borehole Name: UE-25 RF #64
SMF ID: 1259
Scale: 1 division = 1 ft TD: 105.0'

SAMPLE MANAGEMENT FACILITY
GEOLOGIC LOG (Continuation Page)

Logged By: Hopkins Date: 11-3-05
Verified By (Printed Name/Signature): Michael Pitterle Michael Pitterle Date: 10-23-06

Cuttings ☐ Core ☒ QA:QA
From: 64.0' To: 88.0'

Date Drilled	Depth	Fracture: Piece Length	Fracture: Frequency	Fracture: Graphic	Fracture Description/Remarks	Lithology: Welding	Lithology: Rock Type	Lithology: Unit	Lithologic Description/Remarks
1	2	3	4	5	6	7	8	9	10
5/23/05	65.0				Sonic Core			QTa	Alluvium as above
	3.7/5.7	N/A	N/A		Note: The QTa/Tpcrn3 contact is within the 68.7'-70.1' unrecovered interval. Assumed a contact depth of 69.5' based on drilling information provided by the driller.				@ approx. 67.5' Paleosol: pink (7.5YR7/4), Predominately a mixture of very fine sand, clay, and silt. Weakly to non reactive with HCL.
	70.7							Tpcrn3	69.5'-105.0' Tiva Canyon Tuff (Tpc)
	4.7/4.7	N/A	N/A						from 69.5'-82.0' Crystal-rich nonlithophysal zone Pumice-Poor subzone (Tpcrn3).
	75.4								Ignimbrite (pyroclastic flow): moderately welded, vapor-phase corroded and crystallized matrix, weak red (10R5/3); 1-3% pumice, gray (N6), white (N8) and weak red (10R4/2), 1:3 to 1:10 aspect ratios. The pumice is crystallized, vapor-phase corroded, and some are silicified Many of the corroded pumice have scattered euhedral hematite crystals, black (N2.5) with a metallic luster and asicular hornblende (<1mm); <1% lithics, crystallized welded tuff, gray (N6); 10% crystal fragments of sanidine and plagioclase; <1% biotite (oxidized) and pyroxene (?), some of the vapor phase corroded groundmass
	4.5/6.0	N/A	N/A						
	81.4								
5/24/05	2.4/4.0	N/A	N/A					Tpcrn2	
	85.4								
	3.1/3.1	N/A	N/A						

LP-SMF-002Q-BSC Note: All Blanks Are Intentional FORM NO. LSMF2-1 (Rev. 11/21/2005)

Figure RAI 2.2.1.1.1-004-1 (Sheet 5 of 7)

Borehole Name: UE-25 RF #6H
SMF ID: 1259
Scale: 1 division = 1 ft TD: 105.0'

SAMPLE MANAGEMENT FACILITY
GEOLOGIC LOG (Continuation Page)

Logged By: Hopkins Date: 11-3-05
Verified By (Printed Name/Signature): Michael Pitterle Michael Pitterle Date: 10-23-06

Cuttings ☐ Core ☒ QA:QA
From: 88.0' To: 105.0'

Date Drilled	Depth	Fracture: Piece Length	Fracture: Frequency	Fracture: Graphic	Fracture Description/Remarks	Lithology: Welding	Lithology: Rock Type	Lithology: Unit	Lithologic Description/Remarks
1	2	3	4	5	6	7	8	9	10
5/24/05	88.5				Sonic Core			Tpcrn2	Tiva Canyon Tuff as above is filled with light gray (N7) botryoidal silica.
	3.4/3.4	N/A	N/A						
	91.9								from 82.0'-105.0' Crystal-rich nonlithophysal zone Mixed pumice Subzone (Tpcrn2).
	3.5/3.5	N/A	N/A						Ignimbrite (pyroclastic flow): moderately to densely welded, crystallized, reddish-gray (2.5YR 6/1); 10-15% pumice, reddish-gray (7.5R5/1), white (N9), weak red (10R5/3), corroded; No lithics were observed; 10-12% crystal fragments of sanidine and plagioclase; <1% biotite (bronze) and hornblende.
	95.4								
	3.9/3.9	N/A	N/A						
	99.3								
	2.1/2.1	N/A	N/A						
	101.4								
	1.6/3.6	N/A	N/A						82.0'-86.0' may be a transitional zone between Tpcrn3 and Tpcrn2 - loose the vapor phase corroded matrix and have increasing amounts of pumice.
	105.0								
					TD @ 105.0'				@ 86.6'-87.7' Fracture Fill: Mixture of clay altered ash and Tpcrn2 fragments. Color is light reddish-gray (2.5YR7/1). Locally (near 86.6') deposit is clast supported. Approx. 5% pumice, altered, white (N9).

LP-SMF-002Q-BSC Note: All Blanks Are Intentional FORM NO. LSMF2-1 (Rev. 11/21/2005)

Figure RAI 2.2.1.1.1-004-1 (Sheet 6 of 7)

Borehole Name: UE-25 RF#64	SAMPLE MANAGEMENT FACILITY GEOLOGIC LOG (Continuation Page)	Cuttings ☐ Core ☒ QA:QA
SMF ID: 1259		From: N/A To: N/A
Scale: N/A TD: 105.0'	Logged By: Hopkins Date: 11-3-05	Verified By (Printed Name/Signature): Michael Pitterle Michael Pitterle Date: 10-23-06

Date Drilled	Depth	Fracture: Piece Length	Fracture: Frequency	Fracture: Graphic	Fracture Description/Remarks	Lithology: Welding	Lithology: Rock Type	Lithology: Unit	Lithologic Description/Remarks
1	2	3	4	5	6	7	8	9	10
					Sonic Core				Cont. @ 88.7' - 93.5' Fracture Fill: Fracture fill consists of partially clay altered tephra, non welded, pinkish-white (7.5YR8/1); 5-10% altered pumice (clay/zeolitic?), white (N9) to pinkish-white (7.5YR8/1); < 1% lithics of welded tuff; 5-10% crystal fragments of sanidine and plagioclase; < 1% biotite and pyroxene. Poorly developed internal stratification. Locally, in the fracture-filling material, there are lithic clast supported breccias with lithic clasts from Tpcrn2. @ approx. 87.0' - 88.7' Tpcrn2 comprises approx. 75% of the rock with the fracture filling at 25%. The fracture fill material changes in this "narrowing" zone. @ approx. 88.6' foliation of Tpcrn2 at this depth is approx. 90° to the core axis (subhorizontal). @ 95.0' - 98.5' Scattered zones of fracture filling as 88.7' - 93.5'.

LP-SMF-002Q-BSC Note: All Blanks Are Intentional FORM NO. LSMF2-1 (Rev. 11/21/2005)

Figure RAI 2.2.1.1.1-004-1 (Sheet 7 of 7)

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-31

SHEET 1 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/26/2006 FINISHED: 2/28/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,613.57 E 571,326.9
TOTAL DEPTH: 563.1 ft.
DEPTH TO BEDROCK: 105.5 ft.

STATE: Nevada
GROUND ELEVATION: 3657.07
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit to approximately 6.0'. Set 10-3/4" conductor casing in 12-3/4" hole to approximately 5.0' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 158.7'. Change over to LS224 Core Rig with 3-7/8" HQ-3 conventional coring system and 4-1/2" casing. Core and advance casing to depth of 563.1' (TD). Drilling Conditions: Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to approximately 5.0'. 9" casing from 0.0 to 158.7'. 4-1/2" casing from 158.7 to 563.1 ' (TD). **Hole Completion:** Remove 4-1/2" casing and 9" casing. Install 3-1/2" PVC casing to depth of 563.1'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 563.1' (TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(GP)s (SP)g (GP)s (SP)g (GP)s (SP)gc (GP)s (SP)gc (GP)s (SP)g (GP)s (SP)g (SP)g (GP)sc (SP)g (GP)sc (SP)g (GP)sc		**0.0 to 105.5 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 8.8 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, light reddish brown, moderate to strong reaction with HCl. **8.8 to 10.4 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, pink, strong reaction with HCl. **10.4 to 13.8 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 60 percent coarse to fine, hard, angular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, reddish yellow and light reddish brown, no to strong reaction with HCl. **13.8 to 15.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, light reddish brown, no reaction with HCl. **15.0 to 16.4 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular gravel; about 45 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, light reddish brown, strong reaction with HCl. **16.4 to 17.9 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 60 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; dry, light reddish brown, moderate reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 25 percent hard, drilled cobbles; maximum size 110 mm; remainder minus 3-inch. **17.9 to 20.6 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 45 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pink, strong reaction with HCl. **20.6 to 40.4 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 65 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; trace of hard, subangular and drilled cobbles; maximum size 120 mm; dry, pink, strong reaction with HCl. **40.4 to 49.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, pink, strong reaction with HCl. **49.0 to 51.1 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, pink, strong reaction with HCl. **51.1 to 54.3 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, light reddish brown, strong reaction with HCl. **54.3 to 55.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 70 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular to subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 25 mm; dry, light reddish brown to reddish yellow, no reaction with HCl. **55.7 to 70.4 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; trace of nonplastic fines with quick dilatancy and low toughness; trace of hard, angular to subangular and drilled cobbles; maximum size 80 mm; dry, light reddish brown, strong reaction with HCl. **70.4 to 72.6 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, angular to subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pink, strong reaction with HCl. **72.6 to 77.9 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; trace of hard, subangular and drilled cobbles; maximum size 85 mm; dry, light reddish brown, moderate reaction with HCl. **77.9 to 83.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, light reddish brown, no reaction with HCl. **83.7 to 105.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; dry, light reddish brown and pink, strong reaction with HCl. The rock fragments in the interval from 102.6 to 105.5 are similar to the rock in the bedrock section below 105.5 ft.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-2 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-31

SHEET 2 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/26/2006 FINISHED: 2/28/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,613.57 E 571,326.9
TOTAL DEPTH: 563.1 ft.
DEPTH TO BEDROCK: 105.5 ft.

STATE: Nevada
GROUND ELEVATION: 3657.07
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
							(GP)sc		TOTAL SAMPLE (BY VOLUME): About 5 percent hard, subangular to drilled cobbles; maximum size 115 mm; remainder minus 3-inch.
	105						Tmbt1		**105.5 to 195.4 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded Tuff, nonwelded, massively bedded, crystallized, locally silicified, pink, pinkish-white very pale brown, and light gray, 5 to 30 percent pumice, 0 to 6 percent lithic fragments of crystallized welded tuff, less than 1 to 8 percent crystal fragments of quartz, sanidine and plagioclase, less than 1 percent biotite, less than 1 percent magnetite and manganese oxides locally. Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), moderately to slightly weathered (W4), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp at 25 degrees to the core axis.
	110								
	115								
	120								
	125								
	130								
	135								
	140								
	145								
	150								
	155								
	160	4		5	100	73			
	165	5		6	69	26			
	170	5		4	100	90			
		5		6	92	29			
	175	5		6	100	59			
	180	5		4	100	96			
	185	5		6	96	56			
	190	7		9	83	0			
	195	5		6	100	60	Tpki		**195.4 to 328.3 ft. RHYOLITE OF COMB PEAK - TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, locally vitric, white, pink, very pale brown, pinkish-white, pinkish-gray, pale yellow, 15 to 70 percent pumice, 5 to 30 percent lithic fragments of crystallized welded tuff, 1 to 8 percent crystal fragments of mostly sanidine and plagioclase with lesser quartz, less than 1 percent biotite, magnetite and lesser hornblende. Generally the tuff is very soft (H7) to mostly moderately hard (H4), moderately weathered (W5), unfractured (FD0) to very intensely fractured (FD9) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	200	4		4	100	89			
	205	4		4	100	77			
	210	4		1	100	98			
	215	4		1	98	96			
		4		1	100	100			

Figure RAI 2.2.1.1.1-004-2 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-31

SHEET 3 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/26/2006 FINISHED: 2/28/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,613.57 E 571,326.9
TOTAL DEPTH: 563.1 ft.
DEPTH TO BEDROCK: 105.5 ft.

STATE: Nevada
GROUND ELEVATION: 3657.07
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		1	100	100			
	225	4		6	81	46			
		7		9	100	0			
	230	4		9	83	0			
	235	4		7	96	52			
	240	4		2	100	97			
	245	4		2	100	89			
	250	4		1	100	100			
	255	4		1	100	100			
	260	4		0	100	98			
	265	4		1	100	98			
	270	4		0	100	100			
	275	4		4	98	79	Tpki		
	280	4		4	100	81			
		4		9	28	0			
	285	4		3	100	100			
	290	4		1	100	97			
	295	4		2	100	94			
	300	4		2	100	90			
	305	4		3	100	85			
	310	4		3	100	92			
	315	4		3	100	96			
	320	4		0	100	96			
		4		0	100	100			
	325	4		0	100	98			
		4		0	100	83			
	330	4		3	100	97	Tpbt5		**328.3 to 336.0 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff, nonwelded, crystallized, pinkish-white, very pale brown, 5 to 40 percent pumice, 1 to 3 percent lithic fragments of crystallized welded tuff, 5 to 10 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and lesser hornblende. Generally the tuff is moderately hard (H4), moderately weathered (W5), unfractured (FD0) to slightly fractured (FD3) averaging slightly to very slightly fractured (FD2). Lower contact is unconformable and sharp.
	335	4		3	100	89	Tpcrv		

Figure RAI 2.2.1.1.1-004-2 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-31

SHEET 4 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/26/2006 FINISHED: 2/28/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,613.57 E 571,326.9
TOTAL DEPTH: 563.1 ft.
DEPTH TO BEDROCK: 105.5 ft.

STATE: Nevada
GROUND ELEVATION: 3657.07
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	340	4		3	94	79	Tpcrv	
	345	3		4	100	71		
	350	3		5	91	57	Tpcrn	
	355	4		6	100	54		
	360	3		7	100	24		
	365	3		5	96	54		
	370	3		5	100	56		
	375	3		4	100	63		
	380	3		4	100	82		
	385	3		4	100	92		
	390	3		3	100	98		
	395	3		5	100	60		
	400	3		5	100	55		
	405	3		4	100	78		
	410	3		4	96	63		
	415	3		4	100	67		
	420	3		6	100	31		
	425	3		6	96	38		
	430	3		6	100	28	Tpcpun	
	435	3		5	85	55		
	440	3		3	100	95		
	445	3		4	100	80		
	450	3		7	98	33		
	455	3		8	91	11		
		3		9	28	0	Tpcpul	

CLASSIFICATION AND PHYSICAL CONDITION

336.0 to 348.3 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv): Pyroclastic flow, nonwelded, to densely welded, crystallized to vitric, pale red, pink, black, 5 to 15 percent pumice, less than 1 to 2 percent lithic fragments, 1 to 15 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and lesser hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to moderately fractured (FD5) averaging moderately to slightly fractured (FD4). Lower contact is conformable and gradational.

348.3 to 427.6 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, moderately to densely welded, vapor-phase altered locally, pale red, light gray, light reddish-gray with pale red mottling, 1 to 25 percent pumice, 2 to 15 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite, and lesser hornblende, less than 1 to 4 percent lithophysae are found near the base of the unit. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered (W3), slightly fractured (FD3) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is conformable and gradational.

427.6 to 456.2 ft. TIVA CANYON TUFF CRYSTAL-POOR NONLITHOPHYSAL ZONE (Tpcpun): Pyroclastic flow, densely welded, crystallized, vapor-phase alteration locally, pinkish-gray with pale red mottling, 7 to 10 percent pumice, less than 1 percent lithic fragments of crystallized welded tuff, 2 to 4 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.

Figure RAI 2.2.1.1.1-004-2 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-31

SHEET 5 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/26/2006 FINISHED: 2/28/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,613.57 E 571,326.9
TOTAL DEPTH: 563.1 ft.
DEPTH TO BEDROCK: 105.5 ft.

STATE: Nevada
GROUND ELEVATION: 3657.07
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	3		9	28	0	Tpcpul		**456.2 to 514.6 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red with minor white mottling, or light bluish-gray mottling, 2 to 5 percent pumice, locally spherulitic up to 20 percent, 1 to 15 percent lithophysae (locally absent), 1 to 3 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and pyroxene, scattered manganese oxides and magnetite, 5 to 30 percent vapor-phase spots. Generally the tuff is hard (H3), slightly weathered to fresh (W2), very slightly fractured (FD1) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	465	3		9	63	0			
	470	3		3	100	92			
	475	3		7	96	36			
	480	3		7	100	8			
	485	3		5	100	52			
	490	3		5	98	62			
	495	3		6	98	37			
	500	3		4	96	83			
	505	3		1	100	100			
	510	3		3	100	80			
	515	3		7	100	32	Tpcpmn		**514.6 to 555.0 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, clay alteration locally, pale red, 1 to 5 percent pumice, 2 to 3 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and pyroxene, scattered spherulites. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	520	3		5	98	62			
	525	3		5	100	63			
	530	3		4	100	74			
	535	3		5	100	61			
	540	3		9	94	13			
		4		7	71	24			
		3		9	80	0			
	545	3		9	100	0			
	550	3		8	100	14			
		3		5	100	53			
	555	3		7	100	45	Tpcpll		**555.0 to 562.9 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, light reddish-brown with pale red mottling, 2 to 3 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite, 3 to 15 percent lithophysae. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
	560	3		5	100	73			

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-2 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-33

SHEET 1 OF 2

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/17/2006 FINISHED: 10/17/2006
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,729.9 E 570,459.95
TOTAL DEPTH: 169.0 ft.
DEPTH TO BEDROCK: 87.6 ft.

STATE: Nevada
GROUND ELEVATION: 3671.30
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 300 RS Sonic Drill Rig, LS-224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
Boart Longyear

Drilling Method:
Sonic core with 12-3/4" bit from 0.0 to 5.4'. Set 10-3/4" conductor casing in 12-3/4" hole to 5.4' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 154.8'. Change over to LS224 Core Rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 169.0' (TD). Remove casing and coring system.

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
Set 10-3/4" conductor casing from 0.0' to 5.4'. 9" casing from 0.0 to 154.8'. 4-1/2" casing from 154.8 to 169.0' (TD).

Hole Completion:
Remove 4-1/2" casing and 9" casing. Back fill hole from 169.0' (TD) up to ground level with Bentonite Chips.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
						(GP-GM)s	
						(SM)g	
						(GP-GM)s	
						(GP)s	
5						(SP-SM)gc	
10						(GP)sc	
15							
20							
25						(SP-SM)gc	
						(GP)s	
30						(GP-GM)s	
35						(GP)sc	
40							
						(SP-SM)g	
45						(GP)s	
						(SP)g	
50						(GP-GM)s	
						(SP)g	
						(GP)s	
55						(SP)g	
						(GP)s	
						(SP-SM)g	
60						(GP-GM)s	
						(SP-SM)g	
						(GP-GM)sc	
65						(SP-SM)g	
						(GP)s	
70						(SP)g	
75							
						(GP-GM)sc	
80							
85							
90						Tpki	
95							

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 87.6 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 0.4 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 10 percent fines of low plasticity with medium dry strength, quick dilatancy and low toughness; maximum size 20 mm; dry, light reddish brown, no reaction with HCl. Roots present, topsoil.
0.4 to 0.8 ft. SILTY SAND WITH GRAVEL (SM)g: About 60 percent coarse to fine, subangular to subrounded sand; about 25 percent predominantly fine, hard, subangular to subrounded gravel; about 15 percent fines of medium plasticity with high dry strength, slow dilatancy and medium toughness; maximum size 25 mm; dry, light reddish brown, weak reaction with HCl. Roots present, topsoil.
0.8 to 1.8 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 10 percent fines of medium plasticity with very high dry strength, slow dilatancy and medium toughness; maximum size 35 mm; dry, yellowish red, no reaction with HCl. Roots present.
1.8 to 6.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 55 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, yellowish red, strong reaction with HCl.
6.0 to 7.3 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 45 percent coarse to fine, hard, subangular gravel; about 45 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 90 mm; dry, reddish yellow, strong reaction with HCl.
7.3 to 23.8 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 115 mm; dry, reddish yellow, strong reaction with HCl.
23.8 to 26.3 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 45 percent coarse to fine, hard, angular to subangular gravel; about 45 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with medium dry strength, quick dilatancy and low toughness; dry, reddish yellow, strong reaction with HCl.
26.3 to 31.1 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 50 percent coarse to fine, hard, angular to subangular gravel; about 45 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, light reddish brown, pink, strong reaction with HCl.
31.1 to 32.6 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 60 percent coarse to fine, hard, subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, reddish yellow, strong reaction with HCl.
32.6 to 43.4 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 65 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subrounded sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 80 mm; dry, light reddish brown, strong reaction with HCl.
43.4 to 44.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 60 percent coarse to fine, angular to subangular sand; about 30 percent predominantly fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pink, strong reaction with HCl.
44.4 to 46.7 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 60 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, strong reaction with HCl.
46.7 to 50.6 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 65 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 120 mm; dry, reddish yellow, strong reaction with HCl.
50.6 to 51.1 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 65 percent coarse to fine, hard, angular gravel; about 25 percent coarse to fine, angular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pink, strong reaction with HCl.
51.1 to 52.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 70 percent coarse to fine, angular to subangular sand; about 0 percent coarse to fine, hard, angular to subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, gray and pink, no reaction with HCl.
52.0 to 53.5 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 60 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 65 mm; dry, gray and pink, no reaction with HCl.
53.5 to 54.5 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 85 percent coarse to fine, angular sand; about 15 percent predominantly fine, hard, angular to subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 20 mm; dry, pink, no reaction with HCl. Pumice/ash found in this interval.
54.5 to 57.3 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 60 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-3 (Sheet 1 of 2)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-33

SHEET 2 OF 2

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/17/2006 FINISHED: 10/17/2006
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,729.9 E 570,459.95
TOTAL DEPTH: 169.0 ft.
DEPTH TO BEDROCK: 87.6 ft.

STATE: Nevada
GROUND ELEVATION: 3671.30
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135						Tpki		sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, light reddish brown, strong reaction with HCl. **57.3 to 59.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, light reddish brown, moderate reaction with HCl. **59.1 to 61.3 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 60 percent coarse to fine, hard, angular to subrounded gravel; about 30 percent coarse to fine, angular to subrounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, pink, strong reaction with HCl. **61.3 to 62.5 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent predominantly fine, hard subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 15 mm; dry, pink, strong reaction with HCl. **62.5 to 65.1 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 90 mm; dry, pink, strong reaction with HCl. **65.1 to 68.3 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 45 percent coarse to fine, hard, subangular to subrounded gravel; about 45 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, pink, strong reaction with HCl. **68.3 to 69.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 70 percent coarse to fine, hard, subangular gravel; about 25 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, light reddish brown, strong reaction with HCl. **69.0 to 70.1 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, angular sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 65 mm; dry, pink, strong reaction with HCl.
	140						Tpbt5		**70.1 to 87.6 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 120 mm; dry, pink, strong reaction with HCl.
	145, 150						Tpcrv		**87.6 to 137.3 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, vitric to crystallized, locally vapor-phase altered, white, light gray, 10 to 40 percent pumice, 5 to 20 percent lithic fragments of welded tuff, rare lithic fragments of nonwelded tuff, 1 to 2 percent crystal fragments of primarily feldspar with minor magnetite, biotite and pyroxene. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	155	4		6	58	31			**137.3 to 143.5 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff and pumiceous tephra, reworked, nonwelded, clay-altered, pinkish-gray to very pale brown, 15 to 60 percent pumice, 2 to 5 percent lithic fragments of welded tuff, 2 to 10 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite, magnetite and pyroxene. Generally the tuff is moderately to slightly weathered (W4). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	160	4		5	100	34			**143.5 to 156.9 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded, locally clay altered, locally incipiently crystallized, locally silicified, very pale brown, pink, light reddish-brown, pale red, reddish-black, reddish-yellow, 10 to 25 percent pumice, less than 1 to 2 percent volcanic lithic fragments, 5 to 15 percent crystal fragments of sanidine, plagioclase and minor biotite. Generally the tuff is moderately hard (H4), slightly weathered (W3), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	165	4		6	80	46	Tpcrn		**156.9 to 169.0 ft. TIVA CANYON CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, gray, pale red, light reddish-gray, less than 1 to 25 percent pumice, lithic fragments rare to absent, 5 to 20 percent crystal fragments of sanidine, plagioclase, with minor biotite and rare pyroxene. Generally the tuff is moderately hard (H4), slightly weathered (W3), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is undetermined.
		4		6	100	38			
							BOTTOM OF HOLE		

Figure RAI 2.2.1.1.1-004-3 (Sheet 2 of 2)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-34

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/6/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 764,941.8 E 570,753.04
TOTAL DEPTH: 628.2 ft.
DEPTH TO BEDROCK: 115.4 ft.

STATE: Nevada
GROUND ELEVATION: 3684.12
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit from 0.0 to 10.1'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 5.2' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 283.1'. Change over to LS224 Core Rig with 3-7/8" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 619.9'. Remove casing and coring system. Ream hole with 6-1/4" tricone bit to total depth of 628.2' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to 5.2'. 9" casing from 0.0 to 283.1'. 4-1/2" casing from 283.1 to 619.9'. **Hole Completion:** Remove 4-1/2" casing and 9" casing. Install 3-1/2" PVC casing to depth of 493.2'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 628.2' (TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(GP-GM)sc (GP)sc (SP)g (SP-SM)g (GP)s (SP-SM)gc (GP-GM)sc (SP-SM)g (GM)sc (SP)g		**0.0 to 40.7 ft. NON-ENGINEERED FILL:** **0.0 to 33.6 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, angular gravel; about 30 percent coarse to fine, angular sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 120 mm; dry, light greenish gray, no reaction with HCl. (waste material from tunnel muck) **33.6 to 40.7 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 65 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 5 percent fines of low plasticity with slow dilatancy and low toughness; moist, brown, strong reaction with HCl. (pad fill) TOTAL SAMPLE (BY VOLUME): About 5 percent hard drilled and subangular cobbles; maximum size 210 mm; remainder minus 3-inch. **40.7 to 115.4 ft. QUATERNARY ALLUVIUM (Qal):** **40.7 to 50.4 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, angular to subrounded gravel; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, very pale brown, strong reaction with HCl. **50.4 to 55.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, light brown, strong reaction with HCl. **55.7 to 57.3 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 45 mm; dry, light brown, strong reaction with HCl. **57.3 to 71.8 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 65 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, light brown, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard drilled and subangular cobbles; maximum size 120 mm; remainder minus 3-inch. **71.8 to 76.2 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 90 mm; dry, reddish brown, strong reaction with HCl. **76.2 to 78.2 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, reddish yellow, moderate reaction with HCl. **78.2 to 88.2 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subrounded sand; about 15 percent fines of low plasticity with quick dilatancy and low toughness; trace of hard drilled and subangular cobbles; maximum size 120 mm; dry, pink, strong reaction with HCl. **88.2 to 100.4 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, pinkish gray, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-4 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-34

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/6/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 764,941.8 E 570,753.04
TOTAL DEPTH: 628.2 ft.
DEPTH TO BEDROCK: 115.4 ft.

STATE: Nevada
GROUND ELEVATION: 3684.12
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215						(SP-SM)gc; (GM)sc; Tmbt1; Tpki		**100.4 to 101.9 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, angular sand; about 45 percent coarse to fine, hard, angular gravel; about 10 percent fines of low plasticity with slow dilatancy and low toughness; trace of hard drilled cobbles; maximum size 120 mm; dry, light gray, strong reaction with HCl. **101.9 to 115.4 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 15 percent fines of low plasticity with slow dilatancy and low toughness; trace of hard drilled cobbles; maximum size 120 mm; dry, light gray, strong reaction with HCl. **115.4 to 138.1 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded, reworked tuff, massively bedded, nonwelded, clay altered locally, white, very pale brown, 14 to 25 percent pumice, 5 to 10 percent volcanic lithic fragments, 5 to 10 percent crystal fragments of feldspar, quartz and magnetite. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD). **138.1 to 266.0 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow and pumice fall deposits, non to slightly welded, crystallized, locally clay altered, white, light gray, pale yellow, 5 to 80 percent pumice, 1 to 30 percent volcanic lithic fragments, 1 to 3 percent crystal fragments of sanidine and plagioclase, 1 or less than 1 percent biotite, magnetite, hornblende and sphene. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).

Figure RAI 2.2.1.1.1-004-4 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-34

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/6/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 764,941.8 E 570,753.04
TOTAL DEPTH: 628.2 ft.
DEPTH TO BEDROCK: 115.4 ft.

STATE: Nevada
GROUND ELEVATION: 3684.12
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220						Tpki		
	225								
	230								
	235								
	240								
	245								
	250								
	255								
	260								
	265								
	270						Tpbt5		**266.0 to 277.0 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded and reworked pumice fall deposits, moderately to poorly indurated, crystallized, pinkish white, white, very pale brown, 2 to 15 percent pumice, 1 percent or less lithic fragments, 1 to 5 percent crystal fragments of feldspar and biotite. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	275								
	280						Tpcrv		**277.0 to 285.4 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded, crystallized, very pale brown, light reddish brown, reddish brown, dusky red, 8 to 15 percent pumice, less than 1 percent lithic fragments of welded tuff, 3 to 15 percent crystal fragments of plagioclase, sanidine and lesser biotite, pyroxene and hornblende. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	285	4		5	100	88			**285.4 to 365.4 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely welded crystallized, pale red, reddish gray, light reddish gray, 5 to 25 percent pumice, less than 2 percent lithophysae locally, less than 1 percent lithic fragments of volcanic tuff, less than 5 to 12 percent crystal fragments. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
		5		6	98	36			
	290	5		5	96	70			
	295	4		7	96	31			
	300	4		4	84	91			
	305	4		4	100	68			
	310	0		0	0	0	Tpcrn		
		4		7	100	55			
	315	4		5	96	80			
	320	4		6	100	62			
	325	4		7	98	55			
	330	4		6	96	67			
	335	4		9	59	10			

Figure RAI 2.2.1.1.1-004-4 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-34

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/6/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 764,941.8 E 570,753.04
TOTAL DEPTH: 628.2 ft.
DEPTH TO BEDROCK: 115.4 ft.

STATE: Nevada
GROUND ELEVATION: 3684.12
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		8	85	30	Tpcrn		
	345	4		9	56	7			
	350	4		8	93	18			
		4		7	89	55			
	355	0		0	0	0			
		4		7	76	43			
	360	4		6	84	48			
	365	4		7	8	0	Tpcpun		**365.4 to 393.5 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, pale red, 2 to 5 percent pumice, less than 1 percent lithophysae, 2 to 5 percent crystal fragments of sanidine and plagioclase with lesser biotite and rare hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	370	4		7	4	0			
	375	4		5	100	81			
	380	3		6	76	21			
	385	3		7	88	48			
	390	4		8	65	0			
	395	4		9	61	0	Tpcpul		**393.5 to 438.6 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pinkish gray to pale red with mottled pattern, 2 percent pumice, about 5 percent lithophysae, about 3 percent crystal fragments of sanidine and plagioclase with lesser biotite and rare hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is unconformable and sharp (faulted).
	400	4		8	88	22			
		4		7	100	14			
	405	4		7	100	12			
		4		9	56	0			
	410	4		4	100	70			
	415	4		5	100	50			
	420	4		5	100	48			
	425	3		4	100	100			
	430	3		7	81	0			
		4		6	67	18			
	435	4		9	0	0			
	440	0		0	0	0	Breccia/Fault Zone		**438.6 to 482.7 ft. BRECCIA/FAULT ZONE:** Contains rotated and fragmented blocks from the Tiva Canyon Tuff Crystal-Poor Middle Nonlithophysal Zone (Tpcpmn): Pyroclastic flow, densely welded, crystallized, pale red with gray streaks, about 1 percent pumice, less than 1 percent lithic fragments, about 2 percent crystal fragments of sanidine and plagioclase with lesser biotite and rare hornblende. Generally the breccia/fault zone is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is sharp (faulted).
		4		9	54	0			
	445	4		8	92	32			
	450	4		9	30	0			
		3		7	73	44			
	455	3		9	100	0			
		3		9	88	21			
		3		4	69	47			

Figure RAI 2.2.1.1.1-004-4 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-34

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/6/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 764,941.8 E 570,753.04
TOTAL DEPTH: 628.2 ft.
DEPTH TO BEDROCK: 115.4 ft.

STATE: Nevada
GROUND ELEVATION: 3684.12
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	460	3		4	69	47		
		3		9	68	0		
		3		9	57	0		
	465	4		9	43	0		
	470	3		6	100	22	Breccia/Fault Zone	
		3		6	100	45		
	475	~~3~~		~~9~~	~~100~~	~~0~~		
		3		6	100	62		
		3		6	100	40		
	480	3		4	97	60		
	485	3		4	89	53		
		3		9	68	0		
	490	3		9	24	0		
	495	3		4	94	57		
	500	~~3~~		~~5~~	~~100~~	~~50~~		
		3		9	100	17		
		3		9	100	0		
	505	3		9	100	0		
		3		6	93	25	Tpcpln	
	510	3		6	100	43		
	515	3		7	100	31		
		3		8	97	34		
	520	3		9	100	28		
		3		6	98	44		
	525	3		5	100	76		
	530	4		6	94	41	Breccia/Fault Zone	
	535	4		5	96	65		
	540	4		5	100	50		
	545	4		7	100	42	Tpy/Tpcpv	
	550	4		6	88	54		
	555	4		4	69	29		
	560	5		7	100	35	Breccia/Fault Zone; Tptrv	
	565	4		6	98	54		
	570	4		5	100	88	Tptrm	
	575	4		4	100	95		

CLASSIFICATION AND PHYSICAL CONDITION

482.7 to 532.6 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln): Pyroclastic flow, densely welded, crystallized, pale red, reddish gray, gray, mottled locally, pumice absent above 512.5 ft, 3 to 5 percent pumice below, 1 to 2 percent lithic fragments, 2 percent crystal fragments of sanidine and plagioclase, with lesser biotite and rare hornblende. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp (faulted).

Note: Available data for the interval 532.6 to 560.6 ft can support two interpretations, but is insufficient to eliminate either. Alternate interpretations are presented below.

Interpretation A:
532.6 to 535.3 ft. BRECCIA/FAULT ZONE: Blocks of rotated Tiva Canyon Tuff Crystal-Poor Lower Nonlithophysal Zone (Tpcpln). Lowermost part of Tiva Canyon Crystal-Poor Lower Nonlithophysal zone, the Crystal-Poor Vitric Zone, and the upper vitric portion of the Yucca Mountain Tuff are removed by faulting. Generally the breccia/fault zone is moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6). Lower contact is sharp (faulted).
535.3 to 560.6 ft. YUCCA MOUNTAIN TUFF (Tpy): Pyroclastic flow, non to moderately welded, crystallized, vitric locally, pink, very pale brown, 5 to 10 percent pumice, less than 1 to 2 percent lithic fragments, 2 percent crystal fragments of sanidine, plagioclase and lesser biotite. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp (faulted).
Interpretation B:
532.6 to 535.3 ft. BRECCIA ZONE, BRECCIA/FAULT ZONE: Blocks of rotated Tiva Canyon Tuff Crystal-Poor Lower Nonlithophysal Zone (Tpcpln). Generally this zone is moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6). Lower contact is sharp (faulted).
535.3 to 560.6 ft. TIVA CANYON TUFF CRYSTAL-POOR VITRIC ZONE (Tpcpv): Pyroclastic flow, non to moderately welded, crystallized, vitric locally, pink, very pale brown, 5 to 10 percent pumice, less than 1 to 2 percent lithic fragments, 2 percent crystal fragments of sanidine, plagioclase and lesser biotite. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp (faulted).
560.6 to 561.3 ft. BRECCIA/FAULT ZONE: Breccia blocks, light reddish brown. Generally the this zone is moderately soft (H5) and intensely fractured (FD7).

Figure RAI 2.2.1.1.1-004-4 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-34

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/6/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 764,941.8 E 570,753.04
TOTAL DEPTH: 628.2 ft.
DEPTH TO BEDROCK: 115.4 ft.

STATE: Nevada
GROUND ELEVATION: 3684.12
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		4		4	100	95			The lower portion of the Yucca Mountain Tuff (Tpy), all of PTN bedded tuffs, Pah Canyon Tuff (Tpp), and the Pre-Pah Canyon bedded tuffs have been removed by faulting. Contact with underlying unit is sharp, dipping at about 45 degrees to the core axis. **561.3 to 566.0 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH VITRIC ZONE (Tptrv):** Pyroclastic flow, nonwelded, vitric, white, pale yellow. Unit rests conformably on underlying unit; welded portions of this zone possibly were not emplaced. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to mostly intensely fractured (FD7). Lower contact is conformable and gradational. **566.0 to 619.9 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tptrn):** Pyroclastic flow, densely welded crystallized, pinkish gray, reddish gray, pale red, white vapor-phase striations below about 598 ft, 20 to 30 percent pumice, less than 1 percent volcanic lithic fragments, 10 to 15 percent crystal fragments of sanidine, plagioclase, lesser biotite and rare hornblende. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is undetermined.
	580	4		4	100	74			
	585	4		4	96	73			
	590	4		6	100	57			
	595	4		4	98	89	Tptrn		
	600	4		3	100	97			
	605	4		4	100	85			
	610	4		4	100	91			
	615	4		4	100	76			
	620								
	625								
		BOTTOM OF HOLE							

Figure RAI 2.2.1.1.1-004-4 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-35

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 10/3/2006 FINISHED: 7/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,762.53 E 573,480.05
TOTAL DEPTH: 624.8 ft.
DEPTH TO BEDROCK: 110.7 ft.

STATE: Nevada
GROUND ELEVATION: 3693.82
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS-224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit from 0.0 to 10.0'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 4.8' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 197.9'. Change over to LS224 Core Rig with 3-7/8" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 624.6'. Remove casing and coring system. Ream hole with 6-1/4" tricone bit to total depth of 624.8' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to 4.8'. 9" casing from 0.0 to 197.9'. 4-1/2" casing from 197.9 to 624.6'. **Hole Completion:** Remove 4-1/2" casing and 9" casing. Install 3-1/2" PVC casing to depth of 624.4'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 624.8' (TD) up to 15' below ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(GM)sc (SP)g (GP-GM)s (SP)g (GP)s (SP)gc (GP-GM)s (SP-SM)g (GP-GM)s (SP)g (GP)sc (SP-SM)g (GP-GM)s (SP-SM)gc (GP-GM)sc (SP-SM)gc (SP-SM)g (SP)g (GP-GM)s (SM)gc (GP-GM)s (SP)g (GP-GM)sc (SP-SM)gc (GP-GM)s (SP)g (GP-GM)s (GP-GM)g (GP)sc (SP)g (GP)sc (SP)g (GP-GM)s (SP-SM)g (GP-GM)sc		**0.0 to 110.7 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 2.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 45 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 15 percent fines of low plasticity, with medium dry strength, quick dilatancy, and medium toughness; trace of hard, subrounded cobbles; maximum size 125 mm; dry, pale yellow, strong reaction with HCl. Roots and twigs present, topsoil. **2.0 to 2.8 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 25 mm; dry, light yellowish brown, no reaction with HCl. **2.8 to 6.8 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pink, strong reaction with HCl. **6.8 to 11.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, angular to subangular sand; about 50 percent coarse to fine, hard, angular to subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 65 mm; dry, pink, weak reaction with HCl. **11.0 to 13.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 65 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, strong reaction with HCl. **13.0 to 14.6 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 50 percent coarse to fine, subangular sand; about 45 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 80 mm; dry, pink, strong reaction with HCl. **14.6 to 15.9 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, pink, strong reaction with HCl. **15.9 to 17.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 45 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, no reaction with HCl. **17.0 go 23.0 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 60 percent coarse to fine, hard, angular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent fines of low plasticity with no to low dry strength, quick dilatancy and medium toughness; maximum size 50 mm; dry, very pale brown, no reaction with HCl. **23.0 to 24.6 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, very pale brown, no reaction with HCl. **24.6 to 27.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 45 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 100 mm; dry, light yellowish brown, no reaction with HCl. **27.0 to 28.9 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 55 mm; dry, pinkish gray, strong reaction with HCl. **28.9 to 30.0 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pink, strong reaction with HCl. **30.0 to 32.7 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 125 mm; dry, light yellowish brown, strong reaction with HCl. **32.7 to 37.8 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 100 mm; dry, very pale brown, strong reaction with HCl. **37.8 to 41.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 80 mm; dry, pink, strong reaction with HCl. **41.0 to 56.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and medium toughness; maximum size 75 mm; dry, reddish yellow, strong reaction with HCl. **56.8 to 58.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, pink, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-5 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-35

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 10/3/2006 FINISHED: 7/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,762.53 E 573,480.05
TOTAL DEPTH: 624.8 ft.
DEPTH TO BEDROCK: 110.7 ft.

STATE: Nevada
GROUND ELEVATION: 3693.82
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195						(GP-GM)sc; Tmbt1		**58.0 to 59.0 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, angular to subangular gravel; about 35 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with no to low dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, pinkish gray, strong reaction with HCl. **59.0 to 61.0 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 50 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, angular gravel; about 15 percent fines of low plasticity with low to medium dry strength, quick dilatancy and medium toughness; trace of hard subangular cobbles; maximum size 140 mm; dry, light pink, strong reaction with HCl. **61.0 to 65.0 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pink, no to strong reaction with HCl. **65.0 to 66.3 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 65 percent coarse to fine, angular to subangular sand; about 35 percent predominantly fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low dry strength; maximum size 25 mm; dry, pale brown, no reaction with HCl. **66.3 to 68.7 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 120 mm; dry, light reddish brown, none to strong reaction with HCl. **68.7 to 72.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent predominantly fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; dry, pink, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subrounded to subangular cobbles; maximum size 145 mm; remainder minus 3-inch. **72.0 to 72.8 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, light reddish brown, strong reaction with HCl. **72.8 to 74.5 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, pinkish gray, strong reaction with HCl. **74.5 to 75.3 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, very pale brown, strong reaction with HCl. **75.3 to 76.2 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with low to medium dry strength, quick dilatancy and low toughness; maximum size 30 mm; dry, pale yellow, strong reaction with HCl. **76.2 to 79.8 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 55 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 130 mm; dry, light gray, strong reaction with HCl. **79.8 to 81.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 15 mm; dry, light yellowish brown, no reaction with HCl. **81.7 to 86.6 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 125 mm; dry, pale brown, strong reaction with HCl. **86.6 to 87.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, pale brown, strong reaction with HCl. **87.7 to 88.6 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, very pale brown, strong reaction with HCl. **88.6 to 90.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, very pale brown, no reaction with HCl. **90.8 to 110.7 ft. POORLY GRADED GRAVEL WITH SILT, SAND, AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; dry, pink, no reaction with HCl. Includes sandy intervals from 94.3 to 94.8 ft, 103.5 to 104.0 ft, and 105.7 to 106.0 ft. TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular and drilled cobbles; maximum size 150 mm; remainder minus 3-inch.
	200	5		9	88	0	Tpki		**110.7 to 197.9 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, pumice fall deposits, massively bedded, locally reworked, vitric, locally argillic, white, very pale brown, 0 to 90 percent pumice, 1 to 5 percent lithic fragments, less than 5 to 30 percent crystal fragments of sanidine, plagioclase, minor quartz, minor magnetite, minor to rare biotite and hornblende. Generally the tuff is moderately soft (H5), slightly weathered to fresh (W2), and very intensely fractured (FD9). Lower contact is unconformable and sharp. **197.9 to 358.7 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pumice fall deposits, nonwelded vitric to locally crystallized, white, pale yellow, very pale brown, 5 to 80 percent pumice, less than 1 to 20 percent lithic fragments of volcanic rock, less than 1 to 10 percent crystal fragments of plagioclase, sanidine, lesser biotite and rare sphene. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to very intensely fractured (FD9) averaging slightly to very slightly fractured (FD2). Lower contact is unconformable and sharp, irregular, dipping 80 degrees to core axis.
	205	4		7	92	31			
	210	4		3	100	100			
	215	4		5	100	84			
		4		4	100	100			

Figure RAI 2.2.1.1.1-004-5 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-35

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 10/3/2006 FINISHED: 7/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,762.53 E 573,480.05
TOTAL DEPTH: 624.8 ft.
DEPTH TO BEDROCK: 110.7 ft.

STATE: Nevada
GROUND ELEVATION: 3693.82
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		3	100	100	Tpki		
	225	4		1	100	100			
	230	4		5	98	84			
	235	4		5	96	71			
	240	4		0	100	99			
	245	4		1	100	99			
	250	4		3	100	95			
	255	4		1	100	100			
	260	4		0	100	100			
	265	4		0	100	100			
	270	4		0	100	100			
	275	4		1	100	99			
	280	4		0	100	98			
	285	4		4	100	90			
	290	4		4	100	92			
	295	4		1	100	97			
	300	4		4	100	93			
	305	4		1	100	99			
	310	4		0	100	100			
	315	4		1	100	99			
	320	4		2	100	97			
	325	4		2	100	91			
	330	4		4	100	98			
	335	4		1	100	100			

Figure RAI 2.2.1.1.1-004-5 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-35

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 10/3/2006 FINISHED: 7/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,762.53 E 573,480.05
TOTAL DEPTH: 624.8 ft.
DEPTH TO BEDROCK: 110.7 ft.

STATE: Nevada
GROUND ELEVATION: 3693.82
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	340	4		1	100	100		
		4		1	100	100		
	345	4		0	100	100	Tpki	
	350	4		1	98	94		
	355	5		2	100	90		
	360	5		3	100	89		
	365	5		5	100	93	Tpbt5	
	370	4		5	100	77		
	375	3		8	100	21	Tpcrv	
	380	3		6	100	84		
	385	4		6	100	63		
		4		7	100	24		
	390	4		6	100	54		
	395	4		6	98	62		
	400	4		7	100	47		
	405	4		8	100	33		
	410	4		7	95	41		
	415	4		9	76	0		
		4		5	100	40	Tpcrn	
	420	4		5	98	78		
	425	4		5	100	70		
	430	4		5	100	60		
	435	4		6	96	66		
	440	4		6	96	41		
	445	4		7	100	60		
	450	4		8	100	38		
	455	4		8	96	39		

CLASSIFICATION AND PHYSICAL CONDITION

358.7 to 373.5 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5): Bedded tuffs, pyroclastic flows, nonwelded, crystallized, pink, reddish-yellow, pale red, pinkish-gray, light gray, very pale brown, white, light brownish-gray, 15 to 30 percent pumice, less than 1 to 5 percent lithic fragments of volcanic rock, 2 to 5 percent crystal fragments of plagioclase, sanidine, and lesser biotite. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), slightly weathered (W3) to mostly slightly weathered to fresh (W2), slightly to very slightly fractured (FD2) to moderately fractured (FD5) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp, slightly irregular, and 80 degrees to the core axis.

373.5 to 376.1 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv): Pyroclastic flow, densely welded, crystallized to vitric, pinkish gray, dark gray, light reddish-brown, 15 to 40 percent pumice, less than 1 percent lithic fragments, 10 to 15 percent crystal fragments of sanidine, plagioclase, and lesser biotite. Generally the tuff is soft (H6) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely fractured (FD7). Lower contact is conformable and gradational.

376.1 to 468.0 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, densely welded, crystallized, dusky red, pale red, reddish-gray, light reddish-gray, less than 5 to 25 percent pumice, less than 2 percent lithophysae locally, less than 1 percent lithic fragments of volcanic rock, less than 5 to 15 percent crystal fragments of sanidine, plagioclase, and lesser biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.

Figure RAI 2.2.1.1.1-004-5 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-35

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 10/3/2006 FINISHED: 7/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,762.53 E 573,480.05
TOTAL DEPTH: 624.8 ft.
DEPTH TO BEDROCK: 110.7 ft.

STATE: Nevada
GROUND ELEVATION: 3693.82
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		8	96	39			
		4		9	100	25			
		3		8	100	28	Tpcrn		
	465	3		6	100	50			
	470	3		7	100	28			**468.0 to 491.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, reddish-gray, pale red, 5 to 10 percent pumice, less than 1 percent lithophysae, 2 to 5 percent crystal fragments of sanidine, plagioclase, with lesser biotite and rare hornblende. Generally the tuff is hard (H3), fresh (W1), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	475	3		7	100	56			
	480	3		7	100	38	Tpcpun		
	485	3		7	100	27			
		3		9	56	0			
	490	3		8	100	24			
		3		9	100	0			**491.0 to 564.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pinkish-gray, pale red, 2 percent pumice, 5 to 10 percent lithophysae, 3 percent crystal fragments of sanidine, plagioclase, with lesser biotite and rare hornblende. Generally the tuff is hard (H3), fresh (W1), moderately fractured (FD5) to very intensely fractured (FD9) very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
		3		9	100	0			
	495	3		9	100	30			
		3		9	100	0			
		3		9	100	0			
	500	3		9	92	0			
		3		9	80	0			
		3		9	100	0			
	505	3		7	92	54			
	510	3		6	98	69			
	515	3		8	74	22			
	520	3		6	92	47			
		3		8	86	20			
	525	3		9	68	0			
		3		7	90	48	Tpcpul		
	530	3		9	78	0			
		3		7	71	28			
	535	3		7	64	16			
		3		7	79	19			
	540	3		7	100	38			
	545	3		6	100	63			
	550	3		5	92	67			
	555	3		7	95	30			
	560	3		7	100	28			
		3		7	97	24			
	565	3		8	100	27			**564.0 to 619.5 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, dark reddish-gray, up to 5 percent pumice, less than 1 to 5 percent lithophysae, less than 1 percent lithic fragments of welded volcanic rock, 2 percent crystal fragments of plagioclase, sanidine, and lesser biotite. Generally the tuff is hard (H3), fresh (W1), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	570	3		8	100	36	Tpcpmn		
	575	3		6	100	42			
		3		7	100	28			

Figure RAI 2.2.1.1.1-004-5 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-35

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 10/3/2006 FINISHED: 7/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,762.53 E 573,480.05
TOTAL DEPTH: 624.8 ft.
DEPTH TO BEDROCK: 110.7 ft.

STATE: Nevada
GROUND ELEVATION: 3693.82
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	580	3		7	100	28	Tpcpmn		
		3		6	100	62			
	585	3		7	100	65			
	590	3		6	100	73			
	595	3		6	98	59			
	600	3		5	100	67			
	605	3		6	100	63			
	610	3		7	100	37			
	615	3		8	100	42			
	620	3		8	91	26	Tpcpll		**619.5 to 624.6 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, pale red, dark reddish-gray, 5 percent pumice, 5 percent lithophysae, 2 percent crystal fragments of sanidine, plagioclase, and lesser biotite. Generally the tuff is hard (H3), fresh (W1), very intensely to intensely fractured (FD8). Lower contact is undetermined.
									BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-5 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-36

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/6/2006 FINISHED: 12/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,479.71 E 572,154.56
TOTAL DEPTH: 588.3 ft.
DEPTH TO BEDROCK: 171.8 ft.

STATE: Nevada
GROUND ELEVATION: 3664.56
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
Boart Longyear

Drilling Method:
Sonic core with 12-3/4" bit from 0.0 to 6.8'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 5.0' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 227.8'. Drill 227.8 to 299.2' with 7-5/16" down hole hammer. Change over to LS224 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 588.3' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
Set 10-3/4" conductor casing from 0.0' to 5.0'. 9" casing from 0.0 to 227.8'. 4-1/2" casing from 227.8 to 588.3' (TD).

Hole Completion:
Remove casing and coring system. Plug and abandon hole by back filling with 3/8" coarse grade bentonite chips from 588.3'(TD) up to ground level.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
5						(GP)sc	
10						(SP)g	
						(GP-GM)s	
						(GP)s	
						(SP)g	
15						(GP-GM)sc	
						(SP)g	
						(GP)s	
20						(SP)g	
						GP	
						(GP-GM)s	
25						(SP)g	
						(SP-SM)g	
30						(GP-GM)s	
						(SP)g	
35						(GP-GM)s	
40						(SP-SM)g	
						(GP)s	
						(SP-SM)g	
45						(GP-GM)sc	
						(GP)s	
50						(SP-SM)g	
						(GP-GM)sc	
55						(SP)gc	
60						(GP-GM)sc	
						(SP-SM)g	
65						(GP-GM)s	
						(GP)s	
70						(SP-SM)gc	
75						(GP)sc	
						(SP)gc	
						(GP-GM)s	
80						(SP-SM)g	
85						(GP)sc	
90							
95						(SP-SM)g	
						(SP)g	
						(SP-SM)gc	

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 171.8 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 9.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 75 percent coarse to fine, hard, angular to subangular gravel; about 20 percent coarse to fine, angular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 80 mm; dry, pale brown, no reaction with HCl.

9.5 to 11.8 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 60 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; moist, reddish brown, weak reaction with HCl.

11.8 to 12.7 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, light reddish brown, strong reaction with HCl.

12.7 to 14.2 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 75 percent coarse to fine, hard, subangular gravel; about 20 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, reddish yellow, no reaction with HCl.

14.2 to 15.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 65 mm; moist, brown, no reaction with HCl.

15.0 to 17.2 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc: About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; dry, pink, strong reaction with HCl.

TOTAL SAMPLE (BY VOLUME): About 30 percent hard, subangular to drilled cobbles; maximum size 125 mm; remainder minus 3-inch.

17.2 to 18.5 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 50 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 20 mm; moist, brown, no reaction with HCl.

18.5 to 20.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 55 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, light brown, weak reaction with HCl.

20.0 to 21.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 50 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; moist, brown, no reaction with HCl.

21.0 to 21.9 ft. POORLY GRADED GRAVEL (GP): About 85 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent coarse to fine, angular sand; about 5 percent fines of low plasticity with high dry strength, quick dilatancy and low toughness; maximum size 35 mm; dry, pink and gray, strong reaction with HCl.

21.9 to 24.7 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 60 percent coarse to fine, hard, subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, pink, no reaction with HCl.

24.7 to 25.6 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 85 percent coarse to fine, angular sand; about 15 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 25 mm; dry, pink, no reaction with HCl.

25.6 to 28.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 75 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, light gray, no reaction with HCl.

28.7 to 32.2 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 65 percent coarse to fine, hard, subangular gravel; about 25 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, white and light gray, no reaction with HCl.

32.2 to 34.9 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 70 percent coarse to fine, angular to subangular sand; about 25 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pink, no reaction with HCl.

34.9 to 40.0 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 65 percent coarse to fine, hard, subangular to subrounded gravel; about 25 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, light reddish brown, no reaction with HCl.

40.0 to 40.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 45 percent coarse to fine, subangular sand; about 45 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, light reddish brown, weak reaction with HCl.

40.7 to 41.9 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 65 percent coarse to fine, hard, subangular to subrounded gravel; about 30 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-6 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-36

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/6/2006 FINISHED: 12/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,479.71 E 572,154.56
TOTAL DEPTH: 588.3 ft.
DEPTH TO BEDROCK: 171.8 ft.

STATE: Nevada
GROUND ELEVATION: 3664.56
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215						(GP-GM)sc; (SP-SM)g; (GP-GM)s; (GP-GM)g; (GP-GM)sc; Tmr		**41.9 to 43.5 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, pink, strong reaction with HCl. **43.5 to 45.0 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard cobbles; maximum size 80 mm; dry, pinkish white, strong reaction with HCl. **45.0 to 51.9 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 70 percent coarse to fine, hard, subangular gravel; about 25 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, very pale brown, strong reaction with HCl. **51.9 to 52.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent fines of low plasticity with medium dry strength, quick dilatancy and low toughness; maximum size 20 mm; dry, pink, no reaction with HCl. **52.6 to 55.4 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular sand; about 10 percent fines of low plasticity, with very high dry strength, quick dilatancy and medium toughness; trace of hard cobbles; maximum size 80 mm; dry, pinkish gray, strong reaction with HCl. **55.4 to 59.9 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 60 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 125 mm; dry, light reddish brown, no reaction with HCl. **59.9 to 62.5 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, subangular to subrounded gravel; about 30 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with high dry strength, quick dilatancy and low toughness; trace of hard cobbles; maximum size 100 mm; dry, pink, strong reaction with HCl. **62.5 to 64.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with high dry strength, quick dilatancy and low toughness; maximum size 30 mm; dry, pinkish gray, strong reaction with HCl. **64.7 to 65.7 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 70 percent coarse to fine, hard, angular to subrounded gravel; about 20 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with medium dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, pinkish gray, strong reaction with HCl. **65.7 to 71.5 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, pinkish gray, strong reaction with HCl. **71.5 to 75.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 90 mm; dry, pink, no reaction with HCl. **75.0 to 75.8 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 50 percent coarse to fine, hard, subangular gravel; about 45 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 90 mm; dry, light reddish brown, no reaction with HCl. **75.8 to 77.6 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 50 percent coarse to fine, subangular sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; dry, pink, weak reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 50 percent hard, drilled cobble; maximum size 125 mm; remainder minus 3-inch. **77.6 to 79.5 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 70 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, pink, strong reaction with HCl. **79.5 to 80.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 15 mm; dry, pink, weak reaction with HCl. **80.1 to 93.4 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, angular to subrounded sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of subangular to subrounded cobbles; maximum size 95 mm; dry, pink, strong reaction with HCl. **93.4 to 95.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 25 mm; dry, light reddish brown, no reaction with HCl. **95.4 to 97.2 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 80 percent coarse to fine, subangular sand; about 15 percent predominantly fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 25 mm; dry, light reddish brown, no reaction with HCl. **97.2 to 99.7 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent fines of low plasticity with high dry strength, quick dilatancy and medium toughness; dry, pinkish gray, no reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 25 percent hard drilled cobbles; maximum size 120 mm; remainder minus 3-inch. **99.7 to 135.2 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with high dry strength, quick dilatancy and low toughness; dry, pink, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular and drilled cobbles; maximum size 120 mm; remainder minus 3-inch.

Figure RAI 2.2.1.1.1-004-6 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-36

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/6/2006 FINISHED: 12/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,479.71 E 572,154.56
TOTAL DEPTH: 588.3 ft.
DEPTH TO BEDROCK: 171.8 ft.

STATE: Nevada
GROUND ELEVATION: 3664.56
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	220						Tmr	
	225							
	230							
	235							
	240							
	245							
	250							
	255							
	260							
	265							
	270							
	275							
	280						Tmbt1	
	285							
	290							
	295							
	300	7		6	84	26		
	305	7		4	100	81		
	310	7		4	98	87		
	315	7		5	100	61		
	320	7		4	98	75		
	325	5		4	100	89		
	330	4		3	100	85		
	335	5		4	100	69		

CLASSIFICATION AND PHYSICAL CONDITION

135.2 to 135.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with high dry strength, quick dilatancy, and low toughness; maximum size 50 mm; dry, pink, strong reaction with HCl.

135.7 to 136.7 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 60 percent coarse to fine, hard, subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with high dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, pinkish gray, strong reaction with HCl.

136.7 to 137.9 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 50 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent fines of low plasticity with high dry strength, quick dilatancy and medium toughness; maximum size 35 mm; dry, pink, strong reaction with HCl.

137.9 to 171.8 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc: About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; dry, pink, strong reaction with HCl.

TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular and drilled cobbles; maximum size 115 mm; remainder minus 3-inch.

171.8 to 225.2 ft. RAINIER MESA TUFF (Tmr): Pyroclastic flow, nonwelded, vitric, clay altered locally, light gray, white, light brownish-gray, 2 percent pumice, less than 5 percent lithic fragments of welded volcanic rock, 10 to 40 percent crystal fragments of sanidine, plagioclase, with minor quartz and biotite, rare magnetite. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).

225.2 to 381.3 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1): Bedded/reworked tuff, pumice fall deposits, paleosols, massively bedded, nonwelded, vitric to crystallized, clay altered locally, pinkish-gray, reddish-gray, pink, light gray, light reddish-brown, pinkish-gray, white, very pale brown, less than 1 to greater than 90 percent pumice, less than 1 to 25 percent silica nodules locally, 1 to 40 percent lithic fragments of welded volcanic rock, 2 to 35 percent crystal fragments of feldspar with minor biotite, quartz, and magnetite. Generally the tuff is moderately hard (H4) to very soft (H7) averaging soft (H6), slightly weathered to fresh (W2), unfractured (FD0) to very intensely to intensely fractured (FD8) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.

Figure RAI 2.2.1.1.1-004-6 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-36

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/6/2006 FINISHED: 12/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,479.71 E 572,154.56
TOTAL DEPTH: 588.3 ft.
DEPTH TO BEDROCK: 171.8 ft.

STATE: Nevada
GROUND ELEVATION: 3664.56
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	5		6	86	30			
		7		8	97	14			
	345	5		7	100	44			
	350	5		7	100	67			
	355	5		0	100	95			
	360	5		1	100	100	Tmbt1		
	365	5		3	98	86			
	370	5		2	98	94			
	375	5		5	94	78			
	380	4		3	94	98			**381.3 to 546.4 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, vitric to crystallized, white, pale yellow, very pale brown, less than 5 to 40 percent pumice, less than 5 to 30 percent lithic fragments of volcanic rock, less than 1 to 3 percent crystal fragments of sanidine, biotite (locally predominant), and rare magnetite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), very slightly fractured (FD1) to moderately fractured (FD5) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	385	4		3	100	98			
	390	4		1	100	98			
	395	4		1	100	96			
	400	4		3	100	99			
	405	4		4	100	83			
	410	4		2	98	98			
	415	4		4	100	87			
	420	4		3	98	92	Tpki		
	425	4		4	100	70			
	430	4		4	100	82			
	435	4		4	100	84			
	440	4		4	84	83			
	445	4		4	100	75			
	450	4		3	100	92			
	455	4		3	100	90			

Figure RAI 2.2.1.1.1-004-6 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-36

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/6/2006 FINISHED: 12/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,479.71 E 572,154.56
TOTAL DEPTH: 588.3 ft.
DEPTH TO BEDROCK: 171.8 ft.

STATE: Nevada
GROUND ELEVATION: 3664.56
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		4	100	83			
	465	4		4	96	85			
	470	4		3	100	97			
	475	4		3	100	92			
	480	4		3	98	96			
	485	4		3	100	94			
	490	4		4	100	94			
	495	4		4	98	88			
	500	4		4	100	82	Tpki		
	505	4		5	100	74			
	510	4		1	100	99			
	515	4		4	98	84			
	520	4		3	98	90			
	525	4		4	100	64			
	530	4		3	94	81			
	535	4		4	100	72			
	540	4		4	100	77			
	545	4		4	100	74			
	550	6		6	100	64	Tmbt5		**546.4 to 553.2 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tmbt5):** Bedded tuff, tuffaceous sandstone, nonwelded, vitric, clay altered, reworked locally, pinkish-gray, 10 percent pumice, less than 5 percent lithic fragments, less than 3 to 7 percent crystal fragments of sanidine, plagioclase, lesser biotite (locally predominant), hornblende and magnetite. Generally the tuff is moderately hard (H4) to soft (H6) averaging moderately soft (H5), slightly weathered (W3), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	555	4		6	94	73			**553.2 to 566.7 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded, vitric, vapor-phase alteration locally, white, pink, reddish-brown, brown, reddish-gray, reddish-yellow, 10 to 20 percent pumice, less than 1 percent lithic fragments, 5 to 20 percent crystal fragments of sanidine, plagioclase, minor biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is conformable and gradational over approximately 1 meter.
	560	4		4	100	64	Tpcrv		
	565	4		6	96	74			
	570	4		9	4	0	Tpcrn		**566.7 to 588.3 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, pale red, pink, 1 to 10 percent pumice, less than 1 percent lithic fragments locally, 5 to 15 percent crystal fragments of sanidine, plagioclase, rare biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
	575	4		5	89	82			

Figure RAI 2.2.1.1.1-004-6 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-36

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/6/2006 FINISHED: 12/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,479.71 E 572,154.56
TOTAL DEPTH: 588.3 ft.
DEPTH TO BEDROCK: 171.8 ft.

STATE: Nevada
GROUND ELEVATION: 3664.56
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		4		5	89	82			
	580	4		5	100	77	Tpcrn		
	585	4		6	98	69			
		BOTTOM OF HOLE							

Figure RAI 2.2.1.1.1-004-6 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-37

SHEET 1 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/31/2006 FINISHED: 6/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,562.35 E 571,995.84
TOTAL DEPTH: 724.8 ft.
DEPTH TO BEDROCK: 130.1 ft.

STATE: Nevada
GROUND ELEVATION: 3647.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS 224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit from 0.0 to 10.4'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 4.8' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 185.2'. Change over to LS 224 Core Rig with 3-7/8" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 724.4'. Remove casing and coring system. Change over to GP 24 300 RS Sonic Rig. Ream hole with 6-3/8" tricone bit to total depth of 724.8' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to 4.8'. 9" casing from 0.0 to 185.2'. 4-1/2" casing from 185.2 to 724.4'. **Hole Completion:** Remove 4-1/2" casing and 9" casing. Install 3-1/2" PVC casing to depth of 724.7'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 724.8' (TD) up to 5.4' below ground surface. Top of 3 1/2" PVC casing is 0.9' above ground level. Top of conductor casing is 1.2' above ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(GP-GM)s (GP)sc (GP-GM)sc (SP-SM)g (GP-GM)sc (SP-SM)gc (GP)sc (SP)g (GP)sc (SP-SM)g (GP-GM)sc (SP-SM)g (GP-GM)sc (SP-SM)gc (GP)s (SP)g (SM)gc (SP-SM)gc (GP)s (SP)g (GP)s (SP-SM)gc (SP-SM)g (SP-SM)gc		**0.0 to 130.1 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 1.5 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 65 percent coarse to fine, hard, angular gravel; about 35 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, strong reaction with HCl. **1.5 to 8.7 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 130 mm; dry, pink, strong reaction with HCl. **8.7 to 18.9 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 10 percent fines of low plasticity with low dry strength, quick dilatancy and medium toughness; trace of hard subangular cobbles; maximum size 155 mm; dry, light reddish brown, strong reaction with HCl. **18.9 to 19.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, angular to subangular sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 45 mm; dry, pink, strong reaction with HCl. **19.8 to 27.0 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular and drilled cobbles; maximum size 195 mm; dry, pink, no reaction with HCl. **27.0 to 35.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 110 mm; dry, pinkish gray, no reaction with HCl. **35.0 to 37.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 80 mm; dry, light brown, no reaction with HCl. **37.5 to 38.4 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, angular to subangular sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 25 mm; dry, light brown, no reaction with HCl. **38.4 to 44.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 110 mm; dry, pinkish gray, no reaction with HCl. **44.0 to 45.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 75 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, pinkish gray, strong reaction with HCl. **45.4 to 52.3 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular and drilled cobbles; maximum size 120 mm; dry, pinkish gray, strong reaction with HCl. **52.3 to 53.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 10 percent fines of low plasticity with medium dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, pinkish gray, strong reaction with HCl. **53.7 to 55.5 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular and drilled cobbles; maximum size 120 mm; dry, pink, strong reaction with HCl. **55.5 to 56.5 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent fines of low plasticity with medium dry strength, quick dilatancy and low toughness; trace of hard, subangular cobbles; maximum size 120 mm; dry, pink, strong reaction with HCl. **56.5 to 59.4 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, pink, strong reaction with HCl. **59.4 to 60.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, light reddish brown, weak reaction with HCl. **60.7 to 63.4 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 40 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent fines of low to medium plasticity with low dry strength, slow

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-7 (Sheet 1 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-37

SHEET 2 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/31/2006 FINISHED: 6/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,562.35 E 571,995.84
TOTAL DEPTH: 724.8 ft.
DEPTH TO BEDROCK: 130.1 ft.

STATE: Nevada
GROUND ELEVATION: 3647.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SP-SM)gc		dilatancy and low toughness; trace of hard subangular cobbles; maximum size 105 mm; dry, white, strong reaction with HCl. **63.4 to 65.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent fine, hard, subangular to subrounded gravel; about 10 percent non to low plasticity fines with low dry strength, quick to slow dilatancy, and low toughness; dry, white, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 40 percent hard, drilled and subrounded cobbles; maximum size 175 mm; remainder minus 3-inch.
	110						(SM)g		**65.0 to 67.8 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent fines of low plasticity with low dry strength, quick dilatancy and medium toughness; maximum size 75 mm; moist, light reddish gray, strong reaction with HCl.
	115						(GP)sc		**67.8 to 71.3 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 40 percent predominantly fine, hard, subangular to subrounded gravel; about 5 percent fines of low plasticity with no to low dry strength, quick dilatancy and low toughness; maximum size 75 mm; moist to dry, light reddish brown, light reddish gray and light gray, no to strong reaction with HCl.
	120						(SP-SM)g		**71.3 to 79.4 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent fines of low plasticity with no dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, light gray, strong reaction with HCl.
	125						(GP-GM)sc		**79.4 to 82.6 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low to medium plasticity with medium dry strength, slow dilatancy and medium toughness; trace of hard subangular cobbles; maximum size 90 mm; dry, light gray, moderate reaction with HCl.
	130						(SP-SM)g		**82.6 to 84.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity, low dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, pinkish gray and light gray, moderate to strong reaction with HCl.
	135								**84.7 to 111.2 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity with low dry strength, slow to quick dilatancy and low toughness; dry, white, strong reaction with HCl.
	140								TOTAL SAMPLE (BY VOLUME): About 5 percent hard subrounded and drilled cobbles; maximum size 145 mm; remainder minus 3-inch.
	145								**111.2 to 112.3 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent predominantly fine, hard, subangular to subrounded gravel; about 15 percent fines of medium plasticity with medium dry strength, slow dilatancy, and low toughness; maximum size 70 mm; dry, white, strong reaction with HCl.
	150								**112.3 to 120.6 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 45 percent coarse to fine subangular to subrounded sand; about 5 percent fines of low plasticity with low dry strength, slow to quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 125 mm; dry, white, strong reaction with HCl.
	155						Tmr		**120.6 to 122.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subrounded to rounded sand; about 30 percent coarse to fine, hard, subrounded to rounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy, and low toughness; maximum size 55 mm; dry, light reddish brown, strong reaction with HCl.
	160								**122.4 to 128.3 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subrounded to rounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; dry, light reddish brown, strong reaction with HCl.
	165								TOTAL SAMPLE (BY VOLUME): About 5 percent hard drilled and subangular cobbles; maximum size 150 mm; remainder minus 3-inch.
	170								**128.3 to 130.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, strong reaction with HCl.
	175								**130.1 to 179.1 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow, bedded tuff, and ash-fall tephra, nonwelded, vitric, white, very pale brown, pinkish white, light gray, yellowish red and gray mottled, about 5 percent pumice and abundant pumice fragments, less than 1 percent lithic fragments of densely welded tuff, less than 1 to 20 percent phenocrysts of feldspar and lesser quartz, less than 1 percent biotite, abundant hornblende locally. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	180								**179.1 to 305.7 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded and reworked tuff and pumice fall deposits, nonwelded, massively bedded, vitric, zeolitic and argillic locally, pale brown, light brown, very pale brown, white, light gray, pale yellow, 1 to 90 percent pumice, 1 to 15 percent lithic fragments of welded tuff and lava, 3 to 10 percent crystal fragments of feldspar and lesser quartz, less than 1 percent hornblende, biotite, pyroxene, magnetite. Generally the tuff is hard (H3) to very soft (H7) averaging moderately soft (H5), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	185	7		9	100	0			
	190	7		9	82	17			
	195	5		6	66	42			
	200	5		6	98	55	Tmbt1		
	205	6		7	92	0			
	210	6		6	94	64			
	215	6		6	100	79			
		6		5	94	64			

Figure RAI 2.2.1.1.1-004-7 (Sheet 2 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-37

SHEET 3 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/31/2006 FINISHED: 6/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,562.35 E 571,995.84
TOTAL DEPTH: 724.8 ft.
DEPTH TO BEDROCK: 130.1 ft.

STATE: Nevada
GROUND ELEVATION: 3647.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	6		6	100	59			
	225	6		6	96	53			
	230	6		7	98	64			
	235	7		5	100	65			
	240	4		4	100	91			
	245	4		3	98	91			
	250	5		5	94	65			
	255	5		6	92	56			
	260	4		4	95	84	Tmbt1		
	265	4		4	100	80			
	270	4		5	96	67			
	275	4		3	100	74			
	280	4		3	100	95			
	285	4		6	92	69			
	290	4		3	100	88			
		4		5	71	72			
	295	4		6	88	35			
	300	4		5	98	87			
	305	4		7	88	21			**305.7 to 454.5 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded to partially welded, crystallized, white, pale yellow, 20 to 30 percent pumice, 5 to 10 percent lithic fragments of crystallized welded tuff, 2 percent feldspar phenocrysts, less than 1 percent hornblende, biotite, magnetite, and rare sphene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to very intensely fractured (FD9) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	310	4		6	73	54			
	315	4		7	74	14			
	320	4		6	100	67	Tpki		
	325	4		6	100	62			
	330	4		9	14	0			
	335	4		9	41	0			

Figure RAI 2.2.1.1.1-004-7 (Sheet 3 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-37

SHEET 4 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/31/2006 FINISHED: 6/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,562.35 E 571,995.84
TOTAL DEPTH: 724.8 ft.
DEPTH TO BEDROCK: 130.1 ft.

STATE: Nevada
GROUND ELEVATION: 3647.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		4		9	100	0			
	340	4		9	68	0			
		4		8	100	33			
	345	4		5	100	100			
	350	4		4	92	71			
	355	4		4	92	75			
	360	4		1	96	98			
	365	4		4	98	93			
	370	4		3	100	0			
		4		4	50	92			
	375	4		4	100	95			
	380	4		2	98	100			
	385	4		0	100	96			
	390	4		1	96	90			
		4		1	100	97			
	395	4		4	98	69	Tpki		
	400	4		1	82	93			
	405	4		0	100	100			
	410	4		3	100	100			
	415	4		3	100	94			
	420	4		3	100	100			
	425	4		3	100	92			
	430	4		2	100	98			
	435	4		3	100	91			
	440	4		3	100	98			
	445	4		3	98	92			
	450	4		7	100	0			
		4		3	57	90			
	455	4		8	100	0			**454.5 to 462.5 ft. POST-TIVA CANYON TUFF BEDDED TUFFS (Tpbt5):** Reworked tephra, ash-fall tuff, nonwelded, partially vitric, partially crystallized, very pale brown, pale yellow, pale
		4		6	63	80	Tpbt5		

Figure RAI 2.2.1.1.1-004-7 (Sheet 4 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-37

SHEET 5 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/31/2006 FINISHED: 6/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,562.35 E 571,995.84
TOTAL DEPTH: 724.8 ft.
DEPTH TO BEDROCK: 130.1 ft.

STATE: Nevada
GROUND ELEVATION: 3647.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		5	100	54	Tpbt5		olive, 10 to 30 percent pumice, 1 to 10 percent lithic fragments of welded tuff, 3 to 5 percent feldspar crystal fragments, less than or equal to 1 percent biotite, pyroxene and hornblende. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
		4		7	82	81			**462.5 to 476.0 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded (starting at 470.3 ft), crystallized, very pale brown, pink, pale yellow, light gray, 10 to 15 percent pumice, less than 1 percent lithic fragments of densely welded tuff, 10 percent feldspar phenocrysts, 1 percent biotite, lesser pyroxene and rare hornblende. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	465	4		8	100	10	Tpcrv		
	470	4		8	65	41			
		4		4	100	69			
	475	4		9	100	0			**476.0 to 558.2 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, partially to moderately and densely welded, crystallized, pale red, light bluish gray, white, light gray, 5 to 25 percent pumice, less than 1 percent lithic fragments of welded tuff locally, 7 to 15 percent phenocrysts of feldspar, less than 1 percent biotite, 1 to 5 percent lithophysae locally. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	480	4		4	39	61			
	485	4		5	94	68			
	490	4		6	100	44			
	495	4		6	100	62			
	500	4		6	100	63			
	505	4		9	100	9			
	510	4		7	96	15			
	515	4		5	98	46	Tpcrn		
	520	4		6	88	37			
	525	4		4	96	87			
	530	4		5	96	74			
	535	4		6	96	51			
	540	4		8	100	0			
	545	4		8	93	38			
	550	4		5	73	72			
	555	4		4	100	69			
	560	4		5	94	67			**558.2 to 592.4 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, reddish gray, pinkish gray, pale red and light bluish gray mottled, 6 to 8 percent pumice, 1 to 2 percent lithophysae, 2 to 4 percent feldspar phenocrysts, less than 1 percent biotite, rare manganese oxide. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	565	4		6	94	39	Tpcpun		
	570	4		6	96	44			
	575	4		6	91	45			

Figure RAI 2.2.1.1.1-004-7 (Sheet 5 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-37

SHEET 6 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/31/2006 FINISHED: 6/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,562.35 E 571,995.84
TOTAL DEPTH: 724.8 ft.
DEPTH TO BEDROCK: 130.1 ft.

STATE: Nevada
GROUND ELEVATION: 3647.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		4		6	91	45	Tpcpun		
	580	3		8	98	21			
		3		9	100	0			
	585	4		7	82	27			
	590	4		6	31	34			
	595	4		7	92	12	Tpcpul		**592.4 to 678.1 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, light gray, pinkish gray, pale red, reddish gray, up to 5 percent pumice, 2 to 5 percent lithophysae, 2 percent feldspar phenocrysts, less than 1 percent biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
		4		9	89	0			
		4		8	73	33			
	600	3		9	100	0			
		3		9	59	0			
		3		9	100	0			
	605	3		8	82	35			
		4		8	100	14			
	610	3		9	98	0			
		3		5	100	75			
	615	4		3	96	78			
	620	4		4	100	59			
	625	4		4	100	79			
	630	4		6	96	51			
	635	4		4	100	71			
	640	4		6	100	50			
	645	4		4	96	65			
	650	4		5	100	42			
	655	4		6	98	42			
	660	4		6	100	74			
	665	4		5	100	73			
	670	4		3	100	89			
	675	3		3	100	82			
	680	3		6	100	53	Tpcpmn		**678.1 to 719.2 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, less than 5 percent pumice, less than 1 percent lithic fragments of crystallized welded tuff, 2 percent feldspar phenocrysts, less than 1 percent biotite, rare sphene and manganese oxide. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
	685	3		5	77	50			
	690	3		5	95	58			
	695	3		5	100	92			

Figure RAI 2.2.1.1.1-004-7 (Sheet 6 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-37

SHEET 7 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/31/2006 FINISHED: 6/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,562.35 E 571,995.84
TOTAL DEPTH: 724.8 ft.
DEPTH TO BEDROCK: 130.1 ft.

STATE: Nevada
GROUND ELEVATION: 3647.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		5	100	92			
	700	3		4	100	96			
	705	3		4	100	90			
		3		5	100	63	Tpcpmn		
		3		5	100	76			
	710	3		4	100	96			
		3		4	100	75			
	715	3		4	100	86			
	720	3		4	100	74	Tpcpll		**719.2 to 724.4 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, pale red, dark reddish gray, gray, 2 percent pumice, 2 percent lithophysae, less than 1 percent lithic fragments of crystallized welded tuff, 2 percent feldspar phenocrysts, less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4). Lower contact is undetermined.
		BOTTOM OF HOLE							

Figure RAI 2.2.1.1.1-004-7 (Sheet 7 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-38

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/8/2006 FINISHED: 4/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,759.66 E 571,873.77
TOTAL DEPTH: 691.7 ft.
DEPTH TO BEDROCK: 148.7 ft.

STATE: Nevada
GROUND ELEVATION: 3673.51
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit from 0.0 to 10.2'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 5.0' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 258.7'. Change over to LS224 Core Rig with 3-7/8" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 269.3'. Change over to 4" coring system. Core 269.3 to 372.2'. Change back over to HQ-3 core system. Core to depth of 677.1'. Remove casing and coring system. Ream hole with 6-1/4" tricone bit to total depth of 691.7'(TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to 5.0'. 9" casing from 0.0 to 258.7'. 4-1/2" casing from 258.7 to 677.1'. **Hole Completion:** Remove 4-1/2" casing and 9" casing. Ream hole with 6 1/4" Tricono bit to 691.7' (TD). Install 3 1/2" PVC casing to depth of 686.8'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 691.7'(TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(SP-SM)g (GP-GM)sc (SP)g (GP-GM)sc (SP)gc (GP)s (GP-GM)sc (SP-SM)g (GP)s (SP)g (GP)sc (SP-SM)g (GP)s (SP)g (GP-GM)s (SP-SM)g (GP-GM)s (SP-SM)g (GP-GM)s (GM)s (GP-GM)s (SM)g (GM)s (SP-SM)g (GM)s (GP-GM)s (SP)gc (GP)s (SP)g (GP)sc (SP)g (GP-GM)sc		**0.0 to 148.7 ft: QUATERNARY ALLUVIUM (Qal).** **0.0 to 0.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, light yellowish brown, weak reaction with HCl. Roots present. **0.7 to12.0 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy, and low toughness; trace of hard cobbles; maximum size 120 mm; dry, light yellowish brown, strong reaction with HCl. **12.0 to 13.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 25 mm; dry, pale brown, no reaction with HCl. **13.0 to 20.0 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular sand; about 10 percent fines of no to plasticity, with high dry strength, quick dilatancy and low toughness; trace of hard cobbles; maximum size 100 mm; dry, pale brown, no reaction with HCl. **20.0 to 27.5 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 80 percent coarse to fine, subangular sand; about 15 percent predominantly fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 120 mm; dry, very pale brown, no reaction with HCl. **27.5 to 28.4 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, very pale brown, no reaction with HCl. **28.4 to 33.1 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 95 mm; dry, pink, no reaction with HCl. **33.1 to 35.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with medium dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, pink, no reaction with HCl. **35.8 to 37.3 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent predominantly fine, hard, subangular gravel; about 40 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pink, no reaction with HCl. **37.3 to 38.2 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 75 percent coarse to fine, angular to subangular sand; about 25 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, reddish yellow, no reaction with HCl. **38.2 to 39.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 65 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, angular sand; trace of nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 80 mm; dry, very pale brown, no reaction with HCl. **39.0 to 39.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 65 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 20 mm; dry, pink, no reaction with HCl. **39.6 to 40.7 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 65 percent coarse to fine, hard, subangular gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, pink, no reaction with HCl. **40.7 to 41.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 70 percent coarse to fine, subangular sand; about 30 percent predominantly fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 20 mm; dry, pink, no reaction with HCl. **41.7 to 48.3 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with medium dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, pink, no reaction with HCl. **48.3 to 50.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular sand; about 40 percent predominantly fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pink, no reaction with HCl. **50.6 to 53.3 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 60 percent coarse to fine, hard, subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, light brown, no reaction with HCl. **53.3 to 58.3 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, light brown, no reaction with HCl. **58.3 to 59.1 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, angular to

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-8 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-38

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/8/2006 FINISHED: 4/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,759.66 E 571,873.77
TOTAL DEPTH: 691.7 ft.
DEPTH TO BEDROCK: 148.7 ft.

STATE: Nevada
GROUND ELEVATION: 3673.51
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215						(GP-GM)sc; (SP-SM)g; (GP-GM)sc; (SM)gc; (SP)gc; (GP)s; (GP-GM)sc; Tmr; Tmbt1		subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, light brown, no reaction with HCl. **59.1 to 62.4 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 15 percent fines of low plasticity with high dry strength, quick dilatancy and medium toughness; maximum size 70 mm; dry, light gray, no reaction with HCl. **62.4 to 65.5 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 70 percent coarse to fine, hard, subangular gravel; about 20 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with medium dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, light brown, no reaction with HCl. **65.5 to 67.2 ft. SILTY SAND WITH GRAVEL (SM)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 15 percent predominantly fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with high dry strength, quick dilatancy and low toughness; maximum size 20 mm; dry, light brown, no reaction with HCl. **67.2 to 68.7 ft. SILTY GRAVEL WITH SAND (GM)s:** About 60 percent coarse to fine, hard, subangular gravel; about 25 percent coarse to fine, subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, pinkish gray, no reaction with HCl. **68.7 to 70.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand, about 35 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, pinkish gray, no reaction with HCl. **70.0 to 71.1 ft. SILTY GRAVEL WITH SAND (GM)s:** About 50 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 15 percent fines of low plasticity with high dry strength, quick dilatancy and medium toughness; maximum size 45 mm; dry, pinkish gray, no reaction with HCl. **71.1 to 73.3 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 60 percent coarse to fine, hard, subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, light brown, no reaction with HCl. **73.3 to 75.2 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 50 percent coarse to fine, angular to subangular sand, about 45 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 80 mm; dry, very pale brown, no reaction with HCl. **75.2 to 77.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 60 percent coarse to fine, hard, subangular gravel; about 35 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, light brown, no reaction with HCl. **77.0 to 78.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 65 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, pink, light brown, no reaction with HCl. **78.7 to 82.2 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 55 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard cobbles; maximum size 120 mm; dry, light brown, no reaction with HCl. **82.2 to 83.3 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 50 percent coarse to fine, subangular sand; about 45 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 20 mm; dry, light reddish brown, no reaction with HCl. **83.3 to 124.0 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; dry, light reddish brown, pinkish gray, no to strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard, subangular and drilled cobbles; maximum size 110 mm; remainder minus 3-inch. **124.0 to 125.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 45 percent coarse to fine, hard, subangular gravel; about 45 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with medium dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, strong reaction with HCl. **125.0 to 132.0 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 60 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, subangular sand; about 10 percent fines of low plasticity with high dry strength, quick dilatancy and medium toughness; dry, reddish yellow, pinkish gray, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular cobbles; maximum size 120 mm; remainder minus 3-inch. **132.0 to 132.9 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, subangular gravel; about 15 percent nonplastic fines with medium dry strength, quick dilatancy and low toughness; dry, pinkish gray, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 35 percent hard, subangular and drilled cobbles; maximum size 115 mm; remainder minus 3-inch. **132.9 to 134.6 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; dry, reddish yellow, no reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 15 percent hard, subangular cobbles; maximum size 110 mm; remainder minus 3-inch." **134.6 to 135.6 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, light reddish brown, strong reaction with HCl. **135.6 to 148.7 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; dry, very pale brown, no reaction with HCl.

Figure RAI 2.2.1.1.1-004-8 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-38

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/8/2006 FINISHED: 4/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,759.66 E 571,873.77
TOTAL DEPTH: 691.7 ft.
DEPTH TO BEDROCK: 148.7 ft.

STATE: Nevada
GROUND ELEVATION: 3673.51
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220								TOTAL SAMPLE (BY VOLUME): About 15 percent hard, subangular and drilled cobbles; maximum size 130 mm; remainder minus 3-inch. **148.7 to 196.5 ft. RAINIER MESA TUFF (Tmr):** Ignimbrite, nonwelded, locally bedded, vitric, white, light pink, 15 to 40 percent pumice, less than or equal to 1 percent lithic fragments of welded tuff, 15 to 30 percent crystal fragments of sanidine, plagioclase and quartz, less than 1 percent biotite. Generally the tuff is fresh (W1). The lower contact was in an unrecovered zone. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD). **196.5 to 331.0 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, nonwelded, crystallized to vitric, white, pink, pinkish gray, light gray, very pale brown, 10 to 90 percent pumice, less than 1 to 12 percent lithic fragments of welded tuff, 2 to 20 percent crystal fragments of sanidine, plagioclase and quartz, less than 1 percent biotite and hornblende and magnetite. Generally the tuff is moderately soft (H5) to mostly hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	225								
	230								
	235								
	240								
	245								
	250								
	255								
	260	3		7	50	30			
	265	4		7	54	25			
	270	0		0	0	0			
	275	5		6	100	100	Tmbt1		
	280	4		4	93	83			
	285	5		4	100	56			
	290	4		5	91	67			
	295	5		7	50	21			
	300	0		0	0	0			
	305	5		6	100	100			
	310	0		0	0	0			
		5		7	100	100			
	315	0		0	0	0			
	320	5		4	100	100			
	325	5		4	93	92			
	330	5		5	86	75			**331.0 to 469.5 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, locally reworked and bedded, nonwelded, crystallized, white, pink, 20 to 90 percent pumice, 2 to 25 percent lithic fragments of crystallized welded tuff, 1 to 7 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and hornblende. Generally the tuff is hard (H3) to moderately soft (H5) averaging moderately hard (H4), slightly weathered to fresh (W2),
	335	4		7	80	0	Tpki		

Figure RAI 2.2.1.1.1-004-8 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-38

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/8/2006 FINISHED: 4/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,759.66 E 571,873.77
TOTAL DEPTH: 691.7 ft.
DEPTH TO BEDROCK: 148.7 ft.

STATE: Nevada
GROUND ELEVATION: 3673.51
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		5	100	100	Tpki		unfractured (FD0) to intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
		4		5	100	99			
	345	3		5	62	63			
	350	3		4	91	33			
	355	4		6	58	100			
	360	4		5	93	48			
	365	3		6	22	48			
	370	4		7	48	7			
		3		5	100	100			
	375	3		4	100	75			
	380	3		4	100	98			
	385	3		4	90	98			
	390	3		4	94	91			
	395	3		4	100	84			
	400	3		4	98	99			
	405	3		3	100	84			
	410	4		3	100	90			
	415	4		3	100	94			
	420	3		0	100	96			
	425	4		1	100	99			
	430	4		3	100	100			
	435	4		4	100	94			
	440	4		4	100	97			
	445	4		5	100	92			
	450	4		3	100	100			
	455	4		5	100	87			

Figure RAI 2.2.1.1.1-004-8 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-38

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/8/2006 FINISHED: 4/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,759.66 E 571,873.77
TOTAL DEPTH: 691.7 ft.
DEPTH TO BEDROCK: 148.7 ft.

STATE: Nevada
GROUND ELEVATION: 3673.51
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		4	100	94	Tpki		
	465	4		5	100	79			
	470	4		4	100	84	Tpbt5		**469.5 to 482.1 ft. POST TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff, nonwelded, crystallized, pinkish white, pinkish gray, pink, 5 to 80 percent pumice, 1 to 15 percent lithic fragments of crystallized welded tuff, 2 to 7 percent crystal fragments of plagioclase and sanidine, less than or equal to 1 percent and lesser biotite and magnetite. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), fresh (W1), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	475	5		6	100	63			
	480	5		5	100	40			
	485	4		5	98	50	Tpcrv		**482.1 to 495.7 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, non to partially welded, moderately welded, densely welded, pale red, pink, light reddish brown, 5 to 10 percent pumice, less than 1 to 4 percent lithic fragments of crystallized welded tuff, 3 to 12 percent crystal fragments of sanidine and plagioclase, 1 percent biotite and lesser pyroxene. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), fresh (W1), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	490	4		7	89	30			
	495	5		7	74	37			**495.7 to 570.2 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately welded, densely welded, crystallized, light gray, light reddish gray, pale red, reddish gray, pinkish gray, 1 to 25 percent pumice, 5 to 6 percent lithophysae locally, 5 to 12 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and lesser pyroxene. Generally the tuff is moderately soft (H5), to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
		5		8	88	0			
	500	4		8	58	0			
	505	4		7	100	33			
	510	4		5	98	60			
	515	4		4	100	82			
	520	4		5	98	67			
	525	4		5	98	57			
	530	4		6	98	54	Tpcrn		
	535	4		5	100	69			
	540	4		4	100	57			
	545	4		6	83	48			
	550	4		7	71	24			
	555	4		7	61	19			
		4		9	86	0			
		4		7	88	29			
	560	4		9	48	0			
	565	4		8	72	19			
		4		8	43	0			
	570	4		8	94	0			**570.2 to 584.4 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, light reddish gray, light reddish brown mottling, 8 to 12 percent pumice, 3 to 5 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite. Generally the tuff is hard (H3), to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely
	575	4		6	75	32	Tpcpun		

Figure RAI 2.2.1.1.1-004-8 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-38

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/8/2006 FINISHED: 4/5/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,759.66 E 571,873.77
TOTAL DEPTH: 691.7 ft.
DEPTH TO BEDROCK: 148.7 ft.

STATE: Nevada
GROUND ELEVATION: 3673.51
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	580	3		6	74	29	Tpcpun		fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	585	3		5	100	57			**584.4 to 661.8 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red, 5 percent pumice, 2 to 10 percent lithophysae, 3 to 5 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite, vapor-phase partings locally. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	590	3		8	68	0			
		3		8	100	0			
	595	3		9	21	0			
		0		0	0	0			
		0		0	0	0			
		0		0	0	0			
	600	0		0	0	0			
		3		9	58	0			
		3		9	73	0			
		3		9	100	0			
	605	3		9	52	0			
		3		9	67	0			
		0		0	0	0			
		3		7	92	23			
	610	3		6	93	55			
	615	3		9	21	0			
		3		9	100	0			
	620	3		7	100	17			
		3		5	100	97	Tpcpul		
	625	3		6	89	38			
		3		6	87	43			
		3		9	100	0			
	630	3		5	100	65			
	635	3		5	100	67			
		3		7	89	21			
	640	3		5	59	49			
	645	0		0	0	0			
		3		8	100	0			
		3		9	100	0			
	650	3		7	100	33			
	655	3		5	96	56			
		3		6	100	26			
	660	3		9	100	0			
		3		5	100	50			**661.8 to 677.1 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, light gray, white, pale red mottling, 5 to 7 percent pumice, 2 to 3 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite, vapor-phase partings locally. Generally the tuff is hard (H3), fresh (W1), moderately fractured (FD5) to very intensely fractured (FD9) averaging moderately fractured (FD5). Lower contact is undetermined.
	665	3		6	100	37			
		3		9	67	0			
		0		0	0	0			
	670	0		0	0	0	Tpcpmn		
		3		9	NR	0			
		3		7	100	11			
		3		9	79	0			
	675	3		8	95	0			
		0		0	0	0			
		0		0	0	0			
	680								
	685								
	690								
	BOTTOM OF HOLE								

Figure RAI 2.2.1.1.1-004-8 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-39

SHEET 1 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 2/28/2007 FINISHED: 8/16/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,094.69 E 571,263.99
TOTAL DEPTH: 479.5 ft.
DEPTH TO BEDROCK: 100.4 ft.

STATE: Nevada
GROUND ELEVATION: 3644.57
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit from 0.0 to 10.5'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 5.8' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 162.3'. Change over to LS224 Core Rig with 3-7/8" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 473.1'. Remove casing and coring system. Ream hole with 6-1/4" tricone bit to total depth of 479.5' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to 5.8'. 9" casing from 0.0 to 162.3'. 4-1/2" casing from 162.3 to 473.1'. **Hole Completion:** Remove 4-1/2" casing and 9" casing. Install 3-1/2" PVC casing to depth of 465.7'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 479.5' (TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(SP-SM)g (SM)gc (SP-SM)g (SP-SM)c (SP-SM)gc (SP)gc (GP)sc (SP)gc (GP)sc (SP)g		**0.0 to 100.4 ft: QUATERNARY ALLUVIUM (Qal):** **0.0 to 0.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 75 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy, and low toughness; maximum size 15 mm; dry, light reddish brown, strong reaction with HCl. Topsoil. **0.4 to 2.0 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 65 percent coarse to fine, angular to subangular sand; about 20 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; about 15 percent coarse to fine, hard, subangular to subrounded gravel; dry, light red, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard, subangular to subrounded cobbles; maximum size 115 mm; remainder minus 3-inch. **2.0 to 19.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy, and low toughness; maximum size 70 mm; dry, light red, strong reaction with HCl. **19.0 to 20.6 ft. POORLY GRADED SAND WITH SILT AND COBBLES (SP-SM)c:** About 85 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with low dry strength, no dilatancy, and low toughness; about 5 percent coarse to fine, hard, angular to subangular gravel; dry, light red, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 30 percent hard, subangular and drilled cobbles; maximum size 130 mm; remainder minus 3-inch. **20.6 to 42.2 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, angular to subangular sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, light red, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard, subangular and drilled cobbles; maximum size 125 mm; remainder minus 3-inch. **42.2 to 62.0 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 60 percent coarse to fine, angular to subrounded sand; about 40 percent coarse to fine, hard, angular to subrounded gravel; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard, subangular to subrounded cobbles; maximum size 90 mm; dry, light gray to very pale brown, strong reaction with HCl. **62.0 to 74.7 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 80 percent coarse to fine, angular to subrounded sand; about 20 percent coarse to fine, hard, angular to subrounded gravel; trace of nonplastic fines with no dry strength and quick dilatancy; trace of hard, subangular to subrounded cobbles; maximum size 80 mm; dry, light gray to very pale brown, moderate to strong reaction with HCl. **74.7 to 77.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, angular to subrounded gravel; about 40 percent coarse to fine, angular to subrounded sand; trace of nonplastic fines with no dry strength, quick dilatancy, and low toughness; dry, light gray to very pale brown, moderate reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard, subangular to subrounded and drilled cobbles; maximum size 95 mm; remainder minus 3-inch. **77.5 to 84.6 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 55 percent coarse to fine, angular to subrounded sand; about 45 percent coarse to fine, hard, angular to subrounded gravel; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, light gray to very pale brown, moderate reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard, subangular to subrounded and drilled cobbles; maximum size 120 mm; remainder minus 3-inch. **84.6 to 89.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 60 percent coarse to fine, hard, angular to subrounded gravel; about 40 percent coarse to fine, angular to subrounded sand; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, light gray to pale brown, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-9 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-39

SHEET 2 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 2/28/2007 FINISHED: 8/16/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,094.69 E 571,263.99
TOTAL DEPTH: 479.5 ft.
DEPTH TO BEDROCK: 100.4 ft.

STATE: Nevada
GROUND ELEVATION: 3644.57
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160						Tpki		TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular to subrounded and drilled cobbles; maximum size 120 mm; remainder minus 3-inch. **89.5 to 100.4 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, angular to subrounded sand; about 45 percent coarse to fine, hard, angular to subrounded gravel; trace of nonplastic fines with no dry strength and quick dilatancy; maximum size 70 mm; dry, light gray to light brown, strong reaction with HCl. **100.4 to 191.2 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, bedded tuff, nonwelded, crystallized to slightly altered, white, gray, 15 to 80 percent pumice, less than 1 to greater than 10 percent lithic fragments of crystallized welded tuff, less than 1 to 30 percent phenocrysts of sanidine, plagioclase, and a trace of quartz, less than 1 percent hornblende and biotite and a trace of sphene and magnetite. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), fresh (W1), very slightly fractured (FD1) to slightly fractured (FD3) averaging slightly to very slightly fractured (FD2). Lower contact is unconformable and sharp at 40 degrees to the core axis.
	165	4		3	100	100			
	170	4		1	100	100			
	175	4		2	100	94			
	180	4		2	100	91			
	185	4		2	100	97			
	190	4		3	100	83			
	195	5		3	100	89	Tpbt5		**191.2 to 199.2 ft. POST TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff, nonwelded, crystallized, clay altered locally, partially reworked locally, pale red, white, pale yellow, pink, pinkish white, very pale brown, 3 to 80 percent pumice, 1 to 5 percent lithic fragments of volcanic rock, 1 to 10 percent crystal fragments of sanidine, plagioclase, biotite and lesser magnetite and hornblende. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), slightly weathered to fresh (W2), slightly fractured (FD3) to moderately fractured (FD5) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	200	4		5	100	75			
	205	4		6	100	43	Tpcrv		**199.2 to 208.0 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, non to partially welded, moderately welded, densely welded, vitric to locally crystallized, pinkish white, reddish brown, light gray, light reddish brown, light gray, dark reddish gray, 5 to 15 percent pumice, less than 1 to 2 percent lithic fragments of volcanic rock, 2 to 15 percent crystal fragments of sanidine, plagioclase and lesser biotite. Generally the tuff is moderately hard (H4), fresh (W1), moderately fractured (FD5) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is conformable and gradational.
	210	4		5	88	48			
	215	4		6	96	50	Tpcrn		**208.0 to 300.0 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely to moderately welded, crystallized, vapor-phase altered locally, light reddish brown, reddish gray, pale red, light reddish brown, pinkish gray, 1 to15 percent pumice, less than 1 percent lithic fragments of volcanic rock locally, 5 to 15 percent crystal fragments of plagioclase, sanidine and biotite with lesser hornblende and rare magnetite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and
		4		6	100	15			

Figure RAI 2.2.1.1.1-004-9 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-39

SHEET 3 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 2/28/2007 FINISHED: 8/16/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,094.69 E 571,263.99
TOTAL DEPTH: 479.5 ft.
DEPTH TO BEDROCK: 100.4 ft.

STATE: Nevada
GROUND ELEVATION: 3644.57
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220								gradational.
		4		8	100	17			
	225	4		4	100	58			
	230	4		6	100	50			
	235	4		6	100	28			
	240	4		3	100	94			
	245	4		4	100	89			
	250	4		3	98	90			
	255	4		6	100	23			
	260	4		5	100	78	Tpcrn		
	265	4		9	23	0			
	270	4		9	63	0			
		4		9	100	0			
	275	4		9	73	0			
		4		6	100	27			
	280	4		9	91	0			
		4		9	59	0			
	285	4		9	92	0			
		4		6	96	52			
	290	4		6	86	55			
	295	4		7	88	22			
		4		9	69	0			
	300	4		6	98	50	Tpcpun		**300.0 to 304.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, pale red, 10 to 15 percent pumice, 5 percent crystal fragments of plagioclase, sanidine, biotite and lesser hornblende. Generally the tuff is moderately hard (H4), fresh (W1), intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	305	4		6	97	42			**304.0 to 397.8 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red, light reddish gray mottled with white vapor-phase spots, less than 5 percent lithophysae locally, 10 to 15 percent pumice, less than 1 percent lithic fragments of volcanic rock, 3 to 5 percent crystal fragments of sanidine, plagioclase, and lesser biotite with possible magnetite in cavities. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
		4		9	NR	0			
	310	3		9	63	0			
		3		9	17	0			
	315	3		9	57	0			
	320	3		8	66	14			
		3		9	53	0	Tpcpul		
		3		8	80	0			
	325	3		8	83	22			
	330	3		7	94	41			
		4		8	62	19			
	335	4		9	56	0			
		4		7	53	18			

Figure RAI 2.2.1.1.1-004-9 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-39

SHEET 4 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 2/28/2007 FINISHED: 8/16/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,094.69 E 571,263.99
TOTAL DEPTH: 479.5 ft.
DEPTH TO BEDROCK: 100.4 ft.

STATE: Nevada
GROUND ELEVATION: 3644.57
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		9	59	0			
		4		9	100	0			
	345	4		6	68	35			
	350	4		6	39	18			
	355	4		9	66	0			
		4		6	90	40			
	360	4		8	73	0			
	365	4		9	42	0			
		4		9	44	0	Tpcpul		
	370	4		6	100	45			
		4		9	100	0			
	375	4		9	56	0			
		4		6	100	45			
	380	3		8	95	24			
		3		6	100	48			
	385	3		6	87	33			
	390	3		9	65	0			
		3		9	76	0			
	395	3		9	79	0			
		3		6	100	50			**397.8 to 473.1 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, less than 1 percent lithophysae locally, less than 1 percent lithic fragments of welded volcanic rock, 2 to 3 percent crystal fragments of plagioclase, sanidine, and lesser biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is undetermined.
	400	3		6	100	25			
	405	3		3	94	91			
	410	3		4	100	80			
	415	3		8	100	0			
		3		6	77	48			
	420	3		9	80	0			
		3		6	93	20			
	425	3		9	100	0			
		3		6	100	48	Tpcpmn		
	430	3		6	100	41			
	435	3		4	100	46			
	440	3		6	100	33			
	445	3		6	96	36			
	450	3		8	73	15			
		3		9	40	0			
	455	3		8	80	30			

Figure RAI 2.2.1.1.1-004-9 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-39

SHEET 5 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 2/28/2007 FINISHED: 8/16/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,094.69 E 571,263.99
TOTAL DEPTH: 479.5 ft.
DEPTH TO BEDROCK: 100.4 ft.

STATE: Nevada
GROUND ELEVATION: 3644.57
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	3		9	28	0	Tpcpmn		
		3		9	38	0			
	465	3		9	41	0			
		3		9	75	0			
	470	3		9	48	0			
		3		9	86	0			
	475								
	BOTTOM OF HOLE								

Figure RAI 2.2.1.1.1-004-9 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-41

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/9/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,714.52 E 572,949.49
TOTAL DEPTH: 658.8 ft.
DEPTH TO BEDROCK: 192.4 ft.

STATE: Nevada
GROUND ELEVATION: 3666.09
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit from 0.0 to 10.5'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 5.3' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 209.0'. Change over to LS224 Core Rig. with 3-7/8" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 650.1'. Remove casing and coring system. Ream hole with 6-1/4" tricone bit to total depth of 658.8' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to 5.3'. 9" casing from 0.0 to 209.0'. 4-1/2" casing from 209.0 to 650.1'. **Hole Completion:** Remove 4-1/2" casing and 9" casing. Install 3-1/2" PVC casing to depth of 654.6'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 658.8' (TD) up to ground level	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(SM)c (SM)gc (GP)s (SM)g (SP)c (SM)gc (SM)g (SP)g (SP-SM)gc (SP)gc		**0.0 to 192.4 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 1.0 ft. SILTY SAND WITH COBBLES (SM)c:** About 70 percent coarse to fine, subangular to subrounded sand; about 30 percent fines of low plasticity with low dry strength, quick dilatancy and low toughness; trace of predominantly fine, hard, angular to subangular gravel; trace of hard, angular cobbles; maximum size 140 mm; dry, red, strong reaction with HCl. Topsoil. **1.0 to 6.5 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 90 mm; dry, light red, strong reaction with HCl. **6.5 to 9.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, moderate reaction with HCl. **9.0 to 14.7 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, light red, weak reaction with HCl. **14.7 to 16.6 ft. POORLY GRADED SAND WITH COBBLES (SP)c:** About 95 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard, angular to subangular gravel; trace of hard, drilled cobbles; maximum size 130 mm; dry, reddish yellow, strong reaction with HCl. **16.6 to 39.4 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 65 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with low dry strength, quick dilatancy, and low toughness; trace of hard, drilled and subangular to subrounded cobbles; maximum size 150 mm; dry, light reddish brown, strong reaction with HCl. **39.4 to 49.2 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 20 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, weak reaction with HCl. **49.2 to 57.8 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light reddish brown, no reaction with HCl. **57.8 to 66.4 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, slow dilatancy and low dry strength; trace of hard, subangular to subrounded cobbles; maximum size 145 mm; dry, light gray, no reaction with HCl. **66.4 to 116.7 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 65 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 165 mm; dry, light gray, light reddish gray, and reddish brown, no to strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-10 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-41

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/9/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,714.52 E 572,949.49
TOTAL DEPTH: 658.8 ft.
DEPTH TO BEDROCK: 192.4 ft.

STATE: Nevada
GROUND ELEVATION: 3666.09
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115						(SP)gc		
	120						(SP-SM)gc		**116.7 to 120.5 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity with low dry strength, slow dilatancy and low toughness; dry, light gray, strong reaction with HCl.
	125						(SM)gc		TOTAL SAMPLE (BY VOLUME): About 10 percent hard subrounded and drilled cobbles; maximum size 125 mm; remainder minus 3-inch.
	130						(SP-SM)g		**120.5 to 125.5 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 40 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent nonplastic fines with no to low dry strength, quick dilatancy and low toughness; trace of hard angular to subangular cobbles; maximum size 105 mm; dry, reddish brown, light reddish brown, strong reaction with HCl.
	135						(SP-SM)gc		**125.5 to 129.3 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, light reddish brown, strong reaction with HCl.
	140						(GM)sc		**129.3 to 138.3 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; dry, reddish brown, strong reaction with HCl.
	145						(GP-GM)sc		TOTAL SAMPLE (BY VOLUME): About 20 percent hard subrounded and drilled cobbles; maximum size 150 mm; remainder minus 3-inch.
	150								**138.3 to 143.6 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 45 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 15 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; dry, light reddish brown, no reaction with HCl.
	155						(SP-SM)gc		TOTAL SAMPLE (BY VOLUME): About 40 percent hard, subangular to subrounded and drilled cobbles; maximum size 125 mm; remainder minus 3-inch.
	160								**143.6 to 154.3 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; dry, light reddish brown, no reaction with HCl.
	165						(SM)gc		TOTAL SAMPLE (BY VOLUME): About 5 percent hard, subangular to subrounded cobbles; maximum size 125 mm; remainder minus 3-inch.
	170								**154.3 to 159.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; dry, light reddish brown, strong reaction with HCl.
							SM		
	175								TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular and drilled cobbles; maximum size 125 mm; remainder minus 3-inch.
	180						(SM)gc		**159.0 to 171.7 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 80 mm; dry, reddish brown, strong reaction with HCl.
	185								**171.7 to 173.8 ft. SILTY SAND (SM):** About 80 percent coarse to fine, subangular to subrounded sand; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; about 5 percent predominantly fine, hard, subangular to subrounded gravel; maximum size 45 mm; dry, reddish brown, strong reaction with HCl.
	190								**173.8 to 192.4 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subrounded and drilled cobbles; maximum size 150 mm; dry, light reddish brown, strong reaction with HCl.
	195						Tmr		**192.4 to 252.5 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow, partially welded, crystallized vapor-phase altered, pink, pinkish white, light gray, white, 2 to 15 percent pumice, less than or equal to 1 percent lithic fragments of dense volcanic rock, 2 to 3 percent vitric fragments, 8 to 12 percent crystal fragments of feldspar and lesser quartz, less than or equal to 1 percent biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to mostly intensely fractured (FD7). Lower contact is unconformable and sharp.
	200								
	205								
	210	4		6	100	65			
		4		7	100	31			
	215	4		7	100	31			

Figure RAI 2.2.1.1.1-004-10 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-41

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/9/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,714.52 E 572,949.49
TOTAL DEPTH: 658.8 ft.
DEPTH TO BEDROCK: 192.4 ft.

STATE: Nevada
GROUND ELEVATION: 3666.09
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		7	87	27	Tmr		
	225	4		6	96	34			
	230	4		7	100	36			
	235	4		7	100	33			
	240	4		6	100	69			
	245	4		6	100	54			
	250	6		7	92	38			
	255	6		5	96	74	Tmbt1		**252.5 to 270.2 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded and reworked tuffs, massively bedded, poorly consolidated to very friable, crystallized to argillically altered, light gray, white, 10 to 80 percent pumice, less than 1 to 10 percent lithic fragments of volcanic rock, 2 to 3 percent crystal fragments of feldspar and quartz, mafic minerals rare to absent. Generally the tuff is soft (H6) to mostly very soft (H7), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7), averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	260	7		7	96	45			
	265	7		6	92	60			
	270	5		1	100	99	Tpki		**270.2 to 388.5 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, crystallized, white, light gray, 25 to 40 percent pumice, 2 to 10 percent lithic fragments of welded and nonwelded tuff, 3 to 5 percent crystal fragments of feldspar, biotite, hornblende and lesser sphene. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), fresh (W1), unfractured (FD0) to intensely to moderately fractured (FD6), averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	275	5		3	100	87			
	280	5		2	98	93			
	285	5		1	100	98			
	290	5		1	100	100			
	295	4		2	100	99			
	300	4		2	98	95			
	305	4		2	100	100			
	310	4		2	100	99			
	315	5		3	100	82			
	320	5		0	100	100			
	325	5		2	100	98			
	330	5		2	100	100			
	335	5		3	98	83			

Figure RAI 2.2.1.1.1-004-10 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-41

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/9/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,714.52 E 572,949.49
TOTAL DEPTH: 658.8 ft.
DEPTH TO BEDROCK: 192.4 ft.

STATE: Nevada
GROUND ELEVATION: 3666.09
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	5		3	98	83	Tpki		
		5		2	96	83			
	345	5		5	100	83			
	350	5		5	98	57			
	355	5		3	96	94			
	360	5		6	76	53			
	365	5		4	98	83			
	370	5		4	59	58			
	375	5		5	100	81			
	380	4		6	92	54			
		4		6	92	50			
	385	5		4	94	78			
	390	7		3	100	86	Tpbt5		**388.5 to 402.2 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Reworked sand and tephra, poorly consolidated except where cemented by silica, crystallized to vitric, very pale brown, white, pinkish white, light gray, 8 to 10 percent pumice, 2 to 3 percent lithic fragments of volcanic rock, 1 to 2 percent crystal fragments of feldspar, less than 1 percent mafic minerals. Generally the tuff is very soft (H7) to moderately soft (H5) averaging soft (H6), fresh (W1), slightly fractured (FD3) to mostly moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	395	6		4	100	74			
	400	5		4	98	81	Tpcrv		**402.2 to 411.1 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, non to densely welded, very pale brown, very dark gray, 5 to 7 percent pumice, 5 to 20 percent crystal fragments of plagioclase, sanidine, less than 1 percent biotite and lesser hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	405	4		7	98	17			
	410	3		5	85	78	Tpcrn		**411.1 to 525.2 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, locally vapor-phase altered, dark brown, pinkish gray, light gray, 1 to 10 percent pumice, very rare lithic fragments, 10 to 20 percent crystal fragments of sanidine and plagioclase, less than 5 percent biotite, rare hornblende. Generally the tuff is hard (H3) to soft (H6) averaging moderately hard (H4), fresh (W1), moderately fractured (FD5) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
	415	6		7	94	35			
	420	4		7	85	22			
	425	4		6	90	34			
	430	4		6	96	64			
	435	4		7	98	46			
	440	4		6	98	79			
	445	4		6	98	59			
	450	4		6	100	58			
	455	4		6	94	38			

Figure RAI 2.2.1.1.1-004-10 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-41

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/9/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,714.52 E 572,949.49
TOTAL DEPTH: 658.8 ft.
DEPTH TO BEDROCK: 192.4 ft.

STATE: Nevada
GROUND ELEVATION: 3666.09
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		6	94	38			
		4		6	100	70			
	465	4		6	95	55			
	470	4		7	91	46			
	475	4		5	86	60			
	480	4		7	78	28			
	485	4		7	93	38			
	490	3		9	100	0	Tpcrn		
		3		8	91	0			
	495	3		6	96	43			
	500	3		8	72	0			
		4		9	55	0			
	505	4		7	92	25			
		4		5	100	72			
	510	4		7	91	31			
		4		8	55	0			
	515	4		9	100	0			
		4		9	81	0			
	520	4		9	77	0			
		4		9	67	0			
	525	4		9	74	0			**525.2 to 602.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, gray, light reddish gray, reddish gray, 2 to 8 percent lithophysae, 10 to 15 percent vapor-phase alteration spots, less than or equal to 5 percent pumice, less than 1 percent lithic fragments of volcanic rock locally, 2 to 3 percent crystal fragments of feldspar and lesser biotite. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
		4		9	100	0			
	530	4		9	84	0			
	535	4		9	56	0			
		4		6	71	46			
	540	4		9	68	0			
		4		6	90	48			
	545	3		5	78	42			
		3		8	82	18			
	550	3		9	100	0			
		3		8	65	22	Tpcpul		
	555	3		6	95	38			
		3		3	91	82			
	560	3		5	94	62			
	565	3		6	94	62			
	570	3		7	86	52			
		3		9	79	0			
	575	3		9	96	0			

Figure RAI 2.2.1.1.1-004-10 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-41

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/9/2007 FINISHED: 9/12/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,714.52 E 572,949.49
TOTAL DEPTH: 658.8 ft.
DEPTH TO BEDROCK: 192.4 ft.

STATE: Nevada
GROUND ELEVATION: 3666.09
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	580	3		6	100	64			
	585	4		4	100	100			
	590	4		6	71	39	Tpcpul		
	595	4		6	96	63			
	600	4		5	96	67			
	605	3		6	100	60			**602.0 to 650.1 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, reddish gray mottling locally, less than 1 percent lithophysae, 1 to 3 percent pumice, less than 1 percent lithic fragments of volcanic rock, 3 to 5 percent crystal fragments of feldspar and lesser biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is undetermined.
	610	3		6	100	48			
	615	3		4	100	74			
	620	3		5	100	79			
	625	3		4	100	79	Tpcpmn		
	630	3		7	100	0			
		3		4	100	70			
	635	3		6	100	60			
	640	3		5	98	62			
	645	3		6	99	76			
	650								
	655								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-10 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-57

SHEET 1 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2006 FINISHED: 10/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,088.83 E 572,470.05
TOTAL DEPTH: 774.1 ft.
DEPTH TO BEDROCK: 173.6 ft.

STATE: Nevada
GROUND ELEVATION: 3651.90
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** Boart Longyear **Drilling Method:** Sonic core with 12-3/4" bit from 0.0 to 10.3'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 5.0' and cement in place. Change over to 4.91" bit. 9" casing is advanced as hole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 302.3'. Change over to LS224 Core Rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 774.1' (TD). Remove casing and coring system. Ream hole with 6-3/8" tricone bit to total depth of 674.5'. **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0' to 5.0'. 9" casing from 0.0 to 302.3'. 4-1/2" casing from 302.3 to 774.1'. **Hole Completion:** Remove 4-1/2" casing and 9" casing. Plug bottom of hole from 774.1'(TD) up to 666.0'with bentonite chips. Install 3-1/2" PVC casing to depth of 666.0'. Use 1" tremmie pipe to grout PVC casing from depth of 666.0' up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(SP-SM)gc (GP-GM)s (SP-SM)g (GP)s (SP-SM)g (GP)sc (SP-SM)gc (SP)gc (GP)s (SP)g (GP)s (SP)gc (SP)g (SP-SM)g (GP)s (SP-SM)gc (SP-SM)g (GP-GM)sc (SP-SM)g (GP-GM)s (SP)g (GP-GM)s (SP-SM)g (GP-GM)sc (SP-SM)gc		**0.0 to 173.6 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 0.6 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 125 mm; dry, light brown, strong reaction with HCl. **0.6 to 6.1 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, subangular sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, light reddish brown, strong reaction with HCl. **6.1 to 12.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 35 mm; dry, light brown, strong reaction with HCl. **12.0 to 15.2 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 55 mm; dry, pink, no reaction with HCl. **15.2 to 16.5 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, pink, no reaction with HCl. **16.5 to 18.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 65 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 105 mm; dry, light brown, no reaction with HCl. **18.0 to 27.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, light brownish gray, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard subangular and drilled cobbles; maximum size 110 mm; remainder minus 3-inch. **27.0 to 35.3 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 80 percent coarse to fine, angular to subangular sand; about 15 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard drilled cobbles; maximum size 110 mm; dry, pale yellow, no reaction with HCl. **35.3 to 36.9 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 45 percent coarse to fine, subangular to subrounded sand; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, light gray, strong reaction with HCl. **36.9 to 45.1 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; trace of nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 60 mm; dry, pinkish gray, strong reaction with HCl. **45.1 to 50.2 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 45 percent coarse to fine, subangular to subrounded sand; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 55 mm; dry, light gray, pinkish gray, moderate to strong reaction with HCl. **50.2 to 54.7 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 50 percent coarse to fine, hard, subangular to subrounded gravel; trace of fines of no to low plasticity with no dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 110 mm; dry, light gray, no reaction with HCl. **54.7 to 56.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 80 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 15 mm; dry, brownish yellow, no reaction with HCl. **56.0 to 57.5 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity with quick dilatancy and low toughness; maximum size 45 mm; dry, light gray, strong reaction with HCl. **57.5 to 59.7 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 65 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light gray, no reaction with HCl. **59.7 to 66.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, subrounded to rounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 100 mm; dry, light reddish brown to reddish yellow, strong reaction with HCl. **66.0 to 67.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with low dry strength, quick

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-11 (Sheet 1 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-57

SHEET 2 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2006 FINISHED: 10/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,088.83 E 572,470.05
TOTAL DEPTH: 774.1 ft.
DEPTH TO BEDROCK: 173.6 ft.

STATE: Nevada
GROUND ELEVATION: 3651.90
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215						(SP-SM)gc; (GP-GM)sc; (SP-SM)gc; (GP-GM)sc; (GP)sc; (SP)gc; (GP)scb; Tmr		dilatancy and low dry strength; maximum size 30 mm; dry, light reddish brown, moderate reaction with HCl. **67.7 to 72.7 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; dry, reddish gray, moderate reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard, drilled and subangular cobbles; maximum size 120 mm; remainder minus 3-inch. **72.7 to 74.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 35 mm; dry, pale red, no reaction with HCl. **74.4 to 75.9 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent predominantly coarse, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 55 mm; dry, light red, no reaction with HCl. **75.9 to 83.8 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 75 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, pale red to light red, strong reaction with HCl. **83.8 to 85.6 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subrounded to rounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 30 mm; dry, light red, strong reaction with HCl. **85.6 to 86.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 75 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines of low dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, light red, no reaction with HCl. **86.8 to 93.0 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard, subrounded cobbles; maximum size 125 mm; dry, pale red to light red, strong reaction with HCl. **93.0 to 104.9 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy, and low toughness; trace of hard subangular to subrounded cobbles; maximum size 105 mm; dry, yellowish red, strong reaction with HCl. **104.9 to 112.8 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; dry, yellowish brown, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard subangular to subrounded cobbles; maximum size 95 mm; remainder minus 3-inch. **112.8 to 130.7 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular gravel; about 10 percent fines of low plasticity with no dry strength, quick dilatancy and low toughness; dry, pinkish gray, no reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular and drilled cobbles; maximum size 250 mm; remainder minus 3-inch. **130.7 to 135.6 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with no to low dry strength, quick dilatancy and low toughness; trace of hard, subangular cobbles; maximum size 115 mm; dry, pale brown, pinkish gray, no reaction with HCl. **135.6 to 138.0 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 65 percent coarse to fine, hard, subangular to subrounded gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, brown, no reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 20 percent hard, subangular and drilled cobbles; maximum size 110 mm; remainder minus 3-inch. **138.0 to 141.4 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 50 percent medium to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent fines of no to low plasticity with no dry strength, quick dilatancy and low toughness; dry, pinkish gray, moderate reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subangular and drilled cobbles; maximum size 120 mm; remainder minus 3-inch. **141.4 to 173.6 ft. POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP)scb:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 5 percent nonplastic fines with no to low dry strength, quick dilatancy and low toughness; dry, light brown, no to weak reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 20 percent hard subangular and drilled cobbles and boulders; maximum size 410 mm; remainder minus 3-inch. **173.6 to 293.8 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow, bedded and reworked locally, nonwelded, vitric and incipiently crystallized or vapor-phase altered locally, light gray, white, 15 to 20 percent bubble-wall shards and vitric fragments, 10 to 80 percent pumice, less than 1 to 2 percent lithic fragments of volcanic rock, 10 to 20 percent crystal fragments of vitric quartz, plagioclase, sanidine, less than 1 percent biotite, and magnetite. Mafic minerals predominate near the base of the unit, including biotite, hornblende and lesser magnetite, with 5 percent felsic crystals including quartz and feldspar. Generally the tuff is moderately hard (H4), fresh (W1), slightly fractured (FD3) to intensely to moderately fractured (FD6), averaging moderately fractured (FD5). Lower contact is unconformable and sharp.

Figure RAI 2.2.1.1.1-004-11 (Sheet 2 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-57

SHEET 3 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2006 FINISHED: 10/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,088.83 E 572,470.05
TOTAL DEPTH: 774.1 ft.
DEPTH TO BEDROCK: 173.6 ft.

STATE: Nevada
GROUND ELEVATION: 3651.90
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220						Tmr		
	225								
	230								
	235								
	240								
	245								
	250								
	255								
	260								
	265								
	270								
	275								
	280	4		5	100	84			
	285	4		5	90	100			
	290	4		3	96	86			
		4		6	100	38			
	295	4		6	31	27	Tmbt1		**293.8 to 521.5 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuffs, nonwelded, massively to thinly bedded, vitric to altered, locally crystallized, locally reworked, light reddish brown, white, pinkish white, pinkish gray, pink, light gray, light brown, very pale brown, 1 to 80 percent pumice, 1 to 50 percent lithic fragments of volcanic rock, 2 to greater than 90 percent crystal fragments of quartz and feldspar with lesser biotite, hornblende, and magnetite (up to 20 percent locally). Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), slightly weathered to fresh (W2) to mostly fresh (W1), very slightly fractured (FD1) to very intensely fractured (FD9), averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	300	5		7	86	26			
		7		6	96	67			
	305	7		3	92	90			
	310	7		4	90	64			
	315	6		3	96	92			
	320	6		3	98	89			
	325	6		4	100	81			
	330	6		1	100	100			
	335	6		3	90	79			

Figure RAI 2.2.1.1.1-004-11 (Sheet 3 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-57

SHEET 4 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2006 FINISHED: 10/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,088.83 E 572,470.05
TOTAL DEPTH: 774.1 ft.
DEPTH TO BEDROCK: 173.6 ft.

STATE: Nevada
GROUND ELEVATION: 3651.90
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	6		3	90	79			
		6		4	100	85			
	345	6		5	94	65			
	350	6		7	83	41			
	355	6		4	94	69			
	360	6		4	88	71			
	365	6		3	100	93			
	370	7		3	100	94			
	375	6		3	98	94			
	380	7		9	98	14			
	385	7		4	98	77			
	390	7		4	96	57			
	395	6		4	100	63	Tmbt1		
	400	4		3	96	96			
	405	4		2	100	75			
	410	4		3	100	100			
	415	4		1	94	82			
	420	4		3	96	92			
		4		3	100	83			
	425	0		0	0	0			
		4		3	100	98			
	430	4		2	100	97			
	435	4		3	100	94			
	440	4		2	100	100			
	445	4		3	100	93			
	450	4		1	100	99			
	455	4		2	100	100			

Figure RAI 2.2.1.1.1-004-11 (Sheet 4 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-57

SHEET 5 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2006 FINISHED: 10/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,088.83 E 572,470.05
TOTAL DEPTH: 774.1 ft.
DEPTH TO BEDROCK: 173.6 ft.

STATE: Nevada
GROUND ELEVATION: 3651.90
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		2	100	100			
		4		3	100	78			
	465	4		4	100	94			
	470	4		3	100	90			
	475	4		3	100	100			
	480	4		1	82	71			
	485	4		4	100	78			
	490	7		4	100	84	Tmbt1		
	495	7		6	100	60			
	500	5		4	100	77			
	505	4		4	100	68			
	510	4		2	100	97			
	515	4		4	100	86			
	520	4		4	100	76			**521.5 to 654.9 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, vitric to altered and crystallized, white, light gray, 5 to 40 percent pumice, 10 to 15 percent lithic fragments of volcanic rock, 2 to 5 percent crystal fragments of sanidine, plagioclase, and lesser biotite and magnetite with rare hornblende. Generally the tuff is moderately (H4), fresh (W1), unfractured (FD0) to intensely fractured (FD7), averaging slightly fractured (FD3). Lower contact is and sharp (faulted).
	525	4		1	98	95			
	530	4		3	100	92			
	535	4		0	100	100			
	540	4		0	98	99			
	545	4		1	100	100	Tpki		
	550	4		3	100	91			
	555	4		3	100	86			
	560	4		3	98	91			
	565	4		1	100	96			
	570	4		3	98	93			
	575	4		5	90	82			

Figure RAI 2.2.1.1.1-004-11 (Sheet 5 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-57

SHEET 6 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2006 FINISHED: 10/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,088.83 E 572,470.05
TOTAL DEPTH: 774.1 ft.
DEPTH TO BEDROCK: 173.6 ft.

STATE: Nevada
GROUND ELEVATION: 3651.90
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	580	4		5	90	82	Tpki		
		4		6	33	14			
	585	0		0	0	0			
		4		7	15	0			
	590	4		6	65	30			
	595	4		1	100	98			
	600	4		3	100	90			
	605	4		2	86	83			
	610	4		5	100	78			
	615	4		4	100	86			
	620	4		3	100	92			
	625	4		3	100	82			
	630	4		5	85	76			
	635	4		3	96	81			
	640	4		6	92	49			
	645	4		4	100	62			
	650	4		6	83	60			
	655	0		0	0	0	Fault Zone		**654.9 to 699.7 ft. FAULT ZONE:** Within unrecovered interval and offsets the lowermost part (inferred to be approximately 40 ft) of Tuff Unit "X", the Post Tiva Canyon Bedded Tuff (inferred to be approximately 10 ft), and all of the Tiva Canyon Tuff (inferred to be approximately 150 to 200 ft) except for the lowermost contact.
	660	0		0	0	0			
	665	0		0	0	0			
	670	0		0	0	0			
	675	0		0	0	0			
	680	0		0	0	0			
	685								
	690	7		9	6	0			
	695	0		0	0	0			

Figure RAI 2.2.1.1.1-004-11 (Sheet 6 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-57

SHEET 7 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2006 FINISHED: 10/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,088.83 E 572,470.05
TOTAL DEPTH: 774.1 ft.
DEPTH TO BEDROCK: 173.6 ft.

STATE: Nevada
GROUND ELEVATION: 3651.90
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		0		0	0	0	Fault Zone		
	700						Tpcpv		**699.7 to 700.3 ft. TIVA CANYON TUFF CRYSTAL-POOR VITRIC ZONE (Tpcpv):** Pyroclastic flow, nonwelded, altered, white, 90 percent pumice, 1 to 2 percent lithic fragments of volcanic rock, 5 percent crystal fragments of predominantly sanidine. Contact with underlying unit is sharp. Generally the tuff is moderately hard (H4), fresh (W1), intensely fractured (FD7). Lower contact is unconformable and sharp.
		4		7	49	12	Tpbt4		**700.3 to 703.1 ft. PRE-TIVA CANYON TUFF BEDDED TUFF (Tpbt4):** Bedded tuff, nonwelded, poorly to moderately indurated, weathered, argillized paleosol, white, 40 to greater than 80 percent pumice, 2 to 15 percent lithic fragments of volcanic rock, 2 percent crystal fragments of predominantly plagioclase and sanidine with lesser biotite. Generally the tuff is moderately hard (H4), moderately weathered (W5), and intensely fractured (FD7). Lower contact is unconformable and sharp.
	705								**703.1 to 765.9 ft. YUCCA MOUNTAIN TUFF (Tpy):** Pyroclastic flow, nonwelded, partially welded, vitric to crystallized, argillized locally, pink, pale red, light gray, reddish yellow, white, very pale brown, pale yellow-white, 1 to 10 percent pumice, less than 1 to 5 percent lithic fragments of volcanic rock, less than 1 to 2 percent crystal fragments of plagioclase and sanidine, pyroxene and lesser biotite. Generally the tuff is soft (H6) to mostly moderately hard (H4), slightly weathered to fresh (W2), intensely fractured (FD7) to very intensely to intensely fractured (FD8), averaging intensely fractured (FD7). Lower contact is unconformable and sharp.
		4		8	73	0			
	710	4		7	76	0			
	715	4		7	94	0			
	720	4		7	94	0			
	725	4		7	78	0			
	730	4		7	61	0			
	735	0		0	0	0	Tpy		
	740	0		0	0	0			
	745	0		0	0	0			
	750	0		0	0	0			
	755	6		7	53	8			
	760								
	765	4		6	100	11	Tpbt3		**765.9 to 766.7 ft. PRE-YUCCA MOUNTAIN TUFF BEDDED TUFF (Tpbt3):** Bedded tuff, nonwelded, altered, pink, 90 percent pumice, 10 percent lithic fragments of volcanic rock, less than 1 percent crystal fragments of predominantly feldspar with rare biotite. Generally the tuff is moderately hard (H4), fresh (W1), and intensely to moderately fractured (FD6). Lower contact is undetermined.
	770								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-11 (Sheet 7 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-75

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/10/2007 FINISHED: 9/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,417.09 E 570,954.2
TOTAL DEPTH: 616.3 ft.
DEPTH TO BEDROCK: 60.4 ft.

STATE: Nevada
GROUND ELEVATION: 3851.42
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Drill 13" hole from 0.0 to approximately 5.0'. Set approximately 4.5' of 10-3/4" surface casing and cement in place. Sonic core with 4-3/4" bit from 0.0 to depth of 123.0'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 123.0 to 597.9'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/4" tricone bit to 616.3 ' (TD).

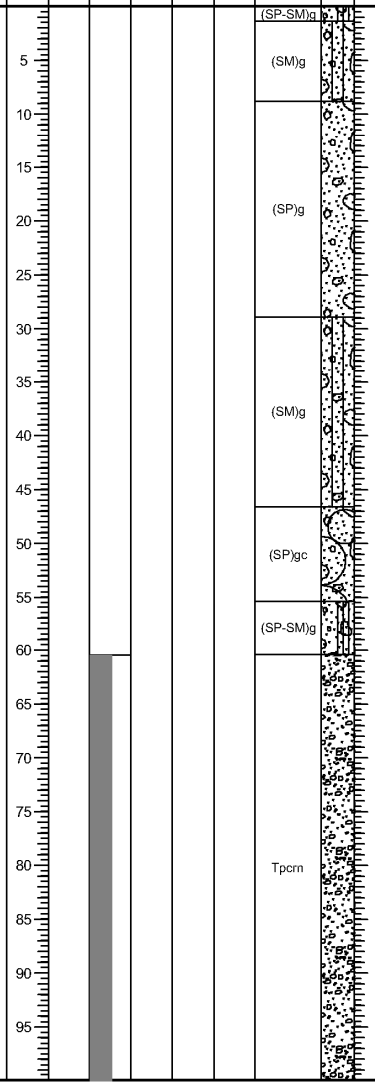
Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
Set 10-3/4" surface casing from 0.0 to approximately 4.5'. 5-7/8" casing from 0.0 to 123.0'. 4-1/2" casing from 123.0 to 597.9'.

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Install 3-1/2" PVC casing to depth of 612.0'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 616.3' (TD) up to ground level.



CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 60.4 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 1.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, light brown, strong reaction with HCl. Roots present.

1.4 to 8.8 ft. SILTY SAND WITH GRAVEL (SM)g: About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 60 mm; dry, yellowish brown, no to strong reaction with HCl.

8.8 to 28.9 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 55 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, light gray, weak reaction with HCl.

28.9 to 46.6 ft. SILTY SAND WITH GRAVEL (SM)g: About 45 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, yellowish brown, strong reaction with HCl.

46.6 to 55.4 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc: About 65 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 85 mm; dry, grayish brown, strong reaction with HCl.

55.4 to 60.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 65 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, yellowish brown, strong reaction with HCl.

60.4 to 136.1 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, moderately to densely welded, crystallized, vapor-phase altered locally, reddish-gray, light reddish-gray, dark reddish-gray, pale red, 5 to 20 percent pumice, less than 1 percent lithic fragments, 7 to 15 percent crystal fragments of feldspar, less than 1 percent biotite, magnetite, and lesser pyroxene and hornblende. Generally the tuff is hard (H3), fresh (W1), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-12 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-75

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/10/2007 FINISHED: 9/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,417.09 E 570,954.2
TOTAL DEPTH: 616.3 ft.
DEPTH TO BEDROCK: 60.4 ft.

STATE: Nevada
GROUND ELEVATION: 3851.42
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						Tpcrn		
	110								
	115								
	120								
		3		9	54	0			
	125	3		6	68	32			
		3		5	100	44			
	130	3		6	100	43			
	135	3		5	93	57			
		3		3	100	97	Tpcpun		**136.1 to 158.5 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, vapor-phase altered, light gray, pinkish-gray, 8 percent pumice, 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly to very slightly fractured (FD3) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is conformable and gradational.
	140	3		3	100	78			
	145	3		7	42	15			
	150	3		6	98	41			
	155	3		7	88	15			
		3		9	100	0			
	160	3		6	94	45	Tpcpul		**158.5 to 218.6 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, vapor-phase mineralization, pale red, light gray, 1 to 3 percent pumice, less than 10 percent lithophysae, 2 percent crystal fragments of feldspar, rare biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly to very slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
		3		7	74	25			
		3		9	100	0			
	165	3		5	100	78			
	170	3		5	100	93			
	175	3		4	100	94			
	180	3		5	88	71			
	185	3		6	96	55			
	190	3		6	75	46			
	195	3		6	43	33			
	200	3		8	100	7			
	205	3		6	100	49			
		3		6	100	73			
	210	3		8	98	0			
		3		7	93	30			
	215	3		6	100	45			

Figure RAI 2.2.1.1.1-004-12 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-75

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/10/2007 FINISHED: 9/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,417.09 E 570,954.2
TOTAL DEPTH: 616.3 ft.
DEPTH TO BEDROCK: 60.4 ft.

STATE: Nevada
GROUND ELEVATION: 3851.42
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	3		6	100	45	Tpcpmn		**218.6 to 242.1 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, vapor-phase alteration, pale red, white, less than 3 percent pumice, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite and lesser hornblende. Generally the tuff is hard (H3), fresh (W1), intensely to moderately fractured (FD6) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
		3		7	100	24			
	225								
		3		6	100	57			
	230						Tpcpmn		
		3		6	91	68			
	235								
		3		6	80	44			
	240								
		3		8	85	0			**242.1 to 272.5 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, vapor-phase alteration, pale red, pinkish-gray, pale red, white, 2 percent pumice, less than 5 percent lithophysae, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), intensely fractured (FD7) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is faulted.
	245	3		7	60	28			
		3		9	96	0			
	250	3		7	100	30			
	255	3		7	38	24	Tpcpll		
		3		9	0	0			
	260	3		9	36	0			
		3		9	44	0			
	265	3		9	40	0			
	270	3		6	86	57			
		3		7	73	27			
		3		8	100	0			**272.5 to 353.4 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, crystallized, gray, reddish-gray, pink, pale red, less than 3 to 6 percent pumice, less than 1 percent lithic fragments, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is moderately hard (H4) to mostly hard (H3), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	275	3		6	100	49			
	280	3		8	100	9			
		3		7	100	0			
	285	3		7	50	0			
		3		7	100	12			
	290	3		7	100	29			
		3		8	89	0			
		3		9	100	0			
	295	3		7	59	16			
		3		7	67	27			
	300	3		7	92	0			
		3		6	74	37			
	305	3		7	70	11	Tpcpln		
		3		7	44	0			
	310	3		8	79	0			
		3		8	94	13			
	315	3		6	100	41			
	320	3		6	100	59			
	325	3		6	100	34			
		3		8	86	0			
	330	3		9	66	0			
		3		8	65	3			
		3		9	100	0			
	335	3		7	100	0			
		3		7	100	23			

Figure RAI 2.2.1.1.1-004-12 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-75

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/10/2007 FINISHED: 9/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,417.09 E 570,954.2
TOTAL DEPTH: 616.3 ft.
DEPTH TO BEDROCK: 60.4 ft.

STATE: Nevada
GROUND ELEVATION: 3851.42
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	3		7	100	23	Tpcpln		
		3		5	98	60			
	345	3		6	100	52			
	350	4		4	100	95			
	355	4		5	100	87	Tpcpv		**353.4 to 385.6 ft. TIVA CANYON TUFF CRYSTAL-POOR VITRIC ZONE (Tpcpv):** Pyroclastic flow, nonwelded to moderately welded, vitric to crystallized, strong vapor-phase alteration, partially argillic locally, pinkish-gray, light gray, light reddish-brown, pinkish-gray, 3 percent pumice, less than 1 percent lithic fragments, less than 1 to 2 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), slightly to very slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	360	4		6	100	72			
	365	4		5	100	61			
	370	4		6	100	60			
	375	4		5	100	85			
	380	4		3	100	100			
	385	4		3	100	96			
							Tpbt4		**385.6 to 388.7 ft. PRE-TIVA CANYON TUFF BEDDED TUFF (Tpbt4):** Bedded tuff, pumice fall deposits, nonwelded, partially vitric, white, pink, 25 percent pumice, 5 to 30 percent lithic fragments, 2 to 10 percent crystal fragments of feldspar, less than 1 percent biotite, lesser pyroxene, trace of sphene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), very slightly fractured (FD1) to slightly fractured (FD3) averaging slightly to very slightly fractured (FD2). Lower contact is unconformable and sharp.
	390	4		1	100	100	Tpy		**388.7 to 425.9 ft. YUCCA MOUNTAIN TUFF (Tpy):** Pyroclastic flow, nonwelded to moderately welded, vitric to crystallized, reworked locally, pinkish-gray, brown, light reddish-brown, dark grayish-brown, light brown, white, 3 to 7 percent pumice, 3 percent lithic fragments of dense volcanic rock, less than 1 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), very slightly fractured (FD1) to intensely fractured (FD7) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	395	4		3	100	96			
	400	4		7	100	67			
	405	4		3	100	94			
	410	4		3	100	100			
	415	4		3	100	86			
	420	4		3	100	91			
	425	4		4	100	97			
	430	4		4	100	95	Tpbt3		**425.9 to 437.6 ft. PRE-YUCCA MOUNTAIN TUFF BEDDED TUFF (Tpbt3):** Bedded tuff, pumice fall deposits, nonwelded, pale red, white, pale yellow, reddish-brown, reddish-gray, very pale brown, pinkish-white, pink, 30 to 80 percent pumice, 3 to 30 percent lithic fragments of crystallized volcanic rock, less than 1 to 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is moderately hard (H4), fresh (W1), moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	435	4		4	100	94			
	440	4		6	100	75	Tpp		**437.6 to 534.1 ft. PAH CANYON TUFF (Tpp):** Pyroclastic flow, nonwelded to partially welded, partially vitric, argillic, vapor-phase alteration locally, light gray, pinkish-white, white, light pink, pink, very pale brown, 15 to 30 percent pumice, 2 to 7 percent lithic fragments, 1 to 5 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is moderately hard (H4), fresh (W1), slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	445	4		6	100	67			
	450	4		3	100	94			
	455	4		4	100	86			

Figure RAI 2.2.1.1.1-004-12 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-75

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/10/2007 FINISHED: 9/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,417.09 E 570,954.2
TOTAL DEPTH: 616.3 ft.
DEPTH TO BEDROCK: 60.4 ft.

STATE: Nevada
GROUND ELEVATION: 3851.42
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	0		0	0	0	Tpp		
	465	4		5	64	52			
	470	4		6	71	53			
		4		3	100	100			
	475	4		4	95	65			
	480	4		5	100	64			
	485	4		4	100	88			
	490	4		3	100	91			
	495	4		4	100	70			
	500	4		3	100	94			
	505	4		4	100	87			
	510	4		3	100	92			
	515	4		4	100	93			
	520	4		4	97	88			
	525	4		3	100	97			
	530	4		3	100	89			
	535	4		5	100	67	Tpbt2		**534.1 to 566.0 ft. PRE-PAH CANYON TUFF BEDDED TUFF (Tpbt2):** Bedded tuff, pumice fall deposits, nonwelded, locally vitric, locally argillic, pinkish-white, pink, very pale brown, white, 10 to greater than 75 percent pumice, 1 to 15 percent lithic fragments of dense crystallized volcanic rock, less than 1 to 15 percent crystal fragments of feldspar, less than 1 to 2 percent biotite and lesser pyroxene. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	540	4		3	100	99			
	545	4		4	100	95			
	550	5		6	60	37			
	555	4		4	98	81			
	560	5		6	100	56			
	565	4		4	98	83			
	570	4		4	96	78	Tptrv		**566.0 to 573.4 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH VITRIC ZONE (Tptrv):** Pyroclastic flow, nonwelded to densely welded, crystallized, vitric locally, pale red, light brown, reddish-gray, 10 to 50 percent pumice, less than 1 to 5 percent lithic fragments, 3 to 15 percent crystal fragments of feldspar, less than 1 percent biotite and lesser pyroxene. Generally the tuff is moderately hard (H4), fresh (W1), moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
	575	4		6	100	33	Tptrn		**573.4 to 597.9 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tptrn):** Pyroclastic flow, densely welded, vapor-phase altered, reddish-yellow, pale red, dark

Figure RAI 2.2.1.1.1-004-12 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-75

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/10/2007 FINISHED: 9/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,417.09 E 570,954.2
TOTAL DEPTH: 616.3 ft.
DEPTH TO BEDROCK: 60.4 ft.

STATE: Nevada
GROUND ELEVATION: 3851.42
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	580	4		7	54	0	Tptm		reddish-gray, reddish-gray, 5 to 50 percent pumice, less than 1 percent lithic fragments, 10 to 15 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is moderately hard (H4), fresh (W1), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
	585	4		6	96	31			
		4		8	73	18			
	590	4		6	100	61			
	595	4		5	100	79			
	600								
	605								
	610								
	615								
	BOTTOM OF HOLE								

Figure RAI 2.2.1.1.1-004-12 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

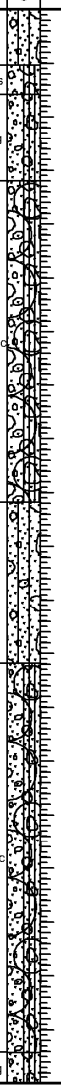
GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-76

SHEET 1 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/22/2007 FINISHED: 8/9/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,731.74 E 570,563.82
TOTAL DEPTH: 282.1 ft.
DEPTH TO BEDROCK: 132.0 ft.

STATE: Nevada
GROUND ELEVATION: 3870.89
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Set 10-3/4" surface casing to approximately 4.5'. Sonic core with 4-3/4" bit from 0.0 to depth of 186.7'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 186.7 to 267.0'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 282.1' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" conductor casing from 0.0 to approximately 4.5'. 5-7/8" casing from 0.0 to 186.7'. 4-1/2" casing from 186.7 to 267.0'. **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Install 3-1/2" PVC casing to depth of 280.4'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 282.1' (TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(SM)g (GP-GM)s (SP SM)g (GP-GM)sc (SM)g (SP-SM)gc (SP-SM)g		**0.0 to 132.0 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 5.2 ft. SILTY SAND WITH GRAVEL (SM)g:** About 65 percent coarse to fine, subangular to subrounded sand; about 20 percent fines of low plasticity with low dry strength, slow dilatancy and low dry strength; about 15 percent coarse to fine, hard, subangular to subrounded gravel; maximum size 25 mm; dry, reddish yellow, strong reaction with HCl. **5.2 to 7.9 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy, and low toughness; maximum size 55 mm; dry, light brown, no reaction with HCl. **7.9 to 16.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light brown, no reaction with HCl. **16.0 to 45.9 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard subangular to subrounded and drilled cobbles; maximum size 120 mm; dry, light brown, strong reaction with HCl. **45.9 to 60.9 ft. SILTY SAND WITH GRAVEL (SM)g:** About 45 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent fines of low to medium plasticity with low dry strength, slow dilatancy and low toughness; maximum size 60 mm; dry, pinkish gray, strong reaction with HCl. **60.9 to 97.1 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity, with no to low dry strength, slow dilatancy and low toughness; trace of hard subangular cobbles; maximum size 100 mm; dry, pinkish gray, strong reaction with HCl. **97.1 to 106.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard,

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-13 (Sheet 1 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-76

SHEET 2 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/22/2007 FINISHED: 8/9/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,731.74 E 570,563.82
TOTAL DEPTH: 282.1 ft.
DEPTH TO BEDROCK: 132.0 ft.

STATE: Nevada
GROUND ELEVATION: 3870.89
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SP-SM)g		subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 30 mm; dry, light gray, weak reaction with HCl.
	110, 115, 120, 125, 130						(SP-SM)gc		**106.6 to 132.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic to low plasticity fines with no to low dry strength, quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 95 mm; dry, light gray, strong reaction with HCl.
	135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185						Tpki		**132.0 to 223.9 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, locally bedded, vitric, locally crystallized, nonwelded, pinkish-white, 30 percent pumice, 2 to 10 percent lithic fragments of densely welded tuff, 2 to 5 percent crystal fragments of sanidine, plagioclase, and lesser sphene, less than 1 percent biotite and lesser hornblende and pyroxene. Generally the tuff is moderately soft (H5) to mostly hard (H3), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is sharp (faulted).
	190	5		4	79	61			
	195	3		4	98	59			
	200	3		4	100	65			
	205	3		7	100	36			
	210	4		7	98	42			
	215	4		7	96	27			
		4		9	33	0			

Figure RAI 2.2.1.1.1-004-13 (Sheet 2 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-76

SHEET 3 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/22/2007 FINISHED: 8/9/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 771,731.74 E 570,563.82
TOTAL DEPTH: 282.1 ft.
DEPTH TO BEDROCK: 132.0 ft.

STATE: Nevada
GROUND ELEVATION: 3870.89
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		5	91	49	Tpki		
		0		0	0	0			
	225	3		5	96	55	Fault Zone		**223.9 to 250.0 ft. FAULT ZONE:** Consisting of Tiva Canyon Tuff, pyroclastic flow, moderately and densely welded, crystallized, vapor-phase altered, lithophysal spots, intervals of calcite cemented fault breccia (matrix supported) with argillic fault gouge intervals, light bluish-gray, white, light reddish-gray, reddish-gray, less than 1 percent lithic fragments of crystallized volcanic rock, 2 to 10 percent phenocrysts of feldspar (mostly sanidine), less than 1 percent biotite and hornblende. Generally the fault zone is soft (H6) to mostly hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is sharp (faulted).
		3		9	0	0			
	230	3		9	78	0			
		3		8	64	14			
	235	6		8	92	17			
	240	3		9	73	0			
		3		9	75	0			
		3		9	35	0			
	245	3		8	28	10			
	250	3		8	62	10			**250.0 to 267.0 ft. TIVA CANYON TUFF CRYSTAL-POOR NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, crystallized, mottled with pinkish-gray and reddish-gray, 5 to 10 percent pumice, 1 to less than 4 percent lithic fragments of welded tuff and rhyolite lavas, less than 1 to 4 percent crystal fragments of feldspar, less than 1 percent biotite and hornblende. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is undetermined.
	255	3		8	100	12	Tpcpln		
		3		8	96	22			
	260	3		7	97	28			
	265	3		5	74	41			
	270								
	275								
	280								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-13 (Sheet 3 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-78

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/17/2007 FINISHED: 7/23/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,082.24 E 570,894.62
TOTAL DEPTH: 397.6 ft.
DEPTH TO BEDROCK: 135.5 ft.

STATE: Nevada
GROUND ELEVATION: 3806.00
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to depth of 149.0'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 149.0 to 397.6'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 397.6' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
5-7/8" casing from 0.0 to 149.0'. 4-1/2" casing from 149.0 to 397.6'.

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Back fill hole from 397.6' (TD) up to ground level with Bentonite Chips.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
5, 10, 15, 20, 25, 30, 35						(SM)g		**0.0 to 135.5 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 39.4 ft. SILTY SAND WITH GRAVEL (SM)g:** About 70 percent coarse to fine, angular to subrounded sand; about 15 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent fines of no to low plasticity with no to low dry strength, quick dilatancy and low toughness; maximum size 45 mm; dry, light yellowish brown, pale brown, pink, no reaction with HCl.
40						(GM)s		**39.4 to 45.3 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, angular to subrounded gravel; about 40 percent coarse to fine, angular to subrounded sand; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 35 mm; dry, pale brown, strong reaction with HCl.
45, 50, 55						(SM)g		**45.3 to 58.5 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 25 mm; dry, pinkish gray, strong reaction with HCl.
60						(GM)s		**58.5 to 65.4 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, pinkish gray, strong reaction with HCl.
65, 70, 75, 80, 85, 90, 95						(SP-SM)g		**65.4 to 105.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, reddish yellow, weak reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-14 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-78

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/17/2007 FINISHED: 7/23/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,082.24 E 570,894.62
TOTAL DEPTH: 397.6 ft.
DEPTH TO BEDROCK: 135.5 ft.

STATE: Nevada
GROUND ELEVATION: 3806.00
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SP-SM)g		**105.1 to 119.4 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent fines of low plasticity with no dry strength, slow dilatancy and low toughness; maximum size 50 mm; dry, reddish yellow, strong reaction with HCl.
	110						(GP-GM)s		
	115								
	120						(SM)g		**119.4 to 135.5 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent fines of low plasticity with no dry strength, slow dilatancy and low toughness; maximum size 45 mm; dry, reddish yellow, strong reaction with HCl.
	125								
	130								
	135						Tmbt1		**135.5 to 149.0 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, pumice fall deposits, massively bedded, mostly crystallized, rarely vitric, very pale brown, white, pinkish-gray, 20 percent pumice, less than 1 to 3 percent lithic fragments of volcanic rock, less than 5 to 20 percent crystal fragments of feldspar and biotite with rare magnetite and quartz. Generally the tuff is slightly weathered (W3). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	140								
	145								
	150	4		6	76	51	Tpbt5		**149.0 to 151.3 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Pyroclastic flow, non to partially welded, crystallized, reddish-gray, 2 to 10 percent pumice, less than 1 percent lithic fragments of welded tuff, 1 to 7 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and lesser pyroxene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
							Tpcrv		**151.3 to 152.8 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, moderately welded, crystallized, partially vapor-phase alteration, 7 to 15 percent pumice, less than 1 percent lithic fragments of welded tuff, 12 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, magnetite, and pyroxene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	155	4		6	94	50	Tpcrn		**152.8 to 238.4 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, vapor-phase alteration locally, brown, light reddish-brown, pale red, white, pinkish-gray, light gray, 1 to 35 percent pumice, less than 3 percent lithophysae locally, less than 1 percent lithic fragments of welded tuff, 7 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, magnetite, pyroxene and hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging moderately fractured (FD5). Lower contact is conformable and gradational.
	160	4		7	91	36			
	165	4		7	93	33			
	170	4		6	89	46			
	175	4		2	100	91			
	180	4		2	96	94			
	185	4		3	100	92			
	190	4		5	100	57			
	195	4		3	100	90			
	200	4		4	81	67			
	205	4		6	83	55			
	210	4		7	55	29			
	215	3		3	100	94			
		3		4	100	83			

Figure RAI 2.2.1.1.1-004-14 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-78

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/17/2007 FINISHED: 7/23/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,082.24 E 570,894.62
TOTAL DEPTH: 397.6 ft.
DEPTH TO BEDROCK: 135.5 ft.

STATE: Nevada
GROUND ELEVATION: 3806.00
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]
220	3		4	100	83	Tpcrn
	3		6	100	52	
225	3		5	88	57	
230	3		6	100	48	
	3		9	29	0	
	3		9	53	0	
235	3		5	86	58	
240	3		6	88	40	Tpcpun
245	3		5	98	59	
250	3		7	73	20	Tpcpul
255	3		9	58	0	
	3		9	53	0	
260	3		9	29	0	
	3		8	78	12	
265	3		8	84	9	
	3		9	100	0	
270	3		7	100	30	
	3		9	88	0	
275	3		3	100	92	
280	3		5	98	72	
285	3		5	89	79	
290	3		5	100	60	
295	3		4	100	82	
300	3		4	96	84	
305	3		5	89	63	
310	3		5	98	72	
315	3		6	85	41	Tpcpmn
320	3		6	100	54	
325	3		3	100	94	
330	3		6	94	53	
335	3		5	100	72	
	3		7	89	36	

GRAPHIC

CLASSIFICATION AND PHYSICAL CONDITION

238.4 to 250.3 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun): Pyroclastic flow, densely welded, crystallized, pinkish-gray, pale red, 7 to 8 percent pumice, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, pyroxene, magnetite, and manganese oxide. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.

250.3 to 313.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul): Pyroclastic flow, densely welded, crystallized, pale red, white, light gray, 5 to 8 percent pumice, 8 to 15 percent lithophysae, less than 1 percent lithic fragments of welded tuff, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and manganese oxide. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.

313.0 to 376.3 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn): Pyroclastic flow, densely welded, crystallized, pale red, white, light gray, 3 to 5 percent pumice, 1 to 2 percent lithophysae, 2 to 15 percent vapor-phase spots, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly fractured (FD3) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.

Figure RAI 2.2.1.1.1-004-14 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-78

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/17/2007 FINISHED: 7/23/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,082.24 E 570,894.62
TOTAL DEPTH: 397.6 ft.
DEPTH TO BEDROCK: 135.5 ft.

STATE: Nevada
GROUND ELEVATION: 3806.00
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	3		7	89	36	Tpcpmn		
	345	3		6	94	59			
	350	3		5	100	58			
	355	3		6	98	69			
	360	3		6	90	54			
	365	3		6	94	47			
	370	3		6	100	51			
	375	3		6	89	52			**376.3 to 389.3 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, pale red, dark reddish-gray, less than 1 percent pumice, 10 to 20 percent lithophysae, 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, pyroxene and magnetite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	380	3		9	64	0	Tpcpll		
	385	3		6	96	60			
	390	3		6	100	58			**389.3 to 397.6 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, crystallized, pale red, 4 to 7 percent pumice, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
		3		9	100	0	Tpcpln		
	395	3		4	100	88			

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-14 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-79

SHEET 1 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/19/2007 FINISHED: 4/27/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,398.83 E 570,480.07
TOTAL DEPTH: 251.6 ft.
DEPTH TO BEDROCK: 132.3 ft.

STATE: Nevada
GROUND ELEVATION: 3818.17
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Sonic core with 4-3/4" bit from 0.0 to depth of 121.4'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 121.4 to 251.6' (TD). 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 5-7/8" casing from 0.0 to 121.4'. 4-1/2" casing from 121.4 to 251.6'. **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Back fill hole from 251.6' (TD) up to ground level with Bentonite Chips.	5 10 15 20 25						(SC)g (SP-SM)g		**0.0 to 132.3 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 0.8 ft. CLAYEY SAND WITH GRAVEL (SC)g:** About 45 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular gravel; about 15 percent fines of medium plasticity with slow dilatancy and low toughness; maximum size 35 mm; dry, pale brown, weak reaction with HCl. Roots and twigs present. **0.8 to 28.3 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 75 percent coarse to fine, subangular sand; about 15 percent coarse to fine, hard, subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, light gray, no reaction with HCl.
	30 35						(SM)g		**28.3 to 38.0 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, pink, strong reaction with HCl.
	40						SP-SM		**38.0 to 45.6 ft. POORLY GRADED SAND WITH SILT (SP-SM):** About 80 percent coarse to fine, subangular to subrounded sand; about 10 percent predominantly fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 20 mm; dry, pinkish gray, strong reaction with HCl.
	45						(SP)g		**45.6 to 49.2 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 70 percent coarse to fine, angular to subangular sand; about 25 percent coarse to fine, hard, angular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, pinkish gray, moderate reaction with HCl.
	50						(SM)g		**49.2 to 55.1 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, brownish yellow, strong reaction with HCl.
	55 60 65 70 75						(SP-SM)g		**55.1 to 77.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of no to low plasticity with quick to slow dilatancy and low toughness; maximum size 55 mm; dry, brownish yellow, reddish yellow, strong reaction with HCl.
	80 85 90 95						(SM)gc		**77.6 to 110.6 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of subangular to rounded cobbles; maximum size 85 mm; dry, reddish yellow, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-15 (Sheet 1 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-79

SHEET 2 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/19/2007 FINISHED: 4/27/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,398.83 E 570,480.07
TOTAL DEPTH: 251.6 ft.
DEPTH TO BEDROCK: 132.3 ft.

STATE: Nevada
GROUND ELEVATION: 3818.17
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SM)gc		
	110								**110.6 to 132.3 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 80 mm; dry, pinkish gray, strong reaction with HCl.
	115								
	120						(SP-SM)gc		
	125								
	130								
	135	4		4	100	70			**132.3 to 187.7 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pyroclastic fall, nonwelded, vitric and crystallized, very pale brown, white, pale yellow, 10 to over 50 percent pumice, 5 to 25 percent lithic fragments of densely welded tuff, 5 to 15 percent crystal fragments of feldspar, less than 1 percent biotite and hornblende, sphene present (locally conspicuous). Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), slightly to very slightly fractured (FD3) to mostly moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	140	4		4	100	74			
	145	4		4	100	93			
	150	4		3	100	99			
	155	4		4	98	58			
	160	4		3	98	84	Tpki		
	165	4		3	100	99			
	170	4		3	100	91			
	175	4		4	100	56			
	180	4		4	98	73			
	185	5		4	94	52			
	190	5		4	100	70			**187.7 to 213.6 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Pyroclastic fall, nonwelded to partially welded, vitric and crystallized, very pale brown, pale brown, light brown, reddish-brown, white, pale yellow, pinkish-gray, gray, 5 to over 50 percent pumice, 1 to 10 percent lithic fragments, 3 to 7 percent crystal fragments of feldspar, less than or equal to 1 percent biotite and hornblende, less than 1 percent pyroxene, sphene present. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), fresh (W1), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	195	5		5	100	50			
		5		5	100	89			
	200	4		4	91	83	Tpbt5		
	205	4		5	100	65			
	210	4		7	75	19			
	215	4		5	100	69			**213.6 to 221.2 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, densely welded, vitric to crystallized, reddish-brown, pale red, reddish-gray, gray, 5 to 10 percent pumice, less than 1 percent lithic fragments, 7 to 25 percent crystal fragments of feldspar, less than 1 percent biotite and hornblende. Generally the tuff is moderately hard (H4).
		4		6	98	48	Tpcrv		

Figure RAI 2.2.1.1.1-004-15 (Sheet 2 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-79

SHEET 3 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/19/2007 FINISHED: 4/27/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,398.83 E 570,480.07
TOTAL DEPTH: 251.6 ft.
DEPTH TO BEDROCK: 132.3 ft.

STATE: Nevada
GROUND ELEVATION: 3818.17
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		6	98	48	Tpcrv		fresh (W1), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational. **221.2 to 251.6 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, nonwelded, partially welded, and moderately to densely welded, vitric to crystallized, vapor-phase mineralization locally, dark gray, light reddish-gray, reddish-gray, dark reddish-gray, pale red, pinkish-gray, light gray, 5 to 20 percent pumice, less than 1 percent lithic fragments, 5 to 15 percent crystal fragments of feldspar, less than 1 percent biotite and pyroxene. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), very intensely fractured (FD9) to mostly intensely fractured (FD7). Lower contact is undetermined.
	225	3		7	58	22	Tpcrn		
		4		7	100	26			
	230	4		9	37	0			
	235	4		7	91	31			
	240	4		7	78	36			
	245	4		7	69	29			
	250	4		7	98	27			

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-15 (Sheet 3 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-80

SHEET 1 OF 2

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/3/2007 FINISHED: 5/9/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,769.28 E 570,480.37
TOTAL DEPTH: 162.7 ft.
DEPTH TO BEDROCK: 127.9 ft.

STATE: Nevada
GROUND ELEVATION: 3796.08
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to depth of 127.9'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 127.9 to 162.7' (TD). 4-1/2" casing is advanced as hole is cored. Remove casing and coring system.

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Casing Record:
5-7/8" casing from 0.0 to 127.9'. 4-1/2" casing from 127.9 to 162.7' (TD).

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Back fill hole from 162.7' (TD) up to ground level with Bentonite Chips.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
0						(SP-SM)g	
5						(SM)g	
10							
15							
20						(SP-SM)g	
						(SM)g	
25						(SP)g	
30						(SP-SM)g	
						(SP)g	
35							
40							
45							
50							
55							
60						(SM)gc	
65							
70							
75							
80							
85						(GM)s	
90							
95						(SP-SM)g	

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 127.9 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 0.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 50 percent coarse to fine, angular to subrounded sand; about 40 percent coarse to fine, hard, subangular gravel; about 10 percent fines of low plasticity with slow dilatancy and low toughness; maximum size 30 mm; dry, light brown, weak reaction with HCl.

0.7 to 20.3 ft. SILTY SAND WITH GRAVEL (SM)g: About 60 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 65 mm; dry, pink, strong reaction with HCl.

20.3 to 21.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pink, no reaction with HCl.

21.6 to 25.9 ft. SILTY SAND WITH GRAVEL (SM)g: About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, pinkish gray, no reaction with HCl.

25.9 to 28.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 75 percent coarse to fine, angular to subangular sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 45 mm; dry, pink, no reaction with HCl.

28.0 to 33.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pink, strong reaction with HCl.

33.1 to 33.9 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 85 percent coarse to fine, angular to subangular sand; about 15 percent predominantly fine, hard, angular to subangular gravel; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 20 mm; dry, pink, no reaction with HCl.

33.9 to 84.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc: About 65 percent coarse to fine, angular to subrounded sand; about 20 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 80 mm; dry, pink, strong reaction with HCl.

84.2 to 88.4 ft. SILTY GRAVEL WITH SAND (GM)s: About 50 percent coarse to fine, hard, angular to subrounded gravel; about 35 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, pale yellow, no reaction with HCl.

88.4 to 103.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 75 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, pinkish gray, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-16 (Sheet 1 of 2)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-80

SHEET 2 OF 2

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/3/2007 FINISHED: 5/9/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,769.28 E 570,480.37
TOTAL DEPTH: 162.7 ft.
DEPTH TO BEDROCK: 127.9 ft.

STATE: Nevada
GROUND ELEVATION: 3796.08
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SP-SM)g		
							(GP-GM)s		**103.0 to 106.5 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pinkish gray, strong reaction with HCl.
	110						(SM)g		**106.5 to 115.0 ft. SILTY SAND WITH GRAVEL (SM)g:** About 65 percent coarse to fine, angular to subangular sand; about 20 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, light gray, strong reaction with HCl.
	115								**115.0 to 127.9 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 45 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 90 mm; dry, light gray, strong reaction with HCl.
	120						(GM)sc		
	125								
	130	3		8	52	8			**127.9 to 162.7 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, partially, moderately and densely welded, crystallized, vapor-phase alteration locally, dark reddish-gray, very dark gray, reddish-brown, pale red, light gray. 2 to 25 percent pumice, 2 percent lithophysae locally, less than 1 percent lithic fragments of crystallized welded tuff locally, 10 to 15 percent crystal fragments of feldspar, less than 1 percent pyroxene, and lesser biotite. Generally the tuff is hard (H3) to soft (H6) averaging moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
		6		9	30	0			
	135	4		7	92	29			
	140	4		6	100	78			
	145	4		4	100	98	Tpcrn		
	150	4		3	100	81			
	155	4		8	92	14			
	160	4		6	100	76			
				BOTTOM OF HOLE					

Figure RAI 2.2.1.1.1-004-16 (Sheet 2 of 2)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-83

SHEET 1 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/25/2007 FINISHED: 6/26/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,679.32 E 573,150.5
TOTAL DEPTH: 482.5 ft.
DEPTH TO BEDROCK: 131.2 ft.

STATE: Nevada
GROUND ELEVATION: 3662.77
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to depth of 124.9'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 124.9 to 482.5' (TD). 4-1/2" casing is advanced as hole is cored. Remove casing and coring system.

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
5-7/8" casing from 0.0 to 124.9'. 4-1/2" casing from 124.9 to 482.5' (TD).

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Back fill hole from 482.5' (TD) up to ground level with Bentonite Chips.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
5, 10, 15, 20						(SP-SM)g		**0.0 to 131.2 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 22.2 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of no to low plasticity with slow to quick dilatancy and low toughness; maximum size 70 mm; dry, reddish yellow, no to strong reaction with HCl. Roots present from 0.0 to 0.5 ft.
25						(SM)g		**22.2 to 28.7 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, pinkish gray, strong reaction with HCl.
30, 35, 40, 45, 50, 55						(SP-SM)g		**28.7 to 56.9 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of no to low plasticity with slow to quick dilatancy and low toughness; maximum size 75 mm; dry, reddish yellow, strong reaction with HCl.
60						(GP-GM)s		**56.9 ft. 63.6 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent fines of low plasticity with slow dilatancy and low toughness; maximum size 65 mm; dry, reddish yellow, strong reaction with HCl.
65, 70, 75, 80, 85, 90, 95						(SM)gc		**63.6 to 110.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, angular to subrounded sand; about 30 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 80 mm; dry, pinkish gray, weak to strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-17 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-83

SHEET 2 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/25/2007 FINISHED: 6/26/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,679.32 E 573,150.5
TOTAL DEPTH: 482.5 ft.
DEPTH TO BEDROCK: 131.2 ft.

STATE: Nevada
GROUND ELEVATION: 3662.77
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SM)gc		
	110						(SP-SM)gc		**110.2 to 117.5 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, angular to subrounded sand; about 35 percent coarse to fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 80 mm; dry, pinkish gray, strong reaction with HCl.
	115								
	120						(SM)gc		**117.5 to 131.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard drilled cobbles; maximum size 130 mm; dry, pinkish gray, no reaction with HCl.
	125								
	130	5		9	52	0	Tmr		**131.2 to 142.3 ft. RAINIER MESA TUFF (Tmr):** Bedded tuff, pumice fall deposits, reworked locally, white, light gray, 30 to 50 percent pumice, 10 to 15 percent crystal fragments of sanidine, plagioclase, quartz and less than 1 percent biotite. Generally the tuff is very soft (H7) to moderately soft (H5) averaging soft (H6), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is unconformable and sharp.
	135	6		4	100	77			
	140	7		8	84	0	Tmbt1		**142.3 to 275.7 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, pumice fall deposits, nonwelded, massively bedded, reworked locally, light reddish-brown, 3 to 80 percent pumice, 0 to 60 percent lithic fragments, 5 to 20 percent crystal fragments of quartz, sanidine, plagioclase, sphene, and minor biotite. Generally the tuff is very soft (H7) to moderately soft (H5) averaging soft (H6), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	145	7		6	92	55			
	150	7		7	76	12			
	155	7		9	44	0			
	160	7		9	100	15			
	165	7		3	98	76			
	170	7		9	74	0			
	175	7		9	92	11			
	180	7		9	31	0			
	185	7		8	84	20			
	190	6		4	100	74			
	195	6		4	88	74			
	200	7		9	100	0			
	205	6		4	100	65			
	210	7		4	98	58			
	215	5		3	98	90			
		5		3	100	95			

Figure RAI 2.2.1.1.1-004-17 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-83

SHEET 3 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/25/2007 FINISHED: 6/26/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,679.32 E 573,150.5
TOTAL DEPTH: 482.5 ft.
DEPTH TO BEDROCK: 131.2 ft.

STATE: Nevada
GROUND ELEVATION: 3662.77
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	5		3	100	95	Tmbt1		
	225	5		3	100	100			
	230	5		3	98	99			
	235	5		4	100	87			
	240	5		4	100	71			
	245	6		3	94	83			
	250	6		4	96	73			
	255	6		4	100	60			
	260	6		4	96	87			
	265	5		3	94	77			
	270	6		4	92	66			
	275	5		4	100	87			
	280	5		2	100	100	Tpki		**275.7 to 435.7 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, crystallized, white, light gray, 7 to 20 percent pumice, 5 to 30 percent lithic fragments, 5 to 10 percent crystal fragments of sanidine, plagioclase, possible quartz, and a trace of hornblende and biotite. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to moderately to slightly fractured (FD4) averaging slightly fractured (FD2). Lower contact is unconformable and sharp at 65 degrees to the core axis.
	285	5		2	100	97			
	290	4		2	100	100			
	295	4		2	100	98			
	300	4		2	100	100			
	305	4		1	98	97			
	310	4		1	100	100			
	315	4		1	100	100			
	320	4		1	98	99			
	325	4		2	100	100			
	330	4		2	100	100			
	335	4		4	100	84			
		4		0	100	96			

Figure RAI 2.2.1.1.1-004-17 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-83

SHEET 4 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/25/2007 FINISHED: 6/26/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,679.32 E 573,150.5
TOTAL DEPTH: 482.5 ft.
DEPTH TO BEDROCK: 131.2 ft.

STATE: Nevada
GROUND ELEVATION: 3662.77
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		0	100	96	Tpki		
	345	4		1	100	100			
	350	4		1	98	93			
	355	4		3	96	88			
	360	4		3	98	95			
	365	4		3	100	95			
	370	4		4	100	78			
	375	4		3	100	82			
	380	4		3	98	93			
	385	4		2	98	99			
	390	4		4	98	84			
	395	4		4	98	91			
	400	4		4	100	67			
	405	4		4	100	82			
	410	4		0	100	100			
	415	4		0	100	100			
	420	4		1	100	100			
	425	4		1	96	97			
	430	4		2	94	90			
	435	4		4	88	65			
		4		4	100	97	Tpbt5		**435.7 to 447.7 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuffs (reworked locally), pumice fall deposits, pyroclastic flows, nonwelded, crystallized, white, very pale brown, reddish-yellow, gray, light reddish-brown, 15 to 20 percent pumice, 5 to 10 percent lithic fragments. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
		4		7	43	0			
	440	4		4	100	84			
		4		6	90	69			
	445	4		4	92	88			
	450	4		5	100	46	Tpcrv		**447.7 to 458.3 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, partially to densely welded, crystallized and locally vitric, pinkish-gray, gray, white, light bluish-gray, reddish-gray, light reddish-brown, light red, dark reddish-gray, 15 to 30 percent pumice, 5 to 25 percent crystal fragments of feldspar and biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is conformable and gradational.
	455	4		6	98	52			

Figure RAI 2.2.1.1.1-004-17 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-83

SHEET 5 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/25/2007 FINISHED: 6/26/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,679.32 E 573,150.5
TOTAL DEPTH: 482.5 ft.
DEPTH TO BEDROCK: 131.2 ft.

STATE: Nevada
GROUND ELEVATION: 3662.77
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		6	98	52	Tpcrn		**458.3 to 482.5 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely welded, crystallized, locally vitric, pinkish gray, light gray, 15 to 25 percent pumice, 5 to 25 percent crystal fragments of feldspar and biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is undetermined.
		4		5	100	44			
	465	4		4	100	80			
	470	4		5	100	76			
	475	4		0	98	98			
	480	4		5	100	97			
		BOTTOM OF HOLE							

Figure RAI 2.2.1.1.1-004-17 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-95

SHEET 1 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/20/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,844.09 E 571,572.51
TOTAL DEPTH: 577.7 ft.
DEPTH TO BEDROCK: 182.1 ft.

STATE: Nevada
GROUND ELEVATION: 3753.03
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Set approximately 4.5' of 10-3/4" surface casing using backhoe and cement in place. Sonic core with 4-3/4" bit from 0.0 to depth of 142.4'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 142.4 to 560.0'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 577.7 ' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 10-3/4" surface casing to approximately 4.5'. 5-7/8" casing from 0.0 to 142.4'. 4-1/2" casing from 142.4 to 560.0'. **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Install 3-1/2" PVC casing to depth of 577.7'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 577.7' (TD) up to ground level. Install 14-1/4" sono tube around PVC well casing.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100						(SP-SM)gc (SP-SM)g (SM)g (GP-GM)s (SP-SM)g (SM)g (SP-SM)g		**0.0 to 182.1 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 1.5 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 80 mm; dry, yellowish red, moderate reaction with HCl. Roots present. **1.5 to 16.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, reddish brown, strong reaction with HCl. **16.1 to 52.8 ft. SILTY SAND WITH GRAVEL (SM)g:** About 45 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, reddish yellow, strong reaction with HCl. **52.8 to 56.6 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, subrounded to rounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, reddish yellow, strong reaction with HCl. **56.6 to 92.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 75 percent coarse to fine, angular to subrounded sand; about 15 percent coarse to fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, reddish brown, pinkish gray, moderate to strong reaction with HCl. **92.0 to 93.7 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pink, strong reaction with HCl. **93.7 to 128.3 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 65 mm; dry, pink, no reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-18 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-95

SHEET 2 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/20/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,844.09 E 571,572.51
TOTAL DEPTH: 577.7 ft.
DEPTH TO BEDROCK: 182.1 ft.

STATE: Nevada
GROUND ELEVATION: 3753.03
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	110								
	115						(SP-SM)g		
	120								
	125								
	130						(GM)s		**128.3 to 129.8 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pinkish gray, strong reaction with HCl. **129.8 to 182.1 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, angular to subrounded sand; about 35 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, gray, pinkish gray, moderate to strong reaction with HCl.
	135								
	140								
	145								
	150								
	155						(SM)g		
	160								
	165								
	170								
	175								
	180								
	185	4		4	100	84			**182.1 to 289.3 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pumice fall deposits, nonwelded, vitric to crystallized, white, light gray, 5 to 80 percent pumice, less than 1 to 20 percent lithic fragments of moderately to densely welded tuff, less than 1 to 5 percent crystal fragments of plagioclase, sanidine, with lesser biotite and rare sphene. Contact with Tpbt5 is sharp, irregular, dipping 70 degrees to the core axis. Generally the tuff is hard (H3) to soft (H6) averaging moderately hard (H4), fresh (W1), very slightly fractured (FD1) to intensely to moderately fractured (FD6) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	190	4		4	100	91			
	195	4		2	100	91			
	200	4		5	100	64			
	205	4		4	100	78	Tpki		
	210	4		2	100	94			
	215	4		3	100	90			
	220	3		1	100	100			
	225	3		1	100	87			
		3		3	100	93			

Figure RAI 2.2.1.1.1-004-18 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-95

SHEET 3 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/20/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,844.09 E 571,572.51
TOTAL DEPTH: 577.7 ft.
DEPTH TO BEDROCK: 182.1 ft.

STATE: Nevada
GROUND ELEVATION: 3753.03
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		3	100	93			
	235	3		1	87	85			
	240	3		4	100	93			
	245	3		4	100	81			
	250	3		3	98	90			
	255	3		3	100	89			
	260	3		3	100	99	Tpki		
	265	3		1	98	94			
	270	4		3	100	87			
	275	4		4	100	97			
	280	4		3	98	98			
	285	6		6	98	59			
	290	7		5	100	73			**289.3 to 308.3 ft. POST TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuffs and pyroclastic flows, pumice fall deposits, vitric to crystallized, nonwelded to densely welded, pink, white, light gray, pinkish-gray, light brown, 5 to 85 percent pumice, 1 to 30 percent lithic fragments, 3 to 30 percent crystal fragments of plagioclase, sanidine, and lesser biotite and hornblende. Generally the tuff is hard (H3) to very soft (H7) averaging moderately soft (H5), fresh (W1), very slightly fractured (FD1) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	295	5		6	96	57	Tpbt5		
	300	4		1	97	95			
	305	4		4	98	95			
	310	3		6	100	54	Tpcrv		**308.3 to 311.7 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, densely welded, vitric, pinkish gray, black, 10 percent pumice, less than 1 percent lithic fragments, 10 to 12 percent crystal fragments. Generally the tuff is hard (H3), fresh (W1), intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	315	3		6	100	71			**311.7 to 415.0 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely welded, crystallized, locally vapor-phase altered, pale red, light gray, white, less than 2 to 50 percent pumice, less than 2 percent lithophysae locally, less than 1 percent lithic fragments locally, 10 to 15 percent crystal fragments of plagioclase, sanidine, lesser biotite, less than 1 percent pyroxene, and possible hornblende. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), very slightly fractured (FD1) to intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
		3		6	92	35			
	320	3		3	100	97			
	325	4		7	98	28			
	330	4		8	35	17			
	335	3		5	82	66	Tpcrn		
	340	3		5	96	90			
	345	3		4	100	94			
	350	3		4	100	73			
		3		4	100	97			

Figure RAI 2.2.1.1.1-004-18 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-95

SHEET 4 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/20/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,844.09 E 571,572.51
TOTAL DEPTH: 577.7 ft.
DEPTH TO BEDROCK: 182.1 ft.

STATE: Nevada
GROUND ELEVATION: 3753.03
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		4	100	97			
	360	3		4	98	73			
	365	3		4	100	65			
	370	3		6	97	51			
	375	3		5	96	65			
	380	3		4	94	76			
	385	3		4	96	75	Tpcrn		
	390	3		6	39	32			
	395	0		0	0	0			
	400	0		0	0	0			
	405	3		7	70	9			
	410	3		1	96	97			
	415	3		6	80	57			**415.0 to 427.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, reddish-gray, pale red, 5 to 10 percent pumice, less than 1 percent lithophysae, 2 to 5 percent crystal fragments of sanidine, plagioclase, lesser biotite, and possible hornblende. Generally the tuff is hard (H3), fresh (W1), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	420	3		5	96	71	Tpcpun		
	425	3		7	89	46			
	430	3		5	91	62			**427.0 to 519.3 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pinkish gray, pale red, gray, 2 percent pumice, 5 to 10 percent lithophysae, 2 to 3 percent crystal fragments of sanidine, plagioclase, lesser biotite, and possible hornblende. Generally the tuff is hard (H3), fresh (W1), slightly fractured (FD3) to very intensely fractured (FD9) averaging moderately fractured (FD5). Lower contact is conformable and gradational.
		3		8	96	31			
	435	3		9	38	0			
	440	3		9	83	0			
		3		5	100	70			
	445	3		4	100	89			
	450	3		5	100	80			
	455	3		4	100	82	Tpcpul		
	460	3		5	96	66			
	465	3		4	100	90			
	470	3		4	98	80			
	475	3		4	100	87			
	480	3		5	92	54			

Figure RAI 2.2.1.1.1-004-18 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-95

SHEET 5 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 4/20/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,844.09 E 571,572.51
TOTAL DEPTH: 577.7 ft.
DEPTH TO BEDROCK: 182.1 ft.

STATE: Nevada
GROUND ELEVATION: 3753.03
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		5	92	54			
	485	3		5	100	95			
	490	3		5	100	74			
	495	3		6	100	73			
	500	3		4	100	66	Tpcpul		
	505	3		6	100	79			
	510	3		3	100	91			
	515	3		4	100	95			
	520	3		3	100	97			**519.3 to 543.9 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, 5 percent pumice locally, less than 1 percent lithophysae, 2 percent crystal fragments of plagioclase, sanidine, and lesser biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly to very slightly fractured (FD2) to moderately fractured (FD5) averaging moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
	525	3		2	100	86			
	530	3		4	100	80			
	535	3		5	100	81	Tpcpmn		
	540	3		5	100	68			
	545	3		4	100	92			**549.3 to 560.0 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, dark reddish-gray, 5 percent pumice, 5 percent lithophysae, up to 10 percent locally, 2 percent crystal fragments of sanidine and plagioclase, with lesser biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is undetermined.
	550	3		4	100	83	Tpcpll		
		3		4	100	100			
	555	3		6	86	51			
	560								
	565								
	570								
	575								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-18 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-97

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/9/2007 FINISHED: 8/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,183.73 E 570,595.93
TOTAL DEPTH: 603.6 ft.
DEPTH TO BEDROCK: 79.1 ft.

STATE: Nevada
GROUND ELEVATION: 3711.04
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Rotosonic. Set 10-3/4" surface casing from 0.0 to approximately 4.5'. Sonic core with 4-3/4" bit to depth of 35.2´. Advance 5-7/8" casing with 6-3/8" shoe to 34.9´. Sonic core from 34.9´ to 134.1´. Casing is advanced as hole is drilled. Change over to CME 85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 134.1' to 583.3'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 603.6' TD.

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
10-3/4" casing from 0.0 to approximately 4.5'. 5-7/8" casing from 0.0 to 134.1'. 4-1/2" casing from 134.1 to 583.3'.

Hole Completion:
Install 3-1/2" PVC casing to depth of 603.5'. Use 1" PVC tremmie pipe to grout PVC casing from bottom of hole 603.6' (TD) up to ground level.

DEPTH	HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	CLASSIFICATION AND PHYSICAL CONDITION
						(GM)s	**0.0 to 79.1 ft. QUATERNARY ALLUVIUM (Qal):**
5						(SP-SM)gc	**0.0 to 3.0 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 15 percent fines of medium plasticity with slow dilatancy and low toughness; maximum size 75 mm; dry, pink, strong reaction with HCl. Roots and organic material present near top of unit. **3.0 to 18.6 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 80 mm; dry, light gray, pink, strong reaction with HCl.
10							
15							
20						(SM)g	**18.6 to 27.0 ft. SILTY SAND WITH GRAVEL (SM)g:** About 65 percent coarse to fine, angular to subangular sand; about 20 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, pink, strong reaction with HCl.
25						(GM)s	
						(SP-SM)g	**27.0 to 27.8 ft. SILTY GRAVEL WITH SAND (GM)s:** About 60 percent coarse to fine, hard, angular to subrounded gravel; about 25 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pale red, no reaction with HCl.
30						(GM)s	**27.8 to 29.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 30 mm; dry, pinkish white, no reaction with HCl.
35						(SM)gc	**29.8 to 31.0 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pale red, no reaction with HCl. **31.0 to 45.9 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 45 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 80 mm; dry, pinkish gray, strong reaction with HCl.
40							
45							
50						(SM)g	**45.9 to 58.5 ft. SILTY SAND WITH GRAVEL (SM)g:** About 70 percent coarse to fine, angular to subangular sand; about 15 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, pinkish gray, weak reaction with HCl.
55							
60						(GM)s	**58.5 to 59.8 ft. SILTY GRAVEL WITH SAND (GM)s:** About 55 percent coarse to fine, hard, angular to subrounded gravel; about 30 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pinkish gray, no reaction with HCl.
						SM	**59.8 to 64.3 ft. SILTY SAND (SM):** About 75 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; about 10 percent coarse to fine, hard, angular to subangular gravel; maximum size 20 mm; dry, pinkish gray, no reaction with HCl.
65						(SP-SM)g	**64.3 to 79.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, pink, pinkish gray, no reaction with HCl.
70							
75							
80						Tmbt1	**79.1 to 272.9 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, locally reworked, possible pyroclastic flows, massively bedded, nonwelded, crystallized and locally clay altered, very pale brown, 3 to 25 percent pumice, 1 to 20 percent lithic fragments of welded tuff, 2 to 15 percent crystal fragments of sanidine, plagioclase and lesser quartz, less than 1 to 15 percent biotite, less than 1 percent magnetite and lesser hornblende. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2) and locally slightly weathered (W3), very slightly fractured (FD1) to intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
85							
90							
95							

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-19 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-97

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/9/2007 FINISHED: 8/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,183.73 E 570,595.93
TOTAL DEPTH: 603.6 ft.
DEPTH TO BEDROCK: 79.1 ft.

STATE: Nevada
GROUND ELEVATION: 3711.04
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105								
	110								
	115								
	120								
	125								
	130								
	135	4		6	97	70			
	140	4		2	89	85			
	145	4		5	91	66			
	150	4		1	92	89			
	155	4		6	100	83			
	160	4		6	94	72	Tmbt1		
	165	4		5	100	73			
	170	4		5	96	74			
	175	4		4	98	77			
	180	4		4	100	100			
	185	4		1	98	93			
	190	4		0	100	99			
	195	4		4	100	95			
	200	4		2	100	98			
	205	4		2	100	100			
	210	4		2	100	98			
	215	4		1	100	96			
		4		1	100	97			

Figure RAI 2.2.1.1.1-004-19 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-97

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/9/2007 FINISHED: 8/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,183.73 E 570,595.93
TOTAL DEPTH: 603.6 ft.
DEPTH TO BEDROCK: 79.1 ft.

STATE: Nevada
GROUND ELEVATION: 3711.04
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		1	100	97	Tmbt1		
	225	4		1	100	100			
	230	4		4	100	89			
	235	4		5	96	79			
	240	4		6	100	84			
	245	4		3	100	94			
		4		6	100	0			
	250	4		5	100	79			
		4		6	100	0			
	255	4		5	100	77			
	260	4		7	81	50			
		4		6	72	57			
	265	4		6	42	16			
	270	4		3	100	100			
	275	4		7	98	63	Tpki		**272.9 to 391.2 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded crystallized, white, pale yellow, 20 to 30 percent pumice, 3 to 25 percent lithic fragments of crystallized welded tuff, 2 percent crystal fragments of sanidine, plagioclase, less than 1 percent biotite, hornblende, sphene, and magnetite. Generally the tuff is moderately hard (H4), fresh (W1), unfractured (FD0) to intensely fractured (FD7) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	280	4		5	100	85			
	285	4		6	100	79			
	290	4		4	98	88			
	295	4		4	98	88			
	300	4		6	100	74			
	305	4		3	100	91			
	310	4		0	100	95			
	315	4		3	100	97			
	320	4		3	100	90			
	325	4		4	100	82			
	330	4		2	100	97			
	335	4		3	100	94			
		4		4	100	94			

Figure RAI 2.2.1.1.1-004-19 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-97

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/9/2007 FINISHED: 8/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,183.73 E 570,595.93
TOTAL DEPTH: 603.6 ft.
DEPTH TO BEDROCK: 79.1 ft.

STATE: Nevada
GROUND ELEVATION: 3711.04
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		4	100	94			
	345	4		1	100	99			
	350	4		1	100	99			
	355	4		0	100	100			
	360	4		3	100	97			
	365	4		1	100	100	Tpki		
	370	4		1	98	98			
	375	4		4	100	91			
	380	4		5	100	94			
	385	4		2	100	89			
	390	4		6	90	65			
	395	4		5	96	69	Tpbt5		**391.2 to 396.1 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff and pyroclastic flow, non to partially welded, crystallized and locally clay altered, pink, pinkish-white, 15 to 70 percent pumice, 2 to 30 percent lithic fragments of welded tuff, 2 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
							Tpcrv		**396.1 to 398.4 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, non to moderately welded, crystallized, light reddish-gray, light bluish-gray, 5 to 8 percent pumice, less than 1 percent lithic fragments of welded tuff, 7 to 10 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Upper and lower contacts are sharp and at 70 degrees and 80 degrees to the core axis respectively. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is conformable and sharp at 80 degrees to the core axis.
	400	3		6	100	61			**398.4 to 451.0 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely welded, crystallized, vapor-phase altered locally, light reddish-brown, pale red, light reddish-gray, white, light gray, 1 to 25 percent pumice, less than 1 percent lithic fragments of welded tuff (locally absent), 5 to 15 percent crystal fragments of sanidine, plagioclase and less than 1 percent biotite and pyroxene and lesser hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	405	4		7	96	42			
	410	4		7	100	57			
	415	4		5	94	56			
	420	4		6	100	64			
	425	4		7	100	25	Tpcrn		
	430	4		4	100	70			
	435	3		6	100	55			
	440	3		6	100	75			
	445	3		7	100	61			
	450	3		4	98	73			
	455	3		8	76	44	Tpcpun		**451.0 to 464.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, reddish-gray, pale red, 2 percent pumice, 1 to 3 percent crystal fragments of sanidine, plagioclase and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to very intensely to intensely fractured (FD8) averaging intensely fractured (FD7). Lower contact is
		3		7	89	51			

Figure RAI 2.2.1.1.1-004-19 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-97

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/9/2007 FINISHED: 8/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,183.73 E 570,595.93
TOTAL DEPTH: 603.6 ft.
DEPTH TO BEDROCK: 79.1 ft.

STATE: Nevada
GROUND ELEVATION: 3711.04
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		7	89	51			conformable and gradational.
	460	3		8	79	35	Tpcpun		
	465	3		7	51	19			**464.0 to 479.5 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red, less than 2 percent lithophysae, 3 to 5 percent pumice, 1 to 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), intensely to moderately fractured (FD6) to mostly intensely fractured (FD7). Lower contact is conformable and gradational.
	470	3		7	76	45	Tpcpul		
	475	3		6	92	77			
		3		6	77	42			
	480	3		7	88	30			**479.5 to 486.5 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, light reddish-brown, with light bluish gray mottling, 2 to 5 percent vapor-phase spots, 1 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), and intensely fractured (FD7). Lower contact is conformable and gradational.
	485	3		7	85	31	Tpcpmn		
	490	3		7	98	24			**486.5 to 495.4 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, crystallized, dark reddish-gray, pale red, 1 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), and intensely fractured (FD7). Lower contact is conformable and gradational.
		3		7	100	44	Tpcpln		
	495	5		6	100	66	Tpcpv Tpbt4		**495.4 to 496.8 ft. TIVA CANYON TUFF CRYSTAL-POOR VITRIC ZONE (Tpcpv):** Pyroclastic flow, non to moderately welded, crystallized, pale red, white, 5 to 8 percent pumice, 2 to 3 percent lithic fragments of welded tuff, 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Upper and lower contacts are faulted. Generally the tuff is moderately soft (H5), fresh (W1), and intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	500	5		5	100	100	Tpy Breccia Zone		**496.8 to 497.9 ft. PRE-TIVA CANYON TUFF BEDDED TUFF (Tpbt4):** Bedded tuff, nonwelded, crystallized, may be clay altered, white, 10 percent pumice, less than 1 percent lithic fragments of welded tuff, 2 to 3 percent crystal fragments of sanidine, plagioclase and biotite. Upper and lower contacts are sharp and at 20 to 50 degrees, and 25 degrees to the core axis respectively. Generally the tuff is moderately soft (H5), slightly weathered to fresh (W2), and intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	505	3		7	25	0	Tpp		**497.9 to 502.4 ft. YUCCA MOUNTAIN TUFF (Tpy):** Pyroclastic flow, non to partially welded, crystallized, very pale brown, light reddish-brown, pale red, 5 to 6 percent pumice (20 to 35 percent pumice in fracture fill near the bottom of the unit), less than 1 percent lithic fragments of welded tuff, less than or equal to 1 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is moderately soft (H5), fresh (W1), and moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is sharp (faulted).
	510	3		6	100	74			**502.4 to 503.1 ft. BRECCIA ZONE:** Composed of fragments of Tpy and Tpp. Generally the breccia zone is hard (H3), fresh (W1), and intensely fractured (FD7). Lower contact is sharp.
	515	3		5	100	66	Tpbt2 Tptrv		**503.1 to 512.4 ft. PAH CANYON TUFF (Tpp):** Pyroclastic flow, moderately to densely welded, crystallized, pink, 10 percent pumice, 1 to 2 percent lithic fragments of welded tuff, 1 to 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to mostly intensely fractured (FD7). Lower contact is sharp (faulted).
	520	3		6	100	64			**512.4 to 515.6 ft. PRE-PAH CANYON TUFF BEDDED TUFF (Tpbt2):** Bedded tuff, nonwelded, crystallized, pale yellow, 70 percent pumice, 2 percent lithic fragments of welded tuff, 1 to 2 percent crystal fragments of sanidine, plagioclase, and 1 percent biotite and pyroxene. Generally the tuff is hard (H3), slightly weathered to fresh (W2), and moderately fractured (FD5). Lower contact is unconformable and sharp.
	525	3		6	100	78			**515.6 to 517.9 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH VITRIC ZONE (Tptrv):** Pyroclastic flow, partially to moderately welded, crystallized, light bluish-gray, 70 percent pumice, 2 percent lithic fragments of welded tuff, 1 to 2 percent crystal fragments of sanidine, plagioclase and less than 1 percent biotite and pyroxene. Generally the tuff is hard (H3), fresh (W1), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is unconformable and sharp and may be erosional.
	530	3		5	100	68			**517.9 to 583.3 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tptrn):** Pyroclastic flow, densely welded, crystallized, light red, reddish-gray, pale red, 10 to 25 percent pumice, 8 to 12 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and hornblende. Generally the tuff is hard (H3), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is undetermined.
	535	3		7	100	56			
	540	3		7	94	58			
	545	3		8	98	39			
		3		7	95	23	Tptrn		
	550	3		9	71	0			
	555	3		7	86	36			
	560	3		8	100	46			
	565	3		8	100	25			
	570	3		7	98	31			
	575	3		6	100	57			
		3		6	100	78			

Figure RAI 2.2.1.1.1-004-19 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-97

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/9/2007 FINISHED: 8/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 767,183.73 E 570,595.93
TOTAL DEPTH: 603.6 ft.
DEPTH TO BEDROCK: 79.1 ft.

STATE: Nevada
GROUND ELEVATION: 3711.04
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	580	3		6	100	78	Tptrm		
		3		8	100	31			
	585								
	590								
	595								
	600								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-19 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-104

SHEET 1 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/23/2007 FINISHED: 6/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,718.89 E 570,162.52
TOTAL DEPTH: 289.2 ft.
DEPTH TO BEDROCK: 50.3 ft.

STATE: Nevada
GROUND ELEVATION: 3682.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to depth of 62.8'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 62.8 to 289.2' (TD). 4-1/2" casing is advanced as hole is cored. Remove casing and coring system.

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
5-7/8" casing from 0.0 to 62.8'. 4-1/2" casing from 62.8 to 289.2'

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Back fill hole from 289.2' (TD) up to ground level with Bentonite Chips.

DEPTH	HARDNESS (ENGINEERING INDEXES)	WELDING (ENGINEERING INDEXES)	FRACTURE DENSITY (ENGINEERING INDEXES)	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
65	4		2	100	96		
70	5		2	100	97		
75	5		6	90	64		
80	5		5	98	83		
85	7		6	67	21		
90	4		4	44	30		
95	7		8	24	8		
	7		9	5	0		

0.0 to 50.3 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 46.5 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 65 percent coarse to fine, angular to subangular sand; about 25 percent coarse to fine, hard, angular to subangular gravel; about 10 percent fines of low plasticity with quick dilatancy and low toughness; maximum size 65 mm; dry, light yellowish brown, strong reaction with HCl. Organic material present.

46.5 to 50.3 ft. CLAYEY SAND WITH GRAVEL (SC)g: About 40 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 30 percent fines of medium plasticity with no dilatancy and low toughness; maximum size 40 mm; dry, white, strong reaction with HCl.

50.3 to 118.2 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1): Bedded tuff, nonwelded, massively bedded, vitric to crystallized, argillic alteration locally, reworked locally, very pale orange, light brownish-gray, pinkish-white, very pale brown, 5 to 20 percent pumice, 1 to 15 percent lithic fragments of densely welded crystallized tuff, 3 to 8 percent crystal fragments of feldspar and lesser quartz, less than 1 percent biotite, hornblende, and magnetite, rare sphene. Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), slightly weathered to fresh (W2), slightly to very slightly fractured (FD2) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-20 (Sheet 1 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-104

SHEET 2 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/23/2007 FINISHED: 6/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,718.89 E 570,162.52
TOTAL DEPTH: 289.2 ft.
DEPTH TO BEDROCK: 50.3 ft.

STATE: Nevada
GROUND ELEVATION: 3682.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		7		9	5	0	Tmbt1		
	105	5		6	92	35			
		4		3	100	92			
	110	7		8	97	46			
	115	4		9	4	0			
	120	4		2	100	88	Tpki		**118.2 to 239.5 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, crystallized, gray, light gray, white, pinkish-white, very pale brown, 20 to 25 percent pumice, 2 to 15 percent lithic fragments, 2 percent crystal fragments of feldspar, less than 1 percent biotite, hornblende, and trace of sphene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to moderately to slightly fractured (FD4) averaging slightly fractured (FD3). Lower contact is sharp (faulted).
	125	4		1	100	100			
	130	4		3	100	94			
	135	4		3	100	92			
	140	4		4	100	81			
	145	4		4	100	88			
	150	4		4	70	51			
	155	4		0	100	100			
	160	4		4	98	83			
	165	4		3	100	93			
	170	4		5	88	58			
	175	4		1	100	100			
	180	4		4	100	83			
	185	4		1	96	96			
	190	4		3	100	91			
	195	4		1	100	99			
	200	4		2	100	100			
	205	4		3	98	81			
	210	4		4	100	83			
	215	4		1	100	100			
		4		2	98	95			

Figure RAI 2.2.1.1.1-004-20 (Sheet 2 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-104

SHEET 3 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/23/2007 FINISHED: 6/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,718.89 E 570,162.52
TOTAL DEPTH: 289.2 ft.
DEPTH TO BEDROCK: 50.3 ft.

STATE: Nevada
GROUND ELEVATION: 3682.59
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		2	98	95	Tpki		
	225	4		2	100	98			
	230	4		4	96	76			
	235	4		3	77	67			
		4		3	81	66			
	240	4		5	95	59	Fault Zone		**239.5 to 250.4 ft. FAULT ZONE:** Fracture fill material, nonwelded to densely welded, vitric to crystallized, locally argillic, locally reworked, white, light gray, very pale brown, pinkish-gray, pale red, dark reddish-gray, 7 to greater than 70 percent pumice, 0 to 20 percent lithic fragments, 1 to 20 percent crystal fragments of feldspar, less than 1 to 2 percent biotite, hornblende and magnetite. Generally the fault zone is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is sharp.
	245	4		6	91	54			
	250	3		9	68	0			
		3		8	86	0	Tpcpul		**250.4 to 289.2 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red, white, less than 5 percent pumice, 3 to 5 percent lithophysae, less than 1 percent lithic fragments, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite and magnetite. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is undetermined.
	255	4		8	89	25			
	260	4		9	78	0			
		4		7	100	29			
	265	4		6	88	28			
	270	4		5	96	61			
	275	4		6	72	27			
		4		6	77	27			
	280	4		6	100	85			
	285	4		6	93	52			
									BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-20 (Sheet 3 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-105

SHEET 1 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/11/2007 FINISHED: 5/17/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,877.36 E 570,120.92
TOTAL DEPTH: 263.5 ft.
DEPTH TO BEDROCK: 35.4 ft.

STATE: Nevada
GROUND ELEVATION: 3679.45
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to depth of 146.9'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 146.9 to 263.5' (TD). 4-1/2" casing is advanced as hole is cored. Remove casing and coring system.

Drilling Conditions:
Not Reported

Drilling Fluid:
Non potable water and drilling additives.

Fluid Loss Interval:
NA

Casing Record:
5-7/8" casing from 0.0 to 146.9'. 4-1/2" casing from 146.9 to 263.5' (TD).

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Back fill hole from 263.5' (TD) up to ground level with Bentonite Chips.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
0–28.0						(SP-SM)gc		**0.0 to 35.4 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 28.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 65 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 80 mm; dry, brownish yellow, strong reaction with HCl.
28.0–33.4						SP-SM		**28.0 to 33.4 ft. POORLY GRADED SAND WITH SILT (SP-SM):** About 85 percent predominantly fine, subangular to subrounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; about 5 percent predominantly fine, hard, angular to subangular gravel; maximum size 75 mm; dry, brownish yellow, strong reaction with HCl.
33.4–35.4						(GC)s		**33.4 to 35.4 ft. CLAYEY GRAVEL WITH SAND (GC)s:** About 45 percent coarse to fine, hard, angular gravel; about 35 percent coarse to fine, angular to subangular sand; about 20 percent fines of medium plasticity with no dilatancy and low toughness; maximum size 60 mm; dry, very pale brown, strong reaction with HCl.
35–263.5						Tmbt1		**35.4 to 127.8 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, reworked locally, nonwelded, mostly vitric, minor clay alteration, pinkish-white, 5 to 50 percent pumice, less than 1 to 5 percent lithic fragments of volcanic rock, 1 to 15 percent crystal fragments of predominantly feldspar, possible quartz, and lesser biotite and hornblende, with minor magnetite. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-21 (Sheet 1 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-105

SHEET 2 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/11/2007 FINISHED: 5/17/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,877.36 E 570,120.92
TOTAL DEPTH: 263.5 ft.
DEPTH TO BEDROCK: 35.4 ft.

STATE: Nevada
GROUND ELEVATION: 3679.45
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						Tmbt1		
	110								
	115								
	120								
	125								
	130						Tpki		**127.8 to 235.8 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Bedded tuff, pyroclastic flow, nonwelded, crystallized, clay altered, very pale brown, white, pale yellow, 20 to 80 percent pumice, 1 to 20 percent lithic fragments of crystallized welded tuff, 1 to 2 percent crystal fragments of sanidine, plagioclase, biotite, rare magnetite and sphene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	135								
	140								
	145								
	150	4		4	96	80			
		~~4~~		~~4~~	~~100~~	~~100~~			
	155	4		5	88	54			
	160	4		5	96	54			
	165	4		4	91	71			
	170	4		3	98	90			
	175	4		3	89	78			
	180	4		0	100	100			
	185	4		4	98	76			
	190	4		0	100	100			
	195	4		5	88	56			
	200	4		3	100	95			
	205	4		3	100	90			
	210	4		3	96	95			
	215	4		4	98	86			
		4		7	22	0			

Figure RAI 2.2.1.1.1-004-21 (Sheet 2 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-105

SHEET 3 OF 3

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/11/2007 FINISHED: 5/17/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,877.36 E 570,120.92
TOTAL DEPTH: 263.5 ft.
DEPTH TO BEDROCK: 35.4 ft.

STATE: Nevada
GROUND ELEVATION: 3679.45
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	220	4		7	22	0	Tpki	
	225	4		2	100	100		
	230	4		4	96	83		
	235	4		5	100	65		
	240	4		6	100	52	Tpbt5	
	245	4		7	98	49	Tpcrv	
		4		9	100	0	Fault Zone	
	250	4		6	89	47		
	255	4		5	100	49	Tpcrn	
	260	4		7	85	21		

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

235.8 to 244.0 ft. POST TIVA CANYON TUFF BEDDED TUFF (Tpbt5): Bedded/reworked tuff, nonwelded, crystallized, pinkish-gray, pink, white, reddish-yellow, very pale brown, light brown, 15 to 80 percent pumice, 2 to 5 percent lithic fragments of welded tuff, 2 to 10 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Upper contact is irregular and 40 to 80 degrees to the core axis. Generally the tuff is moderately hard (H4), fresh (W1), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.

244.0 to 245.7 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv): Pyroclastic flow, non to partially welded, crystallized, very pale brown, pale red, 3 to 8 percent pumice, less than 1 percent lithic fragment of welded tuff, 3 percent crystal fragments of sanidine and plagioclase, and 1 percent biotite and lesser hornblende. Generally the tuff is moderately hard (H4), fresh (W1), intensely fractured (FD7). Lower contact is sharp (faulted) at 70 degrees to the core axis.

245.7 to 252.5 ft. FAULT ZONE: Consists of brecciated fragments of Tiva Canyon Tuff with fracture fill material consisting of very fine ash and sand size fragments of densely and moderately welded tuff, crystallized, pale red, pinkish-white, white, 5 to 10 percent pumice, 8 to 10 percent crystal fragments of sanidine, plagioclase and less than 1 percent biotite and pyroxene. Generally the fault zone is moderately hard (H4), fresh (W1), intensely to moderately fractured (FD6) to very intensely fractured (FD9), averaging intensely fractured (FD7). Lower contact is sharp.

252.5 to 263.5 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, moderately to densely welded, crystallized, pale red, 15 to 30 percent pumice, 10 to 12 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite, hornblende and magnetite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.

Figure RAI 2.2.1.1.1-004-21 (Sheet 3 of 3)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-106

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/22/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,725.05 E 570,245.87
TOTAL DEPTH: 402.2 ft.
DEPTH TO BEDROCK: 62.6 ft.

STATE: Nevada
GROUND ELEVATION: 3677.55
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Drill 13" hole from 0.0 to approximately 5.0'. Set approximately 4.5' of 10-3/4" surface casing and cement in place. Sonic core with 4-3/4" bit from 0.0 to depth of 155.1'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 155.1 to 389.4'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 402.2 ' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** Set 10-3/4" surface casing from 0.0 to approximately 4.5'. 5-7/8" casing from 0.00 to 155.1'. 4-1/2" casing from 155.1 to 389.4'. **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Install 3-1/2" PVC casing to depth of 398.5'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 402.2' (TD) up to ground level. Install 14-1/4" sono tube around 10-3/4" surface casing and 3-1/2" PVC casing	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(SP-SC)g (SP)gc (GM)s (SM)gc (SM)g Tmbt1		**0.0 to 62.6 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 0.9 ft. POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)g:** About 60 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular gravel; about 10 percent fines of medium plasticity, with very slow dilatancy and low toughness; maximum size 60 mm; dry to moist, light brown, weak reaction with HCl. **0.9 to 16.4 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 50 percent coarse to fine, angular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; trace of hard, angular cobbles; maximum size 80 mm; dry, pink, strong reaction with HCl. **16.4 to 35.4 ft. SILTY GRAVEL WITH SAND (GM)s:** About 50 percent coarse to fine, hard, angular gravel; about 35 percent coarse to fine, angular sand; about 15 percent fines of low plasticity with quick dilatancy and low toughness; maximum size 75 mm; dry, white, strong reaction with HCl. **35.4 to 59.4 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard, angular cobbles; maximum size 85 mm; dry, reddish yellow, strong reaction with HCl. **59.4 to 62.6 ft. SILTY SAND WITH GRAVEL (SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, yellowish red, strong reaction with HCl. **62.6 to 125.3 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, pumice fall deposits, nonwelded, massively bedded, crystallized, argillic alteration, reworked locally, pinkish-white, very pale brown, 2 to 80 percent pumice, less than 1 to 7 percent lithic fragments of welded tuff, 3 to 5 percent crystal fragments of sanidine, plagioclase, quartz, and less than 1 percent biotite, magnetite and hornblende. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-22 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-106

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/22/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,725.05 E 570,245.87
TOTAL DEPTH: 402.2 ft.
DEPTH TO BEDROCK: 62.6 ft.

STATE: Nevada
GROUND ELEVATION: 3677.55
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						Tmbt1		
	110								
	115								
	120								
	125						Tpki		**125.3 to 144.9 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, crystallized, pale yellow, 20 to 70 percent pumice, 1 to 2 percent lithic fragments of welded tuff, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, hornblende and sphene. Generally the tuff is fresh (W1). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	130								
	135								
	140								
	145						Tmbt5		**144.9 to 154.0 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tmbt5):** Bedded tuff, pumice fall deposits, pyroclastic flows, nonwelded, crystallized, very pale brown, 10 to 20 percent pumice, less than 1 percent lithic fragments, 2 to 3 percent crystal fragments of sanidine, plagioclase, and 1 percent biotite, hornblende and magnetite. Generally the tuff is fresh (W1). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	150								
	155	3		5	100	86	Tpcrv		**154.0 to 163.1 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded, crystallized, locally vitric, vapor-phase alteration locally, pinkish-white, very pale brown, reddish-yellow, pinkish-gray, reddish-brown, 3 to 20 percent pumice, less than 1 percent lithic fragments of welded tuff, 3 to 20 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, pyroxene and manganese oxide. Generally the tuff is hard (H3), slightly weathered to fresh (W2), and moderately fractured (FD5). Lower contact is conformable and gradational.
	160	3		5	100	80			
	165	4		7	100	48	Tpcrn		**163.1 to 249.3 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, vapor-phase alteration locally, reddish-brown, light reddish-brown, light gray, pinkish-gray, gray, reddish-gray, 1 to 30 percent pumice, 5 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent pyroxene, biotite, and hornblende. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	170	4		6	100	75			
	175	4		5	100	63			
	180	4		7	85	30			
	185	4		6	96	71			
	190	4		7	100	0			
		4		6	37	29			
	195	4		8	15	0			
	200	3		7	13	0			
	205	3		6	39	31			
	210	3		6	18	10			
	215	3		7	4	0			

Figure RAI 2.2.1.1.1-004-22 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-106

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/22/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,725.05 E 570,245.87
TOTAL DEPTH: 402.2 ft.
DEPTH TO BEDROCK: 62.6 ft.

STATE: Nevada
GROUND ELEVATION: 3677.55
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	3		7	4	0	Tpcrn		
	225	3		9	2	0			
	230	0		0	0	0			
	235	3		9	9	0			
	240	0		0	0	0			
		3		9	100	7			
		3		9	50	0			
		3		9	50	0			
	245	3		7	100	21			
		3		7	100	0			
		3		9	100	83			
	250	3		8	100	21	Tpcpun		**249.3 to 277.2 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, pinkish-gray, pale red, 3 to 4 percent pumice, 1 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and manganese oxide. Generally the tuff is hard (H3), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
		3		9	100	0			
		3		9	93	0			
	255	3		9	89	11			
		3		9	100	0			
	260	3		9	100	28			
		3		8	87	41			
	265	3		6	79	50			
	270	3		7	88	33			
	275	3		7	92	45			
		3		7	100	34			
	280	3		6	94	71	Tpcpul		**277.2 to 325.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red, reddish-gray, 3 to 5 percent pumice, 5 to 10 percent lithophysae, less than 1 percent lithic fragments of welded tuff, 1 to 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	285	3		5	100	92			
	290	3		4	100	95			
	295	3		5	100	85			
		3		7	100	38			
	300	3		7	100	59			
	305	3		6	91	73			
	310	3		5	86	67			
	315	3		7	54	24			
		3		7	63	0			
		3		7	83	0			
	320	3		7	91	0			
		3		9	86	0			
		3		9	65	0			
	325	3		7	79	20	Tpcpmn		**325.0 to 363.4 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, 2 to 4 percent pumice, 1 to 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, magnetite and manganese oxide. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	330	3		7	91	29			
		3		8	100	30			
	335	3		6	100	57			
		3		6	100	70			

Figure RAI 2.2.1.1.1-004-22 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-106

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/22/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,725.05 E 570,245.87
TOTAL DEPTH: 402.2 ft.
DEPTH TO BEDROCK: 62.6 ft.

STATE: Nevada
GROUND ELEVATION: 3677.55
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	3		6	100	70	Tpcpmn		
		3		6	96	51			
	345	3		6	100	60			
		3		3	100	90			
	350	3		7	100	0			
		3		7	80	72			
	355	3		6	93	54			
		3		7	100	36			
	360	3		6	100	69			
		3		7	86	51	Tpcpll		**363.4 to 375.3 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, pale red, gray, light reddish-gray, 2 to 3 percent pumice, 15 to 20 percent lithophysae, 1 to 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and manganese oxide. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	365	3		5	93	65			
	370	3		6	100	67			
	375	3		5	98	74	Tpcpln		**375.3 to 389.4 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, crystallized, reddish-gray, 2 to 4 percent pumice, 1 to 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
	380	3		6	94	53			
	385	3		8	68	9			
	390								
	395								
	400								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-22 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-107

SHEET 1 OF 2

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/17/2007 FINISHED: 5/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,608.21 E 570,272.07
TOTAL DEPTH: 178.1 ft.
DEPTH TO BEDROCK: 72.2 ft.

STATE: Nevada
GROUND ELEVATION: 3680.99
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to depth of 71.4'. 5-7/8" casing is advanced as hole is drilled. Change over to 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 71.4 to 178.1' (TD). 4-1/2" casing is advanced as hole is cored. Remove casing and coring system.

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
5-7/8" casing from 0.0 to 71.4'. 4-1/2" casing from 71.4 to 178.1'

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Back fill hole from 178.1' (TD) up to ground level with Bentonite Chips.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]
0–2.5						(SM)g
2.5–6.7						(SP)g
6.7–10.3						(SP-SM)gc
10.3–12.7						(SM)g
12.7–21.2						(SP)g
21.2–26.6						(SM)g
26.6–30.3						(SP)g
30.3–46.9						(SP-SM)gc
46.9–53.0						(SM)g
53.0–54.6						(GP-GM)s
54.6–59.9						(SP-SM)g
59.9–64.6						(GP-GM)s
64.6–72.2						(SP-SM)gc
72.2–75	4		6	62	28	Tpki
75–80	4		5	100	89	Tpki
80–85	4		5	98	74	Tpki
85–90	4		3	100	86	Tpki
90–95	4		3	100	96	Tpki
95–178.1	4		2	100	93	Tpki
	4		2	98	95	Tpki

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 72.2 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 2.5 ft. SILTY SAND WITH GRAVEL (SM)g: About 70 percent coarse to fine, subangular to subrounded sand; about 15 percent predominantly fine, hard, angular to subangular gravel; about 15 percent fines of medium plasticity with quick dilatancy and low toughness; maximum size 25 mm; dry, brown, no reaction with HCl.
2.5 to 6.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 65 percent coarse to fine, angular to subangular sand; about 30 percent coarse to fine, hard, angular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, light yellowish brown, strong reaction with HCl.
6.7 to 10.3 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 45 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 95 mm; dry, light gray, strong reaction with HCl.
10.3 to 12.7 ft. SILTY SAND WITH GRAVEL (SM)g: About 45 percent coarse to fine, angular sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pinkish gray, strong reaction with HCl.
12.7 to 21.2 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 55 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, light reddish brown, strong reaction with HCl.
21.2 to 26.6 ft. SILTY SAND WITH GRAVEL (SM)g: About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 15 percent fines of low plasticity with quick dilatancy and low toughness; maximum size 45 mm; dry, pink, strong reaction with HCl.
26.6 to 30.3 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pinkish gray, strong reaction with HCl.
30.3 to 46.9 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 110 mm; dry, reddish yellow, strong reaction with HCl.

46.9 to 53.0 ft. SILTY SAND WITH GRAVEL (SM)g: About 70 percent predominantly fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, yellowish red, moderate reaction with HCl.

53.0 to 54.6 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, reddish yellow, strong reaction with HCl.
54.6 to 59.9 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, brownish yellow, strong reaction with HCl.
59.9 to 64.6 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s: About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, yellowish brown, strong reaction with HCl.
64.6 to 72.2 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard drilled cobbles; maximum size 130 mm; dry, reddish yellow, strong reaction with HCl.
72.2 to 137.7 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki): Pyroclastic flow, ash-fall/bedded tuff, nonwelded, vitric, white, pinkish-gray, light brown, pale yellow, pink, 20 to 70 percent pumice, 2 to15 percent lithic fragments of crystallized welded tuff, 2 to 5 percent crystal fragments of sanidine, plagioclase, and lesser sphene, less than 1 percent biotite, magnetite and hornblende. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), slightly to very slightly fractured (FD2) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is unconformable, sharp and slightly irregular and dips 15 degrees to the core axis.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-23 (Sheet 1 of 2)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-107

SHEET 2 OF 2

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/17/2007 FINISHED: 5/22/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 763,608.21 E 570,272.07
TOTAL DEPTH: 178.1 ft.
DEPTH TO BEDROCK: 72.2 ft.

STATE: Nevada
GROUND ELEVATION: 3680.99
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
		4		2	98	95		
	105	4		2	100	93		
	110	4		4	100	83		
	115	4		6	89	32		
	120	5		4	96	83	Tpki	
	125	4		5	96	70		
	130	4		2	100	94		
		4		3	83	83		
	135	5		5	96	55		
	140	5		7	100	41	Tpbt5	
	145	5		8	56	27		
	150	4		9	24	0	Tpcrv	
	155	3		9	40	0		
	160	4		8	48	8		
	165	4		6	100	39	Tpcrn	
	170	4		8	100	27		
	175	4		6	100	47		

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

137.7 to 145.4 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5): Reworked/bedded tuffs, crystallized and vitric, argillically altered locally, pinkish-gray, light gray, pale yellow mottled with pale red, 3 to 20 percent pumice, 10 to 15 percent lithic fragments of crystallized densely welded tuff, 3 to 5 percent crystal fragments of feldspar, less than 1 percent biotite, hornblende, magnetite, and magnesium oxide dendritic spots. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely fractured (FD7). Lower contact is unconformable and sharp.

145.4 to 153.7 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv): Pyroclastic flow, nonwelded to partially welded, moderately welded and densely welded, crystallized and vitric, argillically altered locally, vapor-phase altered, very pale brown, light reddish-brown, very dark gray, yellowish-red, reddish-brown, 10 to 15 percent pumice, less than 1 percent lithic fragments of crystallized densely welded tuff, 8 to 15 percent crystal fragments of feldspar, 1 percent biotite, hornblende and a trace of pyroxene, some manganese oxide spots. Generally the tuff is hard (H3) to moderately soft (H5) averaging moderately hard (H4), slightly weathered to fresh (W2), very intensely to intensely fractured (FD8) to mostly very intensely fractured (FD9). Lower contact is conformable and gradational.

153.7 to 178.1 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, moderately welded, densely welded, crystallized, locally vapor-phase altered, dark reddish-gray, reddish-brown, pale red, light gray, 2 to 20 percent pumice, less than 1 percent lithic fragments of crystallized, densely welded tuff locally, 5 to 15 percent feldspar crystal fragments, less than 1 percent biotite and lesser hornblende. Generally the tuff is moderately hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is undetermined.

Figure RAI 2.2.1.1.1-004-23 (Sheet 2 of 2)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-112

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/7/2007 FINISHED: 7/30/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,283.93 E 570,871.94
TOTAL DEPTH: 432.1 ft.
DEPTH TO BEDROCK: 121.0 ft.

STATE: Nevada
GROUND ELEVATION: 3688.76
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP 400RS Sonic Drill Rig, CME-85 core rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Sonic core with 4-3/4" bit to depth of 24.3´. Advance 5-7/8" casing with 6-3/8" shoe to 15.4´. Sonic core from 24.3´ to 134.6´. Casing is advanced as hole is drilled. Change over to CME 85 core rig with 3-7/16" HQ-3 coring system and 4-1/2" casing. Core 134.6' to 412.1'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/4" tricone bit to 432.1' TD. **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 5-7/8" casing from 0.0 to 134.6'. 4-1/2" casing from 134.6 to 412.1'. **Hole Completion:** Install 3-1/2" PVC casing to depth of 407.8'. Use 1-3/8" PVC tremmie pipe to grout PVC casing from bottom of hole 432.1' (TD) up to 38.5' below ground level. Back fill with pea gravel from 38.5' up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(GP-GM)s (SP-SM)g (GP)sc (GP-GM)sc (SP-SM)gc		**0.0 to 34.8 ft. NON-ENGINEERED FILL:** **0.0 to 5.0 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent fines of low plasticity with slow dilatancy and low toughness; maximum size 75 mm; dry, gray, no reaction with HCl. **5.0 to 16.5 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, reddish brown, no reaction with HCl. **16.5 to 34.8 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 45 percent coarse to fine, subangular to subrounded sand; trace of nonplastic fines with quick dilatancy and low toughness; trace of hard angular to subangular cobbles; maximum size 80 mm; dry, reddish yellow, strong reaction with HCl. **34.8 to 121.0 ft. QUATERNARY ALLUVIUM (Qal):** **34.8 to 48.9 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard angular to subangular cobbles; maximum size 80 mm; dry, reddish yellow, strong reaction with HCl. **48.9 to 121.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 90 mm; dry, reddish yellow, brownish gray, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-24 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-112

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/7/2007 FINISHED: 7/30/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,283.93 E 570,871.94
TOTAL DEPTH: 432.1 ft.
DEPTH TO BEDROCK: 121.0 ft.

STATE: Nevada
GROUND ELEVATION: 3688.76
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105								
	110						(SP-SM)gc		
	115								
	120								
							Tmbt1		**121.0 to 123.5 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, nonwelded, massively bedded, crystallized and locally clay altered, light gray, pinkish gray, 15 to 20 percent pumice, less than 1 percent lithic fragments of welded tuff, 1 percent crystal fragments of sanidine, plagioclase and lesser quartz, less than 1 percent biotite and hornblende. Generally the tuff is slightly weathered to fresh (W2). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	125								
	130								**123.5 to 170.1 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, bedded ash and pumice fall, nonwelded, crystallized, beds/seams of clay locally, white, less than 10 to 25 percent pumice, less than 1 to 30 percent lithic fragments of welded tuff, less than 1 to 10 percent crystal fragments of sanidine, plagioclase, and sphene, less than 1 percent biotite and hornblende. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2) and locally slightly weathered (W3), very slightly fractured (FD1) to intensely to moderately fractured (FD6) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	135								
	140	4		6	100	87			
	145	4		2	98	99			
	150	4		1	100	96	Tpki		
	155	4		1	100	100			
	160	4		1	100	100			
	165	4		3	96	95			
	170	4		4	100	89			
	175	5		6	94	74	Tpbt5		**170.1 to 180.1 ft. POST TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff, reworked and approaching tuffaceous sandstone locally, crystallized, pink, light brown, very pale brown, light gray, pinkish white, less than 10 to 15 percent pumice, 2 to less than 20 percent lithic fragments, less than 1 to 5 percent crystal fragments of feldspar, less than or equal to 1 percent biotite and hornblende. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), fresh (W1), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	180	5		5	100	68			
	185	4		4	100	59	Tpcrv		**180.1 to 187.0 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, partially welded, moderately welded and densely welded, crystallized, locally vitric, white, reddish gray, reddish brown, dark gray, 5 to 15 percent pumice, less than or equal to 1 percent lithic fragments of crystallized welded tuff, 3 to 15 percent crystal fragments of feldspar, less than or equal to 1 percent biotite, magnetite, and lesser hornblende and pyroxene. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), fresh (W1), moderately to slightly fractured (FD4) to mostly moderately fractured (FD5). Lower contact is conformable and gradational.
	190	4		5	96	43			
	195	4		6	98	52			
	200	4		6	100	50			**187.0 to 258.4 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely welded, partially welded, crystallized, vapor-phase altered locally, pale red, reddish gray, light reddish brown, 1 to 10 percent pumice, 1 percent lithic clasts of crystallized densely welded tuff, 10 to 15 percent feldspar phenocrysts, less than or equal to 1 percent biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	205	4		6	100	48	Tpcrn		
	210	4		6	100	54			
	215	4		6	98	50			
		4		6	100	32			

Figure RAI 2.2.1.1.1-004-24 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-112

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/7/2007 FINISHED: 7/30/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,283.93 E 570,871.94
TOTAL DEPTH: 432.1 ft.
DEPTH TO BEDROCK: 121.0 ft.

STATE: Nevada
GROUND ELEVATION: 3688.76
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		6	100	32			
	225	4		6	98	44			
	230	4		6	98	46			
	235	4		6	98	50			
	240	4		6	98	60	Tpcrn		
	245	4		6	90	73			
	250	4		8	78	11			
	255	4		6	100	56			
	260	4		6	59	24			**258.4 to 311.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, vapor-phase altered, pinkish gray, reddish gray, mottling with light gray, 15 percent lithophysae, less than 1 percent lithic fragments, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite and manganese oxide spots. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
		3		9	29	0			
		3		9	28	0			
	265	3		9	53	2			
	270	3		7	66	28			
	275	4		5	98	82			
		3		9	71	13			
	280	3		6	100	58			
	285	3		5	100	95	Tpcpul		
	290	3		6	90	30			
	295	3		6	100	62			
	300	3		6	34	26			
	305	4		6	93	48			
	310	4		7	100	20			
	315	3		6	100	82			**311.0 to 379.5 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pinkish gray mottled with light gray, less than 1 percent lithophysae, 2 to 5 percent pumice, less than 1 percent lithic fragments, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is sharp (faulted).
	320	3		6	98	62			
	325	3		6	100	68	Tpcpmn		
	330	3		6	100	36			
	335	3		6	100	52			
		3		6	100	48			

Figure RAI 2.2.1.1.1-004-24 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-112

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/7/2007 FINISHED: 7/30/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,283.93 E 570,871.94
TOTAL DEPTH: 432.1 ft.
DEPTH TO BEDROCK: 121.0 ft.

STATE: Nevada
GROUND ELEVATION: 3688.76
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	3		6	100	48	Tpcpmn		
	345	3		6	100	53			
	350	3		5	100	83			
		3		5	100	86			
	355	3		7	100	29			
	360	3		7	100	34			
		0		0	0	0			
	365	3		8	85	23			
		3		9	58	0			
	370	3		6	100	53			
		3		7	85	31			
	375	3		9	98	14			
	380	3		6	50	37	Fault Zone		**379.5 to 395.3 ft. FAULT ZONE:** Fault breccia of densely welded crystallized tuff, reddish gray, and pale red. Breccia is angular, clast supported, consisting mostly of Tpcpmn. Pumice is less than 5 percent, less than 1 percent lithic clasts of crystallized, densely welded tuffs and lava, 2 to 4 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the fault zone is hard (H3), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is sharp.
	385	3		6	100	82			
	390	3		6	88	54			
		3		9	83	0			
	395	3		7	95	50	Tpcpln		**395.3 to 412.1 ft. TIVA CANYON TUFF, CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, mostly crystallized to partially crystallized, light reddish gray, light gray, gray, 5 to 7 percent pumice, less than 1 percent lithic fragments of crystallized welded tuff and lava, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is undetermined.
	400	3		9	97	25			
	405	3		9	100	20			
	410	3		6	100	51			
	415								
	420								
	425								
	430								
	BOTTOM OF HOLE								

Figure RAI 2.2.1.1.1-004-24 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-30

SHEET 1 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
/BEGUN: 3/14/2007 FINISHED: 8/7/2007/~
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,861.45 E 571,930.16
TOTAL DEPTH: 737.4 ft.
DEPTH TO BEDROCK: 131.8 ft.

STATE: Nevada
GROUND ELEVATION: 3657.01
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 300 RS Sonic Drill Rig, LS224 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
Boart Longyear

Drilling Method:
Sonic core with 12-3/4" bit from 0.0 to 10.1'. Set 10-3/4" conductor casing in 12-3/4" hole to depth of 5.3' and cement in place. Change over to 4.9" bit. 9" casing is advanced as whole is drilled. Sonic core and advance 9" casing with 9" casing shoe to depth of 318.1'. Change over to LS224 Core Rig with 3-7/8" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 728.8'. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to total depth of 737.4' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
Set 10-3/4" conductor casing from 0.0' to 5.3'. 9" casing from 0.00 to 318.1'. 4-1/2" casing from 318.1 to 728.8'.

Hole Completion:
Remove 4-1/2" casing and 9" casing. Install 3-1/2" PVC casing to depth of 733.1'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 737.4' (TD) up to ground level.

DEPTH	HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]
						(SP-SM)gc
5						(GP)sc
10						(SP)g
						(GP)s
						(SP)g
15						(GP)sc
20						(SP-SM)gc
25						(SP)g
30						
35						(GP-GM)sc
40						
						(SP)g
45						(GM)s
50						(SM)g
55						(GM)sc
60						
65						(SM)gc
70						
75						
80						
85						(GM)sc
90						
95						

GRAPHIC

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 131.8 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 1.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 75 percent coarse to fine, angular to subangular sand; about 15 percent coarse to fine, hard, angular gravel; about 10 percent fines of low plasticity with quick dilatancy and low toughness; dry, light reddish brown, no reaction with HCl. Grass present, topsoil.

TOTAL SAMPLE (BY VOLUME): About 40 percent hard drilled cobbles; maximum size 170 mm; remainder minus 3-inch.

1.0 to 9.1 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 55 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard, subangular and drilled cobbles; maximum size 125 mm; dry, light reddish brown, strong reaction with HCl.

9.1 to 11.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 55 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 45 mm; dry, pink, strong reaction with HCl.

11.0 to 12.7 ft. POORLY GRADED GRAVEL WITH SAND (GP)s: About 65 percent coarse to fine, hard, angular to subangular gravel; about 35 percent coarse to fine, angular to subangular sand; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 35 mm; dry, light reddish brown, moderate reaction with HCl.

12.7 to 13.8 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 70 percent coarse to fine, angular to subangular sand; about 25 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 25 mm; dry, light reddish brown, no reaction with HCl.

13.8 to 17.5 ft. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)sc: About 65 percent coarse to fine, hard, angular to subangular gravel; about 30 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 115 mm; dry, light brown, no reaction with HCl.

17.5 to 22.9 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 45 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 130 mm; dry, pinkish gray, strong reaction with HCl.

22.9 to 31.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 50 percent coarse to fine, angular to subangular sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 30 mm; dry, light reddish brown, strong reaction with HCl.

31.0 to 40.3 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc: About 65 percent coarse to fine, hard, angular to subangular gravel; about 25 percent coarse to fine, angular to subangular sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, very pale brown, no reaction with HCl.

TOTAL SAMPLE (BY VOLUME): About 5 percent hard subangular and drilled cobbles; maximum size 130 mm; remainder minus 3-inch.

40.3 to 44.1 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 55 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 45 mm; dry, light reddish brown, no reaction with HCl.

44.1 to 47.9 ft. SILTY GRAVEL WITH SAND (GM)s: About 40 percent coarse to fine, hard, subangular to subrounded gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 30 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, reddish brown, strong reaction with HCl.

47.9 to 51.8 ft. SILTY SAND WITH GRAVEL (SM)g: About 50 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, light brown, no reaction with HCl.

51.8 to 62.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc: About 45 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 20 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 115 mm; dry, reddish brown, strong reaction with HCl.

62.0 to 70.1 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc: About 50 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 25 percent nonplastic fines with slow dilatancy and low toughness; dry, reddish brown, strong reaction with HCl.

TOTAL SAMPLE (BY VOLUME): About 10 percent hard subrounded and drilled cobbles; maximum size 150 mm; remainder minus 3-inch.

70.1 to 111.2 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc: About 45 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; dry, reddish brown, strong reaction with HCl.

TOTAL SAMPLE (BY VOLUME): About 5 percent hard subrounded and drilled cobbles; maximum size 150 mm; remainder minus 3-inch.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-25 (Sheet 1 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-30

SHEET 2 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/14/2007 FINISHED: 8/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,861.45 E 571,930.16
TOTAL DEPTH: 737.4 ft.
DEPTH TO BEDROCK: 131.8 ft.

STATE: Nevada
GROUND ELEVATION: 3657.01
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(GM)sc		
	110								**111.2 to 120.8 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent fines of low plasticity with slow dilatancy and low toughness; dry, reddish brown, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard subrounded and drilled cobbles; maximum size 120 mm; remainder minus 3-inch.
	115						(SM)gc		
	120						(GM)sc		**120.8 to 122.5 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 40 percent coarse to fine, hard, subangular to subrounded gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 30 percent nonplastic fines with slow dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 105 mm; dry, reddish brown; strong reaction with HCl.
	125						(SM)gc		**122.5 to 129.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 25 percent fines of low plasticity with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 135 mm; dry, reddish brown, strong reaction with HCl.
	130						(GM)sc (SM)g		**129.2 to 130.2 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 45 percent coarse to fine, hard, subangular to subrounded gravel; about 25 percent coarse to fine, subangular to subrounded sand; about 30 percent fines of low plasticity with slow dilatancy and low toughness; dry, reddish gray, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard, subrounded cobbles; maximum size 120 mm; remainder minus 3-inch.
	135								**130.2 to 131.8 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 20 percent fines of low plasticity with slow dilatancy and low toughness; maximum size 60 mm; dry, light reddish brown, strong reaction with HCl.
	140								**131.8 to 170.0 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow, bedded tuff, locally reworked, locally altered, nonwelded, vitric, pinkish-white, light brownish-gray, pale brown, 30 to 60 percent pumice, less than 1 to 2 percent lithic fragments of volcanic rock, 8 to 20 percent crystal fragments of feldspar and lesser quartz, less than 1 percent biotite and magnetite. Generally the tuff is moderately to slightly weathered (W4). Lower contact is unconformable and sharp. This rock unit was drilled using the Sonic method. Sonic drilling renders the core unsuitable for logging hardness (H) and fracture density (FD).
	145								
	150						Tmr		
	155								
	160								
	165								
	170								**170.0 to 348.0 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded Tuff, nonwelded, devitrified and locally clay altered, locally reworked, massively bedded, pinkish-white, light yellowish-brown, very pale brown, white, light gray, pinkish-gray, 3 to 50 percent pumice, up to 15 percent glass blebs and shards locally, 1 to 20 percent lithic fragments of crystallized welded tuff, 1 to 10 percent crystal fragments of quartz, sanidine and plagioclase, less than 1 percent biotite, hornblende and magnetite. Generally the tuff is very soft (H7) to mostly moderately hard (H4), averaging moderately soft (H5), moderately to slightly weathered (W4), slightly to very slightly fractured (FD2) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp at 60 degrees to the core axis.
	175								
	180								
	185								
	190								
	195						Tmbt1		
	200								
	205								
	210								
	215								

Figure RAI 2.2.1.1.1-004-25 (Sheet 2 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-30

SHEET 3 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/14/2007 FINISHED: 8/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,861.45 E 571,930.16
TOTAL DEPTH: 737.4 ft.
DEPTH TO BEDROCK: 131.8 ft.

STATE: Nevada
GROUND ELEVATION: 3657.01
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220								
	225								
	230								
	235								
	240								
	245								
	250								
	255								
	260								
	265								
	270								
	275								
	280						Tmbt1		
	285								
	290								
	295								
	300								
	305								
	310								
	315								
	320	6		4	96	84			
	325	7		6	98	58			
	330	5		2	100	100			
	335	4		2	98	94			

Figure RAI 2.2.1.1.1-004-25 (Sheet 3 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-30

SHEET 4 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/14/2007 FINISHED: 8/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,861.45 E 571,930.16
TOTAL DEPTH: 737.4 ft.
DEPTH TO BEDROCK: 131.8 ft.

STATE: Nevada
GROUND ELEVATION: 3657.01
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		4	100	87	Tmbt1		
	345	4		4	100	94			
	350	4		3	96	88	Tpki		**348.0 to 448.1 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, crystallized, white, 25 to 80 percent pumice, 5 to 20 percent lithic clasts of welded tuff, 1 to 2 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and hornblende, less than 1 percent sphene. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp, is at 60 degrees to the core axis and may be erosional.
	355	4		6	100	80			
	360	4		7	67	24			
	365	5		7	100	58			
	370	4		7	74	0			
	375	4		4	98	77			
	380	4		3	100	93			
	385	4		5	100	88			
	390	4		2	94	87			
	395	4		3	98	96			
	400	4		3	100	90			
	405	4		4	96	61			
	410	4		3	100	100			
	415	4		3	100	94			
	420	4		2	86	79			
	425	4		6	92	42			
	430	4		0	98	97			
	435	4		4	100	80			
	440	4		5	79	58			
	445	5		5	98	83			
	450	5		4	100	79	Tpbt5		**448.1 to 455.4 ft. POST TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff, reworked, may also include a tephra, nonwelded, crystallized (locally zeolitic), pink, pale red, pale brown, white, 5 to 80 percent pumice, 1 to 30 percent lithic fragments of volcanic welded tuff, 1 to 7 percent crystal fragments of sanidine and plagioclase, and less than 1 percent biotite, hornblende, and magnetite. Generally the tuff is moderately soft (H5), slightly weathered (W3), moderately fractured (FD5) to mostly moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	455	5		4	100	84	Tpcrv		

Figure RAI 2.2.1.1.1-004-25 (Sheet 4 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-30

SHEET 5 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/14/2007 FINISHED: 8/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,861.45 E 571,930.16
TOTAL DEPTH: 737.4 ft.
DEPTH TO BEDROCK: 131.8 ft.

STATE: Nevada
GROUND ELEVATION: 3657.01
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		5		4	100	84			
	460	5		5	93	81	Tpcrv		**455.4 to 466.8 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, non to densely welded, crystallized, locally vitric, very pale brown, white, light gray, reddish-gray, reddish-yellow, 5 to 15 percent pumice, less than 1 percent vitric fragments of welded tuff, 3 to 15 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite and pyroxene. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), moderately to slightly weathered (W4), moderately to slightly fractured (FD4), to mostly moderately fractured (FD5). Lower contact is conformable and gradational.
	465	4		5	98	68			**466.8 to 563.0 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely welded, crystallized, light reddish-brown, pinkish-gray, pale red, light gray, white, 2 to 25 percent pumice, less than 1 percent lithic fragments of welded tuff, 1 to 3 percent lithophysae from 531.8 to 563.0 ft, 5 to 15 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite pyroxene and hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered (W3), slightly fractured (FD3), to intensely to moderately fractured (FD6), and mostly moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
	470	4		3	100	93			
	475	4		4	100	82			
	480	4		3	100	93			
	485	4		3	100	97			
	490	4		4	100	84			
	495	4		4	100	90			
	500	4		4	100	84			
	505	4		4	100	74			
	510	4		3	100	97			
	515	4		3	100	94	Tpcrn		
	520	4		5	96	89			
	525	4		6	88	75			
	530	4		6	100	61			
	535	4		5	93	78			
	540	4		4	87	73			
	545	4		5	85	68			
	550	4		5	96	71			
	555	4		6	98	69			
	560	3		4	98	77			
	565	4		6	100	66			**563.0 to 580.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, white, light gray with pale red mottling, 2 to 3 percent pumice, 1 to 2 percent lithophysal cavities, 2 to 4 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered (W3), moderately to slightly fractured (FD4), to very intensely to intensely fractured (FD8), and mostly intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	570	3		6	94	58	Tpcpun		
	575	3		4	98	83			

Figure RAI 2.2.1.1.1-004-25 (Sheet 5 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-30

SHEET 6 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/14/2007 FINISHED: 8/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,861.45 E 571,930.16
TOTAL DEPTH: 737.4 ft.
DEPTH TO BEDROCK: 131.8 ft.

STATE: Nevada
GROUND ELEVATION: 3657.01
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		4	98	83	Tpcpun		
	580	3		8	86	27			**580.0 to 658.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, white, light gray locally with pink mottling, pale red with white mottling and spots, 4 to 5 percent pumice, 5 to 20 percent lithophysal cavities, up to 30 percent vapor-phase spots, 2 to 3 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered (W3), slightly fractured (FD3), to very intensely fractured (FD9), averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
		4		9	63	0			
	585	4		8	64	24			
		4		9	68	0			
	590	4		7	100	59			
		4		8	86	24			
	595	3		6	81	54			
	600	4		8	100	20			
	605	3		6	100	83			
	610	3		5	91	86			
	615	3		5	100	79			
	620	4		5	94	50	Tpcpul		
	625	4		3	94	87			
	630	4		4	100	84			
	635	4		4	98	75			
	640	3		3	100	87			
	645	4		7	100	48			
	650	3		5	100	89			
	655	3		4	100	72			**658.0 to 707.0 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red with gray mottling, 2 to 5 percent pumice, scattered lithophysal cavities (less than 1 percent increasing to 1 to 3 percent near the lower lithophysal contact, 1 to 2 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered (W3), slightly to very slightly fractured (FD2), to moderately to slightly fractured (FD4), averaging slightly fractured (FD3). Lower contact is conformable and gradational.
	660	3		3	100	92			
	665	3		2	100	100			
	670	3		2	98	95			
	675	3		2	100	100	Tpcpmn		
	680	3		2	100	91			
	685	3		2	100	92			
	690	3		4	100	93			
	695	3		4	98	74			

Figure RAI 2.2.1.1.1-004-25 (Sheet 6 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-30

SHEET 7 OF 7

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/14/2007 FINISHED: 8/7/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,861.45 E 571,930.16
TOTAL DEPTH: 737.4 ft.
DEPTH TO BEDROCK: 131.8 ft.

STATE: Nevada
GROUND ELEVATION: 3657.01
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		4	98	74			
	700	3		4	100	84	Tpcpmn		
	705	3		3	100	90			**707.0 to 728.2 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, pale red with dark reddish-gray mottling, 2 to 3 percent pumice, 2 percent lithophysal cavities, 2 to 3 percent crystal fragments of sanidine and plagioclase, less than 1 percent biotite. Generally the tuff is hard (H3), slightly weathered (W3), slightly fractured (FD3), to intensely to moderately fractured (FD6), averaging moderately fractured (FD5). Lower contact is undetermined
	710	3		5	100	86			
	715	3		5	100	75	Tpcpll		
	720	3		4	93	69			
	725	3		6	96	72			
	730								
	735								
		BOTTOM OF HOLE							

Figure RAI 2.2.1.1.1-004-25 (Sheet 7 of 7)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF40

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2007 FINISHED: 9/24/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,251.78 E 570,810.49
TOTAL DEPTH: 355.0 ft.
DEPTH TO BEDROCK: 91.1 ft.

STATE: Nevada
GROUND ELEVATION: 3680.23
ANGLE FROM HORIZONTAL: -60° AZIMUTH: 257°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
Longyear LS-244Core Rig and flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
Boart Longyear

Drilling Method:
Angle Hole (60 degrees off from horizontal). Core with 3-3/4" HQ-3 coring system. Core 0.0 to 355.0' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Non-Potable water, EZ-Mud Plus (Polymer), Quik-Gel (Bentonite) and N-Seal Lost Circulation Material

Fluid Loss Interval:
105.0 to 110.5', 115.0 to 120.2',

Casing Record:
Casing not used

Hole Completion:
Hole backfilled from 355.0' (TD) up to ground level with cement.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
5, 10, 15, 20, 25, 30, 35, 40						(SP)g		**0.0 to 91.1 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 45.4 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 45 mm; dry, reddish-brown, brownish-gray, grayish-brown, no to strong reaction with HCl.
45, 50, 55, 60, 65, 70, 75, 80						(SP-SM)gc		**45.4 to 81.8 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard drilled cobbles; maximum size 130 mm; dry, gray, moderate reaction with HCl.
85						(SM)gc		**81.8 to 91.1 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; dry, reddish-brown, strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 10 percent hard drilled cobbles; maximum size 230 mm; remainder minus 3-inch.
90	4		6	100	28			
95	4		4	94	57	Tmbt1		**91.1 to 239.3 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Reworked bedded tuffs, paleosols, pumice fall deposits, nonwelded, massively bedded, locally laminated, crystallized, white, very pale brown, pale yellow, 5 to 80 percent pumice, 2 to 20 percent lithic fragments of welded tuff, 2 to 8 percent crystal fragments of sanidine, plagioclase, and quartz with less than 1 percent biotite and magnetite. Generally the tuff is very soft (H7) to moderately hard (H4) averaging soft (H6), slightly weathered to fresh (W2), slightly to very slightly fractured (FD2) to

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-26 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF40

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2007 FINISHED: 9/24/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,251.78 E 570,810.49
TOTAL DEPTH: 355.0 ft.
DEPTH TO BEDROCK: 91.1 ft.

STATE: Nevada
GROUND ELEVATION: 3680.23
ANGLE FROM HORIZONTAL: -60° AZIMUTH: 257°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		5		3	98	93			intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is sharp (faulted).
	105	5		4	100	70			
	110	5		4	100	87			
	115	4		4	98	91			
	120	4		2	100	96			
	125	5		4	100	77			
	130	4		4	100	67			
	135	7		5	100	93			
	140	7		3	100	91			
	145	7		5	96	58			
	150	7		5	100	89			
	155	7		3	94	88			
	160	6		4	100	86	Tmbt1		
	165	6		6	98	68			
	170	7		3	100	98			
	175	6		3	98	96			
	180	7		3	100	86			
	185	7		3	100	85			
	190	7		2	100	93			
	195	6		5	100	55			
	200	7		3	92	83			
	205	7		4	90	74			
	210	7		7	100	61			
	215	7		5	98	71			

Figure RAI 2.2.1.1.1-004-26 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF40

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2007 FINISHED: 9/24/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,251.78 E 570,810.49
TOTAL DEPTH: 355.0 ft.
DEPTH TO BEDROCK: 91.1 ft.

STATE: Nevada
GROUND ELEVATION: 3680.23
ANGLE FROM HORIZONTAL: -60° AZIMUTH: 257°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	7		6	98	75	Tmbt1		
	225	7		6	100	57			
	230	7		6	100	54			
	235	7		5	85	57			
	240	7		7	65	35	Fault Zone		**239.3 to 288.0 ft. FAULT ZONE/BRECCIA:** Fragments of Tiva Canyon Tuff Crystal Poor densely welded tuff in a matrix of Tmbt1 or crushed welded tuff, pale red, white, pink, light gray. Generally the fault zone/breccia is very soft (H7) to hard (H3) averaging moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely fractured (FD9) averaging moderately to slightly fractured (FD4). Lower contact is sharp (faulted).
	245	7		9	12	0			
	250	0		0	0	0			From 262.6 to 268.2 ft is a block of Tiva Canyon Tuff Crystal-Poor Upper Lithophysal Zone (Tpcpul): Pyroclastic flow, densely welded, crystallized, pale red, light gray, 5 percent pumice, less than 1 percent lithophysae, 2 to 3 percent crystal fragments of sanidine, plagioclase and less than 1 percent biotite.
	255	0		0	0	0			
		0		0	0	0			
	260	3		6	30	17			
	265	3		3	87	61			
	270	3		4	98	80			
	275	4		6	100	78			
	280	4		5	100	85			
	285	4		7	98	37			
	290	3		5	100	76	Tpcpmn		**288.0 to 331.0 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, reddish-gray, up to 1 percent lithophysae locally, 2 to 5 percent pumice, 1 to 2 percent crystal fragments of sanidine, plagioclase and less than 1 percent biotite. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is conformable and gradational. A breccia zone is found from 316.8 to 327.0 ft, consisting of Tpcpmn fragments in a matrix of crushed welded tuff and clay.
	295	3		4	100	71			
	300	3		5	100	70			
	305	3		4	98	75			
	310	3		5	100	62			
	315	3		4	87	62			
	320	4		5	88	56			
		4		6	90	22			
	325	3		5	100	0			
		4		6	100	57			
	330	3		5	100	55	Tpcpll		**331.0 to 341.2 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, pale red, reddish-gray, white, light gray, 3 percent pumice, 10 to 15 percent lithophysae, 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to moderately fractured (FD5) averaging moderately to
	335	3		4	100	86			

Figure RAI 2.2.1.1.1-004-26 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF40

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 9/12/2007 FINISHED: 9/24/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,251.78 E 570,810.49
TOTAL DEPTH: 355.0 ft.
DEPTH TO BEDROCK: 91.1 ft.

STATE: Nevada
GROUND ELEVATION: 3680.23
ANGLE FROM HORIZONTAL: -60° AZIMUTH: 257°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	3		4	100	86	Tpcpll		slightly fractured (FD4). Lower contact is conformable and gradational.
		3		4	100	92	Tpcpln		**341.2 to 355.0 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, crystallized, reddish gray, pale red. 2 to 5 percent pumice, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is very hard (H2) to mostly hard (H3), fresh (W1), moderately to slightly fractured (FD4) to moderately fractured (FD5) averaging moderately to slightly fractured (FD4). Lower contact is undetermined. Breccia zones were found from 348.0 to 349.2 ft and 349.7 to 350.7 ft, consisting of fragments of Tpcpln and possibly Tpcpll in silica and clay cement matrix.
	345								
		2		5	96	43			
	350								
		3		4	100	65			
	355								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-26 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-67

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/18/2007 FINISHED: 7/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,801.1 E 572,249.79
TOTAL DEPTH: 452.2 ft.
DEPTH TO BEDROCK: 143.7 ft.

STATE: Nevada
GROUND ELEVATION: 3775.86
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Sonic core with 4-3/4" bit from 0.0 to 133.1'. 5-7/8" casing is advanced as whole is drilled. Change over to CME-85 Core Rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 452.2' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 5-7/8" casing from 0.0 to 133.1'. 4-1/2" casing from 133.1 to 452.2' (TD). **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Plug and abandon hole using bentonite chips from bottom of hole 452.2' (TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						SM (SP-SM)g (SM)g (SP)g (SP-SM)g (SM)g (SP-SM)g (SM)gc		**0.0 to 143.7 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 8.9 ft. SILTY SAND (SM):** About 70 percent coarse to fine, subangular to subrounded sand; about 20 percent nonplastic fines with quick dilatancy and low toughness; about 10 percent coarse to fine, hard, subangular to subrounded gravel; maximum size 70 mm; dry, light brown, strong reaction with HCl. **8.9 to 35.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, light brown, gray, strong reaction with HCl. **35.6 to 43.9 ft. SILTY SAND WITH GRAVEL (SM)g:** About 45 percent coarse to fine, subangular to subrounded sand; about 40 percent fines of low plasticity with slow dilatancy and low toughness; about 15 percent coarse to fine, hard, subangular to subrounded gravel; maximum size 35 mm; dry, yellowish brown, strong reaction with HCl. **43.9 to 50.5 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, yellowish brown, moderate reaction with HCl. **50.5 to 54.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, gray, weak reaction with HCl. **54.0 to 75.6 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent fines of no to low plasticity with no dry strength, quick to slow dilatancy and low toughness; maximum size 75 mm; dry, yellowish brown, pinkish gray, strong reaction with HCl. **75.6 to 91.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, tan to gray, strong reaction with HCl. **91.1 to 106.8 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 50 percent coarse to fine, angular to subangular sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard, subangular to subrounded cobbles; maximum size 80 mm; dry, yellowish brown, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-27 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-67

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/18/2007 FINISHED: 7/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,801.1 E 572,249.79
TOTAL DEPTH: 452.2 ft.
DEPTH TO BEDROCK: 143.7 ft.

STATE: Nevada
GROUND ELEVATION: 3775.86
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SM)gc		
	110						(SP-SM)g		**106.8 to 119.7 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity with no dry strength, slow dilatancy and low toughness; maximum size 65 mm; dry, yellowish brown, strong reaction with HCl.
	115								
	120						(GM)scb		**119.7 to 143.7 ft. SILTY GRAVEL WITH SAND, COBBLES AND BOULDERS (GM)scb:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; dry, gray, yellowish-gray, no to weak reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 5 percent hard subangular to subrounded and drilled cobbles and boulders, maximum size 575 mm; remainder minus 3-inch.
	125								
	130								
	135								
	140								
	145	6		6	30	40	Tmbt1		**143.7 to 221.5 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded/reworked tuff, nonwelded, massively bedded, pink, white, light gray, less than 1 to 15 percent pumice, 5 to 20 percent lithic fragments of volcanic rock, 10 to 40 percent crystal fragments of sanidine, plagioclase, biotite, magnetite and possible quartz. Generally the tuff is very soft (H7) to mostly soft (H6), fresh (W1), moderately fractured (FD5) to very intensely to intensely fractured (FD8), averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	150	0		0	0	0			
	155	7		8	31	11			
	160								
	165	7		6	94	61			
	170	6		7	96	42			
	175	6		6	89	64			
	180	6		6	77	57			
	185	7		9	54	18			
	190	7		6	85	40			
	195	6		5	89	64			
	200	7		6	67	35			
	205	7		7	96	66			
	210	7		5	100	80			
	215	7		5	100	79			

Figure RAI 2.2.1.1.1-004-27 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-67

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/18/2007 FINISHED: 7/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,801.1 E 572,249.79
TOTAL DEPTH: 452.2 ft.
DEPTH TO BEDROCK: 143.7 ft.

STATE: Nevada
GROUND ELEVATION: 3775.86
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	7		8	100	36	Tmbt1		**221.5 to 389.5 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pumice beds, nonwelded, vitric to crystallized, white, very pale brown, pale yellow, 60 to 85 percent pumice, less than 3 to 25 percent lithic fragments of moderately and densely welded tuff, less than 1 to 10 percent crystal fragments of plagioclase, sanidine, and lesser biotite and rare sphene. Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), fresh (W1), unfractured (FD0) to very intensely fractured (FD9), averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	225	7		8	100	20			
	230	7		9	96	29			
	235	7		9	94	7			
	240	7		8	90	40			
	245	7		7	92	57			
	250	7		4	100	80			
	255	7		7	94	63			
	260	7		8	94	56			
	265	7		4	100	85			
	270	6		5	100	85			
	275	6		3	98	74			
	280	6		3	98	92	Tpki		
	285	6		3	100	97			
	290	6		3	100	92			
	295	6		5	100	73			
	300	5		2	100	100			
	305	4		0	100	98			
	310	4		2	100	98			
	315	4		4	100	100			
	320	4		4	100	100			
	325	4		2	96	91			
	330	4		4	100	89			
	335	4		4	100	82			
		4		4	100	96			

Figure RAI 2.2.1.1.1-004-27 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-67

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/18/2007 FINISHED: 7/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,801.1 E 572,249.79
TOTAL DEPTH: 452.2 ft.
DEPTH TO BEDROCK: 143.7 ft.

STATE: Nevada
GROUND ELEVATION: 3775.86
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	340	4		4	100	96	Tpki	
	345	4		1	100	100		
	350	4		4	100	97		
	355	4		5	100	86		
	360	4		4	91	90		
	365	4		4	98	87		
	370	4		5	100	91		
	375	4		5	100	80		
	380	4		5	92	87		
	385	4		7	85	42		
	390	6		6	100	56	Tpbt5	
	395	6		6	84	40		
	400	5		6	100	55		
	405	4		6	94	60	Tpcrv	
	410	3		7	96	33	Tpcrn	
	415	3		5	94	54		
	420	5		6	100	61		
	425	4		5	100	89		
	430	4		6	100	32		
	435	3		4	100	88		
	440	3		4	94	80		
	445	3		4	100	89		
	450	3		4	96	95		

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

389.5 to 403.1 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5): Reworked bedded tuffs, pyroclastic flows, nonwelded, partly welded, crystallized, pink, pale red, very pale brown, 10 to 30 percent pumice, less than 1 to 5 percent lithic fragments of volcanic rock, 5 to 10 percent crystal fragments of biotite, plagioclase, sanidine and less than 1 percent hornblende. Generally the tuff is moderately soft (H5) to mostly soft (H6), fresh (W1), intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.

403.1 to 409.1 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv): Pyroclastic flow, nonwelded to densely welded, mostly crystallized with a local vitrophyre interval, light reddish brown, pinkish gray, pale red, 10 percent pumice, 7 to 10 percent lithic fragments of volcanic rock, less than 5 to greater than 20 percent crystal fragments of plagioclase, sanidine, and lesser biotite and hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), intensely to moderately fractured (FD6), to mostly intensely fractured (FD7). Lower contact is conformable and gradational.

409.1 to 452.2 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, moderately to densely welded, crystallized, dark reddish gray, pale red, light gray, less than 1 percent to 10 percent pumice, less than 1 percent lithic fragments of volcanic rock, 15 percent crystal fragments of plagioclase, sanidine, and lesser biotite. Generally the tuff is hard (H3) to moderately soft (H5) averaging moderately hard (H4), fresh (W1), moderately to slightly fractured (FD4) to intensely fractured (FD7), averaging moderately fractured (FD5). Lower contact is undetermined.

Figure RAI 2.2.1.1.1-004-27 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

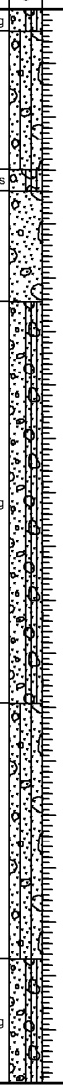
GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-69

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/10/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,083.82 E 571,883.49
TOTAL DEPTH: 582.6 ft.
DEPTH TO BEDROCK: 142.6 ft.

STATE: Nevada
GROUND ELEVATION: 3791.23
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Set 10-3/4" surface casing to approximately 4.5' and cement in place. Sonic core with 4-3/4" bit from 0.0 to 135.4'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 135.4 to 563.6'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 582.6' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 10-3/4" surface casing to approximately 4.5'. 5-7/8" casing from 0.0 to 135.4'. 4-1/2" casing from 135.4 to 563.6'. **Hole Completion:** Remove 5-7/8" casing and 4-1/2" casing. Install 3-1/2" PVC casing to depth of 582.6'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 582.6' (TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(SP-SM)g (SM)g (GP-GM)s (SP)g (SP-SM)g (SM)g (SP-SM)g		**0.0 to 142.6 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 2.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, yellowish red, strong reaction with HCl. **2.0 to 14.9 ft. SILTY SAND WITH GRAVEL (SM)g:** About 65 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, yellowish red, strong reaction with HCl. **14.9 to 16.9 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 55 percent coarse to fine, hard, subangular to subrounded gravel; about 35 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, reddish yellow, strong reaction with HCl. **16.9 to 27.2 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 65 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, yellowish red, weak reaction with HCl. **27.2 to 64.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, reddish yellow, strong reaction with HCl. **64.6 to 88.4 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent fines of low plasticity with no dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, pink, strong reaction with HCl. **88.4 to 104.9 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent fines of low plasticity with no dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, pink, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-28 (Sheet 1 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-69

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/10/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,083.82 E 571,883.49
TOTAL DEPTH: 582.6 ft.
DEPTH TO BEDROCK: 142.6 ft.

STATE: Nevada
GROUND ELEVATION: 3791.23
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SP-SM)g		**104.9 to 142.6 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent fines of low to medium plasticity with low to medium dry strength, quick dilatancy and low toughness; dry, pale red, pale brown, pink, brown, reddish-brown, no to strong reaction with HCl. TOTAL SAMPLE (BY VOLUME): About 12 percent hard drilled cobbles, maximum size 125 mm; remainder minus 3-inch.
	110								
	115								
	120								
	125						(SM)gc		
	130								
	135								
	140	7		9	53	0			**142.6 to 283.5 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pumice fall deposits, nonwelded, mostly vitric, white, 25 to 80 percent pumice, 5 to 20 percent lithic fragments of welded tuff, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent sphene and biotite. Generally the tuff is moderately hard (H4) to very soft (H7) averaging soft (H6), fresh (W1), very slightly fractured (FD1) to very intensely fractured (FD9), averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	145	7		9	82	0			
	150	7		9	75	0			
	155	7		9	18	0			
	160	7		9	100	0			
	165	7		9	98	0			
	170	7		9	65	0			
	175	7		9	96	0			
	180	5		7	98	61	Tpki		
	185	5		7	94	61			
	190	5		7	98	44			
	195	5		6	95	57			
	200	5		4	100	95			
	205	5		5	96	90			
	210	5		4	100	75			
	215	5		4	100	78			

Figure RAI 2.2.1.1.1-004-28 (Sheet 2 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-69

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/10/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,083.82 E 571,883.49
TOTAL DEPTH: 582.6 ft.
DEPTH TO BEDROCK: 142.6 ft.

STATE: Nevada
GROUND ELEVATION: 3791.23
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	5		4	100	78	Tpki		
	225	5		4	100	100			
	230	4		1	100	100			
	235	4		6	96	62			
	240	4		4	94	59			
	245	5		4	100	100			
	250	5		3	100	91			
	255	5		6	100	39			
	260	5		2	94	92			
	265	5		6	94	83			
	270	5		4	92	81			
	275	5		5	100	82			
	280	5		4	100	95			
	285	7		7	63	29			
	290	7		7	100	59	Tpbt5		**283.5 to 293.8 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded/reworked tuff, crystallized, light brown, pink, pinkish-white, gray, very pale brown, 7 to 80 percent pumice, 1 to 4 percent lithic fragments of welded tuff, 2 to 4 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and hornblende. Generally the tuff is soft (H6) to mostly very soft (H7), fresh (W1), intensely to moderately fractured (FD6) to very intensely to intensely fractured (FD8), averaging intensely fractured (FD7). Lower contact is unconformable and sharp.
	295	7		7	100	61			
	300	7		8	33	0			
	305	7		6	85	49	Tpcrv		**293.8 to 304.8 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded, vitric to crystallized, pink, light gray, reddish yellow, white, light gray, 7 to 12 percent pumice, less than 1 percent lithic fragments of welded tuff, 7 to 12 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and hornblende. Generally the tuff is moderately soft (H5) to very soft (H7) averaging soft (H6), slightly weathered to fresh (W2) to mostly fresh (W1), moderately to slightly fractured (FD4) to very intensely to intensely fractured (FD8), averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	310	7		8	92	20			
	315	5		4	94	72			
	320	4		6	100	55	Tpcrn		**304.8 to 373.6 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, densely welded crystallized and locally vapor-phase altered, reddish gray, pale red, light reddish gray, light gray, white, 1 to 30 percent pumice, 6 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, pyroxene, and hornblende. Generally the tuff is hard (H3) to moderately soft (H5) averaging moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7), averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	325	3		6	95	46			
	330	4		8	90	18			
	335	5		6	53	31			
		5		6	100	53			
		4		6	100	56			
		4		6	100	63			

Figure RAI 2.2.1.1.1-004-28 (Sheet 3 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-69

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/10/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,083.82 E 571,883.49
TOTAL DEPTH: 582.6 ft.
DEPTH TO BEDROCK: 142.6 ft.

STATE: Nevada
GROUND ELEVATION: 3791.23
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		6	100	63	Tpcrn		
	345	4		6	96	55			
	350	4		4	100	86			
	355	4		7	98	26			
	360	4		7	100	40			
	365	4		6	100	64			
	370	4		6	100	47			
	375	4		6	84	58	Tpcrl		**373.6 to 394.1 ft. TIVA CANYON TUFF CRYSTAL-RICH UPPER LITHOPHYSAL ZONE (Tpcrl):** Pyroclastic flow, moderately to densely welded, crystallized, white, 10 percent pumice, 3 to 10 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, hornblende and pyroxene. Generally the tuff is moderately hard (H4), fresh (W1), intensely to moderately fractured (FD6) to very intensely to intensely fractured (FD8), averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	380	4		7	96	33			
	385	4		8	81	23			
	390	4		6	96	55			
	395	4		5	100	81	Tpcpun		**394.1 to 435.8 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, reddish gray, 7 percent pumice, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7), averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	400	3		6	98	42			
	405	3		5	94	65			
	410	3		6	100	41			
	415	3		5	100	67			
	420	3		7	84	32			
	425	3		7	98	40			
	430	3		6	98	68			
	435	3		6	88	49	Tpcpul		**435.8 to 493.1 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, reddish-gray, 2 to 3 percent pumice, 2 to 3 percent crystal fragments of sanidine, plagioclase, and lesser biotite and pyroxene. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely to intensely fractured (FD8), averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	440	3		8	100	28			
	445	3		5	100	66			
	450	3		5	96	76			
	455	3		6	100	21			

Figure RAI 2.2.1.1.1-004-28 (Sheet 4 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-69

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/10/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,083.82 E 571,883.49
TOTAL DEPTH: 582.6 ft.
DEPTH TO BEDROCK: 142.6 ft.

STATE: Nevada
GROUND ELEVATION: 3791.23
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	3		7	94	36	Tpcpul		
	465	3		5	100	78			
	470	3		6	98	73			
	475	3		6	98	64			
	480	3		5	100	71			
	485	3		6	100	50			
	490	3		4	94	84			
	495	3		4	100	95	Tpcpmn		**493.1 to 537.5 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, reddish gray, pale red, 2 percent pumice, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and hornblende. Generally the tuff is hard (H3), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely to intensely fractured (FD8), averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	500	3		7	100	38			
	505	3		7	92	15			
	510	3		8	73	1			
	515	3		5	100	62			
	520	3		4	100	90			
	525	3		6	100	65			
	530	3		5	100	76			
	535	3		5	100	70			
	540	3		5	100	73			
	545	3		3	100	83	Tpcpll		**537.5 to 563.6 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, pale red, light reddish-brown, reddish-gray, 2 to 3 percent pumice, 10 to 15 percent lithophysae, 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), slightly fractured (FD3) to very intensely to intensely fractured (FD8), averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
	550	3		6	94	81			
	555	3		5	94	60			
	560	3		6	85	36			
	565	3		7	74	39			
	570	3		7	100	29			
	575	3		8	33	0			

Figure RAI 2.2.1.1.1-004-28 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-69

SHEET 6 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/10/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,083.82 E 571,883.49
TOTAL DEPTH: 582.6 ft.
DEPTH TO BEDROCK: 142.6 ft.

STATE: Nevada
GROUND ELEVATION: 3791.23
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	580								
	BOTTOM OF HOLE								

Figure RAI 2.2.1.1.1-004-28 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-71

SHEET 1 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/6/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,397.98 E 571,410.85
TOTAL DEPTH: 482.1 ft.
DEPTH TO BEDROCK: 161.8 ft.

STATE: Nevada
GROUND ELEVATION: 3811.10
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Set 10-3/4" surface casing to approximately 4.5'. Sonic core with 4-3/4" bit from 0.0 to depth of 134.4'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 134.4 to 471.4'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 482.1' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
Set 10-3/4" conductor casing from 0.0 to approximately 4.5'. 5-7/8" casing from 0.0 to 134.4'. 4-1/2" casing from 134.4 to 471.4'.

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Install 3-1/2" PVC casing to depth of 481.4'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 482.1' (TD) up to ground level.

DEPTH	GEOLOGIC UNIT [USCS]	CLASSIFICATION AND PHYSICAL CONDITION
		0.0 to 161.8 ft. QUATERNARY ALLUVIUM (Qal):
5	(SP-SM)gc	**0.0 to 8.7 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, angular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no to low dry strength, slow to quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 80 mm; dry to moist, pale brown, light brown, no to strong reaction with HCl.
10	SP-SM	**8.7 to 12.6 ft. POORLY GRADED SAND WITH SILT (SP-SM):** About 80 percent coarse to fine, subangular to subrounded sand; about 10 percent predominantly fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity with low dry strength, quick dilatancy and low toughness; maximum size 25 mm; dry, pale brown, no reaction with HCl.
15	(GP-GM)s	**12.6 to 24.7 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 60 mm; dry, light gray, moderate reaction with HCl.
20		
25	(SP-SM)g	**24.7 to 34.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 45 mm; dry, pink, strong reaction with HCl.
30		
35	(SP)g	**34.4 to 35.6 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, subangular to subrounded gravel; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 55 mm; dry, reddish gray, strong reaction with HCl.
	(GM)s	**35.6 to 37.0 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 15 percent fines of low plasticity with low dry strength, quick dilatancy and low toughness; maximum size 65 mm; dry, light yellowish brown, strong reaction with HCl.
40	(SP-SM)g	**37.0 to 69.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with low dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, pinkish gray, strong reaction with HCl.
45		
50		
55		
60		
65		
70	(SP)g	**69.0 to 72.9 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, angular to subangular sand; about 35 percent coarse to fine, hard, angular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light yellowish brown, strong reaction with HCl.
75	(SP-SM)g	**72.9 to 77.3 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, pinkish gray, weak reaction with HCl.
	(GP)s	**77.3 to 79.0 ft. POORLY GRADED GRAVEL WITH SAND (GP)s:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 45 percent coarse to fine, angular to subangular sand; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 50 mm; dry, light yellowish brown, weak reaction with HCl.
80	(SP-SM)g	**79.0 to 111.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with no to low dry strength, quick dilatancy and low toughness; maximum size 60 mm; dry, pink, light yellowish brown, weak to strong reaction with HCl.
85		
90		
95		

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-29 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-71

SHEET 2 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/6/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,397.98 E 571,410.85
TOTAL DEPTH: 482.1 ft.
DEPTH TO BEDROCK: 161.8 ft.

STATE: Nevada
GROUND ELEVATION: 3811.10
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105						(SP-SM)g		
	110								**111.0 to 161.8 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; dry to moist, pink, strong reaction with HCl. In situ conditions are less reliable for the bottom conventionally cored interval 134.4 to 161.8 ft (27.4 ft), as this type of coring tends to wash out the fines. TOTAL SAMPLE (BY VOLUME): About 5 percent hard drilled cobbles; maximum size 300 mm; remainder minus 3-inch.
	115								
	120								
	125								
	130								
	135						(SM)gc		
	140								
	145								
	150								
	155								
	160	6		7	100	81			
	165	6		6	100	47	Tpki		**161.8 to 168.9 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, and pumice fall deposits, nonwelded, vitric, white, 70 to 90 percent pumice, 5 to 7 percent lithic fragments of welded tuff and volcanic glass, 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and sphene. Generally the tuff is soft (H6), fresh (W1), intensely to moderately fractured (FD6) to mostly intensely fractured (FD7). Lower contact is unconformable and sharp.
	170	7		6	75	40			**168.9 to 189.9 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded/reworked tuff and pyroclastic flows, possible paleosol, nonwelded, vitric and crystallized, light brown, white, very pale brown, pink, pinkish-gray, 2 to 80 percent pumice, less than or equal to 1 percent lithic fragments of volcanic rock, less than 1 to 15 percent crystal fragments of sanidine, plagioclase, and lesser biotite, magnetite, and pyroxene. Generally the tuff is very soft (H7), fresh (W1), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	175	7		6	100	80			
	180	7		5	100	87	Tpbt5		
	185	7		6	89	43			
	190	3		5	100	69			**189.9 to 197.4 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, partially to densely welded, vitric to crystallized, pink, very pale brown, reddish-brown, pale red, black, 7 to 15 percent pumice, 1 to 3 percent lithic fragments of welded tuff and glass, 7 to 12 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5), to mostly intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	195	3		6	100	69	Tpcrv		**197.4 to 262.5 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized and locally vapor-phase altered, pale red, 1 to 25 percent pumice, less than 1 percent lithic fragments of welded tuff, 10 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and hornblende. Generally the tuff is moderately soft (H5) to mostly hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely fractured (FD8), averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	200	3		6	100	37			
	205	5		7	100	40	Tpcrn		
	210	3		8	94	44			
	215	4		7	100	15			

Figure RAI 2.2.1.1.1-004-29 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-71

SHEET 3 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/6/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,397.98 E 571,410.85
TOTAL DEPTH: 482.1 ft.
DEPTH TO BEDROCK: 161.8 ft.

STATE: Nevada
GROUND ELEVATION: 3811.10
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	3		6	100	73	Tpcrn		
	225	3		5	100	69			
	230	3		5	100	84			
	235	3		7	100	42			
	240	3		7	100	36			
	245	3		7	51	10			
	250	3		7	100	45			
		3		8	100	0			
	255	3		5	98	62			
	260	3		5	100	78			
	265	3		8	86	22	Tpcrl		**262.5 to 273.4 ft. TIVA CANYON TUFF CRYSTAL-RICH LITHOPHYSAL ZONE (Tpcrl):** Pyroclastic flow, densely welded, crystallized, white, light gray, pinkish gray, 10 to 15 percent pumice, 2 to 5 percent lithophysae, 3 to 10 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is hard (H3), slightly weathered to fresh (W2), intensely fractured (FD7) to very intensely fractured (FD9), averaging very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
	270	3		9	50	0			
	275	3		7	88	31	Tpcpun		**273.4 to 302.2 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, white, light gray, pinkish-gray, 5 percent pumice, 3 to 4 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and hornblende. Generally the tuff is hard (H3), fresh (W1), moderately fractured (FD5) to very intensely fractured (FD9), averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	280	3		7	100	40			
	285	3		9	66	1			
	290	3		6	100	72			
		3		8	95	36			
	295	3		7	96	41			
	300	3		5	100	84			
	305	3		8	32	0	Tpcpul		**302.2 to 357.4 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red, white, 5 percent pumice, 5 to 20 percent lithophysae, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is hard (H3), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9), averaging intensely fractured (FD7). Lower contact is conformable and gradational.
		3		8	78	22			
	310	3		9	74	0			
	315	3		9	62	0			
		3		9	40	0			
	320	3		7	100	44			
	325	3		5	94	76			
	330	3		5	96	80			
	335	3		4	100	88			
		3		7	100	47			

Figure RAI 2.2.1.1.1-004-29 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-71

SHEET 4 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/6/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,397.98 E 571,410.85
TOTAL DEPTH: 482.1 ft.
DEPTH TO BEDROCK: 161.8 ft.

STATE: Nevada
GROUND ELEVATION: 3811.10
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	3		7	100	47	Tpcpul		
		3		9	77	0			
	345	3		5	100	70			
	350	3		4	100	89			
	355	3		5	100	72			
	360	3		5	98	84	Tpcpmn		**357.4 to 428.0 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, white, light gray, 2 to 3 percent pumice, 1 to 5 percent lithophysae, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), slightly to very slightly fractured (FD2) to very intensely fractured (FD9), averaging moderately fractured (FD5). Lower contact is conformable and gradational.
	365	3		2	100	92			
	370	3		4	100	97			
	375	3		5	100	87			
	380	3		5	100	84			
	385	3		5	100	84			
	390	3		5	100	87			
	395	3		4	100	92			
	400	3		4	100	75			
	405	3		4	100	86			
	410	3		4	100	92			
	415	3		6	100	57			
	420	3		9	53	0			
		3		7	100	40			
	425	3		7	88	38			
	430	3		9	42	0	Tpcpll		**428.0 to 444.4 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, pinkish-gray, reddish-gray, gray, 2 to 3 percent pumice, 8 to 10 percent lithophysae, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9), averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	435	3		9	48	0			
		3		9	61	0			
	440	3		6	100	61			
		3		4	98	94			
	445	3		7	100	48	Tpcpln		**444.4 to 471.4 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded, crystallized, pale red, 2 percent pumice, 2 to 3 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9), averaging intensely fractured (FD7). Lower contact is undetermined.
	450	3		7	100	36			
	455	3		8	100	14			

Figure RAI 2.2.1.1.1-004-29 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-71

SHEET 5 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/6/2007 FINISHED: 8/10/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 770,397.98 E 571,410.85
TOTAL DEPTH: 482.1 ft.
DEPTH TO BEDROCK: 161.8 ft.

STATE: Nevada
GROUND ELEVATION: 3811.10
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	3		8	100	13	Tpcpln		
		3		9	100	0			
	465	3		7	100	55			
	470	3		8	100	23			
	475								
	480								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-29 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-81

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 5/23/2007 FINISHED: 6/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,909.64 E 572,923.59
TOTAL DEPTH: 441.3 ft.
DEPTH TO BEDROCK: 176.1 ft.

STATE: Nevada
GROUND ELEVATION: 3673.44
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Sonic core with 4-3/4" bit from 0.0 to 140.1'. 5-7/8" casing is advanced as whole is drilled. Change over to CME-85 Core Rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 441.3' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 5-7/8" casing from 0.00 to 140.1'. 4-1/2" casing from 140.1 to 441.3' (TD). **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Plug and abandon hole using bentonite chips from bottom of hole 441.3' (TD) up to ground level.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95						(GP-GM)s (SM)g (SP-SM)g (SP-SM)gc (SP-SM)g (SP-SM)gc (SM)g		**0.0 to 176.1 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 1.5 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, yellowish red, strong reaction with HCl. **1.5 to 5.4 ft. SILTY SAND WITH GRAVEL (SM)g:** About 65 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, reddish brown, strong reaction with HCl. **5.4 to 12.6 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, reddish yellow, strong reaction with HCl. **12.6 to 25.5 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 70 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 80 mm; dry, light red, strong reaction with HCl. **25.5 to 42.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 55 mm; dry, yellowish red, light reddish brown, strong reaction with HCl. **42.8 to 66.5 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, angular to subangular gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard angular cobbles; maximum size 80 mm; dry, pink, strong reaction with HCl. **66.5 to 100.0 ft. SILTY SAND WITH GRAVEL (SM)g:** About 45 percent coarse to fine, angular to subangular sand; about 40 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, white, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-30 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-81

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valey
BEGUN: 5/23/2007 FINISHED: 6/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,909.64 E 572,923.59
TOTAL DEPTH: 441.3 ft.
DEPTH TO BEDROCK: 176.1 ft.

STATE: Nevada
GROUND ELEVATION: 3673.44
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120						(SP-SM)g		**100.0 to 123.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, pink, strong reaction with HCl.
	125						(GM)s		**123.1 to 126.2 ft. SILTY GRAVEL WITH SAND (GM)s:** About 55 percent coarse to fine, hard, angular to subrounded gravel; about 30 percent coarse to fine, angular to subrounded sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, pale red, strong reaction with HCl.
	130, 135						(SP-SM)g		**126.2 to 139.2 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 45 percent coarse to fine, subangular to subrounded sand; about 45 percent coarse to fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, light reddish gray, strong reaction with HCl.
	140, 145, 150, 155, 160, 165, 170, 175						(SP)gc		**139.2 to 176.1 ft. POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP)gc:** About 65 percent coarse to fine, subangular sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; trace of nonplastic fines with quick dilatancy and low toughness; wet, yellowish brown, no reaction with HCl. This sample recovered using conventional coring. Fines appear to have been washed out of sample due to coring method. TOTAL SAMPLE (BY VOLUME): About 5 percent hard, drilled cobbles; maximum size 145 mm; remainder minus 3-inch.
	180	4		7	94	47	Tmr		**176.1 to 248.9 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow, non to partially welded, crystallized, light reddish-brown, 10 to 15 percent pumice, less than 1 percent lithic fragments of welded tuff, 10 to 15 percent crystal fragments of sanidine, plagioclase, quartz and less than 1 percent biotite. Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is unconformable and sharp.
	185	4		7	94	19			
	190	5		8	91	6			
	195	4		9	68	0			
	200	4		6	96	43			
	205	4		7	100	26			
	210	4		5	94	73			
	215	4		6	100	57			
		4		8	26	0			

Figure RAI 2.2.1.1.1-004-30 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-81

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valey
BEGUN: 5/23/2007 FINISHED: 6/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,909.64 E 572,923.59
TOTAL DEPTH: 441.3 ft.
DEPTH TO BEDROCK: 176.1 ft.

STATE: Nevada
GROUND ELEVATION: 3673.44
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		8	26	0	Tmr		
	225	6		8	96	20			
	230	7		8	100	19			
	235	7		8	70	0			
		7		9	100	21			
	240	7		9	88	0			
	245	6		6	98	68			
	250	6		6	98	82	Tmbt1		**248.9 to 265.8 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded/reworked tuff, pumice fall deposits, nonwelded, massively bedded, mostly vitric, very pale brown, white, 10 to 80 percent pumice, 1 to 2 percent lithic fragments of welded tuff, 2 to 3 percent crystal fragments of sanidine, plagioclase, quartz, and less than 1 percent biotite. Generally the tuff is soft (H6) to mostly very soft (H7), slightly weathered to fresh (W2), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	255	7		5	100	83			
	260	7		6	100	81			
	265	7		6	100	74			
	270	6		6	100	51	Tpki		**265.8 to 373.3 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded vitric, white, pinkish-white, pinkish-gray, 20 to 35 percent pumice, less than 1 to 7 percent lithic fragments of welded tuff, 2 to 12 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), fresh (W1), unfractured (FD0) to very intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp at 70 degrees to the core axis.
	275	5		4	100	92			
	280	5		5	100	84			
	285	5		5	100	91			
	290	5		5	100	84			
	295	5		4	100	95			
	300	5		4	100	92			
	305	5		5	100	87			
	310	5		5	100	84			
	315	5		4	100	100			
	320	5		3	100	97			
	325	5		1	100	93			
	330	5		2	100	100			
	335	5		3	100	82			
		5		6	100	57			

Figure RAI 2.2.1.1.1-004-30 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-81

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valey
BEGUN: 5/23/2007 FINISHED: 6/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,909.64 E 572,923.59
TOTAL DEPTH: 441.3 ft.
DEPTH TO BEDROCK: 176.1 ft.

STATE: Nevada
GROUND ELEVATION: 3673.44
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	340	5		6	100	57		
	345	5		3	100	99		
	350	5		0	100	100		
	355	4		0	100	100	Tpki	
	360	4		0	100	100		
	365	4		3	98	84		
		4		3	100	99		
	370	6		5	94	69		
	375	7		3	98	95	Tpbt5	
	380	5		5	94	68		
	385	5		6	93	71	Tpcrv	
	390	6		7	91	33		
	395	4		6	100	74		
	400	4		4	100	77		
	405	4		3	100	95		
	410	4		4	100	89		
	415	4		5	98	86	Tpcrn	
	420	4		3	100	95		
	425	4		5	100	93		
	430	4		5	100	88		
	435	4		3	98	93		
	440							

BOTTOM OF HOLE

CLASSIFICATION AND PHYSICAL CONDITION

373.3 to 384.3 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5): Bedded/reworked tuff and pyroclastic flows, non to moderately welded, crystallized, locally clay altered, light brown, pale red, pink, white, light gray, 2 to 70 percent pumice, less than 1 percent lithic fragments of welded tuff, 2 to 8 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is very soft (H7) to moderately soft (H5) averaging soft (H6), fresh (W1), slightly fractured (FD3) to moderately fractured (FD5) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.

384.3 to 388.3 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv): Pyroclastic flow, partially to moderately welded, crystallized, white, 5 to 7 percent pumice, less than 1 percent lithic fragments of welded tuff, 6 to 7 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite. Generally the tuff is moderately soft (H5), slightly weathered to fresh (W2), intensely to moderately fractured (FD6). Lower contact is conformable and gradational.

388.3 to 441.3 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, densely welded, crystallized, brown, pale red, light gray, 1 to 25 percent pumice, 8 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, pyroxene, and hornblende. Generally the tuff is soft (H6) to mostly moderately hard (H4), slightly weathered to fresh (W2), slightly fractured (FD3) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is undefined.

Figure RAI 2.2.1.1.1-004-30 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 1 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Sonic core with 4-3/4" bit from 0.0 to 136.2'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 136.2 to 940.2' (TD). 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Drive 7-3/4" casing to depth of 139.3. 7-3/4" casing left in hole with temporary cap on top of casing. **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 7-3/4" casing from 0.0 to 139.3'. 5-7/8" casing from 0.00 to 136.2'. 4-1/2" casing from 136.2 to 940.2' (TD). **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Leave 7-3/4" casing in hole at depth of 139.3'. Install temporary cap on top of 7-3/4" casing.	5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85						(SM)g (SP)g (SP-SM)gc (SM)gc		**0.0 to 159.8 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 17.1 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with no to low dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, reddish brown, light reddish brown, strong reaction with HCl. Roots and dry grass present from 0.0 to 1.5 ft. **17.1 to 23.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 40 mm; dry, light brown, strong reaction with HCl. **23.7 to 43.0 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 80 mm; dry, light reddish brown, moderate reaction with HCl. **43.0 to 101.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, angular to subrounded gravel; about 20 percent fines of no to low plasticity with low dry strength, quick to slow dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 80 mm; dry, pinkish gray, moderate to strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-31 (Sheet 1 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 2 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	95						(SM)gc		
	100								**101.2 to 134.8 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard drilled cobbles; maximum size 85 mm; dry, pinkish gray, gray, weak reaction with HCl.
	105								
	110								
	115						(SP-SM)gc		
	120								
	125								
	130								
	135								**134.8 to 159.8 ft. POORLY GRADED GRAVEL WITH COBBLES (GP)c:** About 100 percent coarse to fine, hard, subangular to subrounded gravel; trace of coarse to fine, subangular to subrounded sand; trace of nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard, drilled cobbles; maximum size 175 mm; dry, gray, no reaction with HCl.
	140								
	145						(GP)c		
	150								
	155								
	160	5		6	100	64			**159.8 to 312.1 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow and pumice fall deposits, nonwelded, crystallized to vitric, light brown, pink, white, 5 to 50 percent pumice, less than or equal to 1 percent lithic fragments of volcanic rock, 15 to 30 percent crystal fragments of sanidine, quartz, and plagioclase, less than 1 percent biotite, magnetite, 2 to 10 percent vitric shards, obsidian nodules or fragments, about 15 to 20 percent of the matrix is vitric ash. Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
		0		0	0	0			
	165	0		0	0	0			
		5		6	98	35			
	170								
		5		6	100	72			
	175								
		4		6	98	58	Tmr		
	180								
		4		6	100	60			
	185								
		4		6	96	34			
	190								
		4		6	100	77			
	195								
		4		4	98	75			

Figure RAI 2.2.1.1.1-004-31 (Sheet 2 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 3 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	200	4		4	98	75			
	205	4		5	100	73			
	210	4		5	91	70			
	215	4		5	100	88			
	220	5		4	96	84			
	225	5		4	100	93			
	230	5		4	100	91			
	235	5		4	94	82			
	240	5		4	98	87			
	245	5		4	100	84			
	250	5		4	100	85	Tmr		
	255	5		4	100	94			
	260	5		4	98	91			
	265	5		4	94	91			
	270	5		6	88	30			
	275	5		6	100	83			
	280	5		5	100	86			
	285	5		4	92	92			
	290	5		4	100	92			
	295	5		4	82	62			
	300	6		5	96	66			
		6		6	100	69			

Figure RAI 2.2.1.1.1-004-31 (Sheet 3 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 4 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	310	6		6	96	68	Tmr		
	315	7		6	100	89	Tmbt1		**312.1 to 537.4 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded/reworked tuff and pumice fall deposits, pyroclastic flows, massively bedded, nonwelded, vitric and crystallized, light gray, very pale brown, white, less than 1 to 80 percent pumice, less than 1 to 15 percent lithic fragments of volcanic rocks, 5 percent vitric and obsidian fragments locally, 3 to 30 percent crystal fragments of sanidine, quartz, and feldspar, less than 1 to 3 percent biotite and hornblende, and lesser magnetite. Generally the tuff is very soft (H7) to hard (H3) averaging moderately soft (H5), fresh (W1), slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	320	7		6	98	67			
	325	7		6	100	82			
	330	7		6	92	80			
	335	7		6	98	56			
		7		6	100	83			
	340	7		6	100	47			
	345	7		6	100	79			
	350	5		6	91	84			
	355	6		6	92	78			
		6		6	100	77			
	360	6		4	100	74			
	365	6		4	100	75			
		6		6	92	65			
	370	6		6	100	72			
	375	6		3	98	94			
	380	5		3	100	100			
	385	5		3	98	97			
	390	4		3	100	96			
	395	4		3	100	93			
	400	4		3	100	100			
	405	4		3	98	93			
	410	4		6	68	42			

Figure RAI 2.2.1.1.1-004-31 (Sheet 4 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 5 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	415	4		6	88	9			
		4		3	100	100			
	420	4		3	100	94			
	425	4		4	100	97			
	430	4		4	94	86			
	435	4		3	100	99			
	440	4		4	100	92			
	445	4		3	100	99			
	450	4		4	100	97			
	455	4		3	100	100			
	460	4		3	100	97			
	465	4		3	100	100	Tmbt1		
	470	4		3	100	93			
	475	4		4	100	99			
	480	4		3	100	96			
	485	4		3	100	98			
	490	4		3	98	95			
	495	4		3	100	97			
	500	4		4	100	87			
	505	4		3	100	100			
	510	4		3	100	100			
		4		4	76	75			
	515	4		4	100	97			
		4		3	100	100			

Figure RAI 2.2.1.1.1-004-31 (Sheet 5 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 6 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	520	4		3	100	100	Tmbt1		
		4		3	100	100			
	525	4		4	100	98			
	530	4		3	96	97			
	535	4		4	100	76			
	540	4		4	98	76	Tpki		**537.4 to 723.0 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pumice fall deposit, nonwelded, crystallized, white, 20 to 50 percent pumice, 2 to 35 percent lithic fragments of welded and nonwelded tuff, 2 to 3 percent crystal fragments of plagioclase and sanidine, less than 1 percent biotite, hornblende and lesser sphene. Generally the tuff is moderately hard (H4) to mostly moderately soft (H5), slightly weathered to fresh (W2), slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
	545	4		3	100	91			
	550	4		3	100	100			
	555	4		4	98	91			
	560	4		3	98	97			
	565	4		3	100	94			
	570	4		3	100	94			
	575	4		4	96	62			
	580	4		3	100	100			
	585	4		3	100	99			
	590	4		3	100	100			
	595	4		3	100	100			
	600	4		3	100	96			
	605	4		3	100	93			
	610	5		3	100	100			
	615	5		3	100	97			
	620	5		3	98	95			
	625	5		3	100	86			

Figure RAI 2.2.1.1.1-004-31 (Sheet 6 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 7 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	630	5		4	98	75			
	635	5		4	98	85			
	640	5		4	100	94			
	645	5		5	91	79			
	650	5		5	98	86			
	655	5		5	100	86			
	660	5		5	100	93			
	665	5		4	100	92			
	670	5		4	100	100			
	675	5		3	98	97	Tpki		
	680	5		3	100	100			
	685	5		5	100	75			
	690	5		3	100	99			
	695	5		5	98	85			
	700	5		5	100	82			
	705	5		3	100	100			
	710	5		3	100	100			
	715	5		6	100	55			
	720	5		6	100	72			
	725	4		5	83	53	Tpbt5		**723.0 to 727.5 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded/reworked tuff, pyroclastic flow, nonwelded, crystallized, pinkish-gray, white, light gray, 15 percent pumice, less than 1 percent lithic fragments, 1 to 2 percent felsic crystal fragments, less than 1 percent biotite, hornblende and pyroxene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), and moderately fractured (FD5). Lower contact is unconformable and sharp.
	730	4		8	79	24	Tpcrv		**727.5 to 733.9 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, partially, moderately and densely welded, crystallized and vapor-phase altered, white, gray, strong brown, 5 to 10 percent pumice, less than or equal to 1 percent lithic fragments of volcanic rock, 3 to 20 percent crystal fragments of plagioclase, sanidine, 1 percent biotite, hornblende and
		4		8	61	25			

Figure RAI 2.2.1.1.1-004-31 (Sheet 7 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 8 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	735	4		8	61	25			pyroxene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to very intensely to intensely fractured (FD8) averaging intensely fractured (FD7). Lower contact is conformable and gradational. **733.9 to 784.7 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately and densely welded, crystallized, vapor-phase altered, pale red, light gray, light reddish-gray, 5 to 25 percent pumice, less than 1 percent lithic fragments of volcanic rock, 5 to 15 percent crystal fragments of plagioclase, sanidine, 1 percent biotite and pyroxene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
	740	4		8	100	35			
	745	4		8	94	14			
		4		8	74	17			
	750	4		6	100	45			
	755	4		6	91	49			
	760	4		8	96	22	Tpcrn		
	765	4		9	52	0			
	770	4		8	60	6			
	775	4		8	57	9			
	780	4		9	62	0			
	785	4		8	92	22			**784.7 to 801.6 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, light reddish-gray, pale red, 5 percent pumice, less than 1 percent lithic fragments of volcanic rock, 3 to 4 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
		3		9	59	0			
	790	3		9	68	0	Tpcpun		
	795	4		7	72	49			
	800	4		6	78	40			**801.6 to 861.0 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, vapor-phase alteration, light gray, pale red, 2 to 10 percent lithophysae, less than 1 to 5 percent pumice, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	805	3		9	38	0			
		4		9	75	0			
	810	4		9	89	0			
		4		8	87	13			
	815	4		5	94	85			
	820	4		6	100	81	Tpcpul		
	825	4		6	94	58			
	830	4		6	96	54			
	835	4		5	100	79			
	840	4		6	92	51			

Figure RAI 2.2.1.1.1-004-31 (Sheet 8 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-82

SHEET 9 OF 9

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/13/2007 FINISHED: 8/29/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,709.65 E 572,577.63
TOTAL DEPTH: 940.2 ft.
DEPTH TO BEDROCK: 159.8 ft.

STATE: Nevada
GROUND ELEVATION: 3667.93
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	845	4		6	92	51			
		4		6	88	61			
	850	4		6	74	59	Tpcpul		
	855	4		8	93	22			
	860	4		7	100	37			**861.0 to 880.9 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, less than 1 percent lithophysae, less than 1 percent pumice, 2 to 3 percent crystal fragments of feldspar, less than 1 percent biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), intensely to moderately fractured (FD6) to mostly intensely fractured (FD7). Lower contact is sharp (faulted).
	865	4		7	91	25			
	870	4		6	96	38	Tpcpmn		
	875	3		6	98	54			
	880	3		6	60	38			**880.9 to 884.9 ft. FAULT ZONE:** Fault breccia in a clay gouge matrix, white to pink. Breccia consists of fragments of volcanic tuff, crystallized, with 10 to 15 percent pumice, 5 percent lithic fragments of welded tuff, 2 percent felsic crystal fragments and rare biotite. Generally the fault zone is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), and intensely to moderately fractured (FD6). Lower contact is faulted.
							Fault Zone		
	885	4		6	100	27	Tptrv		**884.9 to 887.3 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH VITRIC ZONE (Tptrv):** Pyroclastic flow, densely welded, crystallized, pale red, pinkish-gray, less than 1 percent pumice, less than 1 percent lithic fragments, 15 to 20 percent crystal fragments of feldspar, biotite, hornblende and pyroxene. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), and intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	890	4		6	100	55			**887.3 to 940.2 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tptrn):** Pyroclastic flow, densely welded, crystallized, vapor-phase altered locally, light reddish-brown, pale red, reddish-gray, reddish-brown, 5 to 15 percent pumice, up to 1 percent lithic fragments locally, 10 to 15 percent crystal fragments of feldspar, biotite and hornblende. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is undetermined.
	895	4		6	98	87			
	900	4		6	100	70			
	905	4		5	100	62			
	910	4		6	100	60	Tptrn		
	915	4		6	100	56			
	920	4		6	98	70			
	925	4		6	98	48			
	930	4		5	100	69			
	935	4		5	100	83			
	940								

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-31 (Sheet 9 of 9)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 1 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Set 10-3/4" surface casing to approximately 4.0'. Sonic core with 8" bit from 0.0 to 35.2'. Set 7-3/4" conductor casing in 8" hole to depth of 18.4' and cement in place. Sonic core with 4-3/4" bit from 35.2 to 227.9'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 227.9 to 1057.6'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 1077.9' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
Set 10-3/4" surface casing to approximately 4.5'. Set 7-3/4" conductor casing from 0.0 to 18.4'. 5-7/8" casing from 0.0 to 227.9'. 4-1/2" casing from 227.9 to 1057.6'.

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Install 3-1/2" PVC casing to depth of 842.5'. Use 1" trommie pipe to grout PVC casing from bottom of hole 1077.9' (TD) up to ground level.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
								0.0 to 174.0 ft. QUATERNARY ALLUVIUM (Qal):
5, 10						(SP)g		**0.0 to 14.8 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 40 percent predominantly fine, hard, angular to subrounded gravel; about 5 percent nonplastic fines with no to low dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, pale brown, moderate reaction with HCl. Some organic material is present in the top 5 ft.
15, 20						(SP-SM)g		**14.8 to 25.1 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 75 percent coarse to fine, angular to subrounded sand; about 15 percent predominantly fine, hard, angular to subrounded gravel; about 10 percent fines of low plasticity with low dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, pale brown to very pale brown, weak reaction with HCl.
25, 30, 35, 40, 45, 50						(SP-SM)gc		**25.1 to 54.6 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent predominantly fine, hard, angular to subangular gravel; about 10 percent fines of low plasticity with low dry strength, quick dilatancy and low toughness; trace of hard, subangular cobbles; maximum size 105 mm; dry, very pale brown, weak reaction with HCl.
55, 60, 65						(SM)g		**54.6 to 70.2 ft. SILTY SAND WITH GRAVEL (SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 20 percent fines of medium plasticity with quick dilatancy and low toughness; maximum size 45 mm; dry to moist, pinkish gray, moderate reaction with HCl.
70, 75						(SP-SM)gc		**70.2 to 80.9 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 55 percent coarse to fine, angular to subrounded sand; about 35 percent coarse to fine, hard, angular to subangular gravel; about 10 percent fines of medium plasticity with slow dilatancy and low toughness; trace of hard subangular cobbles; maximum size 80 mm; dry, light gray, strong reaction with HCl.
80, 85						(SM)gc		**80.9 to 101.0 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 65 percent coarse to fine, subangular to subrounded sand; about 20 percent predominantly fine, hard, subangular to subrounded gravel; about 15 percent fines of low plasticity with low dry strength, quick to slow dilatancy, and low toughness; trace of hard subangular cobbles; maximum size 105 mm; dry to very wet, very pale brown, moderate reaction with HCl. Moisture content is from drilling method or additives.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-32 (Sheet 1 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 2 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195						(SM)gc; (SP)g; (SP-SM)g; (SP)g; (GP-GM)s; (SP-SM)g; (GP-GM)sc; (SM)g; (SM)gc; (GM)sc; Tmr		**101.0 to 102.0 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic to low plasticity fines with no to low dry strength, quick dilatancy and low toughness; maximum size 35 mm; wet, reddish brown, moderate reaction with HCl. **102.0 to 106.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 65 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity with low dry strength, slow dilatancy and low toughness; maximum size 40 mm; dry to moist, brown, strong reaction with HCl. **106.0 to 110.7 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 35 percent predominantly fine, hard, subangular to subrounded gravel; about 5 percent nonplastic to low plasticity fines with low dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry to moist, brown, strong reaction with HCl. **110.7 to 114.3 ft. POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)s:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 75 mm; dry, yellowish brown, strong reaction with HCl. **114.3 to 120.4 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, yellowish red, strong reaction with HCl. **120.4 to 126.6 ft. POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM)sc:** About 50 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard, subangular to subrounded cobbles; maximum size 80 mm; dry, brownish yellow, strong reaction with HCl. **126.6 to 134.0 ft. SILTY SAND WITH GRAVEL (SM)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, angular to subangular gravel; about 15 percent fines of low plasticity with quick dilatancy and low toughness; maximum size 75 mm; dry, very pale brown, no reaction with HCl. **134.0 to 169.1 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, angular to subrounded sand; about 30 percent coarse to fine, hard, angular to subrounded gravel; about 15 percent fines of medium plasticity with slow dilatancy and low toughness; trace of hard angular to subangular cobbles; maximum size 85 mm; dry, very pale brown, no to strong reaction with HCl. **169.1 to 174.0 ft. SILTY GRAVEL WITH SAND AND COBBLES (GM)sc:** About 45 percent coarse to fine, hard, angular gravel; about 30 percent coarse to fine, subangular to subrounded sand; about 15 percent fines of low plasticity with slow dilatancy and low toughness; trace of hard angular to subangular cobbles; maximum size 85 mm; dry, very pale brown, strong reaction with HCl. **174.0 to 271.1 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow, pumice fall deposits, reworked locally, nonwelded, vitric, white, pinkish-white, gray, 3 to 40 percent pumice, 1 to 40 percent lithic fragments of volcanic rock, 15 to 70 percent crystal fragments of plagioclase, sanidine, quartz, and lesser (but locally up to 20 percent) mafic crystals including biotite, hornblende, possible hematite locally. Generally the tuff is very soft (H7) to mostly soft (H6), slightly weathered to fresh (W2), unfractured (FD0) to intensely to moderately fractured (FD6) averaging slightly to very slightly fractured (FD2). Lower contact is unconformable and sharp.

Figure RAI 2.2.1.1.1-004-32 (Sheet 2 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 3 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	200								
	205								
	210								
	215								
	220								
	225								
	230	6		1	100	88			
	235	6		6	100	63	Tmr		
	240	6		0	98	98			
	245	6		3	100	89			
	250	6		2	100	93			
	255	6		1	100	99			
	260	6		0	100	100			
	265	6		2	98	90			
	270	7		4	100	80			
	275	7		3	100	91			**271.1 to 467.2 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, sandy ash beds, lithic-rich beds, massively bedded, vitric to crystallized, light brown, light yellowish-brown, pink, gray, light gray, 5 to greater than 90 percent pumice, 5 to 40 percent crystal fragments of plagioclase, sanidine, and lesser quartz and biotite. Generally the tuff is very soft (H7) to moderately hard (H4) averaging moderately soft (H5), slightly weathered to fresh (W2), unfractured (FD0) to very intensely fractured (FD9) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	280	7		3	100	86			
	285	7		3	100	84			
	290	6		3	100	82	Tmbt1		
	295	6		3	100	81			
	300	6		3	100	73			
		6		4	100	68			

Figure RAI 2.2.1.1.1-004-32 (Sheet 3 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 4 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		6		4	100	68			
	310	7		4	94	61			
	315	7		5	100	85			
	320	7		4	94	79			
	325	7		9	4	0			
	330	7		9	5	0			
	335	4		9	4	0			
	340	6		3	90	79			
		6		5	87	57			
	345	7		6	100	49			
	350	4		4	100	88			
	355	7		4	100	86			
	360	7		4	100	85	Tmbt1		
	365	7		4	98	83			
	370	4		2	98	96			
	375	4		0	100	98			
	380	4		0	100	100			
	385	4		1	100	100			
	390	4		2	100	99			
	395	4		3	100	82			
	400	4		4	94	78			
	405	4		2	100	95			
	410	5		3	96	93			

Figure RAI 2.2.1.1.1-004-32 (Sheet 4 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 5 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	415	5		3	100	92			
	420	4		0	100	97			
	425	4		1	100	98			
	430	4		1	100	94			
	435	4		3	98	84			
	440	4		1	100	97	Tmbt1		
	445	4		1	100	100			
	450	4		2	100	95			
	455	4		1	100	99			
	460	4		4	100	92			
	465	4		2	100	93			
	470	4		1	100	99			**467.2 to 649.3 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pumice fall beds, nonwelded, crystallized, locally altered, pale yellow, white, 5 to 85 percent pumice, 2 to 25 percent lithic fragments of moderately and densely welded tuff, less than 1 to 20 percent crystal fragments of plagioclase, sanidine, lesser biotite and rare sphene. Generally the tuff is very moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to intensely fractured (FD7) averaging slightly to very slightly fractured (FD2). Lower contact is unconformable and sharp.
	475	4		1	100	96			
	480	4		1	100	100			
	485	4		2	100	91			
	490	4		2	100	95			
	495	4		0	100	100	Tpki		
	500	4		0	98	96			
	505	4		0	100	100			
	510	4		1	100	99			
	515	4		4	100	88			
		4		1	96	97			

Figure RAI 2.2.1.1.1-004-32 (Sheet 5 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 6 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	520	4		1	96	97	Tpki		
	525	4		0	100	100			
	530	4		4	100	78			
	535	4		0	100	100			
	540	4		1	96	96			
	545	4		2	100	97			
		4		1	100	93			
	550	4		0	100	98			
	555	4		1	100	100			
	560	4		1	98	95			
	565	4		1	100	94			
	570	4		0	100	100			
	575	4		1	100	100			
	580	4		0	100	100			
		4		1	100	59			
		4		1	100	100			
	585	4		2	98	94			
	590	4		0	100	100			
	595	4		0	100	100			
	600	4		0	98	98			
		4		1	83	83			
		0		0	0	0			
	605	4		7	94	13			
		4		2	100	100			
	610	4		1	100	85			
	615	4		6	100	70			
	620	4		2	100	100			
	625	4		2	100	98			

Figure RAI 2.2.1.1.1-004-32 (Sheet 6 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 7 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	630	4		1	100	98			
	635	4		1	100	100			
		4		4	84	63	Tpki		
	640	4		1	100	89			
	645	4		1	100	97			
	650	4		0	98	96			
	655	5		2	100	89	Tpbt5		**649.3 to 658.7 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff with pyroclastic flow, nonwelded to moderately welded, crystallized, light reddish-brown, light red, light pinkish-white, light gray, 5 to 70 percent pumice, less than 1 percent lithic fragments of volcanic rock, 5 to 20 percent crystal fragments of biotite, plagioclase and sanidine, and less than 1 percent hornblende. Generally the tuff is moderately hard (H4) to soft (H6) averaging moderately soft (H5), fresh (W1), unfractured (FD0) to intensely fractured (FD7) averaging slightly fractured (FD3). Lower contact is unconformable and sharp.
	660	6		7	98	51			**658.7 to 668.8 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded, crystallized and vitric, pink, pinkish-gray, reddish-brown, 5 to 20 percent pumice, less than 1 percent lithic fragments of volcanic rock, 2 to 15 percent crystal fragments of sanidine, plagioclase, biotite, and lesser hornblende. Generally the tuff is moderately hard (H4) to soft (H6) averaging moderately soft (H5), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	665	5		6	100	65	Tpcrv		
	670	4		5	100	58			**668.8 to 727.8 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, locally vapor-phase altered, pale red, light gray, white, 2 to 15 percent pumice, 5 to 15 percent crystal fragments of plagioclase, sanidine, and lesser biotite, less than 1 percent pyroxene and hornblende. Generally the tuff is moderately soft (H5) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	675	5		6	100	43			
	680	5		6	80	54			
	685	4		5	100	20			
	690	4		5	100	68			
	695	4		6	100	57			
	700	4		5	100	67	Tpcrn		
	705	4		7	100	37			
	710	4		6	96	55			
	715	4		7	96	35			
	720	4		4	100	84			
	725	4		4	100	57			
	730	4		6	96	52			**727.8 to 745.2 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, light gray, 15 percent pumice, 3 to 5 percent crystal fragments of plagioclase, sanidine, and lesser biotite, less than 1 percent pyroxene and hornblende. Generally the tuff is moderately hard (H4), fresh (W1), moderately fractured (FD5) to mostly intensely to moderately fractured (FD6). Lower contact is conformable
		4		6	98	50	Tpcpun		

Figure RAI 2.2.1.1.1-004-32 (Sheet 7 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 8 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	735	4		6	98	50			and gradational.
	740	4		6	87	57	Tpcpun		
	745	4		5	94	56			
	750	4		7	75	24			**745.2 to 856.3 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, vapor-phase altered locally, light gray, pale red, pink, 5 to 10 percent lithophysae, 15 percent pumice, 3 to 5 percent crystal fragments of sanidine, plagioclase, and lesser biotite. Generally the tuff is very soft (H7) to hard (H3) averaging moderately hard (H4), slightly weathered to fresh (W2), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging very intensely to very intensely fractured (FD8). Lower contact is conformable and gradational.
	755	4		9	76	11			
	760	4		9	100	23			
		4		9	54	0			
		4		8	100	27			
	765	4		7	89	22			
	770	4		8	84	21			
	775	6		6	90	41			
		4		8	100	0			
	780	7		5	90	63			
	785	4		9	94	10			
	790	3		9	88	10			
	795	5		8	76	29	Tpcpul		
	800	6		7	100	23			
	805	4		7	90	24			
	810	5		7	82	36			
		3		9	60	0			
	815	3		9	31	0			
	820	3		8	96	38			
	825	3		9	90	13			
	830	3		6	100	57			
	835	3		6	100	50			
	840	3		7	92	24			

Figure RAI 2.2.1.1.1-004-32 (Sheet 8 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 9 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		9	91	7			
	845	3		9	58	0			
		3		6	100	40	Tpcpul		
	850	3		9	30	0			
		3		8	98	15			
	855								**856.3 to 903.2 ft. TIVA CANYON TUFF CRYSTAL-POOR MIDDLE NONLITHOPHYSAL ZONE (Tpcpmn):** Pyroclastic flow, densely welded, crystallized, pale red, pinkish-gray, less than 1 percent lithophysae, less than 1 percent pumice, less than 1 percent lithic fragments of volcanic rock, 2 to 5 percent crystal fragments of sanidine, plagioclase, and lesser biotite. Generally the tuff is hard (H3), fresh (W1), slightly fractured (FD3) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	860	3		7	100	39			
	865	3		6	100	60			
	870	3		5	100	74			
	875	3		4	100	88			
	880	3		3	98	88	Tpcpmn		
	885	3		5	100	73			
	890	3		5	100	54			
	895	3		5	96	61			
	900	3		5	100	66			
	905	3		4	100	91			**903.2 to 919.0 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER LITHOPHYSAL ZONE (Tpcpll):** Pyroclastic flow, densely welded, crystallized, reddish-gray, pale red, 5 percent lithophysae, 5 percent pumice, less than 1 percent lithic fragments of volcanic rock, 2 to 5 percent crystal fragments of sanidine, plagioclase, and lesser biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
	910	3		4	100	79	Tpcpll		
	915	3		4	87	56			
	920	3		4	100	94			**919.0 to 982.4 ft. TIVA CANYON TUFF CRYSTAL-POOR LOWER NONLITHOPHYSAL ZONE (Tpcpln):** Pyroclastic flow, densely welded crystallized, pale red, reddish-gray, white, less than 1 percent lithophysae locally, 5 to 10 percent pumice, 1 percent lithic fragments of volcanic rock, 2 percent crystal fragments of plagioclase, sanidine, and less than 1 percent biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is sharp (faulted).
	925	3		5	100	59			
	930	3		9	33	0			
	935	3		9	56	7	Tpcpln		
		3		9	100	0			
	940	3		9	30	0			
		0		0	0	0			
		0		0	0	0			
	945	3		7	68	33			
		0		0	0	0			

Figure RAI 2.2.1.1.1-004-32 (Sheet 9 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 10 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	950	3		8	81	0	Tpcpln		
		3		8	79	32			
	955	0		0	0	0			
		3		9	13	0			
	960	3		9	95	0			
	965	3		7	100	34			
		3		7	53	14			
	970	3		9	97	0			
	975	3		8	95	16			
		3		8	42	12			
	980	3		9	25	0			
	985	3		9	8	0	Fault Zone		**982.4 to 989.5 ft. FAULT ZONE:** Most of this interval was not recovered. The recovered portion is rubble. Generally the fault zone is hard (H3), fresh (W1), and very intensely fractured (FD9). Lower contact is faulted.
		3		9	83	0			
	990	3		5	100	62	Tptrm		**989.5 to 1007.2 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tptrm):** Pyroclastic flow, densely welded, crystallized, vapor-phase altered locally, reddish-gray, pale red, 10 to 15 percent pumice, 7 to 10 percent crystal fragments of plagioclase, sanidine and biotite, with lesser hornblende. Generally the tuff is hard (H3), fresh (W1), slightly fractured (FD3) to intensely to moderately fractured (FD6) averaging moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
		3		3	96	84			
	995	3		6	100	38			
	1000	3		3	94	87			
	1005	3		5	100	60	Tptrl		**1007.2 to 1016.1 ft. TOPOPAH SPRING TUFF CRYSTAL-RICH LITHOPHYSAL ZONE (Tptrl):** Pyroclastic flow, densely welded, crystallized, pale red, reddish-gray, light gray, 5 to 10 percent lithophysae, 10 to 15 percent pumice, 1 percent lithic fragments of volcanic rock, 5 to 7 percent crystal fragments of plagioclase, sanidine, and lesser biotite. Generally the tuff is hard (H3), fresh (W1), moderately to slightly fractured (FD4) to mostly moderately fractured (FD5). Lower contact is conformable and gradational.
	1010	3		4	100	86			
	1015	3		4	94	82	Tptpul		**1016.1 to 1057.6 ft. TOPOPAH SPRING TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tptpul):** Pyroclastic flow, densely welded, crystallized, pale red, reddish-gray, light gray, 10 percent lithophysae, 10 to 15 percent pumice, 1 percent lithic fragments of volcanic rock, 2 to 5 percent crystal fragments of sanidine, lesser plagioclase and biotite. Generally the tuff is hard (H3), fresh (W1), slightly to very slightly fractured (FD2) to moderately fractured (FD5) averaging moderately to slightly fractured (FD4). Lower contact is conformable and gradational.
	1020	3		3	100	90			
	1025	3		4	96	82			
	1030	3		4	96	76			
	1035	3		2	100	99			
	1040	3		2	100	96			
	1045	3		4	92	89			
	1050	3		5	92	53			
	1055	3		5	100	65			

Figure RAI 2.2.1.1.1-004-32 (Sheet 10 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-85

SHEET 11 OF 11

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 3/23/2007 FINISHED: 11/1/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,343.95 E 572,382.57
TOTAL DEPTH: 1077.9 ft.
DEPTH TO BEDROCK: 174.0 ft.

STATE: Nevada
GROUND ELEVATION: 3655.98
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
		3		5	100	65	Tptpul		
	1060								
	1065								
	1070								
	1075								
	BOTTOM OF HOLE								

Figure RAI 2.2.1.1.1-004-32 (Sheet 11 of 11)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-86

SHEET 1 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/5/2007 FINISHED: 6/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,854.21 E 572,110.61
TOTAL DEPTH: 571.9 ft.
DEPTH TO BEDROCK: 136.0 ft.

STATE: Nevada
GROUND ELEVATION: 3652.85
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
Purpose of Hole: Repository Facilities Geotechnical Investigations **Drill Equipment:** GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing. **Driller:** WDC Exploration **Drilling Method:** Sonic core with 4-3/4" bit from 0.0 to 148.7'. 5-7/8" casing is advanced as whole is drilled. Change over to CME-85 Core Rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 571.9' (TD). **Drilling Conditions:** Not Reported **Drilling Fluid:** Small amounts of drilling additives were added to help in advancing casing. **Fluid Loss Interval:** NA **Casing Record:** 5-7/8" casing from 0.0 to 148.7'. 4-1/2" casing from 148.7 to 571.9' (TD). **Hole Completion:** Remove 4-1/2" casing and 5-7/8" casing. Plug and abandon hole using bentonite chips from bottom of hole 571.9' (TD) up to ground level.	5 10 15 20 25 30 35						(GM)s		**0.0 to 136.0 ft. QUATERNARY ALLUVIUM (Qal):** **0.0 to 36.3 ft. SILTY GRAVEL WITH SAND (GM)s:** About 45 percent coarse to fine, hard, angular to subangular gravel; about 40 percent coarse to fine, angular to subangular sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pink, reddish yellow, no to strong reaction with HCl.
	40 45 50 55 60 65						(SM)gc		**36.3 to 69.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 60 percent coarse to fine, angular to subangular sand; about 25 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 85 mm; dry, pinkish gray, strong reaction with HCl.
	70						SM		**69.2 to 71.2 ft. SILTY SAND (SM):** About 85 percent predominantly fine sand; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of predominantly fine, hard, angular gravel; maximum size 15 mm; dry, pinkish gray, strong reaction with HCl.
	75 80 85						(SP-SM)gc		**71.2 to 89.8 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 85 mm; dry, reddish yellow, strong reaction with HCl.
	90						(SM)g		**89.8 to 92.0 ft. SILTY SAND WITH GRAVEL (SM)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 15 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent fines of low plasticity with slow dilatancy and low toughness; maximum size 40 mm; dry, yellowish red, strong reaction with HCl.
	95						(SP)g		**92.0 to 110.6 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness;

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-33 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-86

SHEET 2 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/5/2007 FINISHED: 6/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,854.21 E 572,110.61
TOTAL DEPTH: 571.9 ft.
DEPTH TO BEDROCK: 136.0 ft.

STATE: Nevada
GROUND ELEVATION: 3652.85
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
									maximum size 60 mm; dry, reddish yellow, strong reaction with HCl.
	105						(SP)g		
	110						(SM)g		**110.6 to 114.1 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 75 mm; dry, yellowish red, strong reaction with HCl.
	115						(SP-SM)g		**114.1 to 136.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, angular to subrounded sand; about 40 percent coarse to fine, hard, angular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 70 mm; dry, pinkish gray, strong reaction with HCl.
	120								
	125								
	130								
	135								**136.0 to 212.5 ft. RAINIER MESA TUFF (Tmr):** Pyroclastic flow, bedded tuff, nonwelded, vitric, incipiently crystallized locally, clay altered locally, very pale brown, white, pinkish-white, 10 to 25 percent pumice, less than 1 percent lithic fragments of welded tuff, 5 to 25 percent crystal fragments of sanidine, plagioclase, quartz and less than or equal to 1 percent biotite, 10 percent hornblende locally. Generally the tuff is moderately hard (H4) to very soft (H7) averaging soft (H6), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	140								
	145								
	150	7		9	59	17			
	155	7		6	94	83			
	160	6		5	100	96			
	165	7		5	96	93			
	170	7		5	100	83	Tmr		
	175	6		4	98	88			
	180	6		6	100	66			
	185	6		6	100	88			
	190	7		7	100	42			
	195	5		5	100	84			
	200	6		6	98	60			
	205	5		6	98	72			
	210	4		6	100	64	Tmbt1		**212.5 to 357.0 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded/reworked tuff and pumice fall deposits, nonwelded, vitric, light brown, white, 10 to 80 percent pumice, 1 to 2 percent lithic fragments of welded tuff, 2 to 7 percent crystal fragments of sanidine, plagioclase, quartz, and less than 1 percent biotite, hornblende, and magnetite. Generally the tuff is moderately hard (H4) to very soft (H7) averaging moderately soft (H5), fresh (W1), moderately to slightly
	215	4		6	100	56			

Figure RAI 2.2.1.1.1-004-33 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-86

SHEET 3 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/5/2007 FINISHED: 6/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,854.21 E 572,110.61
TOTAL DEPTH: 571.9 ft.
DEPTH TO BEDROCK: 136.0 ft.

STATE: Nevada
GROUND ELEVATION: 3652.85
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		6	100	56			fractured (FD4) to mostly intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	225	4		6	98	79			
	230	5		6	98	55			
	235	6		6	92	47			
	240	6		6	100	39			
	245	6		5	94	76			
	250	6		5	93	68			
	255	6		6	98	62			
	260	7		6	96	65			
	265	6		6	93	59			
	270	7		9	98	0			
	275	6		5	96	71	Tmbt1		
	280	4		5	98	88			
	285	4		4	98	86			
	290	6		6	100	62			
	295	5		6	100	56			
	300	4		6	100	60			
	305	6		4	100	61			
	310	4		5	100	89			
	315	4		4	98	85			
	320	4		5	56	41			
	325	6		4	100	93			
	330	5		5	100	85			
	335	5		5	100	90			
		4		5	100	84			

Figure RAI 2.2.1.1.1-004-33 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-86

SHEET 4 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/5/2007 FINISHED: 6/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,854.21 E 572,110.61
TOTAL DEPTH: 571.9 ft.
DEPTH TO BEDROCK: 136.0 ft.

STATE: Nevada
GROUND ELEVATION: 3652.85
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		5	100	84			
	345	4		6	100	69			
		4		6	83	68	Tmbt1		
	350	4		6	90	58			
	355	4		5	100	83			
	360	4		5	97	91			**357.0 to 522.6 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, bedded pumice fall deposits, nonwelded crystallized, white, 20 to 30 percent pumice, 3 to 25 percent lithic fragments of welded tuff, 2 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, hornblende, and sphene. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), unfractured (FD0) to intensely fractured (FD7) averaging moderately to slightly fractured (FD4). Lower contact is unconformable and sharp.
		4		5	100	79			
	365	4		1	100	100			
	370	4		1	90	90			
	375	4		2	100	96			
	380	4		7	81	35			
		0		0	0	0			
	385	4		5	96	74			
	390	4		2	100	96			
	395	4		4	100	90			
	400	4		3	100	97			
	405	4		4	100	98	Tpki		
	410	4		4	100	93			
	415	4		3	100	98			
	420	3		5	100	79			
	425	4		3	100	91			
	430	4		0	100	100			
	435	4		4	58	40			
	440	4		6	74	50			
		3		6	100	57			
	445	3		6	100	93			
	450	3		3	100	97			
		3		7	67	0			
	455	3		4	98	96			

Figure RAI 2.2.1.1.1-004-33 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-86

SHEET 5 OF 5

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 6/5/2007 FINISHED: 6/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 765,854.21 E 572,110.61
TOTAL DEPTH: 571.9 ft.
DEPTH TO BEDROCK: 136.0 ft.

STATE: Nevada
GROUND ELEVATION: 3652.85
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	3		4	100	90			
	465	3		4	98	91			
	470	3		4	100	84			
	475	3		4	96	95			
	480	3		1	98	98			
	485	4		0	100	98			
	490	4		4	100	96	Tpki		
	495	4		4	100	100			
	500	4		4	100	93			
	505	4		4	100	86			
	510	4		3	100	96			
	515	4		3	100	84			
		4		7	100	83			
	520	4		6	100	66			
	525	4		5	88	73			**522.6 to 535.0 ft. POST TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded/reworked tuff and pyroclastic flows, non to partially welded, crystallized, pink, white, pale red, light red, 2 to 10 percent pumice, 2 to 7 percent lithic fragments of welded tuff, 2 to 8 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, hornblende, pyroxene, and magnetite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	530	4		6	100	77	Tpbt5		
	535	4		7	100	39	Tpcrv		**535.0 to 537.3 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, non to partially welded crystallized, pale red, 3 to 4 percent pumice, less than 1 percent lithic fragments of welded tuff, 2 to 3 percent crystal fragments of sanidine, plagioclase, and 1 percent biotite. Generally the tuff is moderately hard (H4), slightly weathered to fresh (W2), intensely fractured (FD7). Lower contact is conformable and gradational.
	540	3		8	100	33			**537.3 to 571.9 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, nonwelded locally, crystallized, locally vapor-phase altered, pale red, 1 to 30 percent pumice, less than 1 to 5 percent lithic fragments of welded tuff, 5 to 15 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite, pyroxene, and hornblende. Generally the tuff is moderately hard (H4) to mostly hard (H3), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.
		3		9	100	11			
	545	3		7	89	39			
	550	4		6	98	84			
	555	4		6	100	76	Tpcrn		
	560	3		4	100	85			
	565	3		4	100	99			
	570	3		6	94	66			
	BOTTOM OF HOLE								

Figure RAI 2.2.1.1.1-004-33 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-92

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/10/2007 FINISHED: 8/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,513.79 E 572,986.63
TOTAL DEPTH: 452.7 ft.
DEPTH TO BEDROCK: 147.9 ft.

STATE: Nevada
GROUND ELEVATION: 3657.91
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to 141.7'. 5-7/8" casing is advanced as whole is drilled. Change over to CME-85 Core Rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 452.7' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
5-7/8" casing from 0.00 to 141.7'. 4-1/2" casing from 141.7 to 452.7' (TD).

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Plug and abandon hole using bentonite chips from bottom of hole 452.7' (TD) up to ground level.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
						(SP)g		**0.0 to 147.9 ft. QUATERNARY ALLUVIUM (Qal):**
5						(SP-SM)gc		**0.0 to 3.1 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 70 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, reddish brown, strong reaction with HCl. Roots present. **3.1 to 19.7 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular to subrounded cobbles; maximum size 90 mm; dry, yellowish brown, strong reaction with HCl.
10								
15								
20						(SM)g		**19.7 to 49.9 ft. SILTY SAND WITH GRAVEL (SM)g:** About 45 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, angular to subangular gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 60 mm; dry, yellowish brown, strong reaction with HCl.
25								
30								
35								
40								
45								
50						SM		**49.9 to 58.0 ft. SILTY SAND (SM):** About 70 percent coarse to fine, subangular to subrounded sand; about 20 percent nonplastic fines with quick dilatancy and low toughness; about 10 percent coarse to fine, hard, subangular to subrounded gravel; maximum size 40 mm; dry, yellowish brown, strong reaction with HCl.
55								
60						(SM)gc		**58.0 to 88.2 ft. SILTY SAND WITH GRAVEL AND COBBLES (SM)gc:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; trace of hard subangular cobbles; maximum size 80 mm; dry, reddish yellow, strong reaction with HCl.
65								
70								
75								
80								
85								
90						(GP-GM)scb		**88.2 to 147.9 ft. POORLY GRADED GRAVEL WITH SILT, SAND, COBBLES AND BOULDERS (GP-GM)scb:** About 50 percent coarse to fine, hard, subangular to subrounded gravel; about 40 percent coarse to fine, subangular to subrounded sand; about 10 percent fines of no to low plasticity with slow to quick dilatancy and low toughness; trace of hard angular to subrounded and drilled cobbles; trace of hard drilled boulders; maximum size 330 mm; dry, yellowish brown, strong reaction with HCl.
95								

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-34 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-92

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/10/2007 FINISHED: 8/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,513.79 E 572,986.63
TOTAL DEPTH: 452.7 ft.
DEPTH TO BEDROCK: 147.9 ft.

STATE: Nevada
GROUND ELEVATION: 3657.91
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145						(GP-GM)sc(h)		
	150	4		4	100	79	Tmbt1		**147.9 to 257.0 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, pumice fall deposits, nonwelded, massively bedded, vitric, locally argillized, locally reworked, white, pink, light reddish brown, 2 to 85 percent pumice, 5 to 30 percent lithic fragments of welded tuff and glassy nodules, 10 to 25 percent crystal fragments of sanidine, plagioclase, with lesser quartz, hornblende, biotite, and magnetite. Generally the tuff is very soft (H7) to moderately hard (H4) averaging soft (H6), slightly weathered to fresh (W2), slightly fractured (FD3) to very intensely to intensely fractured (FD8) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	155	5		3	70	68			
	160	7		2	91	83			
	165	5		5	86	71			
	170	7		5	33	28			
	175	5		4	92	80			
	180	5		5	96	94			
	185	6		5	93	65			
	190	7		5	76	68			
	195								
	200	7		4	91	89			
	205	6		5	100	80			
	210	5		6	92	73			
	215	5		4	91	72			
		7		5	85	65			

Figure RAI 2.2.1.1.1-004-34 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-92

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/10/2007 FINISHED: 8/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,513.79 E 572,986.63
TOTAL DEPTH: 452.7 ft.
DEPTH TO BEDROCK: 147.9 ft.

STATE: Nevada
GROUND ELEVATION: 3657.91
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	7		5	85	65	Tmbt1		
	225	6		4	91	87			
	230	6		3	90	84			
	235	5		5	100	68			
	240	5		5	100	87			
	245	6		8	94	41			
	250	6		5	98	91			
	255	5		5	100	82			
	260	4		0	100	100	Tpki		**257.0 to 407.6 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, nonwelded, vitric to crystallized, white, very pale brown, pale yellow, 20 to 60 percent pumice, less than 2 to 25 percent lithic fragments of moderately and densely welded tuff, less than 1 to 10 percent crystal fragments of sanidine, plagioclase, with lesser biotite and less than 1 percent sphene. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), unfractured (FD0) to intensely to moderately fractured (FD6) averaging slightly fractured (FD3). Lower contact is unconformable, sharp and irregular, possibly erosional at 20 degrees to the core axis.
	265	4		0	98	99			
	270	4		1	100	100			
	275	4		1	100	99			
	280	4		1	100	99			
	285	3		2	100	86			
	290	3		0	100	100			
	295	3		2	100	93			
	300	3		2	100	98			
	305	3		5	94	77			
	310	3		4	100	97			
	315	3		4	100	97			
	320	3		5	98	83			
	325	3		5	98	74			
	330	3		5	98	90			
	335	3		4	96	88			

Figure RAI 2.2.1.1.1-004-34 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-92

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 8/10/2007 FINISHED: 8/20/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 766,513.79 E 572,986.63
TOTAL DEPTH: 452.7 ft.
DEPTH TO BEDROCK: 147.9 ft.

STATE: Nevada
GROUND ELEVATION: 3657.91
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
	340	4		3	98	94	Tpki	
	345	4		6	100	82		
	350	4		5	96	94		
	355	4		5	100	89		
	360	4		5	100	95		
	365	4		3	94	88		
	370	4		4	100	81		
	375	4		6	100	81		
	380	3		3	100	97		
	385	3		6	100	86		
	390	4		3	98	99		
	395	4		4	100	82		
	400	3		3	100	89		
	405	3		4	100	84		
	410	4		4	100	83	Tpbt5	
	415	4		5	100	87		
	420	4		5	95	62	Tpcrv	
		4		7	87	0		
	425	3		6	100	52		
	430	3		3	98	91	Tpcrn	
	435	4		7	98	37		
	440	3		9	24	0		
	445	3		4	100	93		
	450	3		5	98	76		
	BOTTOM OF HOLE							

CLASSIFICATION AND PHYSICAL CONDITION

407.6 to 418.1 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5): Bedded tuffs and pyroclastic flow, nonwelded to partly welded, crystallized, pink, light gray, 20 to 60 percent pumice, 5 to 40 percent lithic fragments, 1 to 2 percent crystal fragments of sanidine, plagioclase, and lesser biotite. Generally the tuff is moderately hard (H4), fresh (W1), moderately to slightly fractured (FD4) to mostly moderately fractured (FD5). Lower contact is unconformable and sharp.

418.1 to 426.6 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv): Pyroclastic flow, nonwelded to densely welded, crystallized to vitric, pink, pinkish-gray, black, 10 percent pumice, 1 to 5 percent lithic fragments of volcanic rock, less than 5 to 15 percent crystal fragments of plagioclase, sanidine, and less than 1 percent biotite and hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), moderately fractured (FD5) to intensely fractured (FD7) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.

426.6 to 452.7 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn): Pyroclastic flow, moderately to densely welded, crystallized, dark reddish gray, pale red, light gray, less than 1 to 10 percent pumice, less than 1 percent lithic fragments of volcanic rock, 12 to 15 percent crystal fragments of plagioclase, sanidine, and lesser biotite. Generally the tuff is moderately hard (H4) to mostly hard (H3), fresh (W1), slightly fractured (FD3) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is undetermined.

Figure RAI 2.2.1.1.1-004-34 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-94

SHEET 1 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/12/2007 FINISHED: 8/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,060.69 E 572,103.92
TOTAL DEPTH: 683.7 ft.
DEPTH TO BEDROCK: 139.3 ft.

STATE: Nevada
GROUND ELEVATION: 3753.35
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and
Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Set 10-3/4" conductor casing to approximately 4.5' and cement in place. Sonic core with 4-3/4" bit to depth of 152.9'. 5-7/8" casing is advanced as hole is drilled. Change over to CME-85 core rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core 152.9 to 665.5'. 4-1/2" casing is advanced as hole is cored. Remove casing and coring system. Ream hole with 6-1/2" tricone bit to 683.7' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
Set 10-3/4" conductor casing from 0.0' to approximately 4.5'. 5-7/8" casing from 0.0 to 152.9'. 4-1/2" from 152.9 to 665.5'.

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Install 3-1/2" PVC casing to depth of 683.7'. Use 1" tremmie pipe to grout PVC casing from bottom of hole 683.7' (TD) up to ground level.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC
						(SP-SM)gc	
5						(SP)g	
10						(SP-SM)g	
15							
20						(SP)g	
25							
30							
35							
40							
45							
50							
55							
60							
65						(SM)g	
70							
75							
80							
85							
90							
95							

CLASSIFICATION AND PHYSICAL CONDITION

0.0 to 139.3 ft. QUATERNARY ALLUVIUM (Qal):

0.0 to 3.5 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc: About 65 percent coarse to fine, subangular to subrounded sand; about 25 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of low plasticity with slow dilatancy and low toughness; trace of hard drilled cobbles; maximum size 80 mm; dry, pale brown, strong reaction with HCl.

3.5 to 7.4 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 55 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with quick dilatancy and low toughness; maximum size 50 mm; dry, pale brown, weak reaction with HCl.

7.4 to 15.3 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g: About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pale brown, strong reaction with HCl.

15.3 to 26.3 ft. POORLY GRADED SAND WITH GRAVEL (SP)g: About 65 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; trace of nonplastic fines with quick dilatancy and low toughness; maximum size 40 mm; dry, pale brown, no to moderate reaction with HCl.

26.3 to 139.3 ft. SILTY SAND WITH GRAVEL (SM)g: About 50 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 20 percent fines of low plasticity with slow to quick dilatancy and low toughness; maximum size 70 mm; dry, light brown, pinkish gray, strong reaction with HCl.

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method.

DTN: GS081083114233.009

Figure RAI 2.2.1.1.1-004-35 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-94

SHEET 2 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/12/2007 FINISHED: 8/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,060.69 E 572,103.92
TOTAL DEPTH: 683.7 ft.
DEPTH TO BEDROCK: 139.3 ft.

STATE: Nevada
GROUND ELEVATION: 3753.35
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105								
	110								
	115								
	120						(SM)g		
	125								
	130								
	135								
	140								**139.3 to 262.5 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded tuff, pumice fall deposits, nonwelded, massively bedded, vitric and locally crystallized and locally argillized, white, very pale brown, light brown, pink, light reddish-brown, light yellowish-brown, 5 to greater than 90 percent pumice, 2 to 30 percent lithic fragments of welded tuff and vitric lavas, 5 to 8 percent of volcanic glass fragments, 2 to 25 percent crystal fragments of sanidine, plagioclase, lesser quartz and less than 1 percent biotite, hornblende and magnetite locally. Generally the tuff is very soft (H7), fresh (W1), moderately to slightly fractured (FD4) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	145								
	150								
	155	7		4	92	82			
	160	7		9	19	0			
	165	7		6	100	72			
	170	7		7	100	59			
	175	7		8	100	25			
	180	7		4	84	81	Tmbt1		
	185	7		5	96	93			
	190	7		6	98	75			
	195	7		4	82	80			
	200	7		7	92	58			
	205	7		5	94	79			
	210	0		0	0	0			
	215	7		9	90	9			

Figure RAI 2.2.1.1.1-004-35 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-94

SHEET 3 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/12/2007 FINISHED: 8/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,060.69 E 572,103.92
TOTAL DEPTH: 683.7 ft.
DEPTH TO BEDROCK: 139.3 ft.

STATE: Nevada
GROUND ELEVATION: 3753.35
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	7		9	100	0	Tmbt1		
	225	7		6	98	83			
	230	7		6	91	73			
	235	7		7	49	22			
	240	7		9	87	35			
	245	7		4	100	94			
	250	7		4	81	70			
	255	7		9	91	0			
	260	7		7	97	82			
	265	7		6	100	70	Tpki		**262.5 to 435.5 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, pumice fall deposits, nonwelded vitric to crystallized, white, pale yellow, 5 to 85 percent pumice, less than 2 to 20 percent lithic fragments of moderately and densely welded tuff, less than 1 to 20 percent crystal fragments of plagioclase, sanidine, and lesser biotite and hornblende, and less than 1 percent sphene. Generally the tuff is very soft (H7) to moderately hard (H4), averaging moderately soft (H5), fresh (W1), very slightly fractured (FD1) to intensely fractured (FD7) averaging moderately fractured (FD5). Lower contact is unconformable and sharp.
	270	6		3	100	94			
	275	5		4	100	98			
	280	5		6	100	76			
	285	5		2	100	100			
	290	4		4	96	86			
	295	5		6	96	61			
	300	5		5	100	88			
	305	5		6	100	82			
	310	4		6	86	42			
	315	4		1	98	98			
	320	4		3	100	98			
	325	4		5	100	93			
	330	4		4	100	82			
	335	4		5	100	87			
		4		4	100	94			

Figure RAI 2.2.1.1.1-004-35 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-94

SHEET 4 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/12/2007 FINISHED: 8/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,060.69 E 572,103.92
TOTAL DEPTH: 683.7 ft.
DEPTH TO BEDROCK: 139.3 ft.

STATE: Nevada
GROUND ELEVATION: 3753.35
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	4		4	100	94	Tpki		
	345	5		6	100	78			
	350	5		3	100	59			
		4		3	100	100			
	355	4		6	100	50			
	360	4		5	100	73			
		4		7	100	0			
	365	4		7	100	76			
	370	4		6	100	74			
	375	5		5	98	53			
	380	5		5	100	74			
	385	4		4	100	85			
	390	5		5	100	93			
	395	5		5	100	99			
	400	5		5	98	70			
	405	5		4	100	100			
	410	5		6	100	84			
		5		6	73	52			
	415	4		6	100	62			
	420	4		6	98	72			
		4		7	54	0			
	425	4		5	98	70			
	430	4		4	96	58			
	435	6		4	100	88			
	440	7		7	93	36	Tpbt5		**435.5 to 446.5 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff, paleosol, pyroclastic flow, nonwelded to partially welded, crystallized, light reddish-brown, light red, white, 15 to 30 percent pumice, 2 to 5 percent lithic fragments, 1 to 3 percent crystal fragments of sanidine, plagioclase and biotite. Generally the tuff is very soft (H7) to moderately hard (H4), averaging soft (H6), fresh (W1), and intensely fractured (FD7). Lower contact is unconformable and sharp.
	445	7		7	96	70			
	450	4		7	53	22	Tpcrv		**446.5 to 452.6 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, nonwelded to densely welded, crystallized to vitric, pinkish-white, light reddish-brown, reddish-brown, black, 10 to 25 percent pumice, 1 percent lithic fragments, 7 to 15 percent crystal fragments of sanidine, plagioclase and biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), intensely fractured (FD7) to mostly very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
		3		8	65	15			
	455	3		9	100	0	Tpcrn		**452.6 to 494.5 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, pale red, white, less than 5 to 20

Figure RAI 2.2.1.1.1-004-35 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-94

SHEET 5 OF 6

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/12/2007 FINISHED: 8/15/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 769,060.69 E 572,103.92
TOTAL DEPTH: 683.7 ft.
DEPTH TO BEDROCK: 139.3 ft.

STATE: Nevada
GROUND ELEVATION: 3753.35
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	460	4		7	100	62			percent pumice, less than 5 percent lithophysae, less than 1 percent lithic fragments, 7 to 15 percent crystal fragments of sanidine, plagioclase, lesser biotite. Generally the tuff is hard (H3) to mostly moderately hard (H4), fresh (W1), intensely to moderately fractured (FD6) to very intensely fractured (FD9) averaging intensely fractured (FD7). Lower contact is conformable and gradational.
	465	4		6	100	63			
	470	4		7	100	43			
	475	4		6	96	58			
		3		9	43	0	Tpcrn		
	480	4		9	80	0			
		4		9	100	20			
	485	4		5	100	73			
	490	3		5	100	64			
	495	3		7	100	40			**494.5 to 522.0 ft. TIVA CANYON TUFF CRYSTAL-RICH LITHOPHYSAL ZONE (Tpcrl):** Pyroclastic flow, densely welded, crystallized, light gray, white, light reddish-gray, 15 percent pumice, 5 to 10 percent lithophysae, 5 to 7 percent crystal fragments of sanidine, plagioclase, lesser biotite. Generally the tuff is hard (H3), fresh (W1), intensely to moderately fractured (FD6) to mostly intensely fractured (FD7). Lower contact is conformable and gradational.
	500	3		6	100	56			
	505	3		7	100	34			
	510	3		7	100	53	Tpcrl		
	515	3		6	96	59			
	520	3		7	100	47			
	525	3		7	100	41			**522.0 to 545.1 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER NONLITHOPHYSAL ZONE (Tpcpun):** Pyroclastic flow, densely welded, crystallized, light reddish-gray, gray, 10 to 15 percent pumice, 1 to 2 percent lithophysae, 2 to 5 percent crystal fragments of plagioclase, sanidine, lesser biotite. Generally the tuff is hard (H3), fresh (W1), intensely fractured (FD7) to very intensely fractured (FD9) averaging very intensely to intensely fractured (FD8). Lower contact is conformable and gradational.
	530	3		7	100	41			
	535	3		6	88	48	Tpcpun		
	540	3		8	77	29			
		3		9	100	0			
	545	3		9	47	0			
		3		7	82	21			**545.1 to 606.5 ft. TIVA CANYON TUFF CRYSTAL-POOR UPPER LITHOPHYSAL ZONE (Tpcpul):** Pyroclastic flow, densely welded, crystallized, pale red, light gray, white, 0 to 10 percent pumice, 0 to 20 percent vapor-phase spots, 2 to 5 percent lithophysae, 2 to 3 percent crystal fragments of plagioclase, sanidine, lesser biotite. Generally the tuff is hard (H3), fresh (W1), very slightly fractured (FD1) to very intensely fractured (FD9) averaging intensely to moderately fractured (FD6). Lower contact is conformable and gradational.
	550	3		9	41	0			
		3		9	100	0			
		3		9	77	0			
	555	3		9	95	10			
		3		9	100	0			
	560	3		4	100	81	Tpcpul		
	565	3		6	100	55			
	570	3		4	100	84			
	575	3		2	100	100			

Figure RAI 2.2.1.1.1-004-35 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-102

SHEET 1 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/24/2007 FINISHED: 8/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,429.43 E 571,221.89
TOTAL DEPTH: 381.4 ft.
DEPTH TO BEDROCK: 153.8 ft.

STATE: Nevada
GROUND ELEVATION: 3739.75
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES

Purpose of Hole:
Repository Facilities Geotechnical Investigations

Drill Equipment:
GP24 400 RS Sonic Drill Rig, CME-85 Core Rig and Flatbed combination water and pipe truck with boom for moving drill pipe and casing.

Driller:
WDC Exploration

Drilling Method:
Sonic core with 4-3/4" bit from 0.0 to 120.5'. 5-7/8" casing is advanced as whole is drilled. Change over to CME-85 Core Rig with 3-3/4" HQ-3 coring system and 4-1/2" casing. Core and advance casing to depth of 381.4' (TD).

Drilling Conditions:
Not Reported

Drilling Fluid:
Small amounts of drilling additives were added to help in advancing casing.

Fluid Loss Interval:
NA

Casing Record:
5-7/8" casing from 0.0 to 120.5'. 4-1/2" casing from 120.5 to 381.4' (TD).

Hole Completion:
Remove 4-1/2" casing and 5-7/8" casing. Plug and abandon hole using bentonite chips from bottom of hole 381.4' (TD) up to ground level.

DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
								0.0 to 153.8 ft. QUATERNARY ALLUVIUM (Qal):
5, 10, 15, 20						(SP-SM)gc		**0.0 to 20.3 ft. POORLY GRADED SAND WITH SILT, GRAVEL AND COBBLES (SP-SM)gc:** About 60 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; trace of hard subrounded cobbles; maximum size 80 mm; dry, yellowish brown, strong reaction with HCl. Roots present.
						(SP)g		**20.3 to 22.9 ft. POORLY GRADED SAND WITH GRAVEL (SP)g:** About 75 percent coarse to fine, subangular to subrounded sand; about 20 percent coarse to fine, hard, subangular to subrounded gravel; about 5 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 55 mm; dry, yellowish brown, no reaction with HCl.
25, 30, 35, 40						(SP-SM)g		**22.9 to 45.0 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 60 mm; dry, yellowish gray, strong reaction with HCl.
45, 50						(SM)g		**45.0 to 53.9 ft. SILTY SAND WITH GRAVEL (SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 30 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent nonplastic fines with quick dilatancy and low toughness; maximum size 35 mm; dry, brownish gray, strong reaction with HCl.
55, 60, 65, 70, 75, 80, 85						(SP-SM)g		**53.9 to 88.9 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 55 percent coarse to fine, subangular to subrounded sand; about 35 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent nonplastic fines with no dry strength, quick dilatancy and low toughness; maximum size 70 mm; dry, light gray, strong reaction with HCl.
90						(SM)g		**88.9 to 93.7 ft. SILTY SAND WITH GRAVEL (SM)g:** About 45 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 15 percent fines of low plasticity with low dry strength, slow dilatancy and low toughness; maximum size 70 mm; dry, pinkish gray, weak reaction with HCl.
95						(SP-SM)g		

COMMENTS: Descriptions of the material may not reflect in situ geologic conditions due to mechanical degradation of the sample by the Sonic drilling method. The materials may have been further degraded by the use of bentonite as a drilling fluid.

DTN: GS080983114233.008

Figure RAI 2.2.1.1.1-004-36 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-102

SHEET 2 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/24/2007 FINISHED: 8/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,429.43 E 571,221.89
TOTAL DEPTH: 381.4 ft.
DEPTH TO BEDROCK: 153.8 ft.

STATE: Nevada
GROUND ELEVATION: 3739.75
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	105, 110, 115, 120, 125, 130, 135, 140, 145, 150						(SP-SM)g		**93.7 to 153.8 ft. POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)g:** About 50 percent coarse to fine, subangular to subrounded sand; about 40 percent coarse to fine, hard, subangular to subrounded gravel; about 10 percent fines of no to low plasticity with no to low dry strength, quick to slow dilatancy and low toughness; maximum size 75 mm; dry, pinkish gray, moderate to strong reaction with HCl.
	155	7		8	75	42	Tmbt1		**153.8 to 173.6 ft. PRE-RAINIER MESA TUFF BEDDED TUFF (Tmbt1):** Bedded/reworked tuff, nonwelded, massively bedded, vitric, light brown, 2 to 30 percent pumice, 1 to 3 percent lithic fragments of welded tuff, less than 1 percent volcanic glass nodules, 1 to 2 percent crystal fragments of sanidine, plagioclase, less than 1 percent biotite and hornblende. Generally the tuff is soft (H6) to mostly very soft (H7), fresh (W1), moderately to slightly fractured (FD4) to very intensely to intensely fractured (FD8) averaging intensely to moderately fractured (FD6). Lower contact is unconformable and sharp.
	160	7		6	100	79			
	165	6		4	91	89			
	170	7		7	83	34			
	175	7		6	100	87	Tpki		**173.6 to 334.4 ft. RHYOLITE OF COMB PEAK, TUFF UNIT "X" (Tpki):** Pyroclastic flow, ash fall deposit, nonwelded, vitric and crystallized, white, 20 to 80 percent pumice, 2 to 25 percent lithic fragments of welded tuff. Generally the tuff is hard (H3) to very soft (H7) averaging moderately hard (H4), slightly weathered to fresh (W2), unfractured (FD0) to intensely fractured (FD7) averaging slightly fractured (FD3). Lower contact is unconformable and sharp and appears erosional.
	180	7		7	100	84			
	185	7		7	100	75			
	190	7		5	94	88			
	195	7		5	100	98			
	200	7		4	92	92			
	205	7		4	100	95			
	210	4		6	100	57			
	215	4		1	98	98			

WHB2_LOG_SONICILGPJ, SONICILGDT, 12/15/08

Figure RAI 2.2.1.1.1-004-36 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-102

SHEET 3 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/24/2007 FINISHED: 8/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,429.43 E 571,221.89
TOTAL DEPTH: 381.4 ft.
DEPTH TO BEDROCK: 153.8 ft.

STATE: Nevada
GROUND ELEVATION: 3739.75
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	220	4		1	98	98			
	225	4		1	100	100			
	230	4		1	100	100			
	235	4		0	100	97			
	240	4		0	100	100			
	245	4		1	100	100			
	250	3		3	100	96			
		4		3	100	0			
	255	3		0	100	96			
	260	3		3	100	100			
	265	3		3	100	93			
	270	3		1	100	100			
	275	3		4	100	86			
	280	3		1	100	100	Tpki		
	285	3		0	100	100			
	290	3		2	98	98			
	295	3		4	100	98			
	300	3		3	98	88			
	305	3		1	100	93			
	310	3		6	100	74			
	315	3		6	100	88			
	320	3		4	100	98			
	325	3		4	100	95			
	330	7		7	81	42			
	335	4		6	87	77	Tpbt5		**334.4 to 342.2 ft. POST-TIVA CANYON TUFF BEDDED TUFF (Tpbt5):** Bedded tuff, nonwelded, crystallized, pinkish-gray, light brown, white, 10 percent pumice, 1 to 2 percent lithic fragments of welded tuff, 2 percent crystal fragments of sanidine, plagioclase, less than 1 percent

Figure RAI 2.2.1.1.1-004-36 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

GEOLOGIC LOG OF DRILL HOLE NO. UE25 RF-102

SHEET 4 OF 4

FEATURE: Waste Handling Building
LOCATION: Midway Valley
BEGUN: 7/24/2007 FINISHED: 8/6/2007
DEPTH TO WATER: Not Encountered

PROJECT: Yucca Mountain Project
COORDINATES: N 768,429.43 E 571,221.89
TOTAL DEPTH: 381.4 ft.
DEPTH TO BEDROCK: 153.8 ft.

STATE: Nevada
GROUND ELEVATION: 3739.75
ANGLE FROM HORIZONTAL: -90°
HOLE LOGGED BY: USBR/SMF
REVIEWED BY: Robert Lung

NOTES	DEPTH	ENGINEERING INDEXES: HARDNESS	WELDING	FRACTURE DENSITY	% CORE RECOVERY	% RQD	GEOLOGIC UNIT [USCS]	GRAPHIC	CLASSIFICATION AND PHYSICAL CONDITION
	340	3		4	100	79	Tpbt5		biotite and hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to intensely to moderately fractured (FD6) averaging moderately fractured (FD5). Lower contact is unconformable and sharp. **342.2 to 344.5 ft. TIVA CANYON TUFF CRYSTAL-RICH VITRIC ZONE (Tpcrv):** Pyroclastic flow, non to partially welded to densely welded, crystallized, light gray, pink, less than 4 to 7 percent pumice, less than 1 percent lithic fragments of welded tuff, 8 to 12 percent crystal fragments of sanidine, plagioclase, and less than 1 percent biotite and pyroxene. Generally the tuff is hard (H3), slightly weathered to fresh (W2), and intensely fractured (FD7). Lower contact is conformable and gradational. **344.5 to 381.4 ft. TIVA CANYON TUFF CRYSTAL-RICH NONLITHOPHYSAL ZONE (Tpcrn):** Pyroclastic flow, moderately to densely welded, crystallized, vapor-phase altered locally, dusky red, pale red, reddish-gray, 1 to 30 percent pumice, 7 to15 percent crystal fragments of sanidine, plagioclase, less than 1 percent biotite, pyroxene and hornblende. Generally the tuff is hard (H3) to mostly moderately hard (H4), slightly weathered to fresh (W2), moderately to slightly fractured (FD4) to mostly intensely to moderately fractured (FD6). Lower contact is undetermined.
							Tpcrv		
	345	3		7	83	52	Tpcrn		
	350	4		4	100	90			
	355	4		6	98	58			
	360	4		6	100	73			
	365	4		6	100	68			
	370	4		6	82	49			
	375	3		6	100	35			
	380	3		6	100	69			

BOTTOM OF HOLE

Figure RAI 2.2.1.1.1-004-36 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

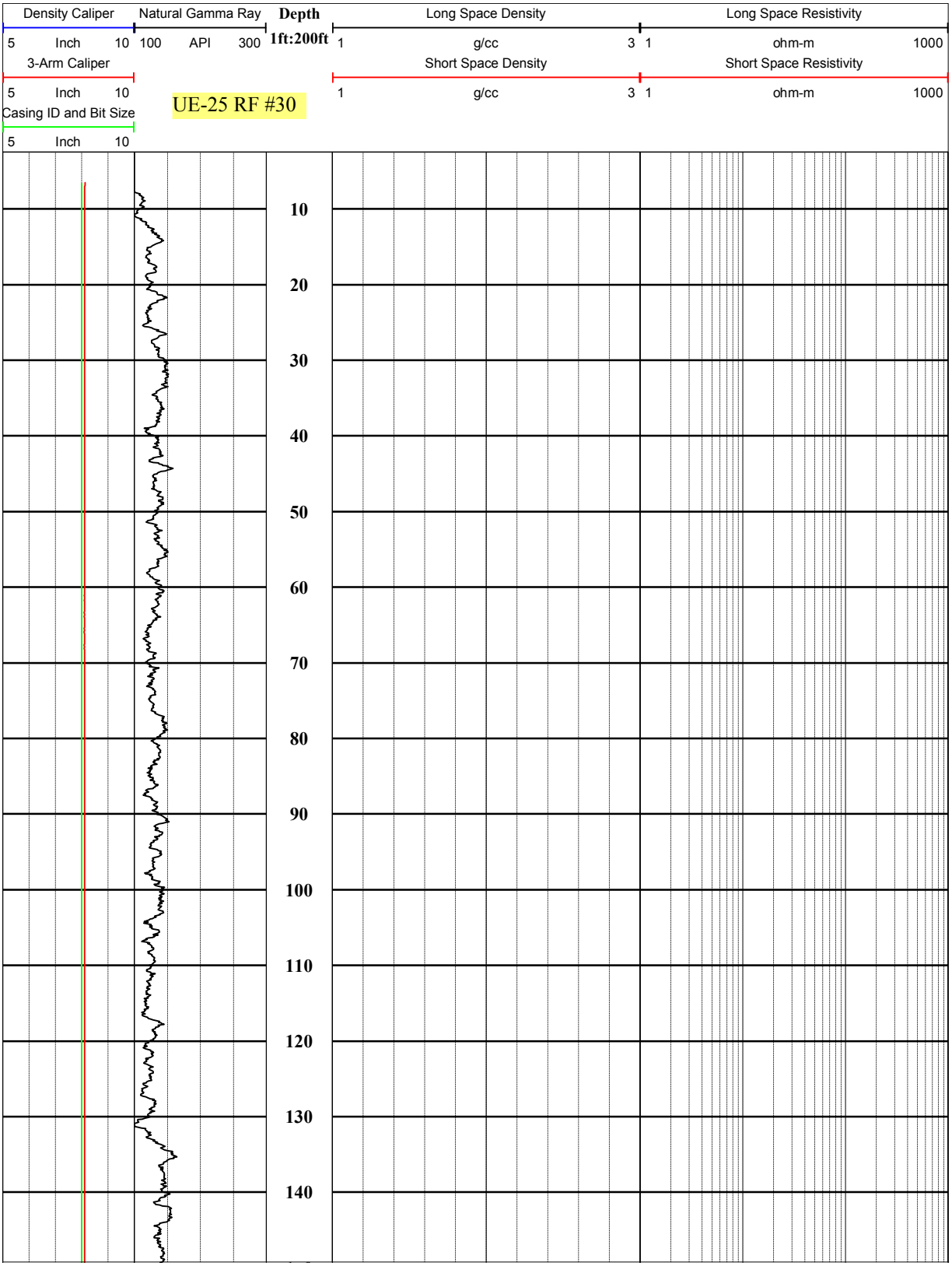


Figure RAI 2.2.1.1.1-004-37 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

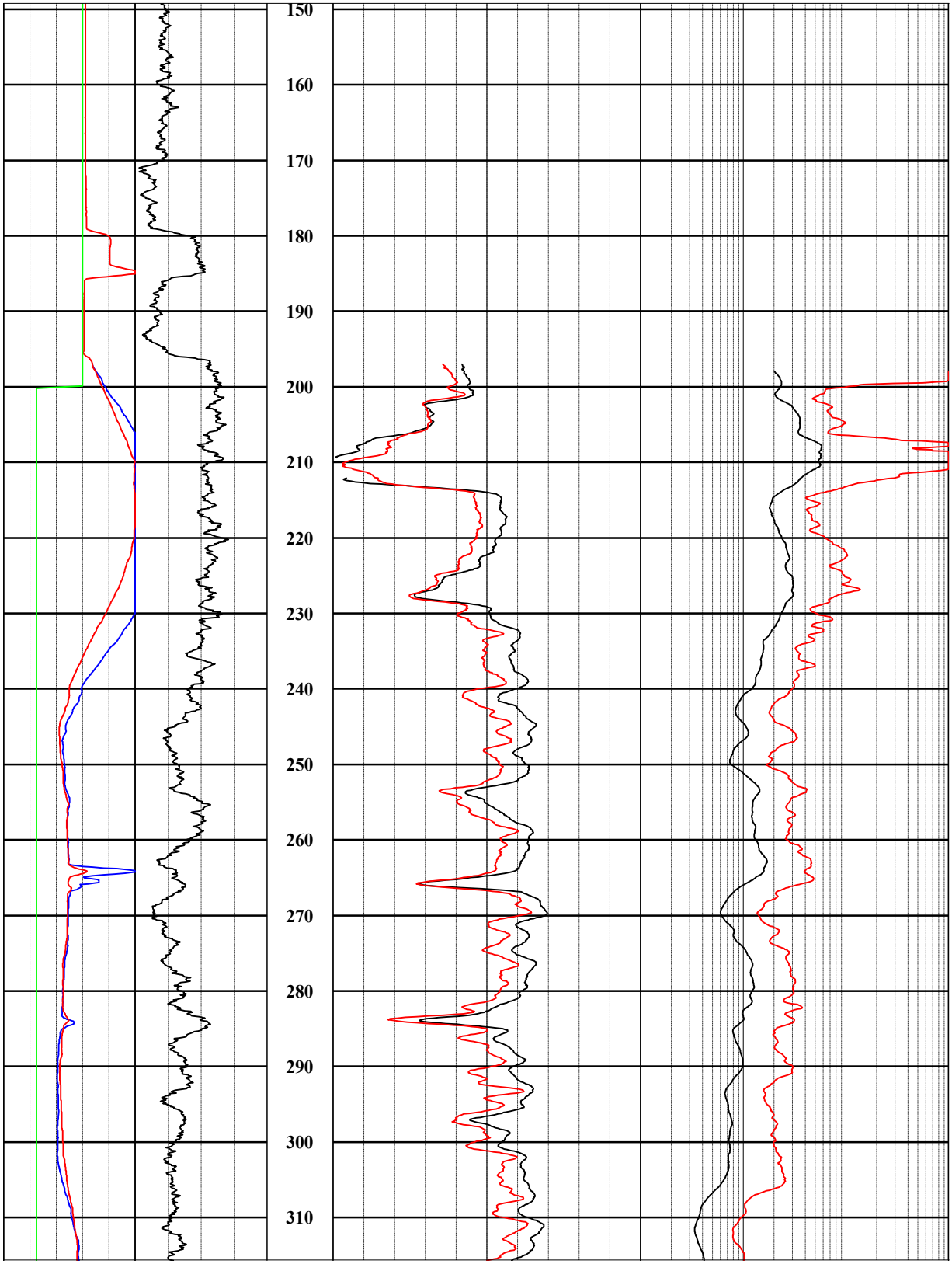


Figure RAI 2.2.1.1.1-004-37 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

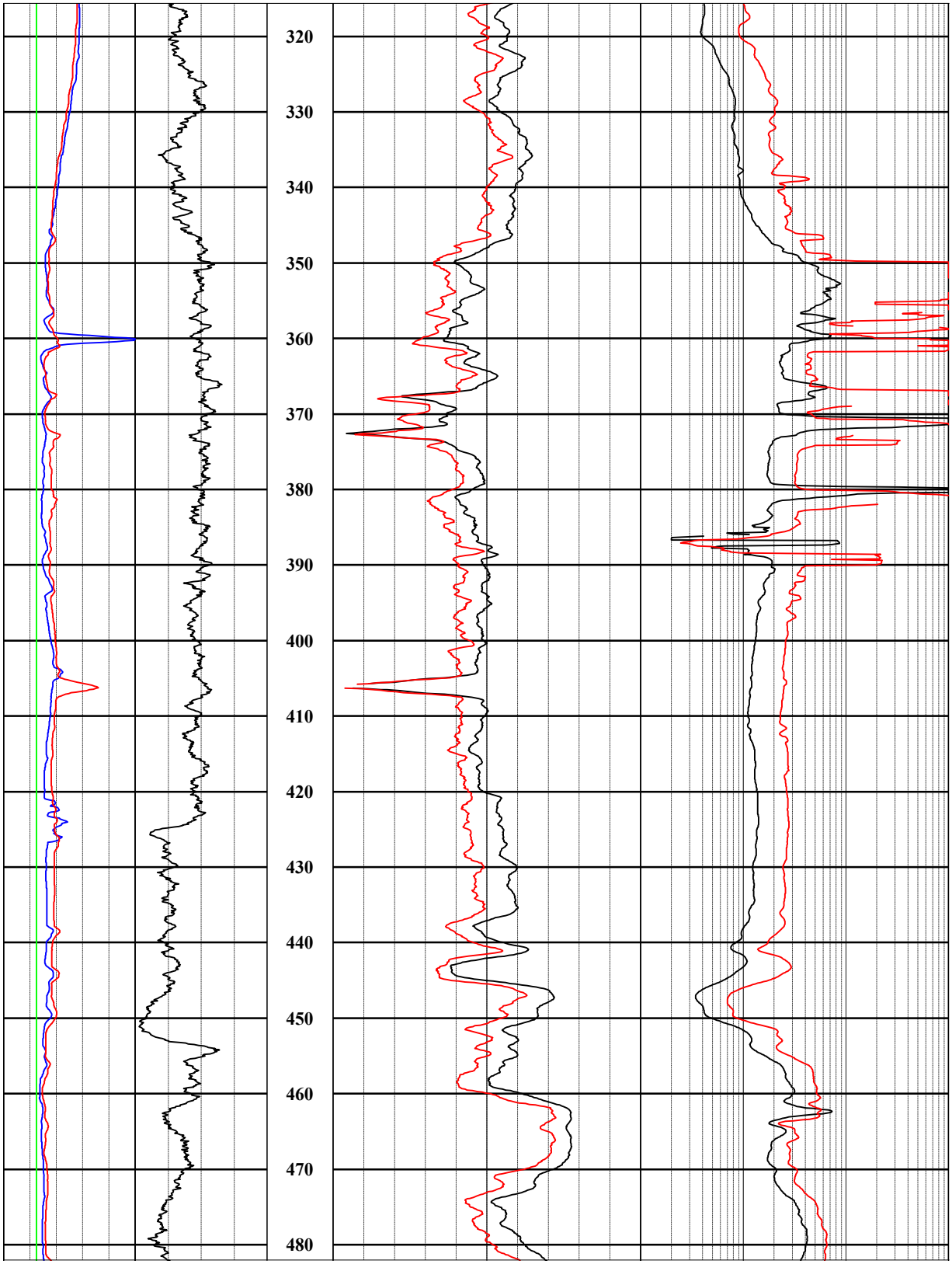


Figure RAI 2.2.1.1.1-004-37 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

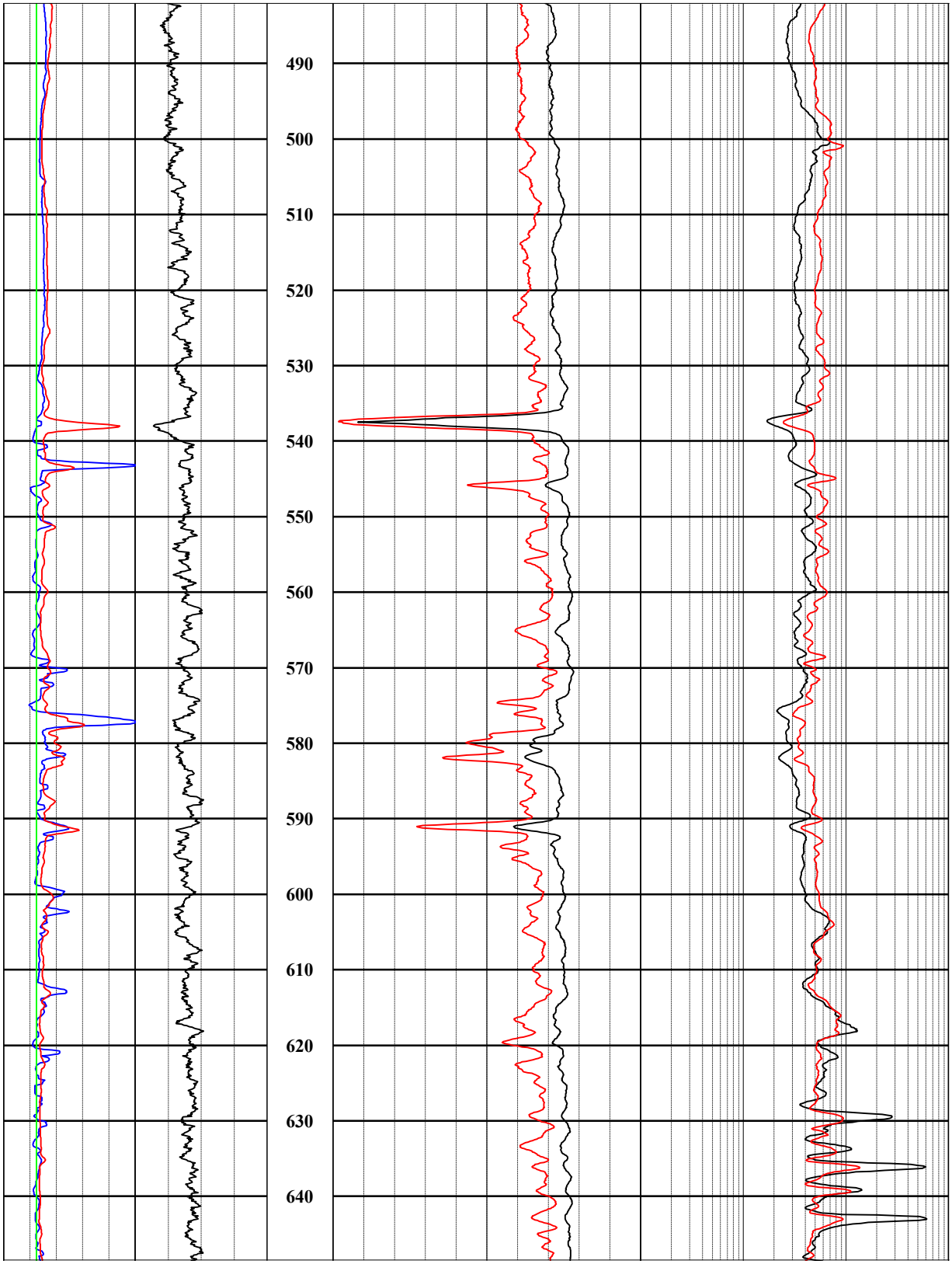


Figure RAI 2.2.1.1.1-004-37 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

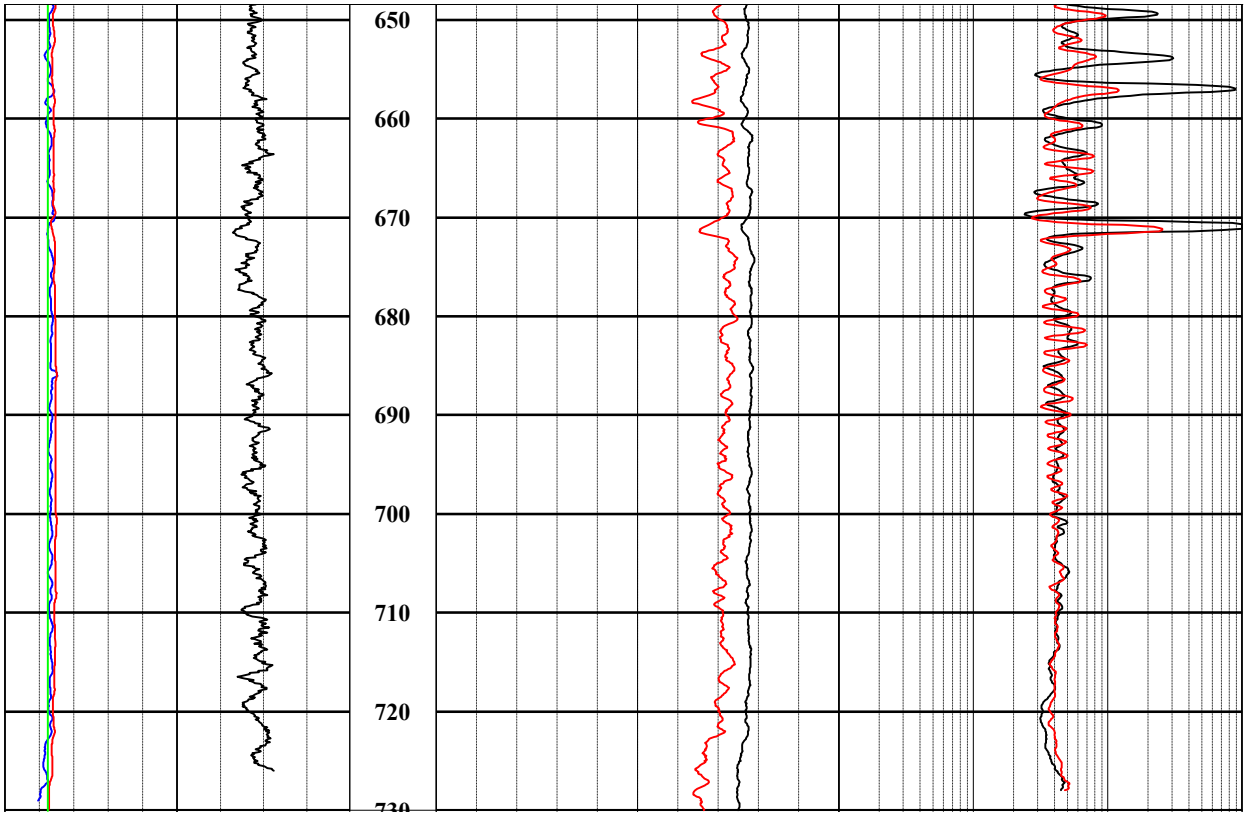


Figure RAI 2.2.1.1.1-004-37 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

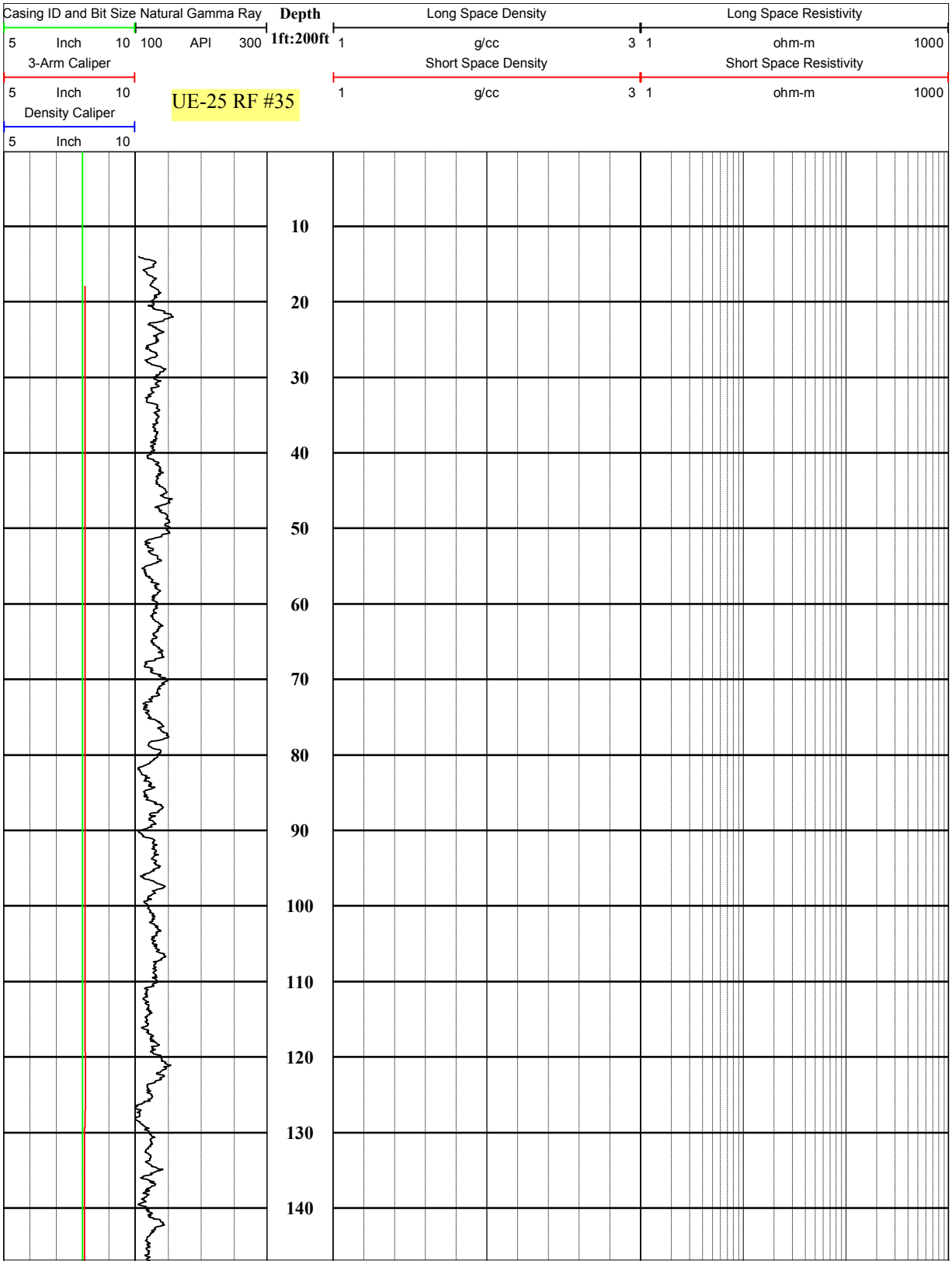


Figure RAI 2.2.1.1.1-004-38 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

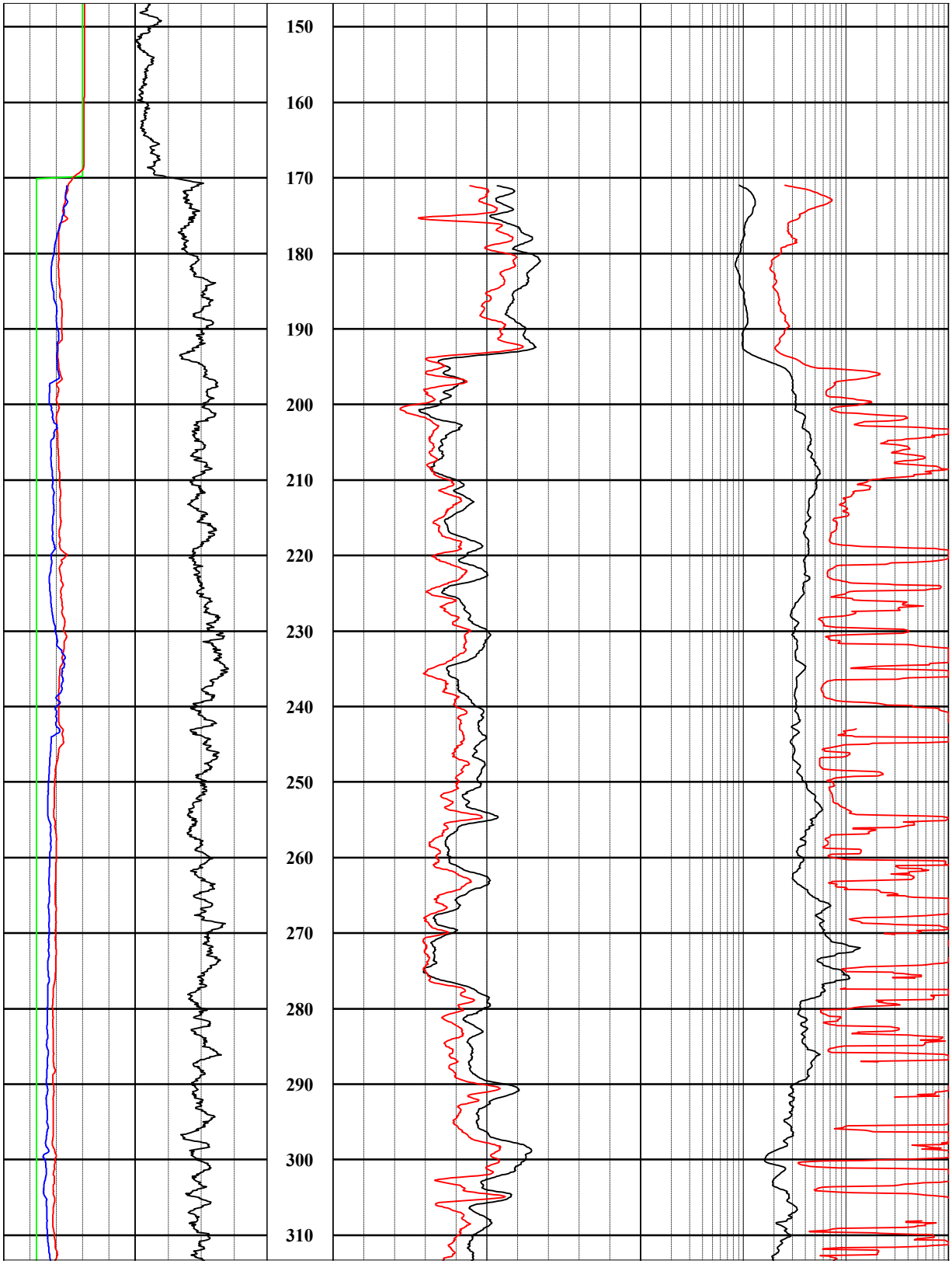


Figure RAI 2.2.1.1.1-004-38 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

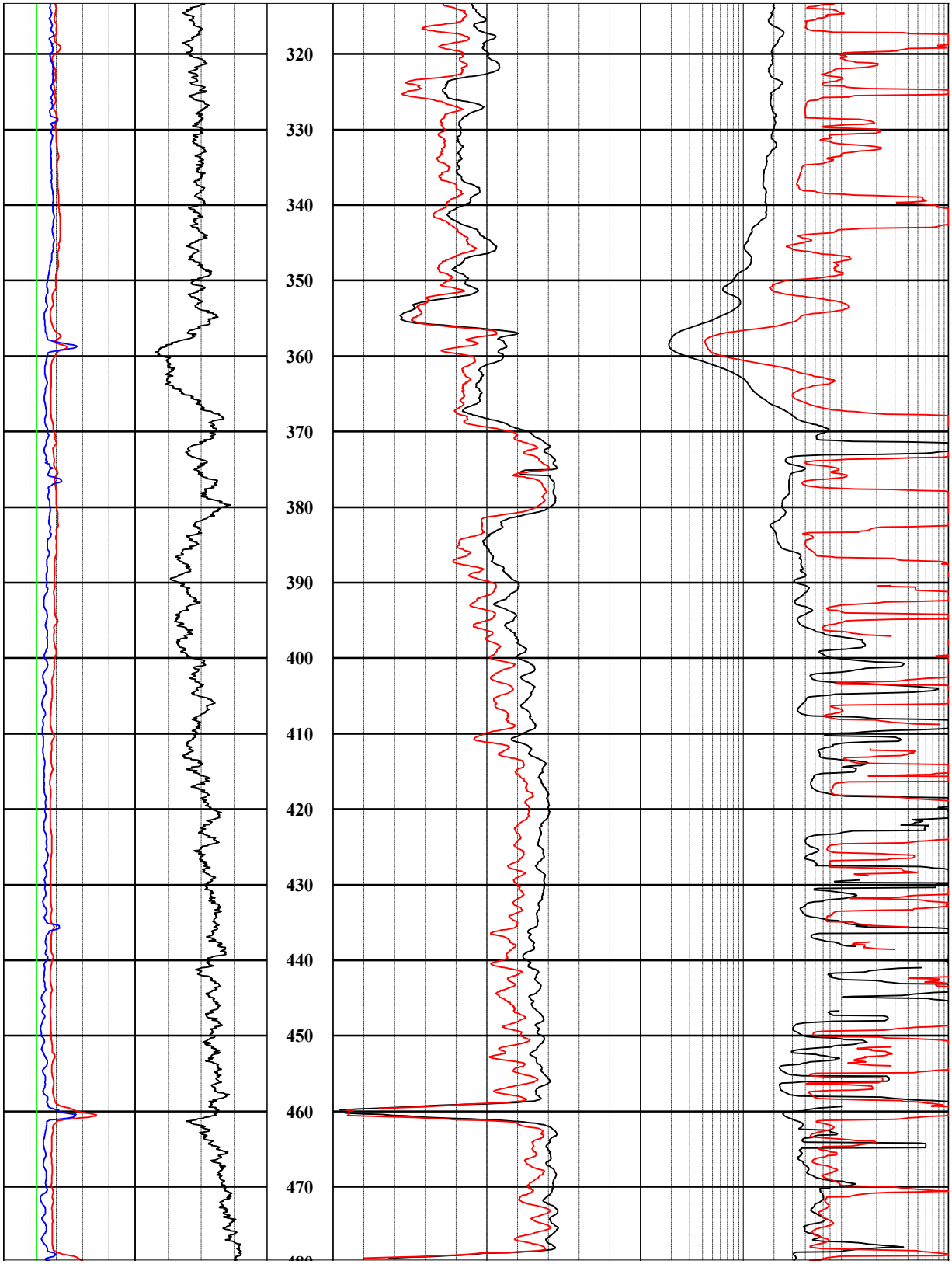


Figure RAI 2.2.1.1.1-004-38 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

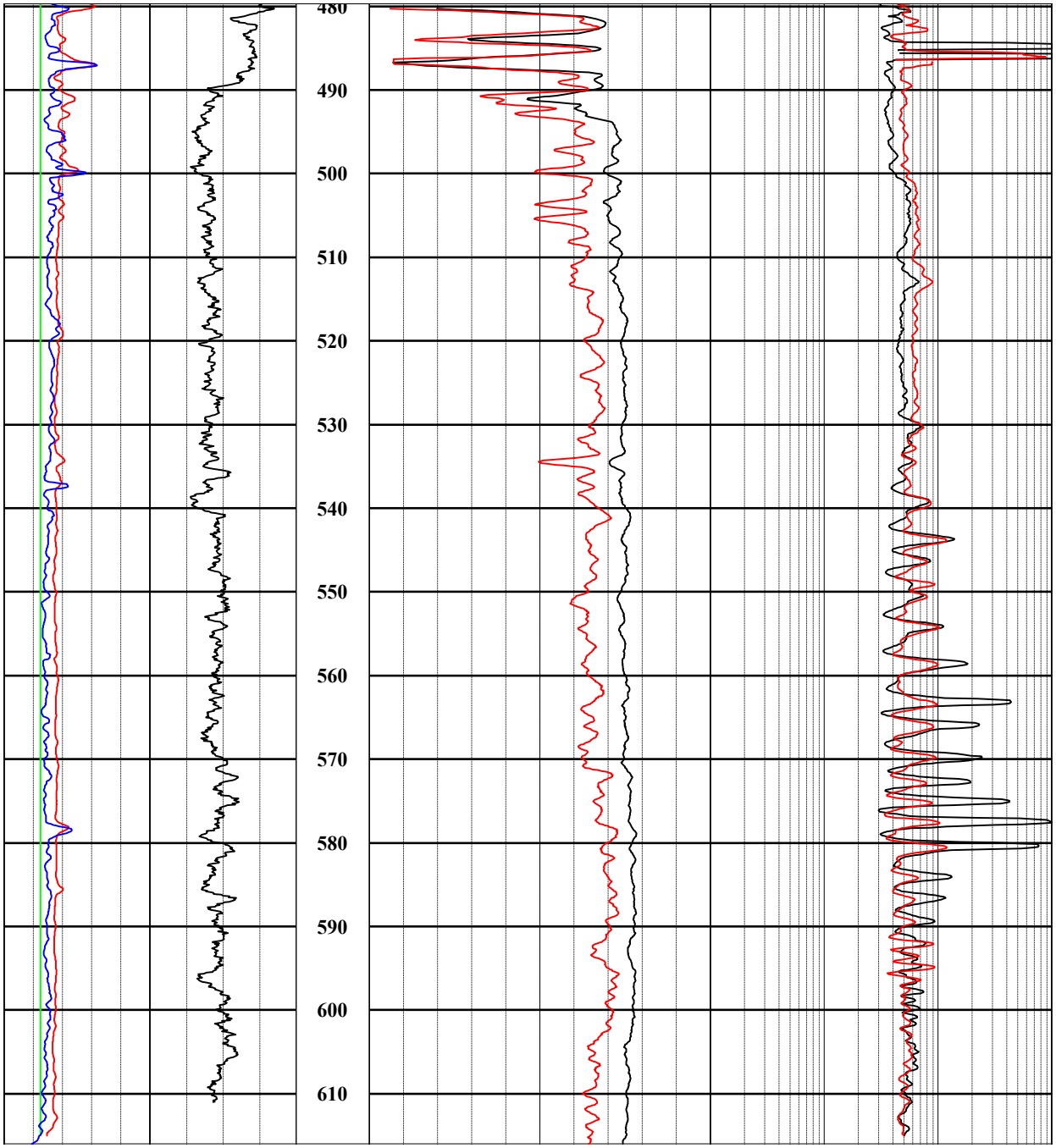


Figure RAI 2.2.1.1.1-004-38 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

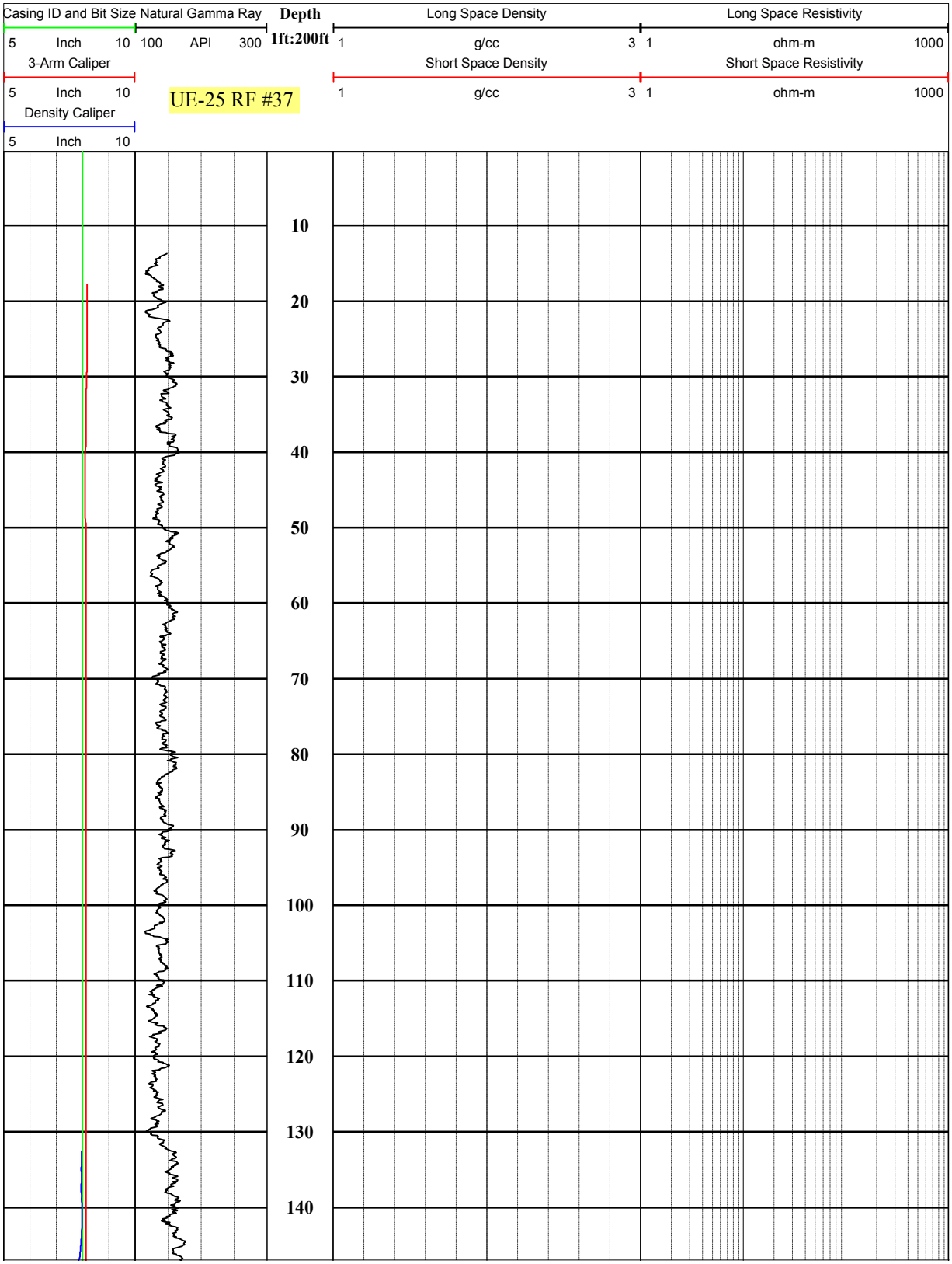
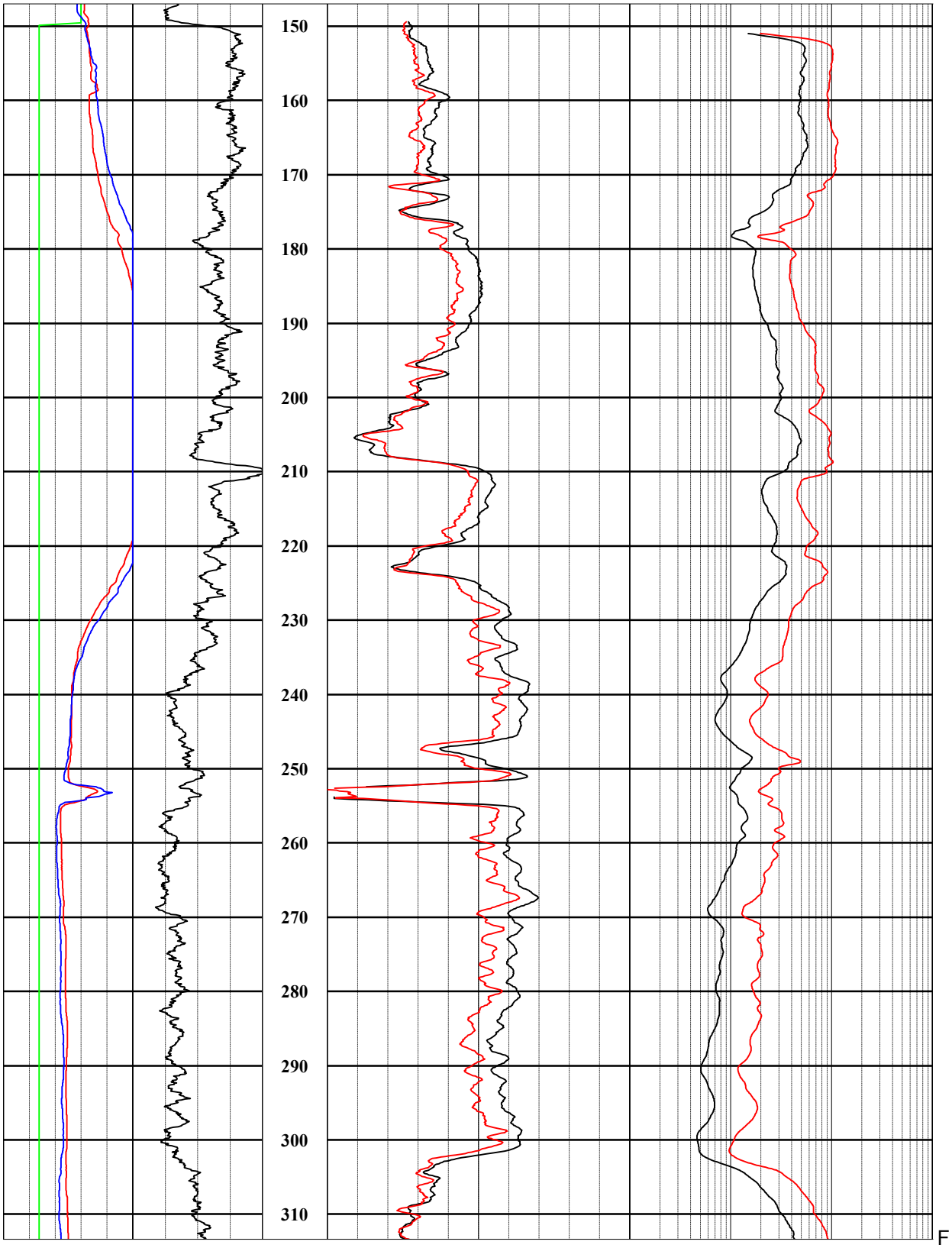


Figure RAI 2.2.1.1.1-004-39 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002



igure RAI 2.2.1.1.1-004-39 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

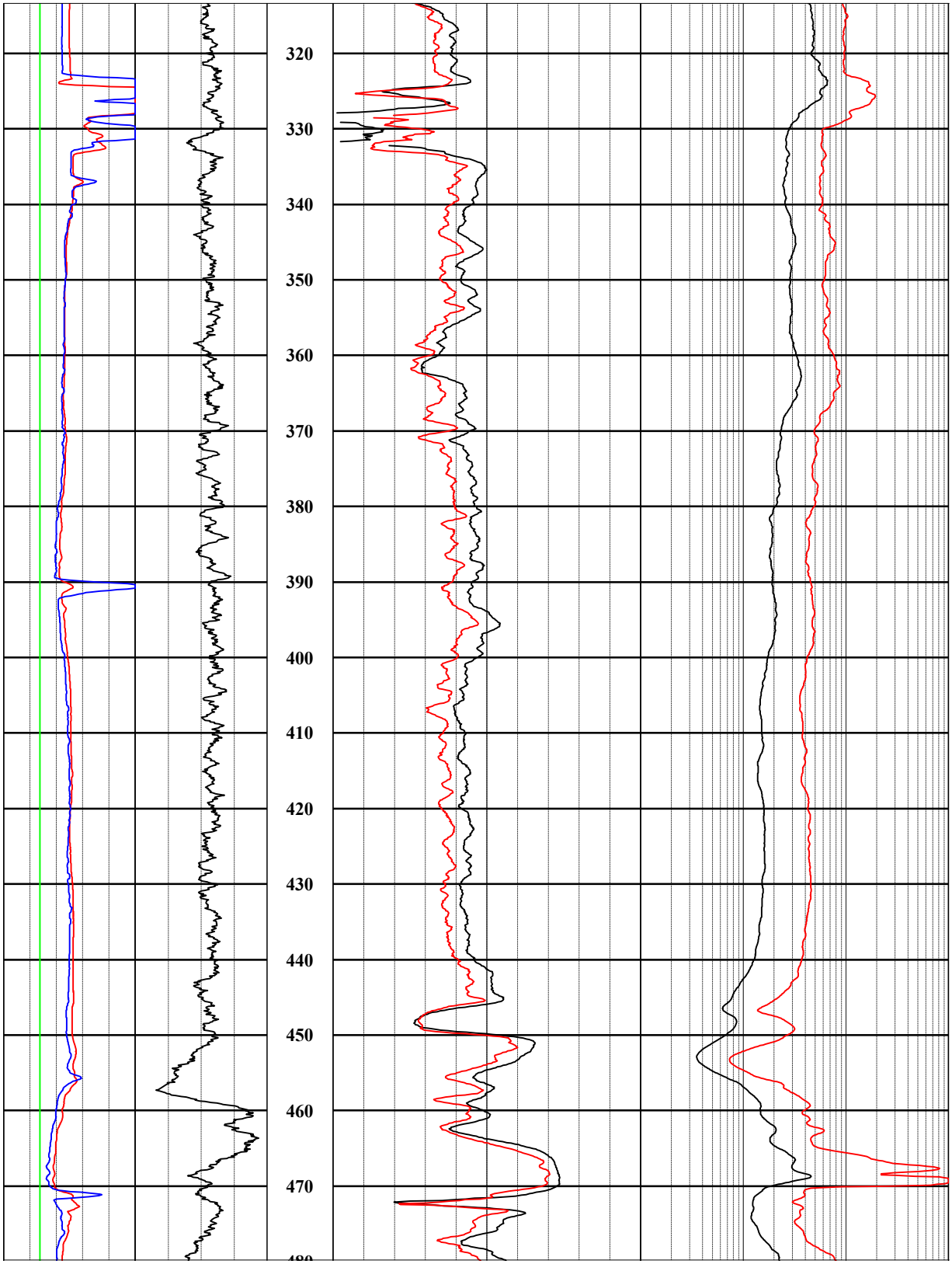


Figure RAI 2.2.1.1.1-004-39 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

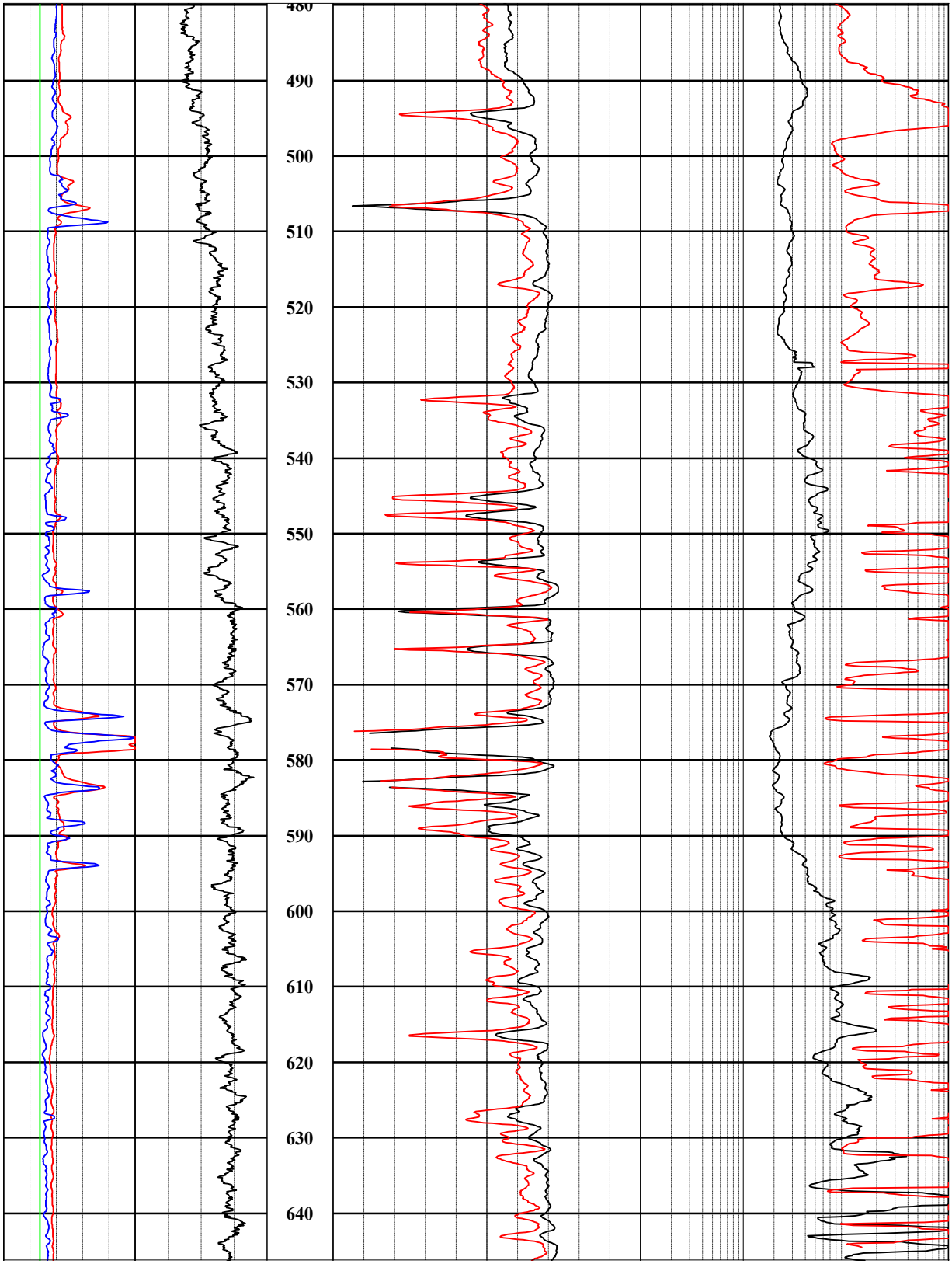


Figure RAI 2.2.1.1.1-004-39 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

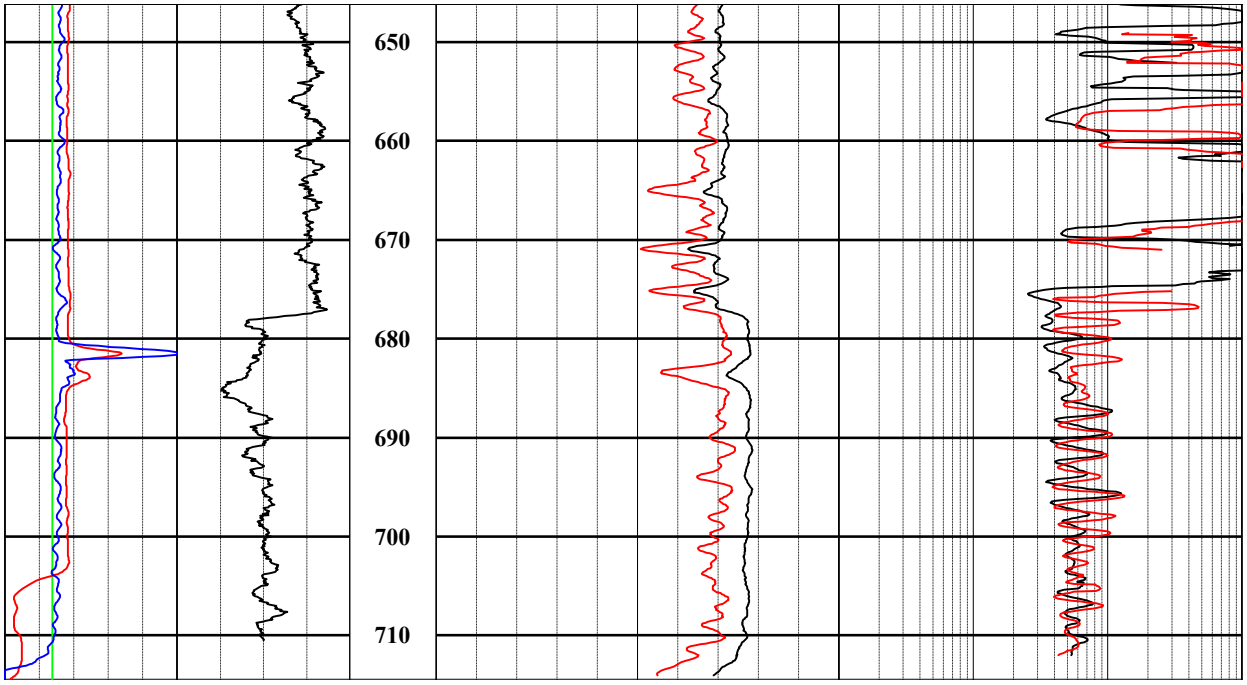


Figure RAI 2.2.1.1.1-004-39 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

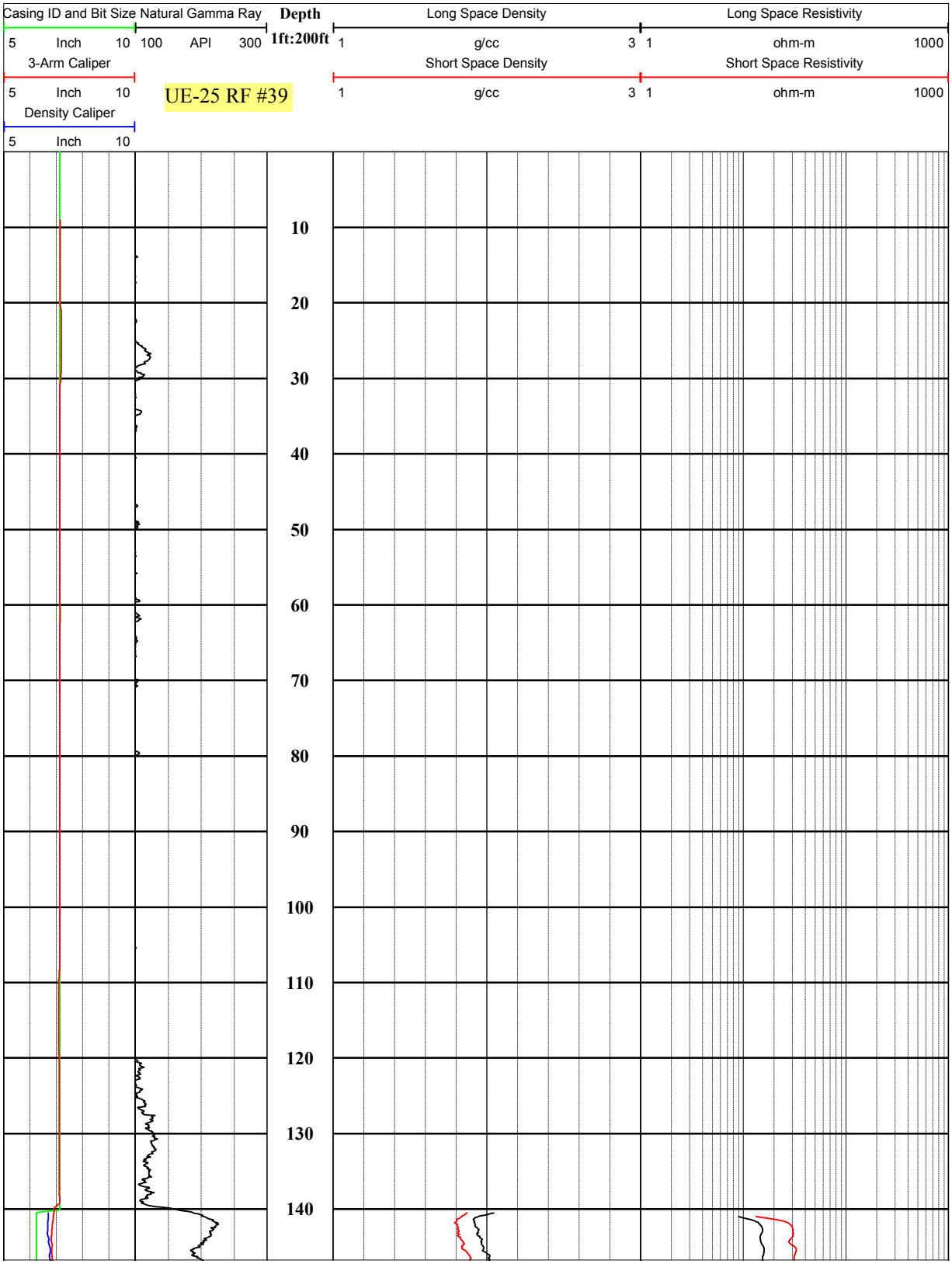


Figure RAI 2.2.1.1.1-004-40 (Sheet 1 of 3)

DTN: MO0801RFGEOLOG.002

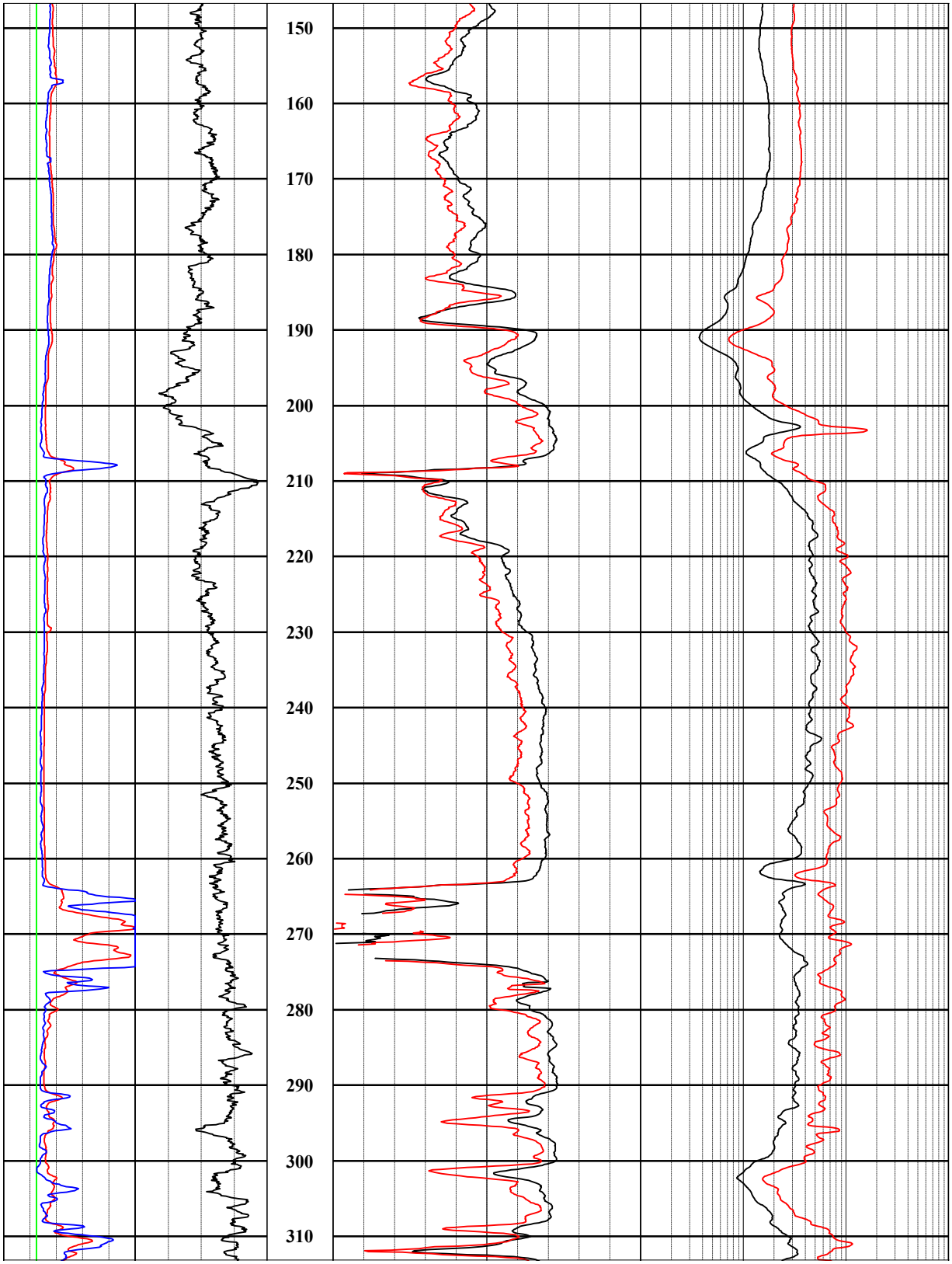


Figure RAI 2.2.1.1.1-004-40 (Sheet 2 of 3)

DTN: MO0801RFGEOLOG.002

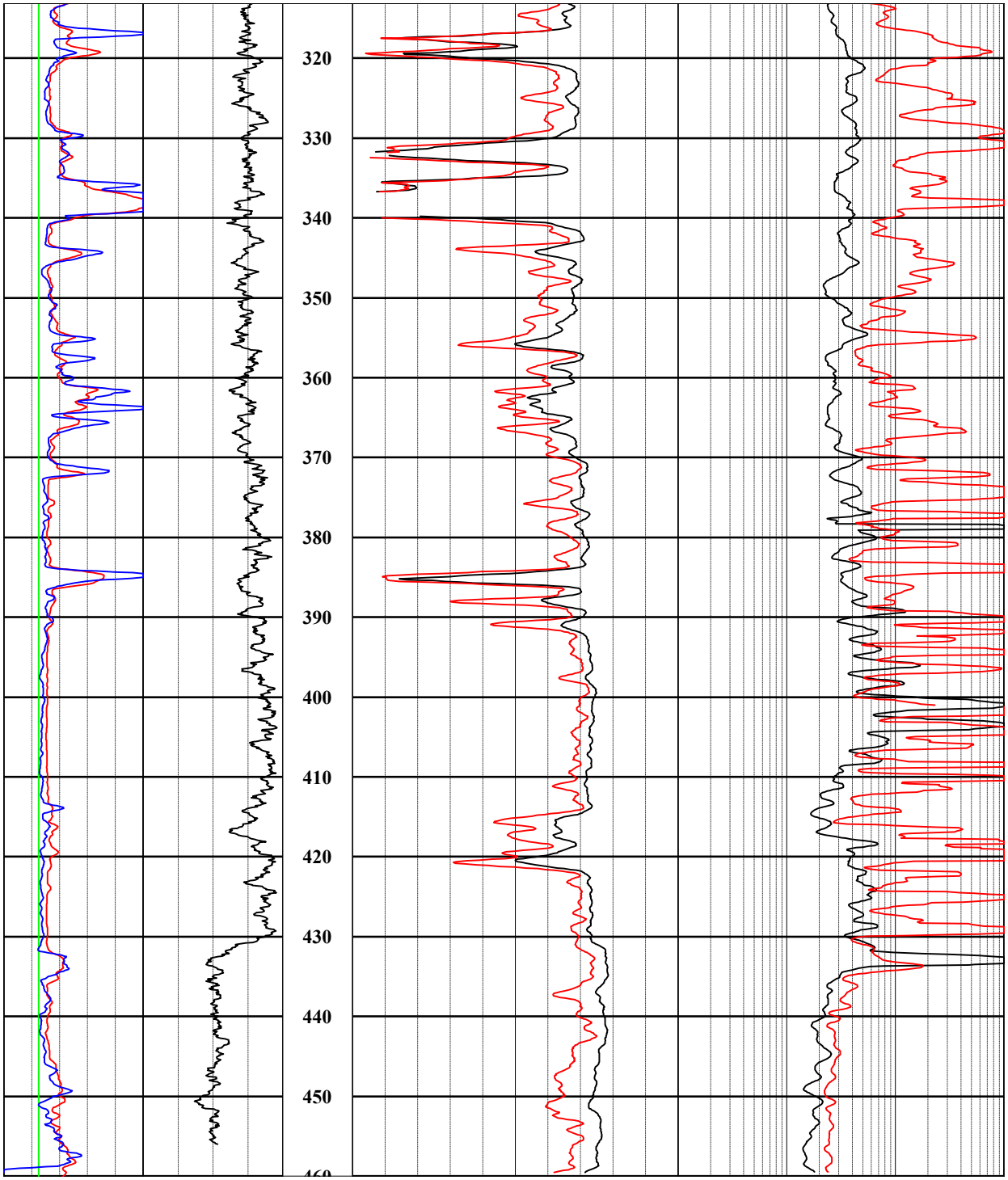


Figure RAI 2.2.1.1.1-004-40 (Sheet 3 of 3)

DTN: MO0801RFGEOLOG.002

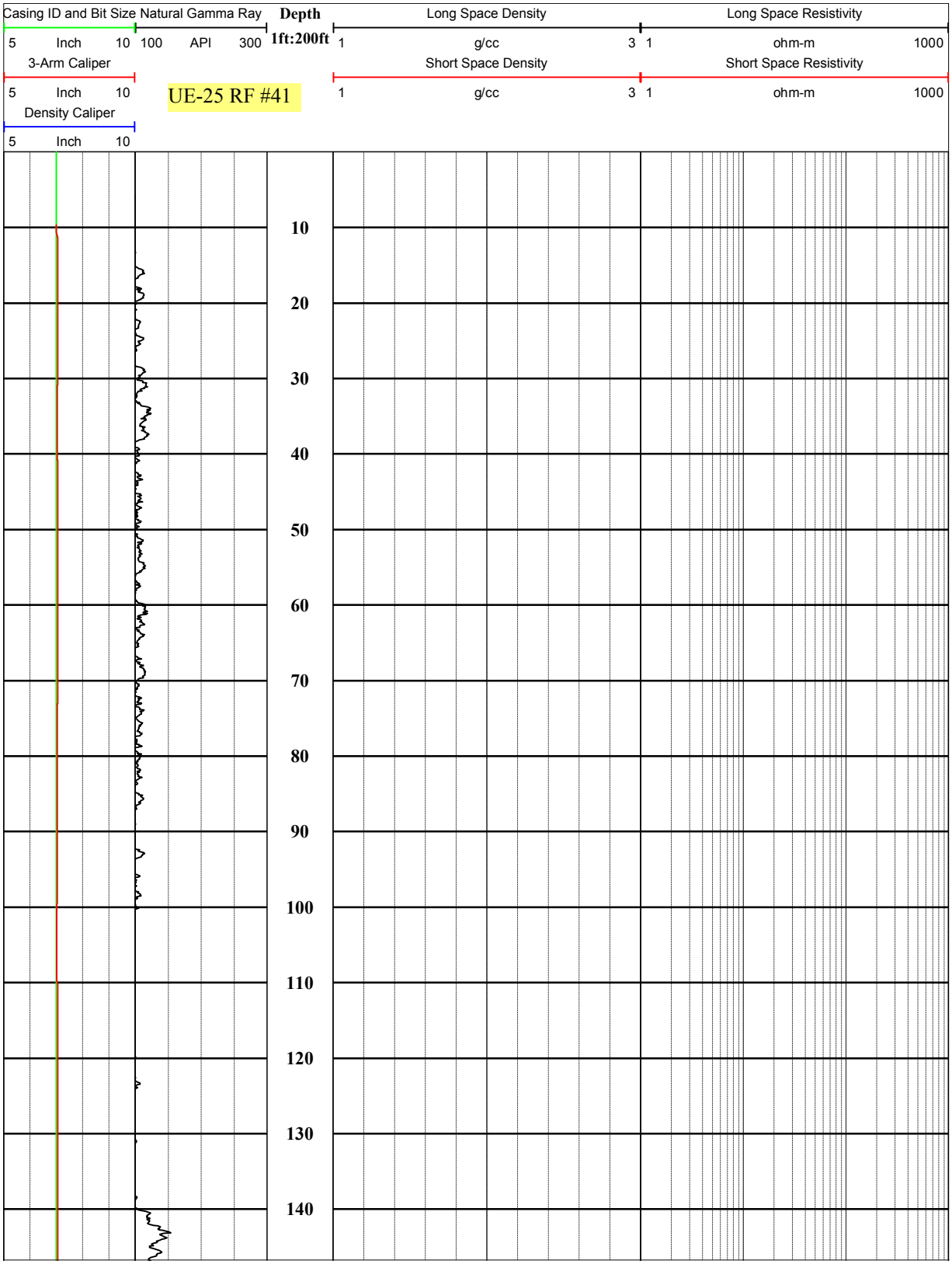


Figure RAI 2.2.1.1.1-004-41 (Sheet 1 of 5)

DTN: MO0801RFGEOLOG.002

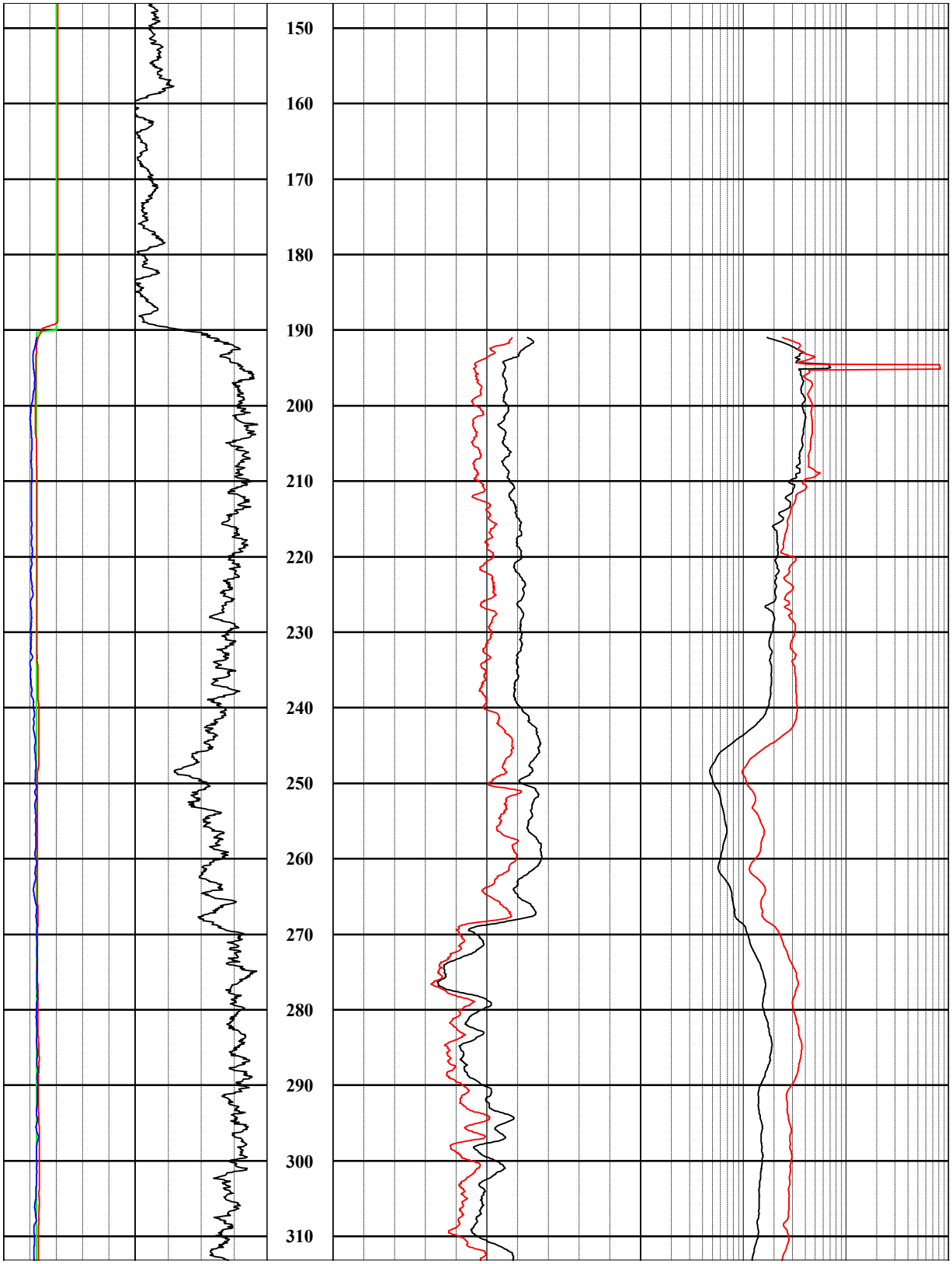


Figure RAI 2.2.1.1.1-004-41 (Sheet 2 of 5)

DTN: MO0801RFGEOLOG.002

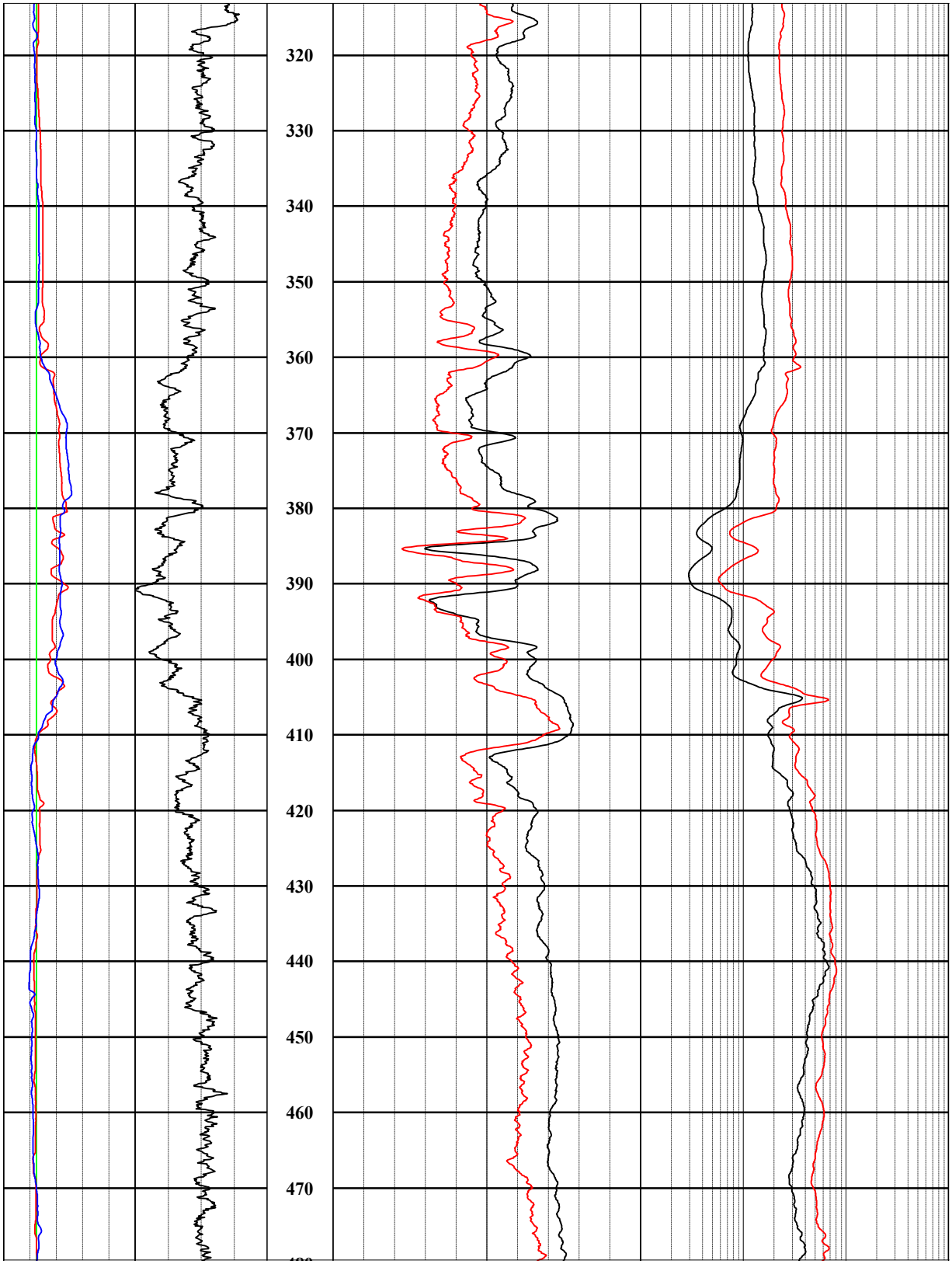


Figure RAI 2.2.1.1.1-004-41 (Sheet 3 of 5)

DTN: MO0801RFGEOLOG.002

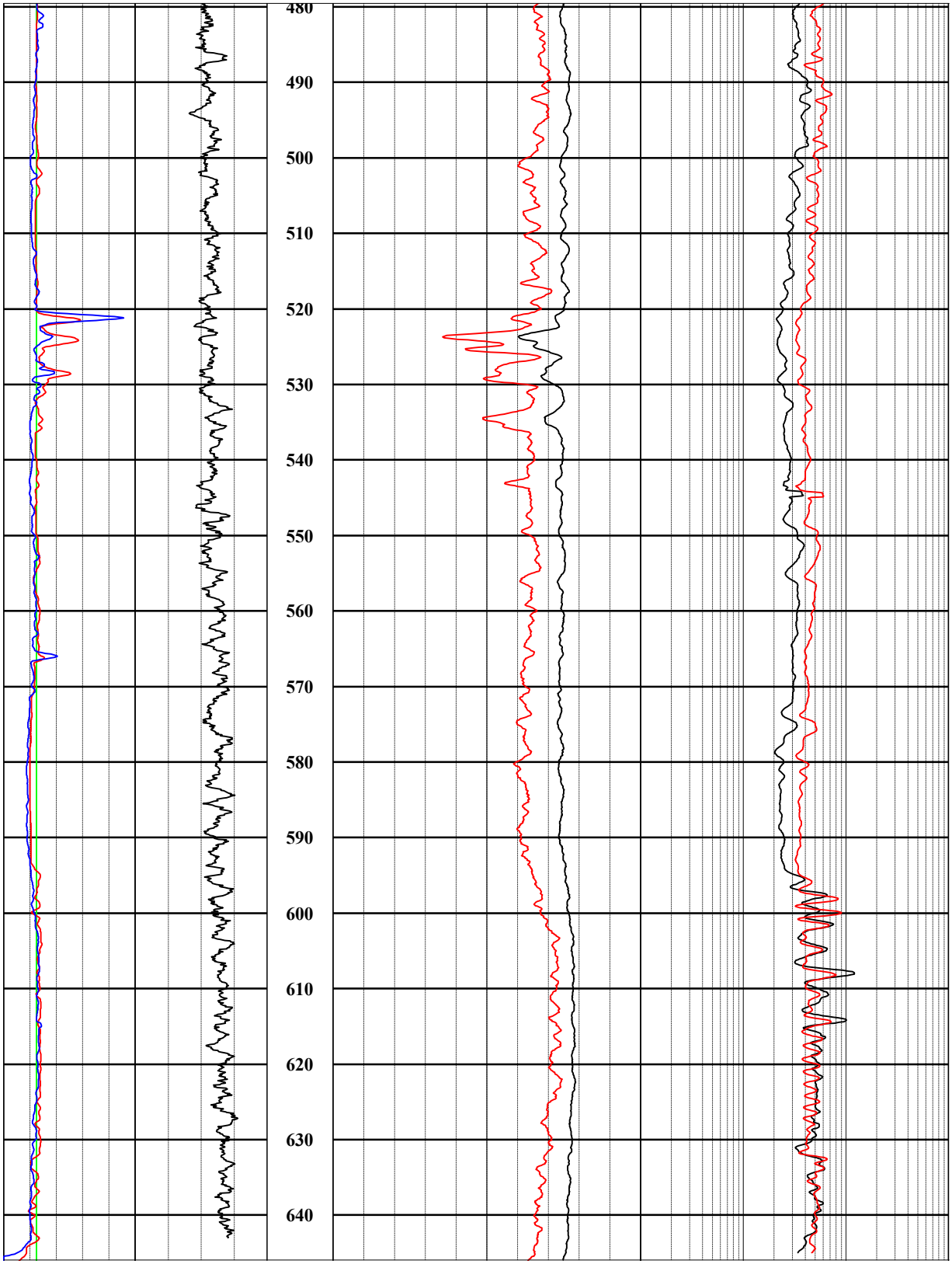


Figure RAI 2.2.1.1.1-004-41 (Sheet 4 of 5)

DTN: MO0801RFGEOLOG.002

Figure RAI 2.2.1.1.1-004-41 (Sheet 5 of 5)

DTN: MO0801RFGEOLOG.002

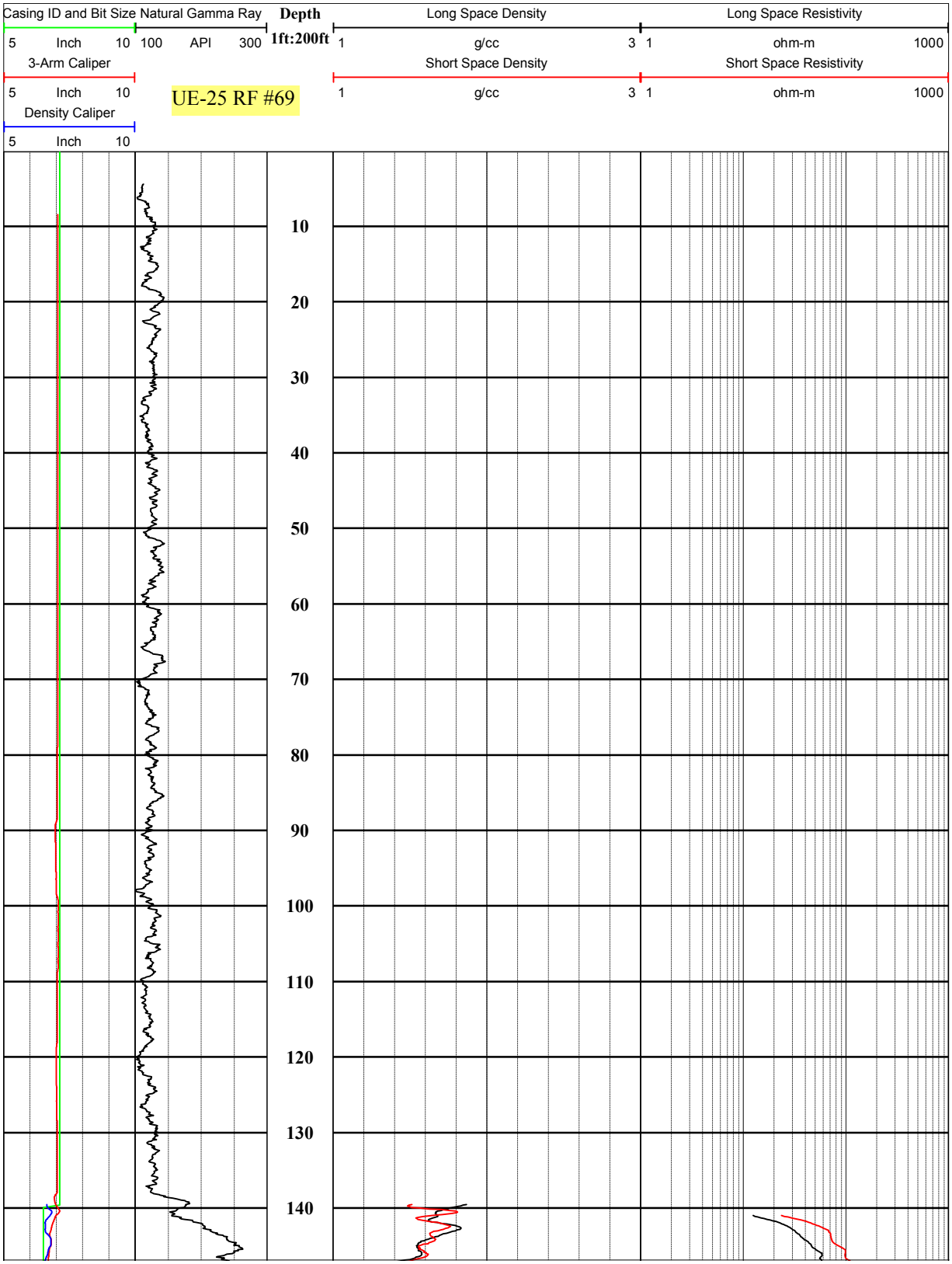


Figure RAI 2.2.1.1.1-004-42 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

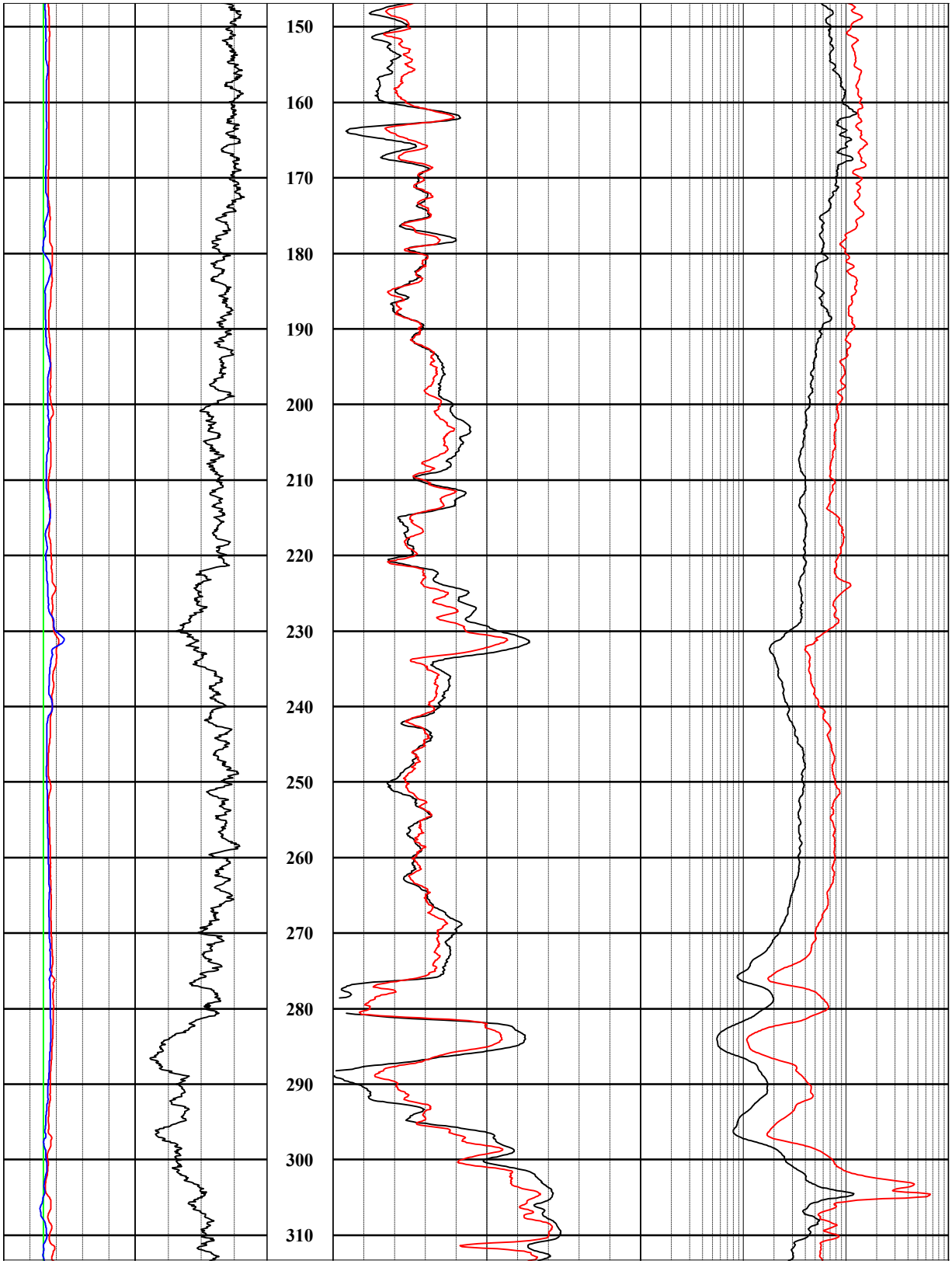


Figure RAI 2.2.1.1.1-004-42 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

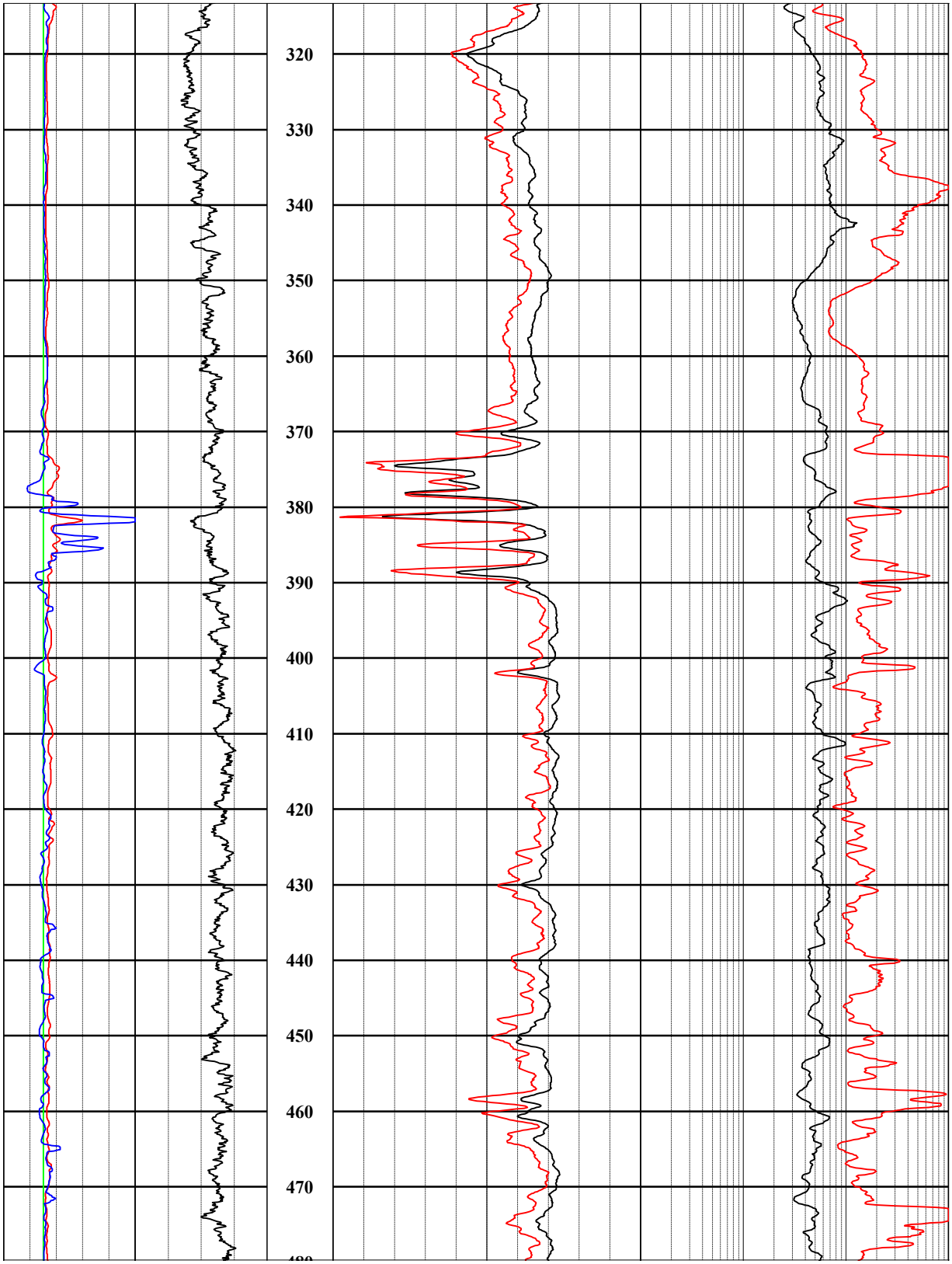


Figure RAI 2.2.1.1.1-004-42 (Sheet 3 of 4)

DTN: MO0801RFGEOLOG.002

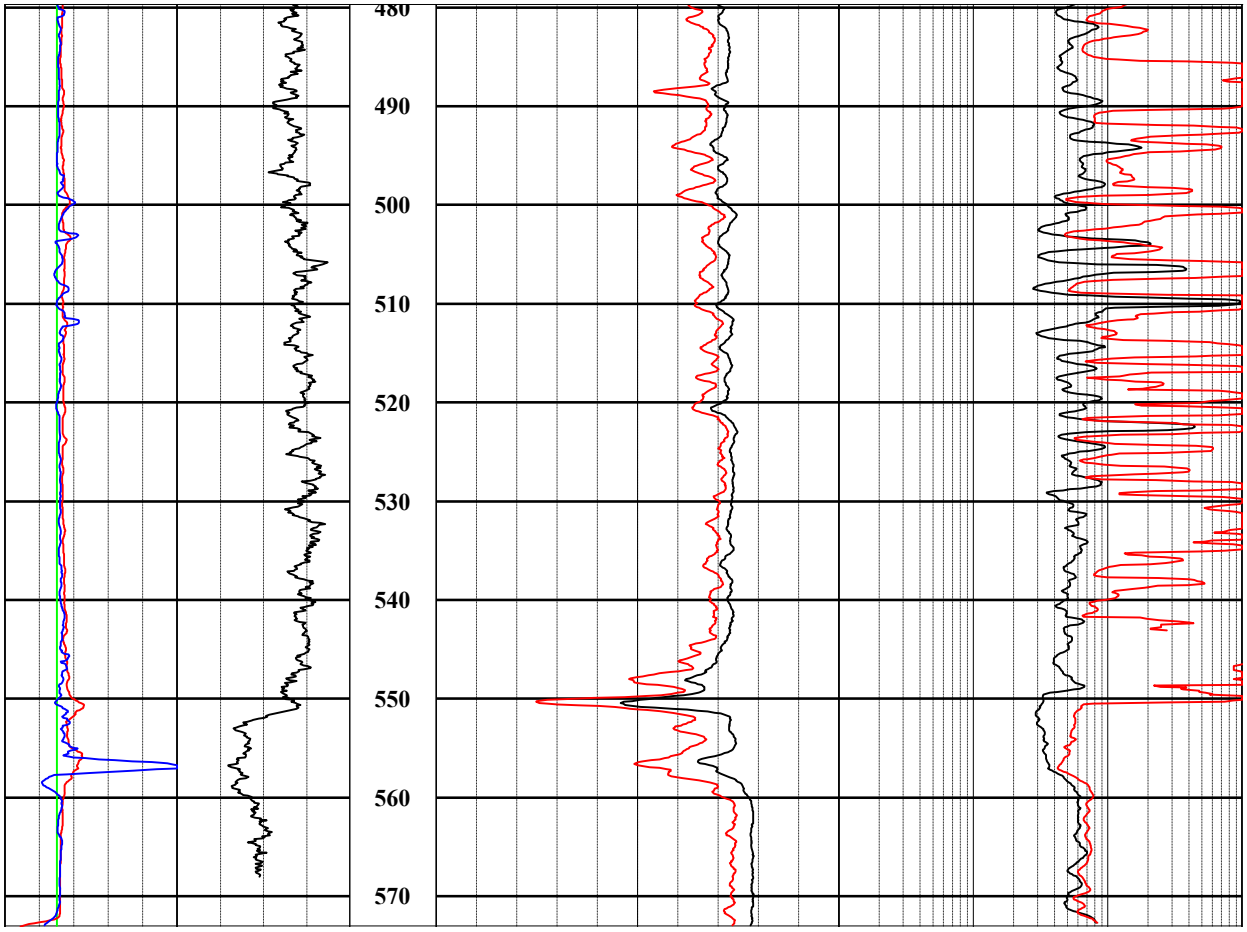


Figure RAI 2.2.1.1.1-004-42 (Sheet 4 of 4)

DTN: MO0801RFGEOLOG.002

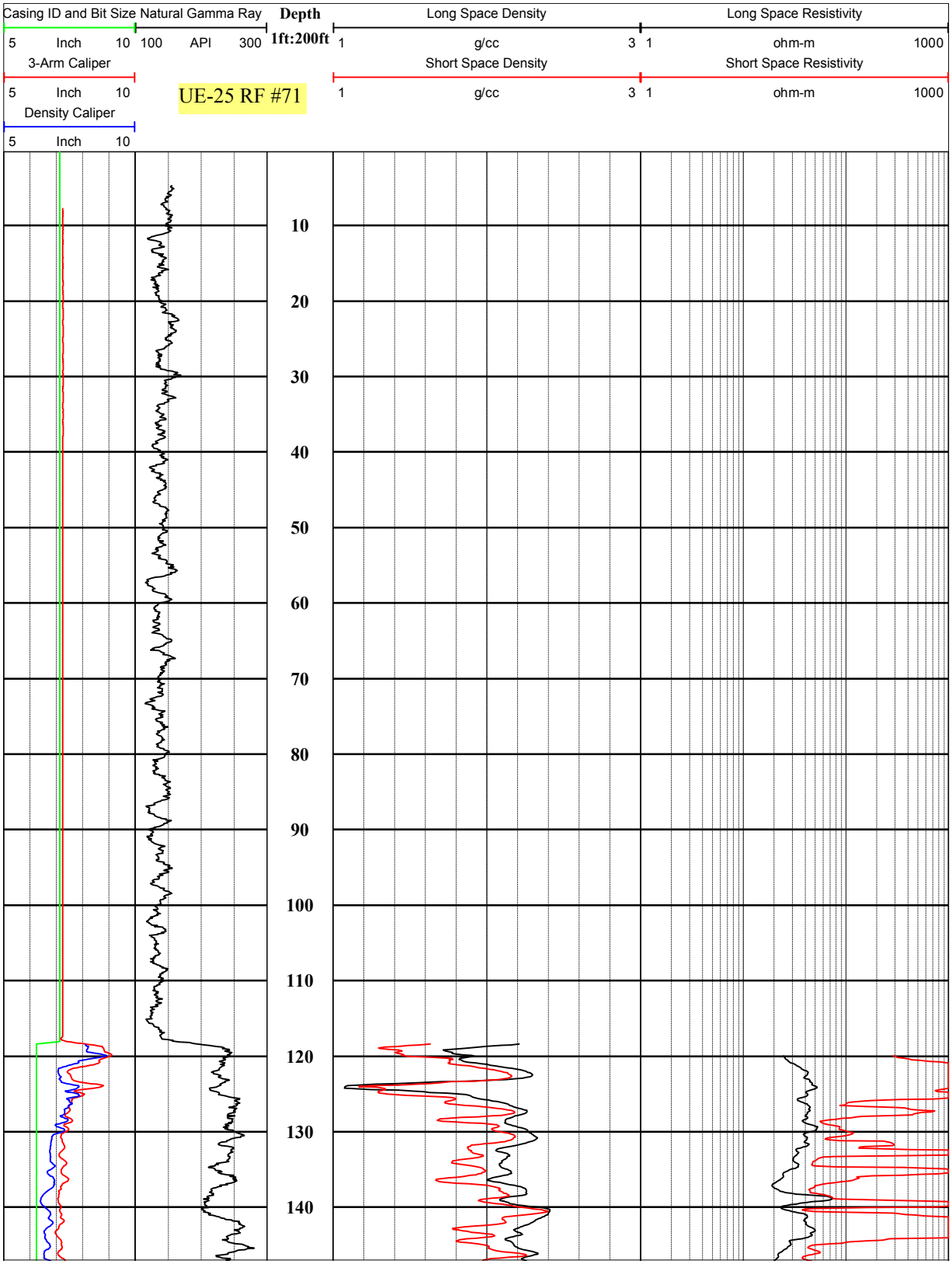


Figure RAI 2.2.1.1.1-004-43 (Sheet 1 of 3)

DTN: MO0801RFGEOLOG.002

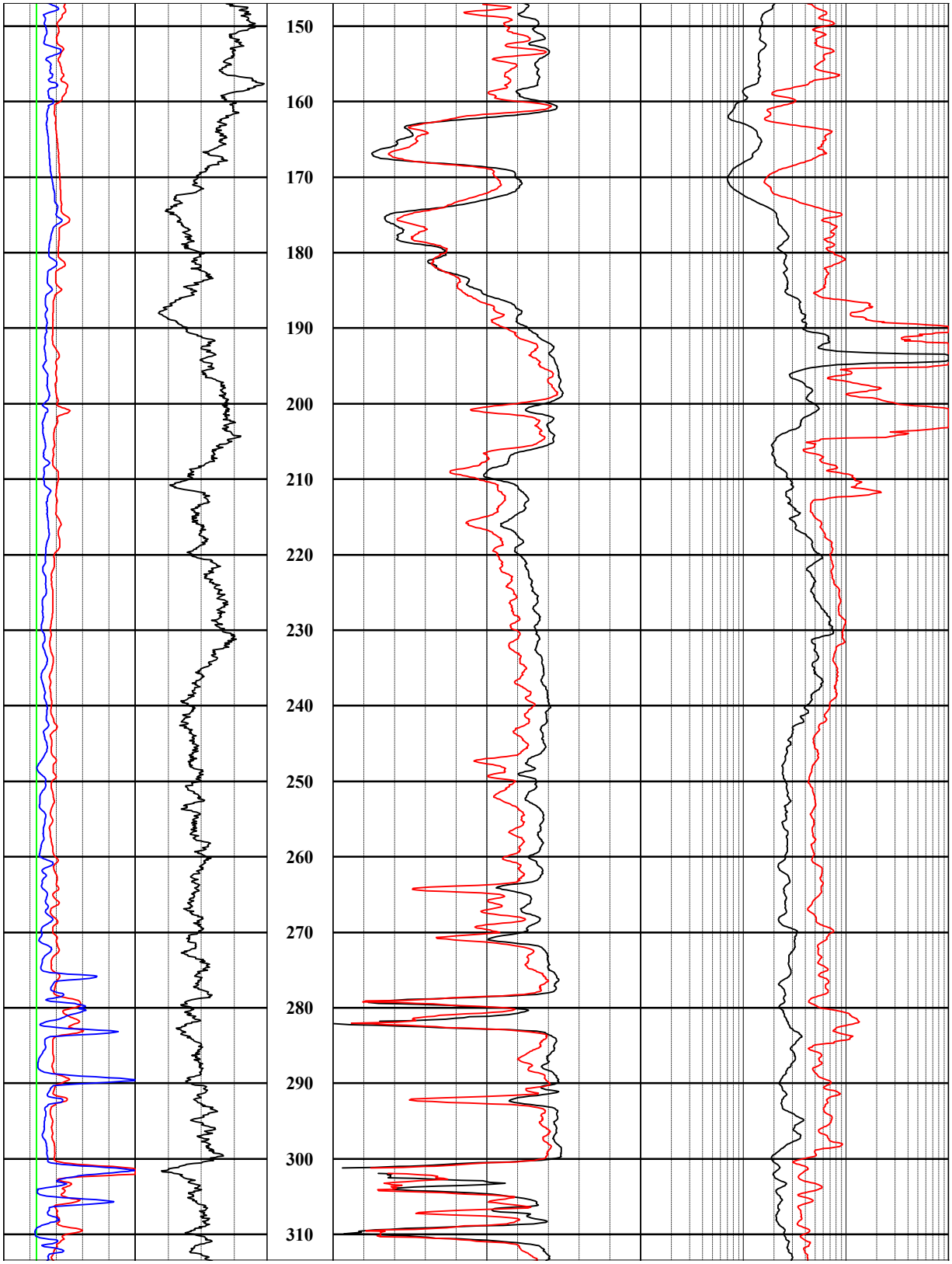


Figure RAI 2.2.1.1.1-004-43 (Sheet 2 of 3)

DTN: MO0801RFGEOLOG.002

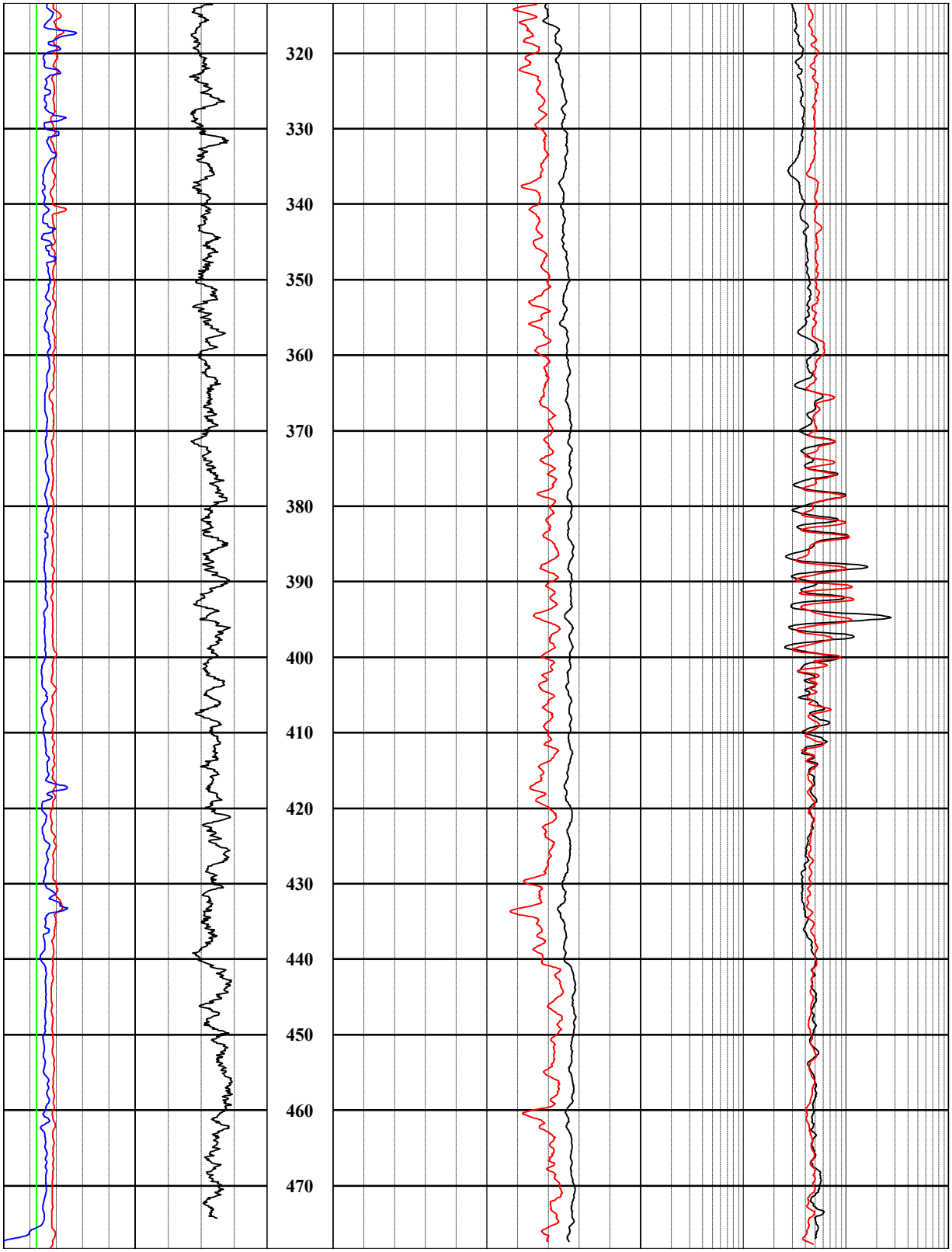


Figure RAI 2.2.1.1.1-004-43 (Sheet 3 of 3)

DTN: MO0801RFGEOLOG.002

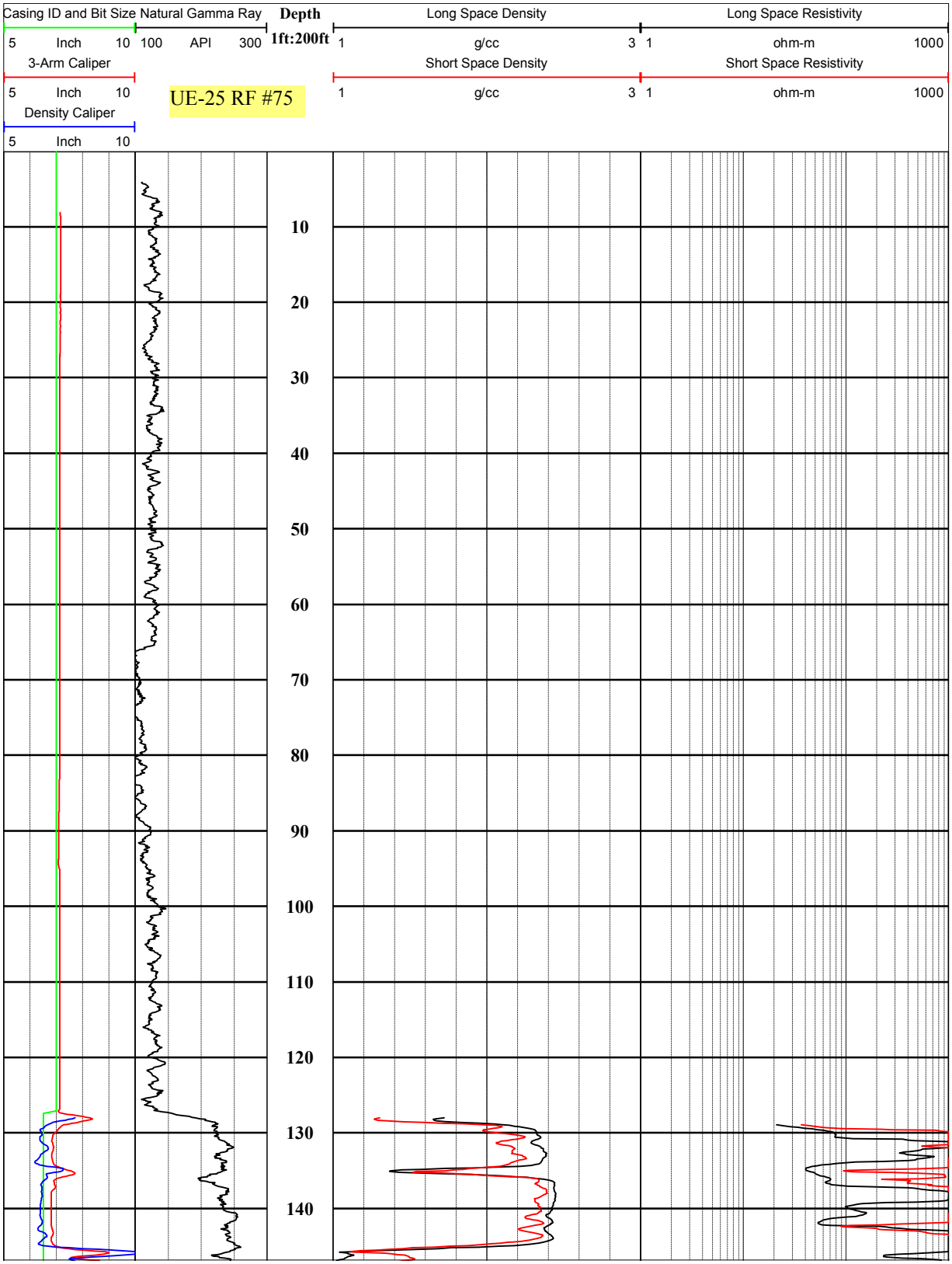


Figure RAI 2.2.1.1.1-004-44 (Sheet 1 of 4)

DTN: MO0801RFGEOLOG.002

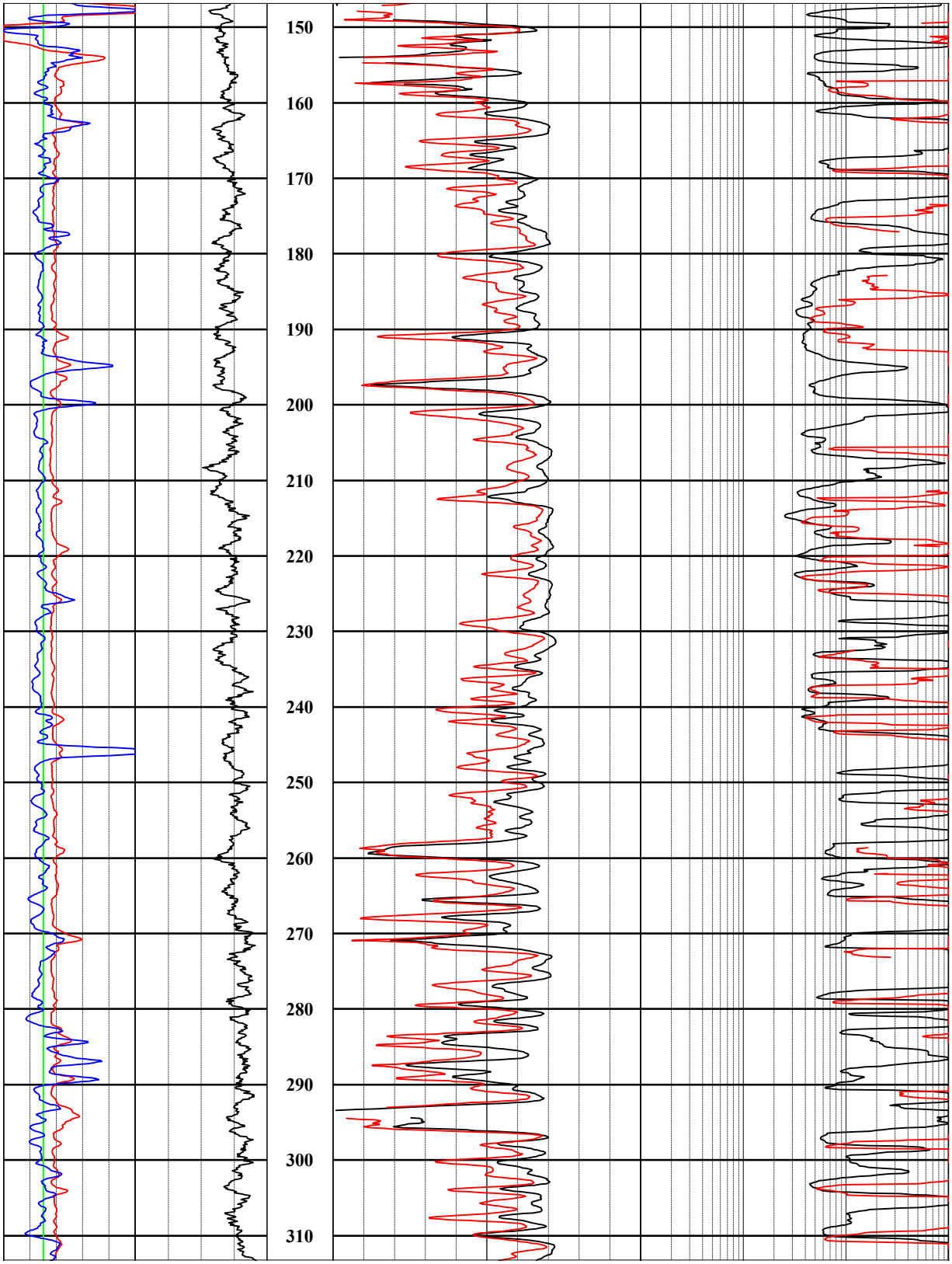


Figure RAI 2.2.1.1.1-004-44 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

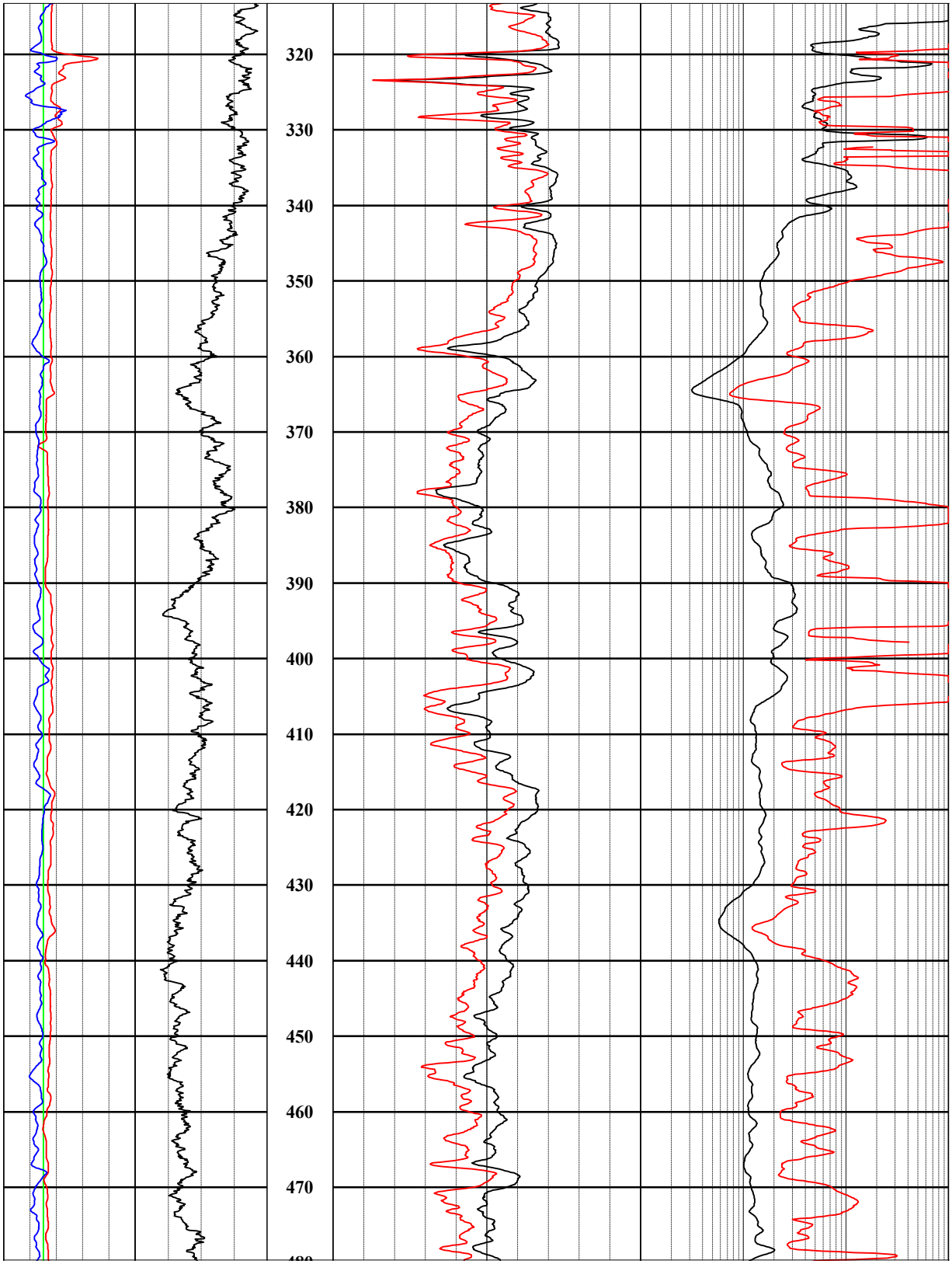


Figure RAI 2.2.1.1.1-004-44 (Sheet 3 of 4)

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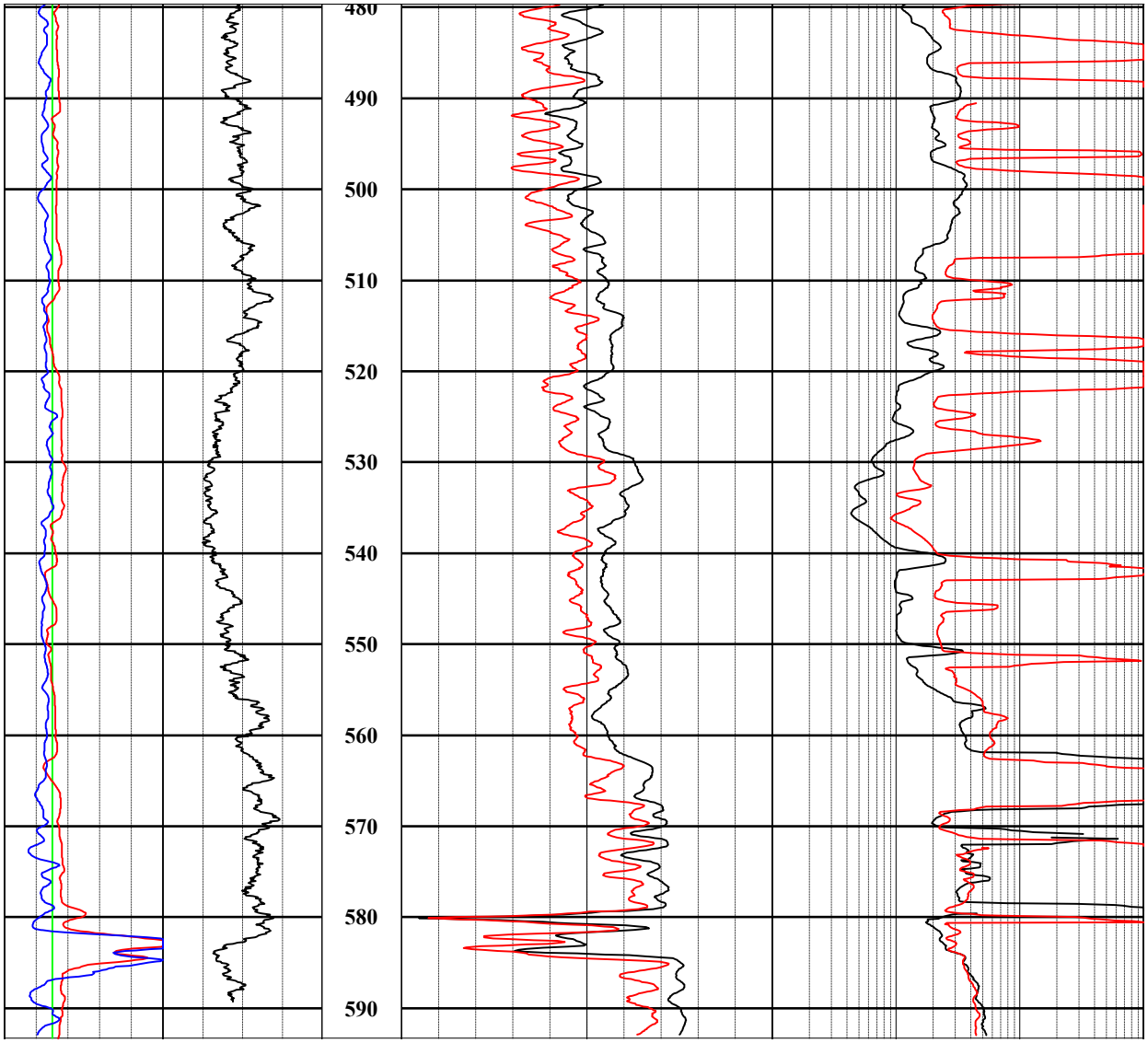

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DTN: MO0801RFGEOLOG.002

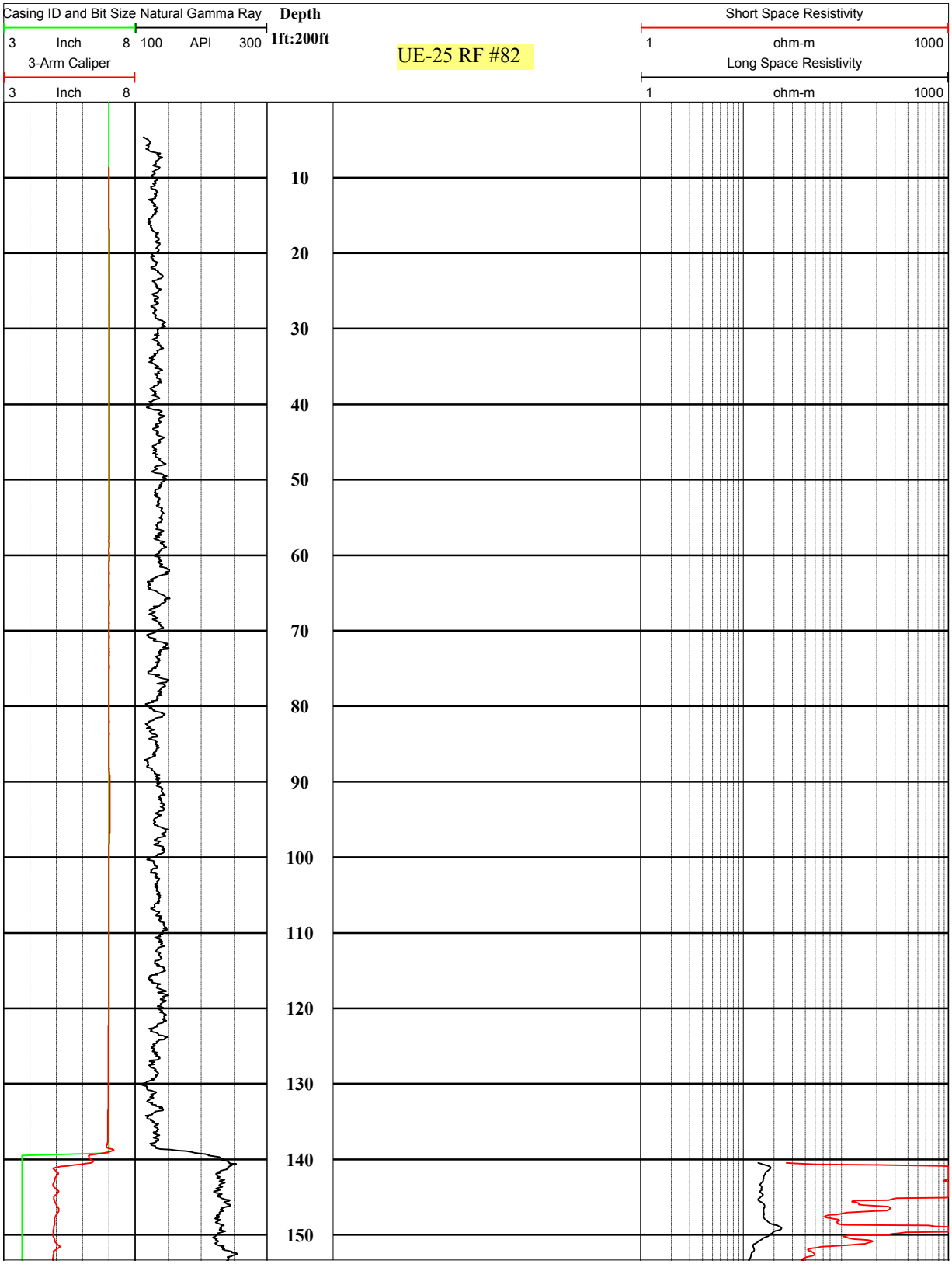

Figure RAI 2.2.1.1.1-004-45 (Sheet 1 of 6)

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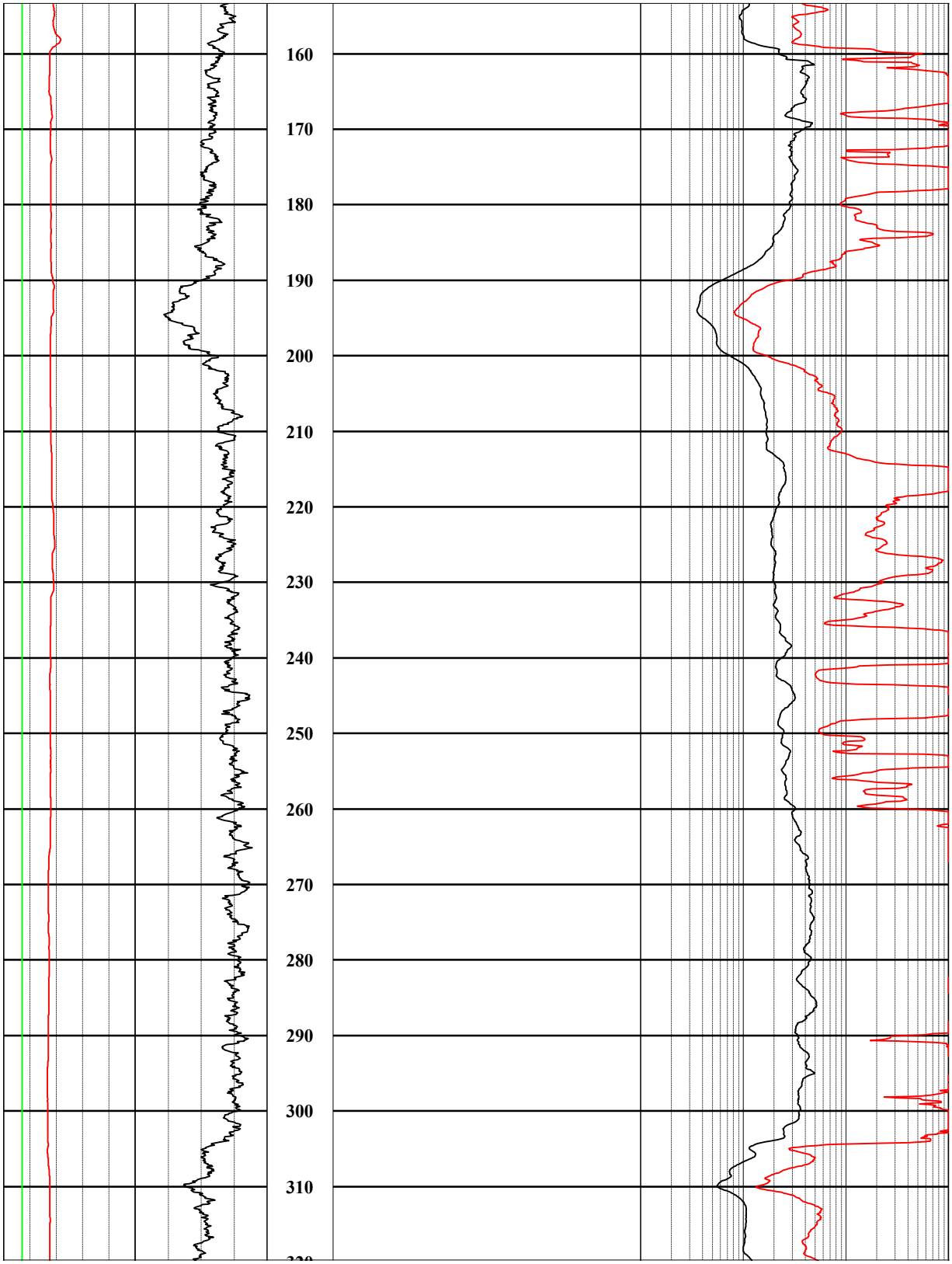

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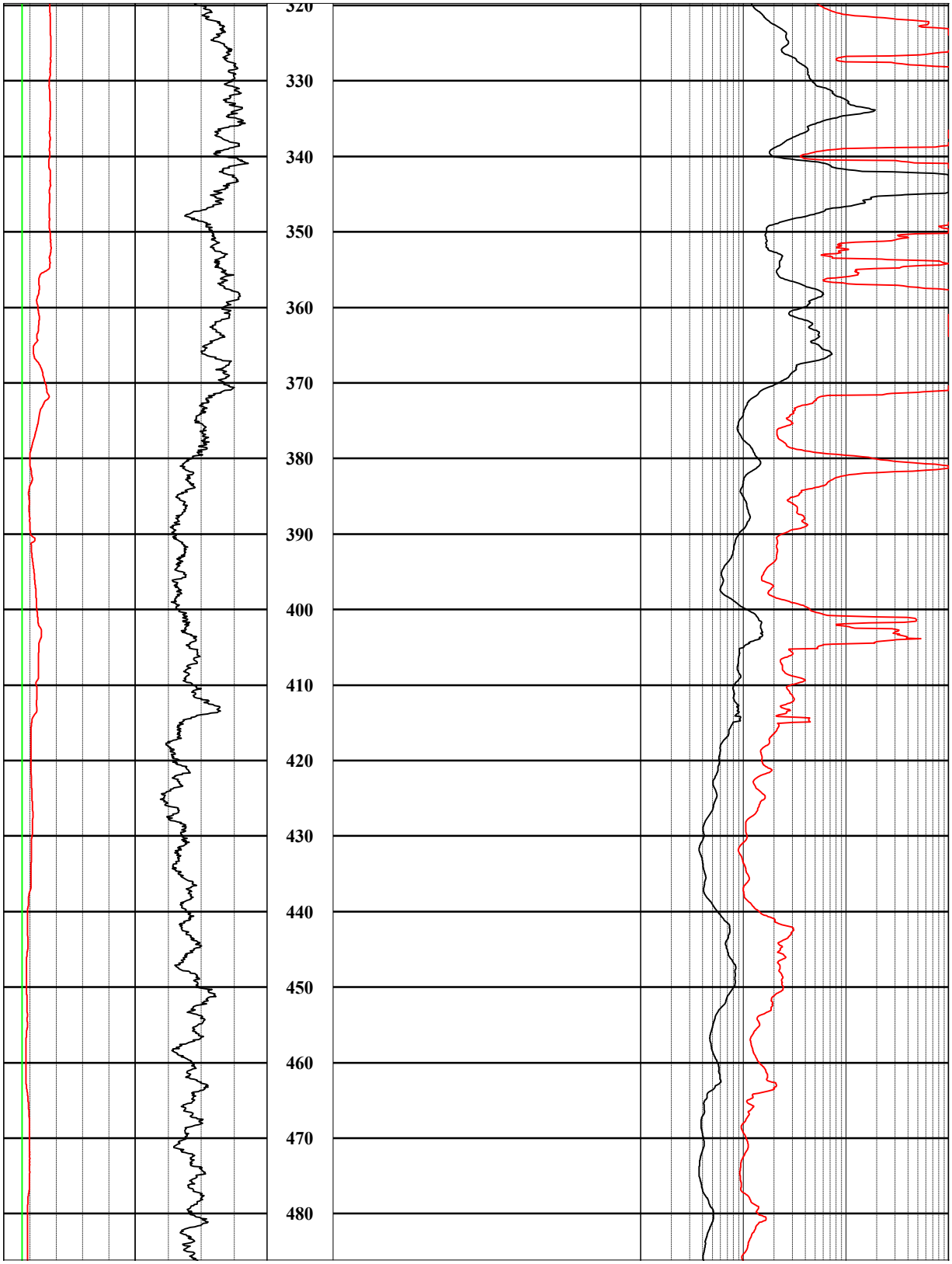

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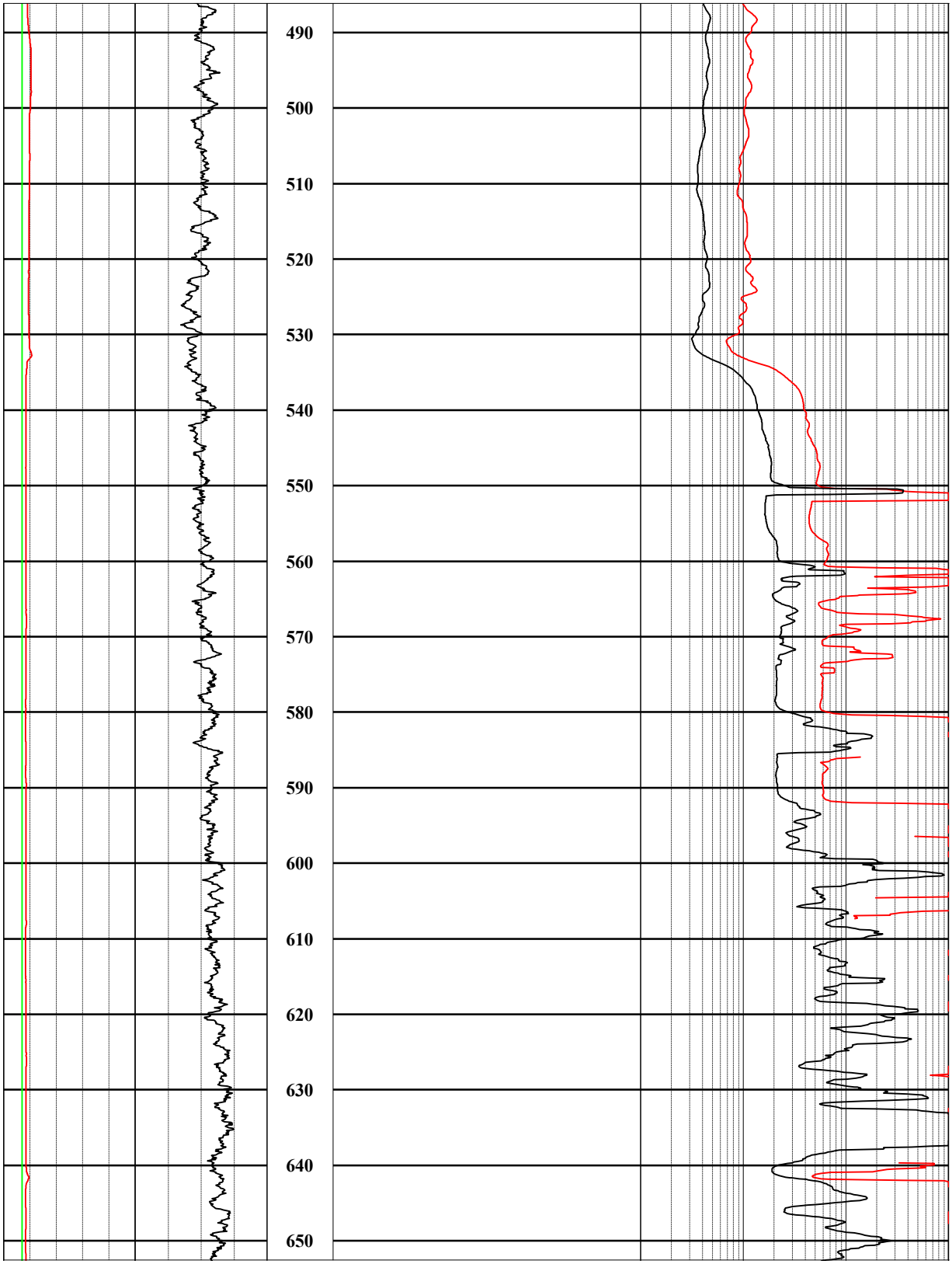
DTN: MO0801RFGEOLOG.002



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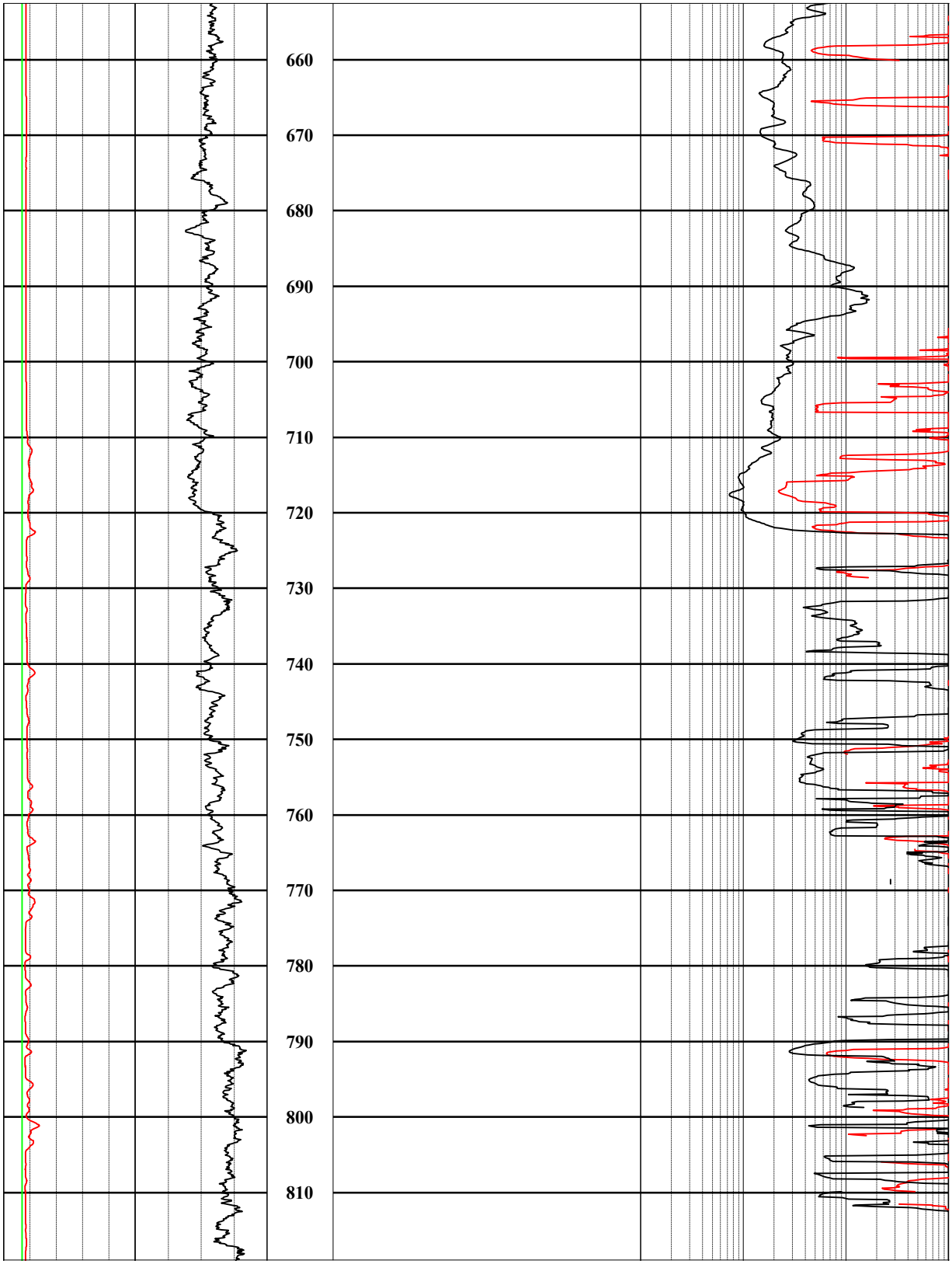

Figure RAI 2.2.1.1.1-004-45 (Sheet 5 of 6)

DTN: MO0801RFGEOLOG.002

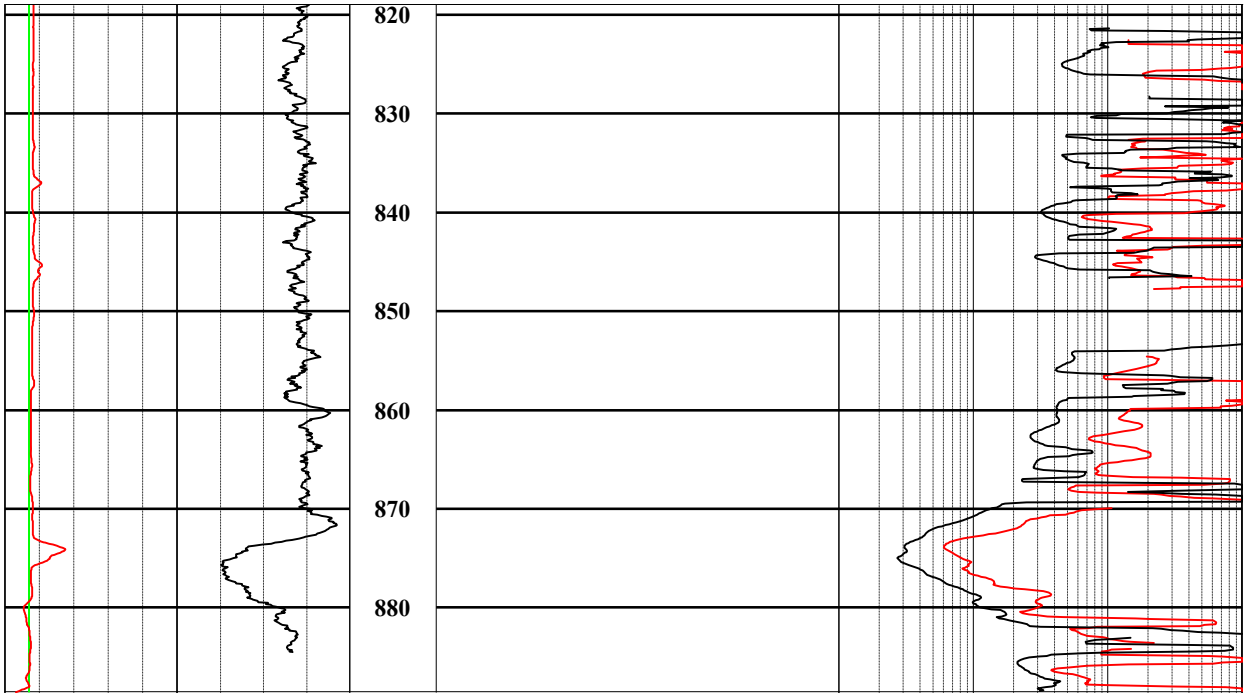

Figure RAI 2.2.1.1.1-004-45 (Sheet 6 of 6)

DTN: MO0801RFGEOLOG.002

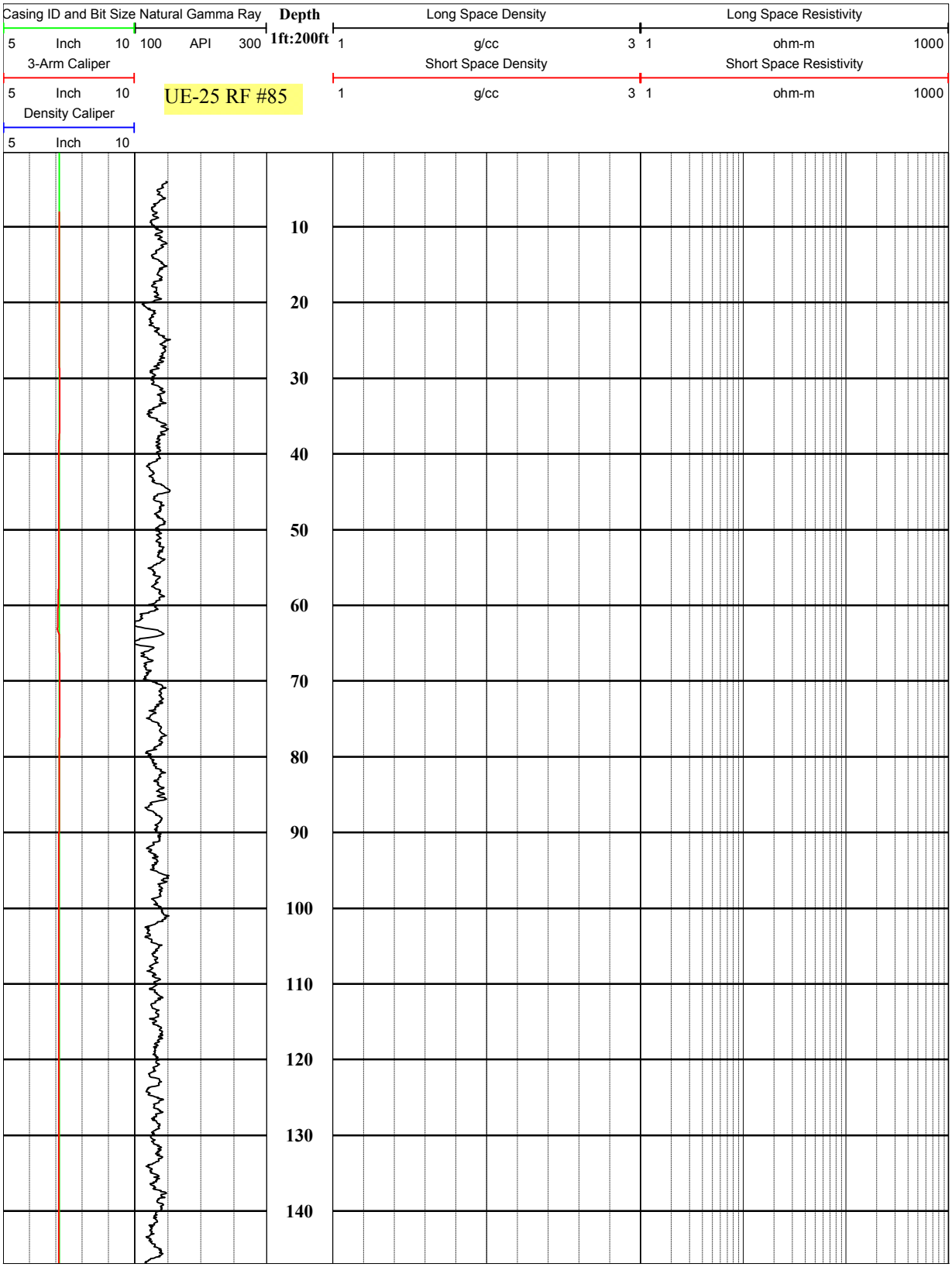

Figure RAI 2.2.1.1.1-004-46 (Sheet 1 of 7)

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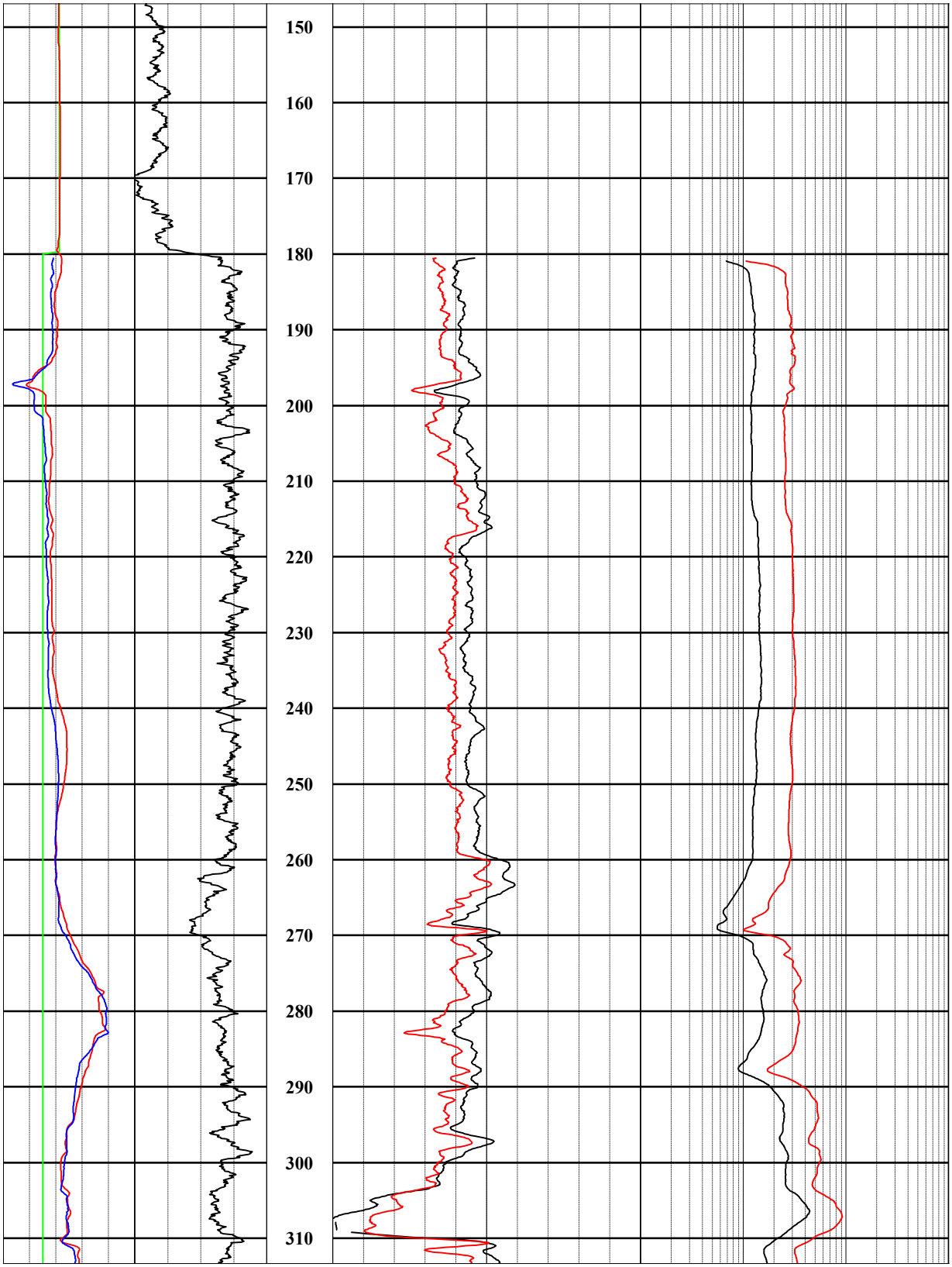

Figure RAI 2.2.1.1.1-004-46 (Sheet 2 of 7)

DTN: MO0801RFGEOLOG.002

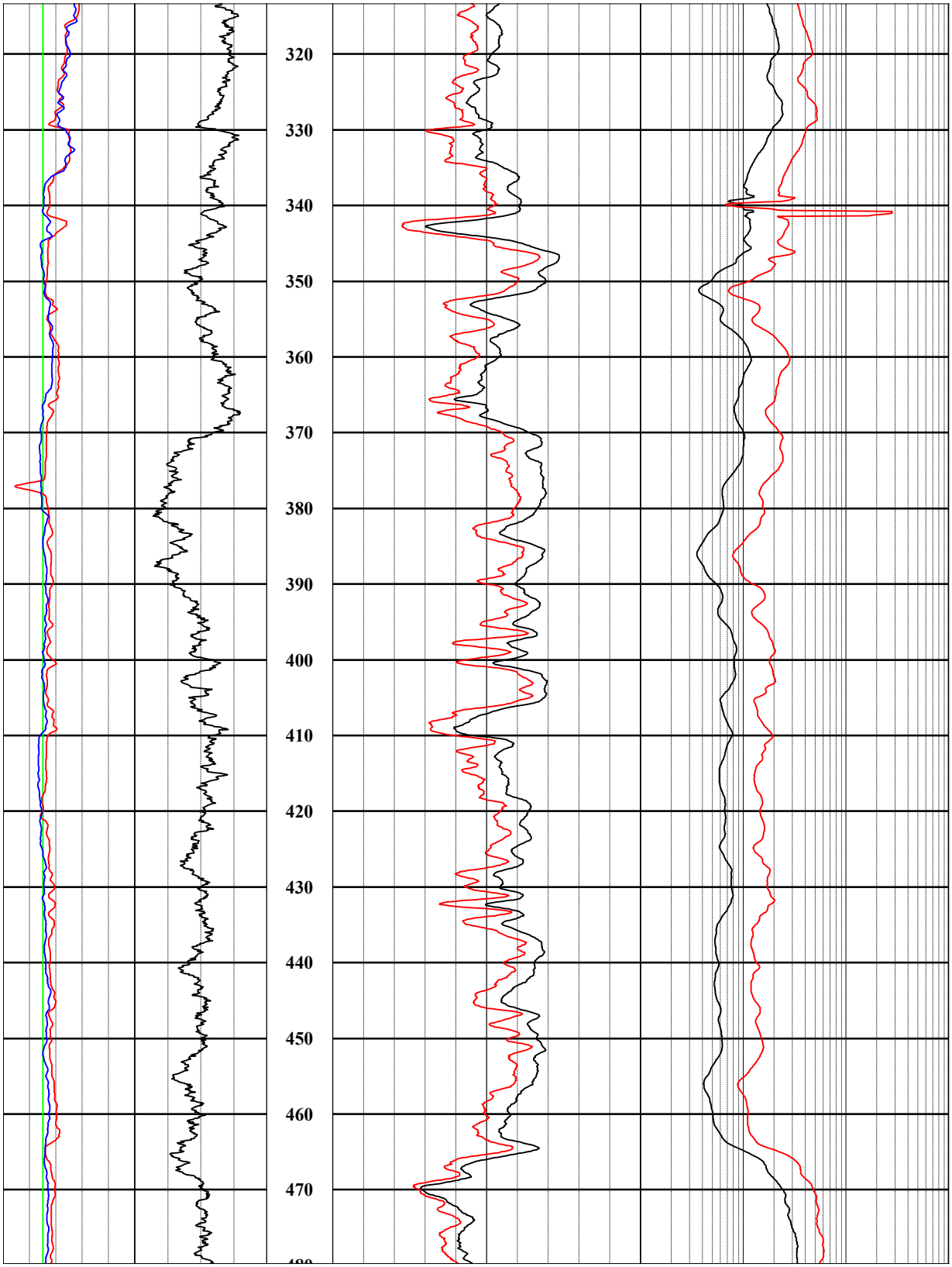

Figure RAI 2.2.1.1.1-004-46 (Sheet 3 of 7)

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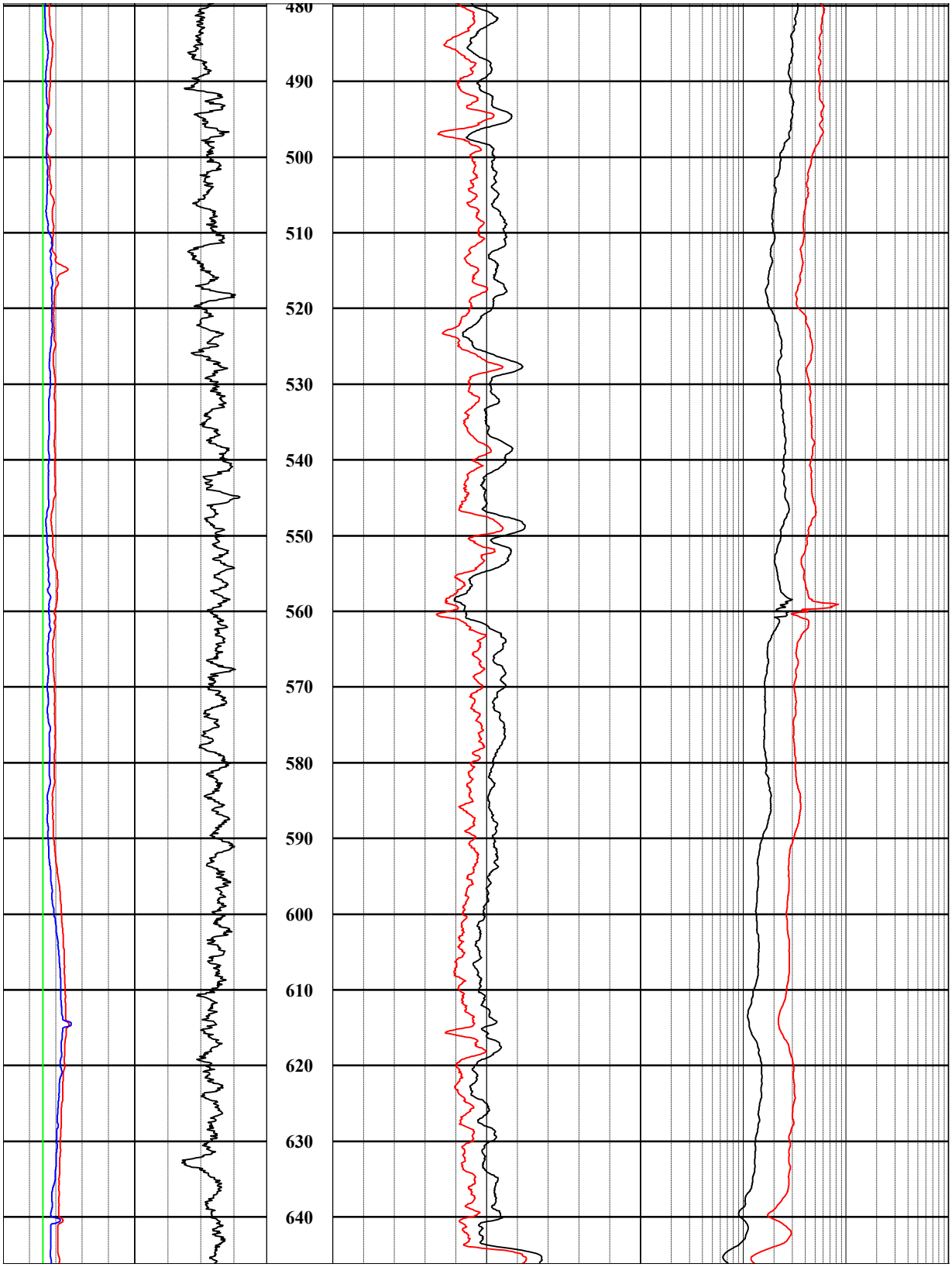

Figure RAI 2.2.1.1.1-004-46 (Sheet 4 of 7)

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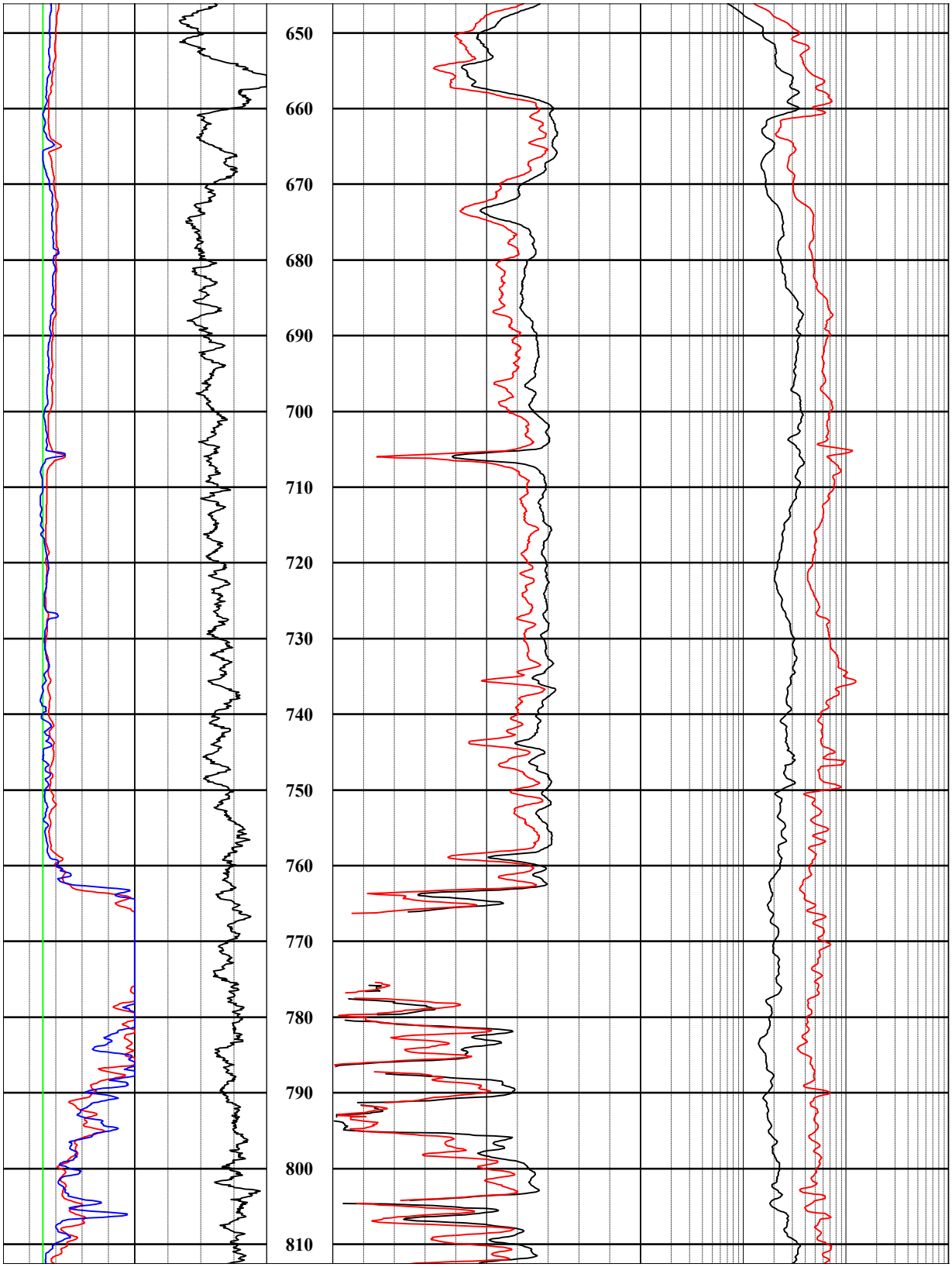

Figure RAI 2.2.1.1.1-004-46 (Sheet 5 of 7)

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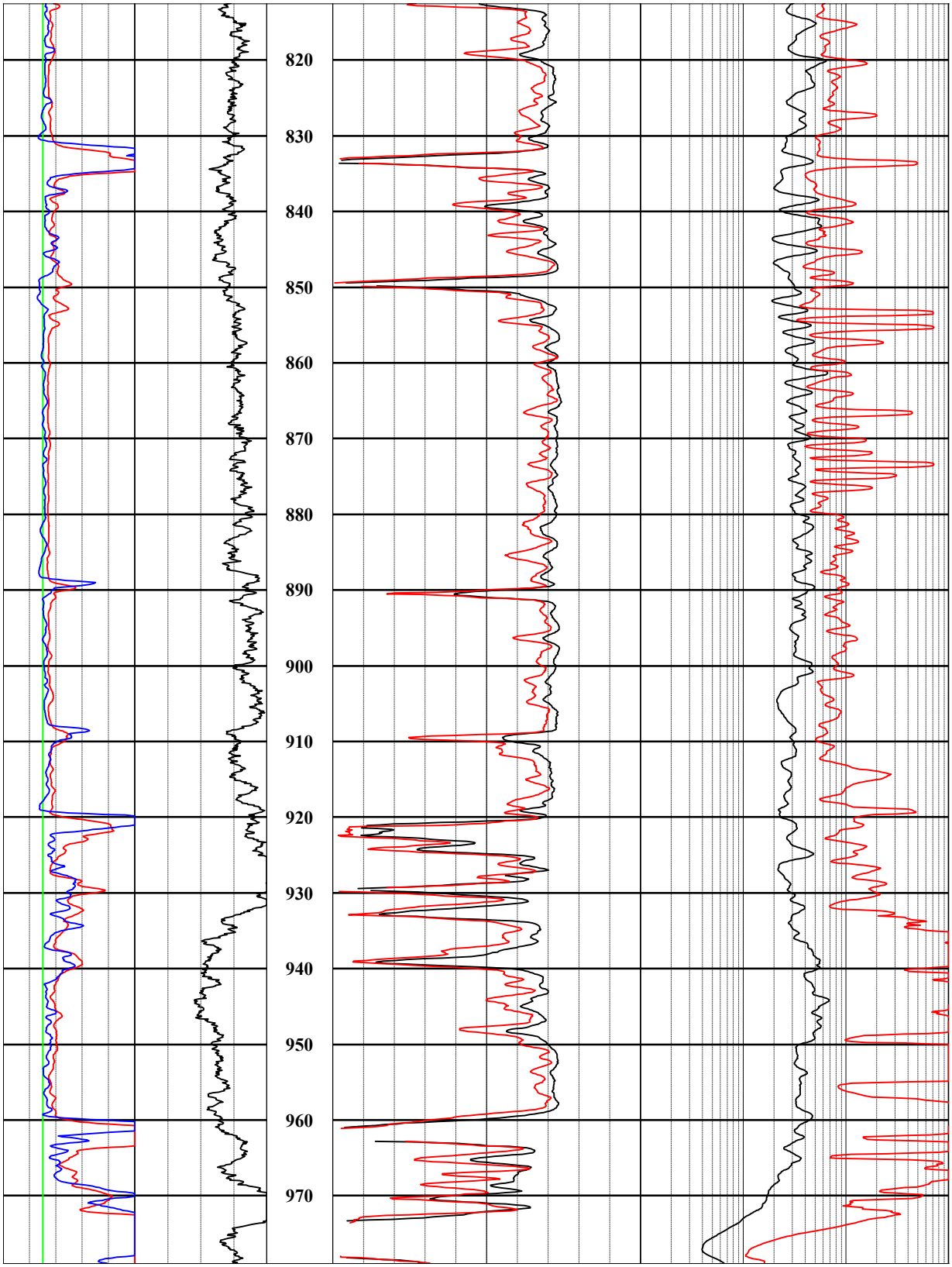

Figure RAI 2.2.1.1.1-004-46 (Sheet 6 of 7)

DTN: MO0801RFGEOLOG.002

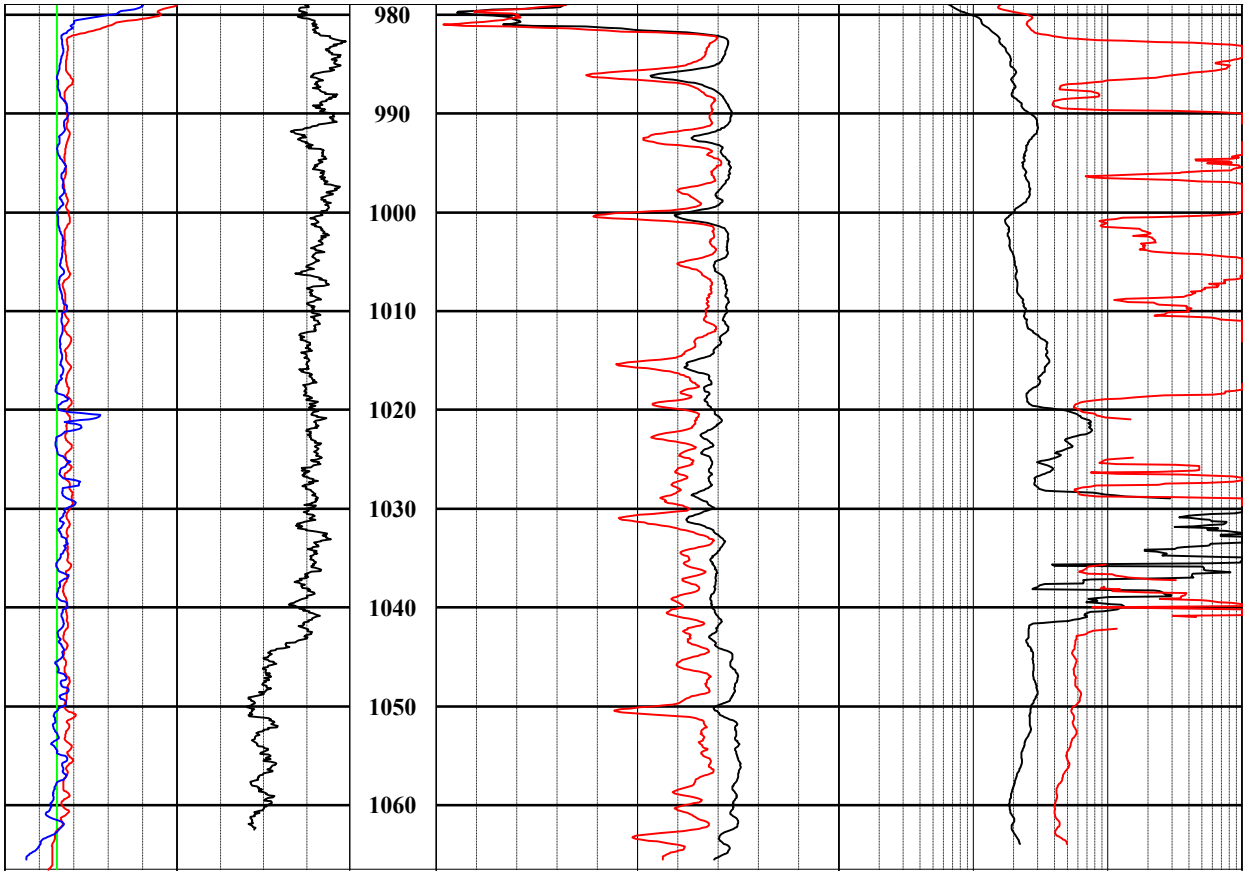

Figure RAI 2.2.1.1.1-004-46 (Sheet 7 of 7)

DTN: MO0801RFGEOLOG.002

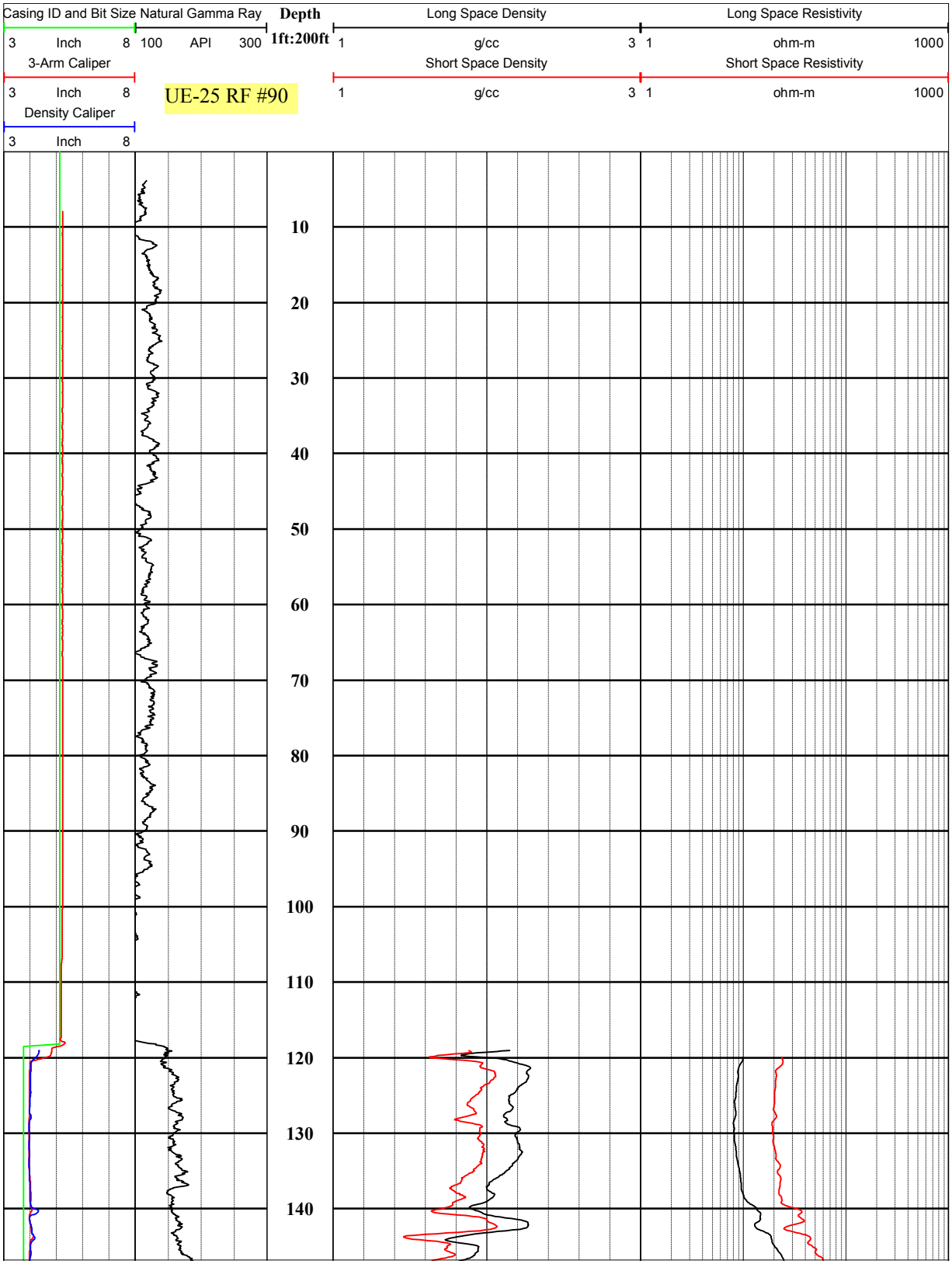

Figure RAI 2.2.1.1.1-004-47 (Sheet 1 of 3)

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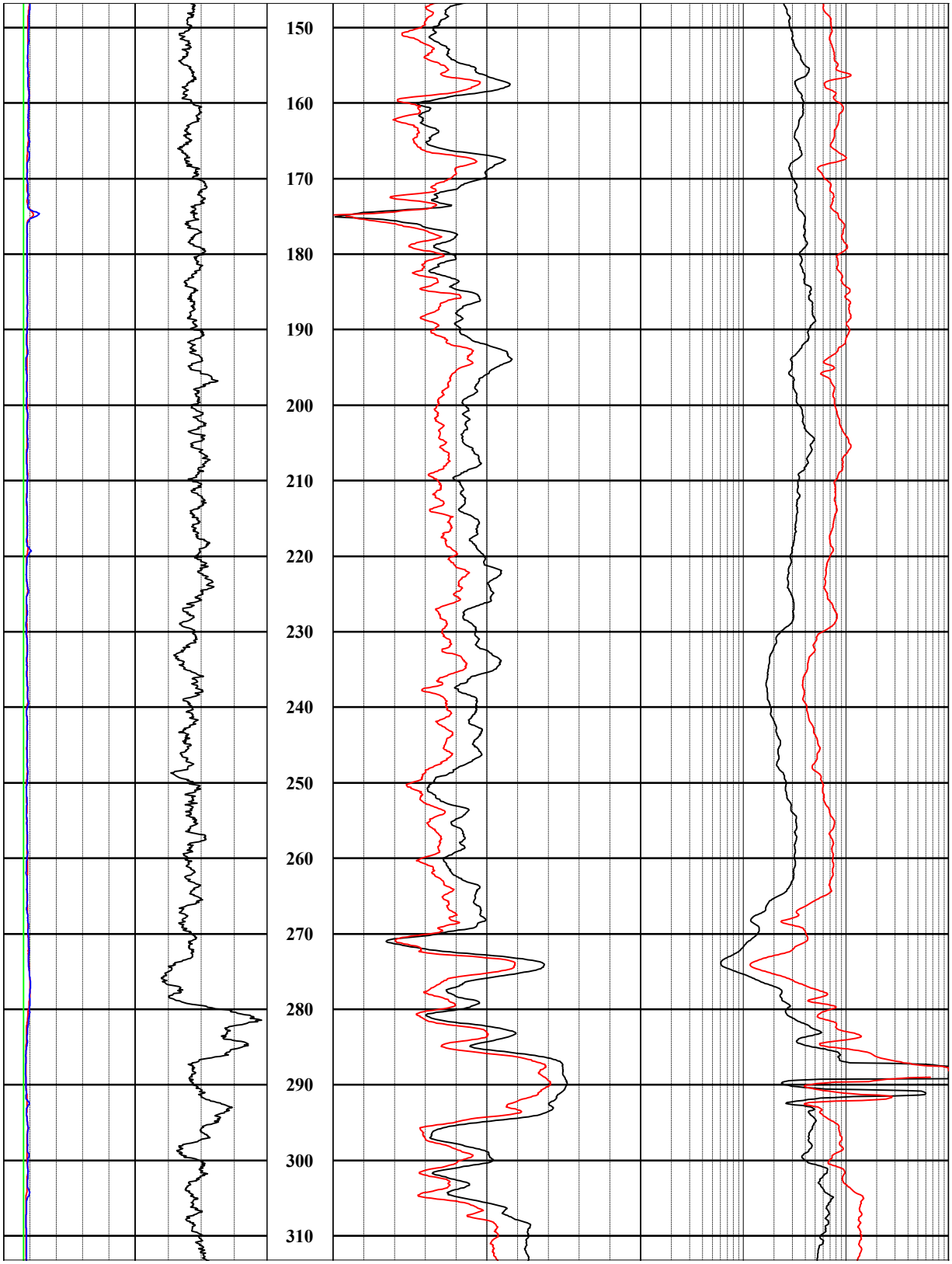

Figure RAI 2.2.1.1.1-004-47 (Sheet 2 of 3)

DTN: MO0801RFGEOLOG.002

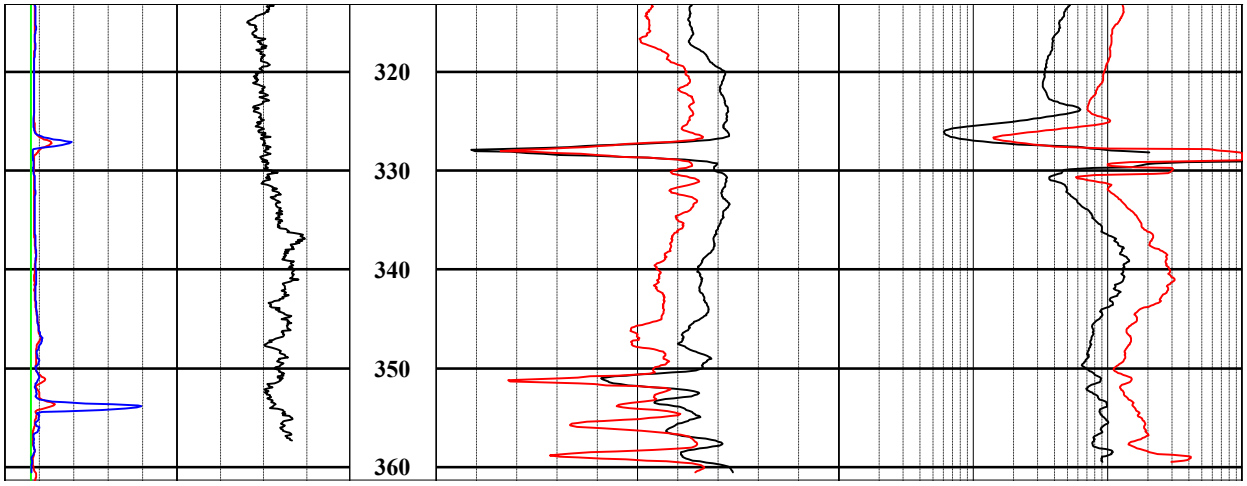

Figure RAI 2.2.1.1.1-004-47 (Sheet 3 of 3)

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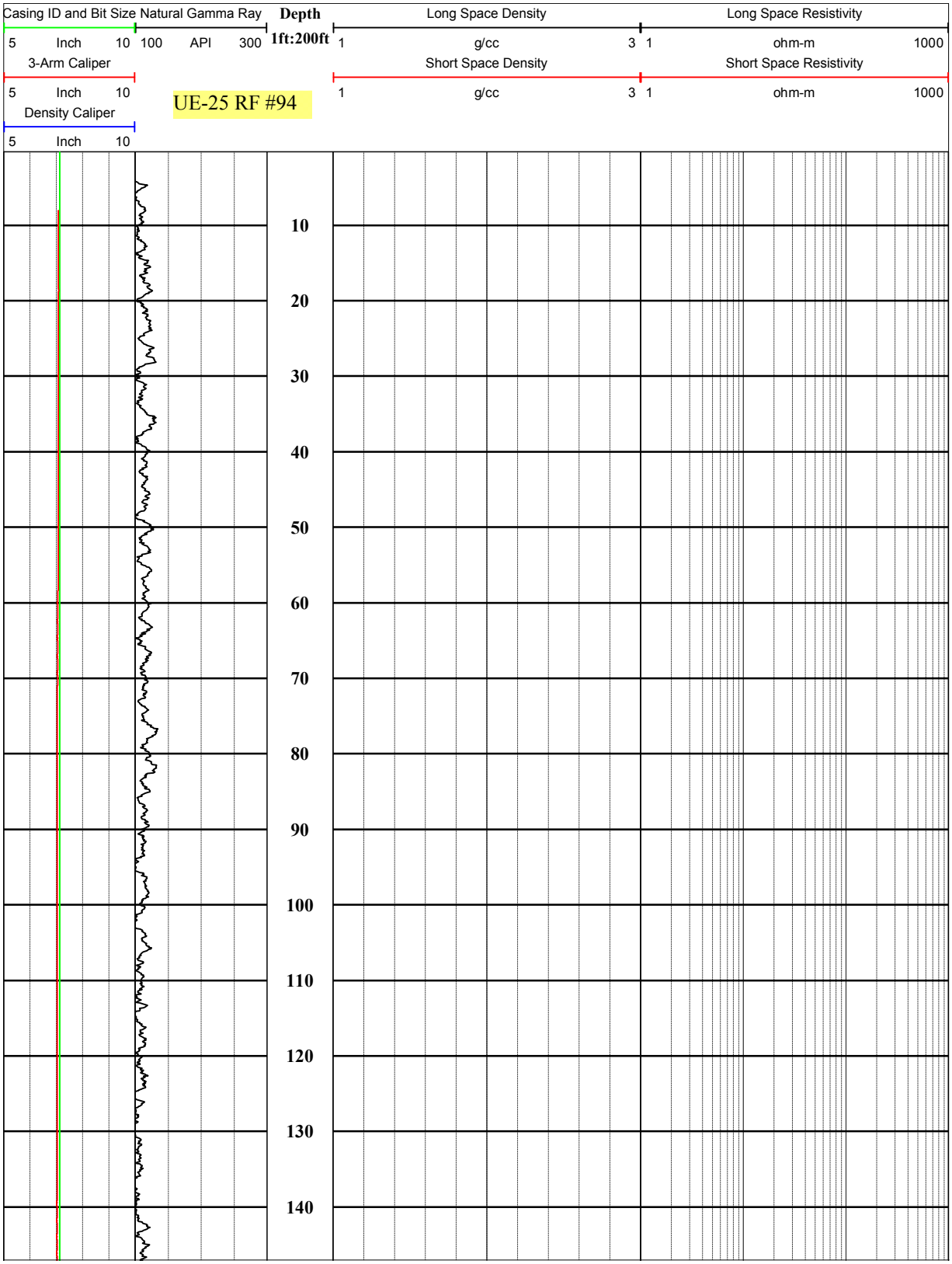

Figure RAI 2.2.1.1.1-004-48 (Sheet 1 of 5)

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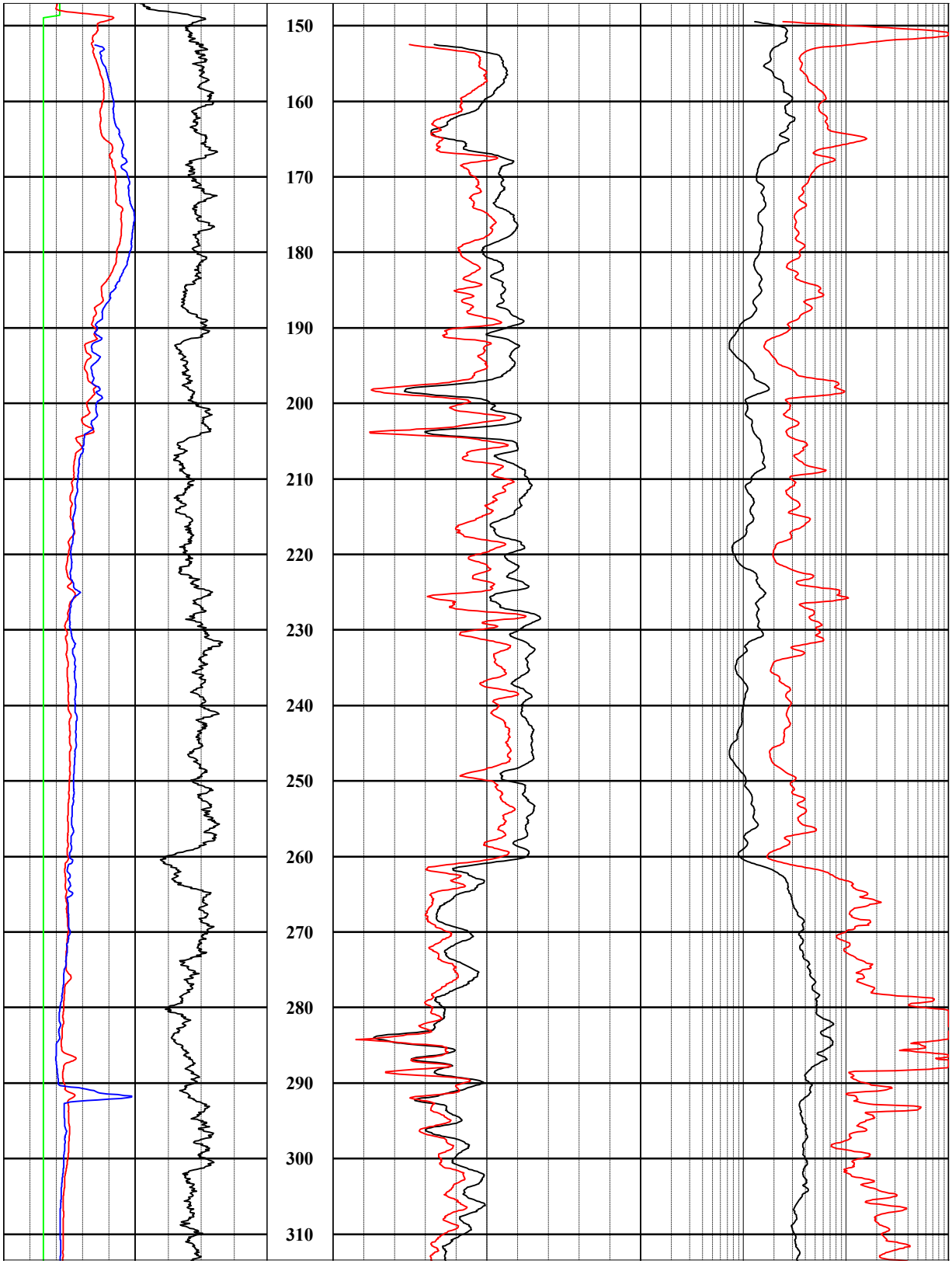

Figure RAI 2.2.1.1.1-004-48 (Sheet 2 of 5)

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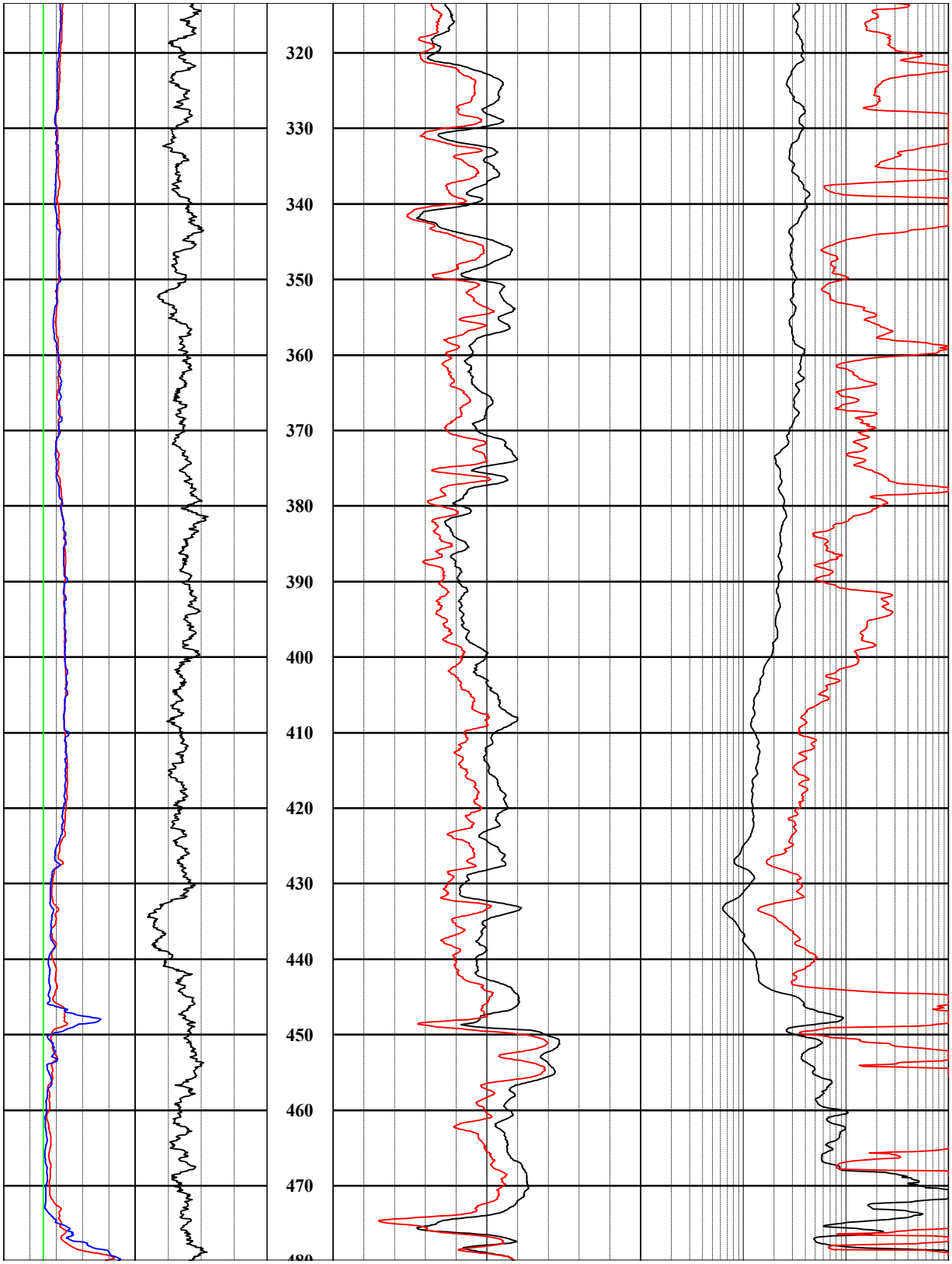

Figure RAI 2.2.1.1.1-004-48 (Sheet 3 of 5)

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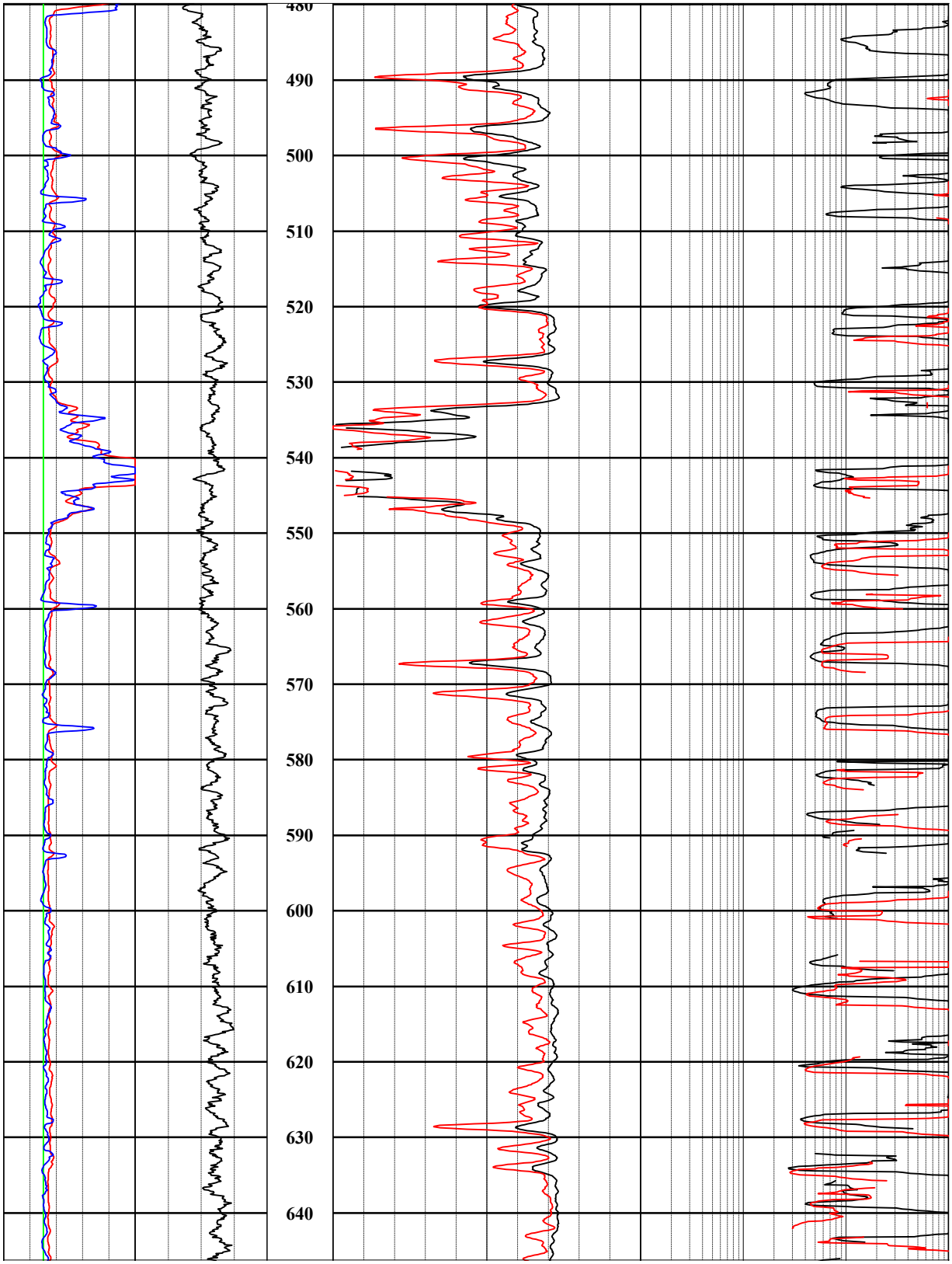

Figure RAI 2.2.1.1.1-004-48 (Sheet 4 of 5)

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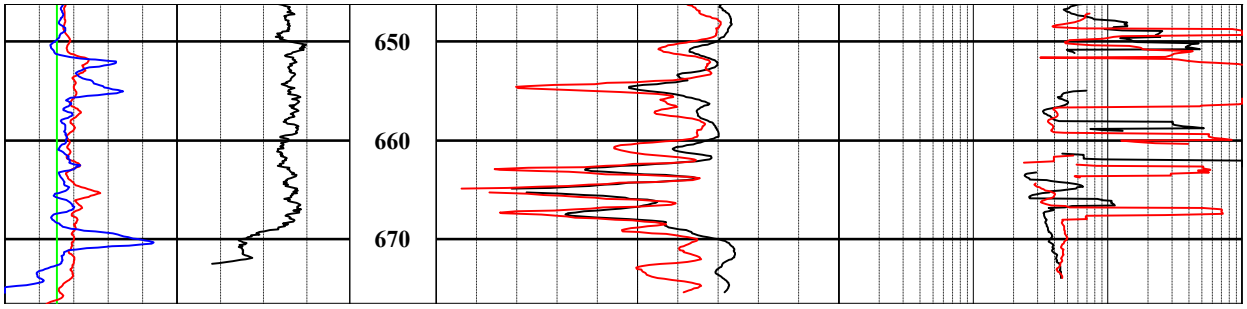

Figure RAI 2.2.1.1.1-004-48 (Sheet 5 of 5)

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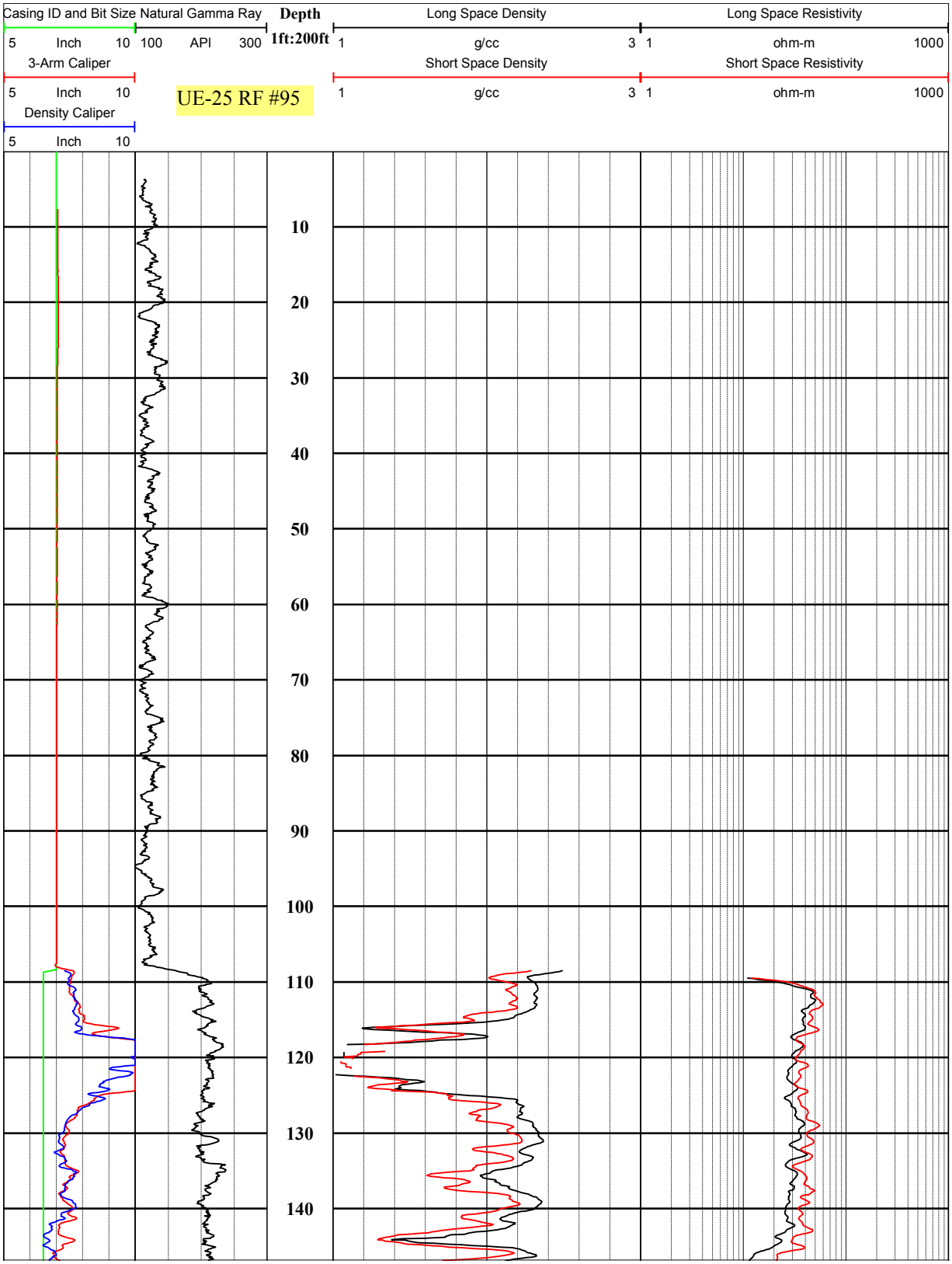

Figure RAI 2.2.1.1.1-004-49 (Sheet 1 of 4)

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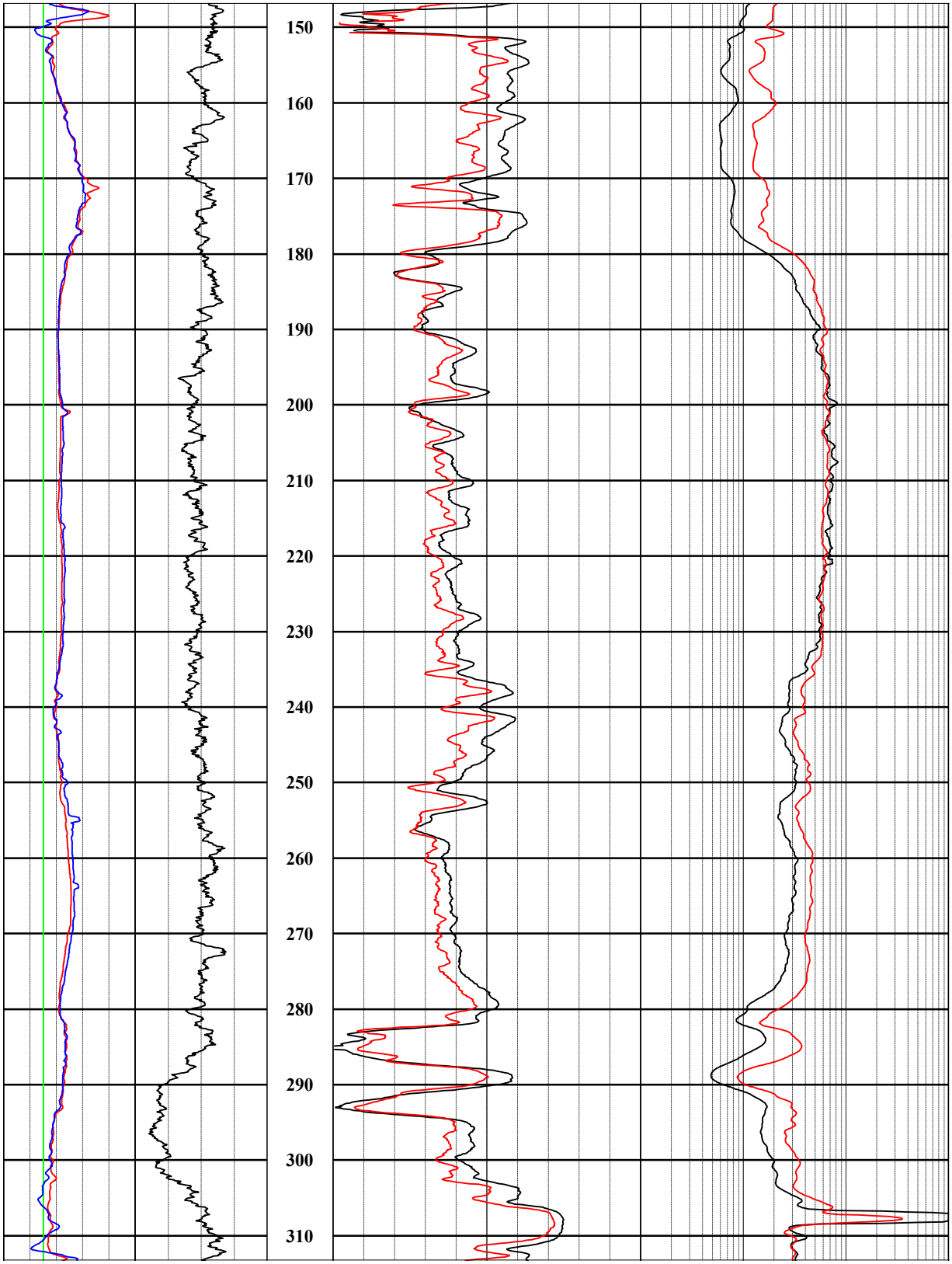

Figure RAI 2.2.1.1.1-004-49 (Sheet 2 of 4)

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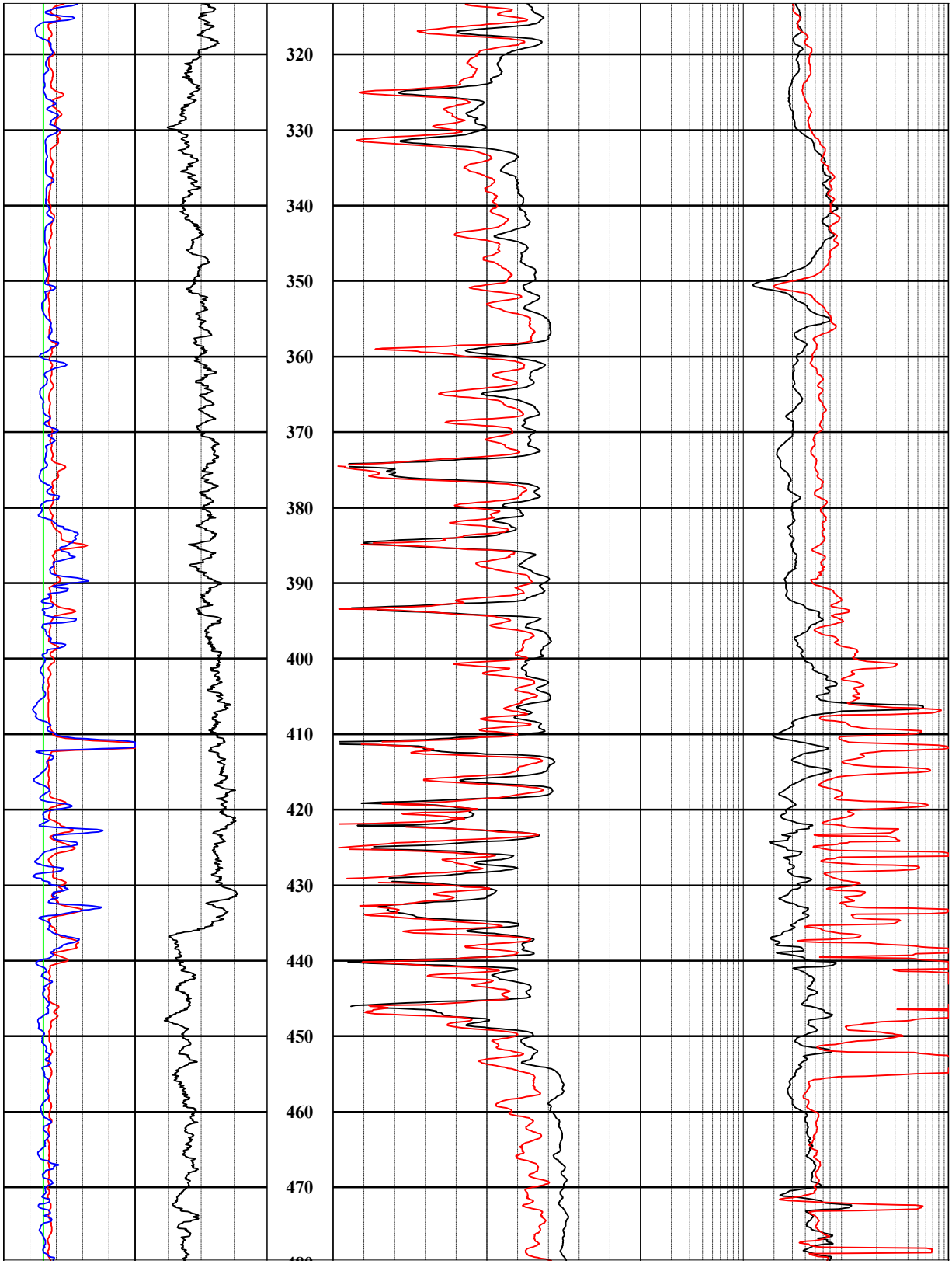

Figure RAI 2.2.1.1.1-004-49 (Sheet 3 of 4)

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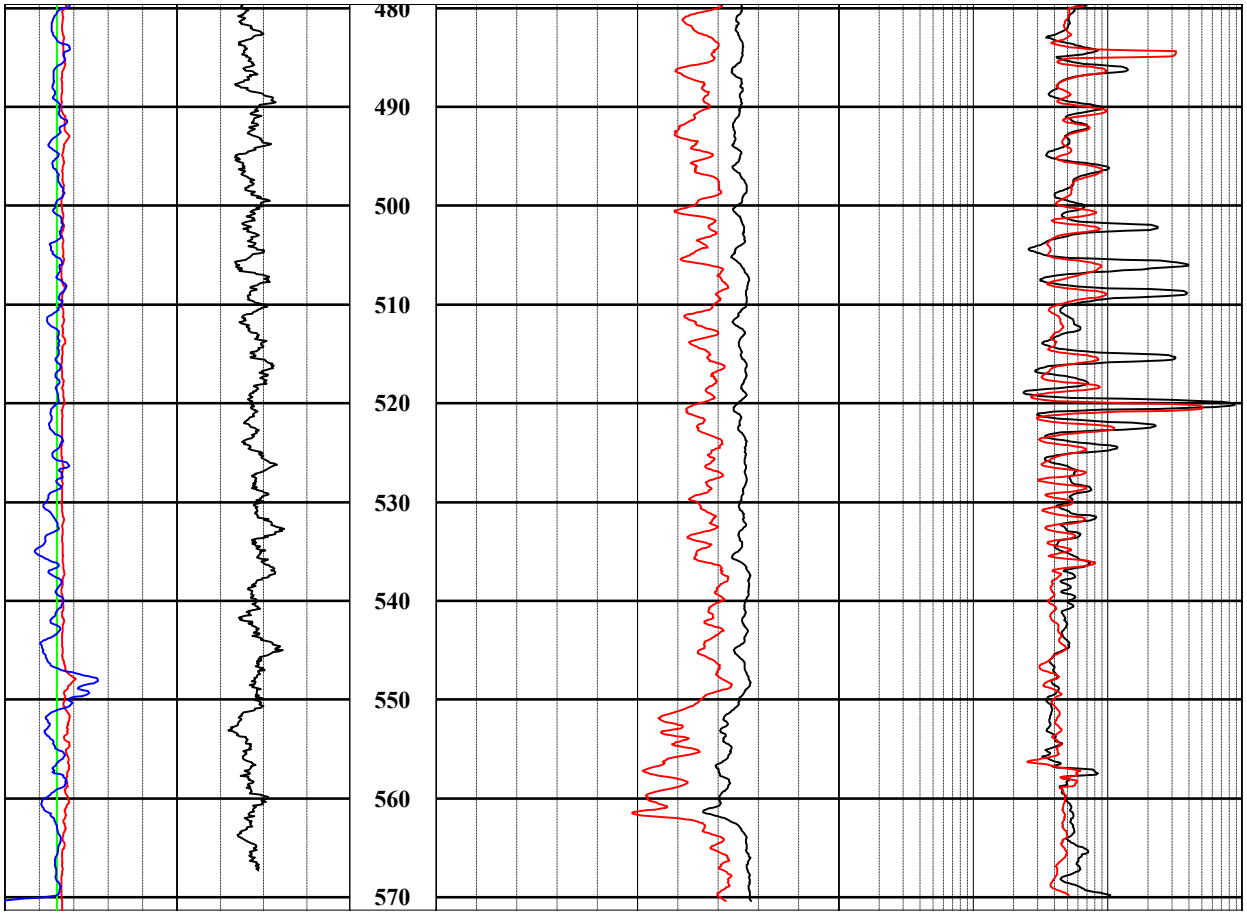

Figure RAI 2.2.1.1.1-004-49 (Sheet 4 of 4)

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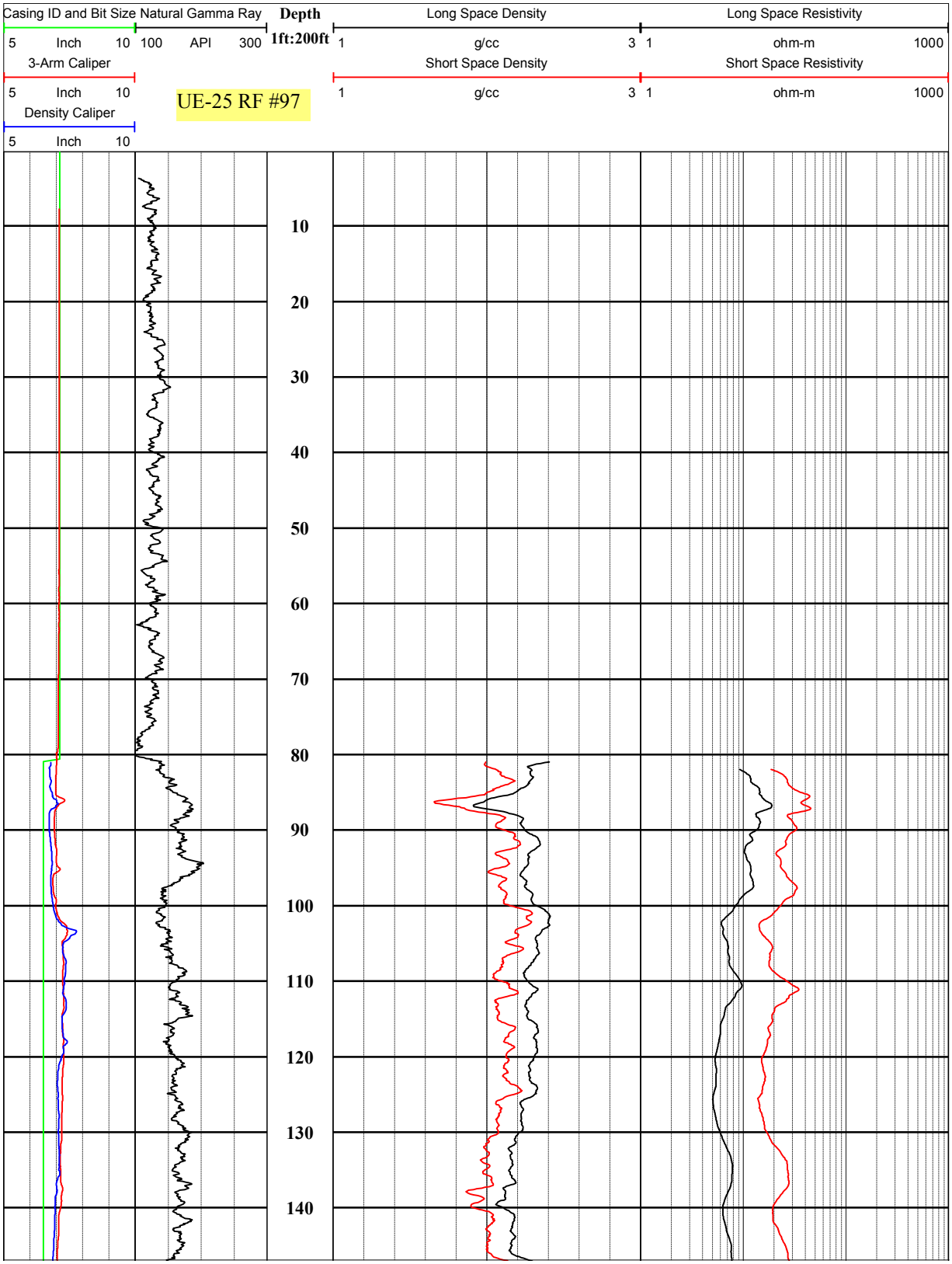

Figure RAI 2.2.1.1.1-004-50 (Sheet 1 of 4)

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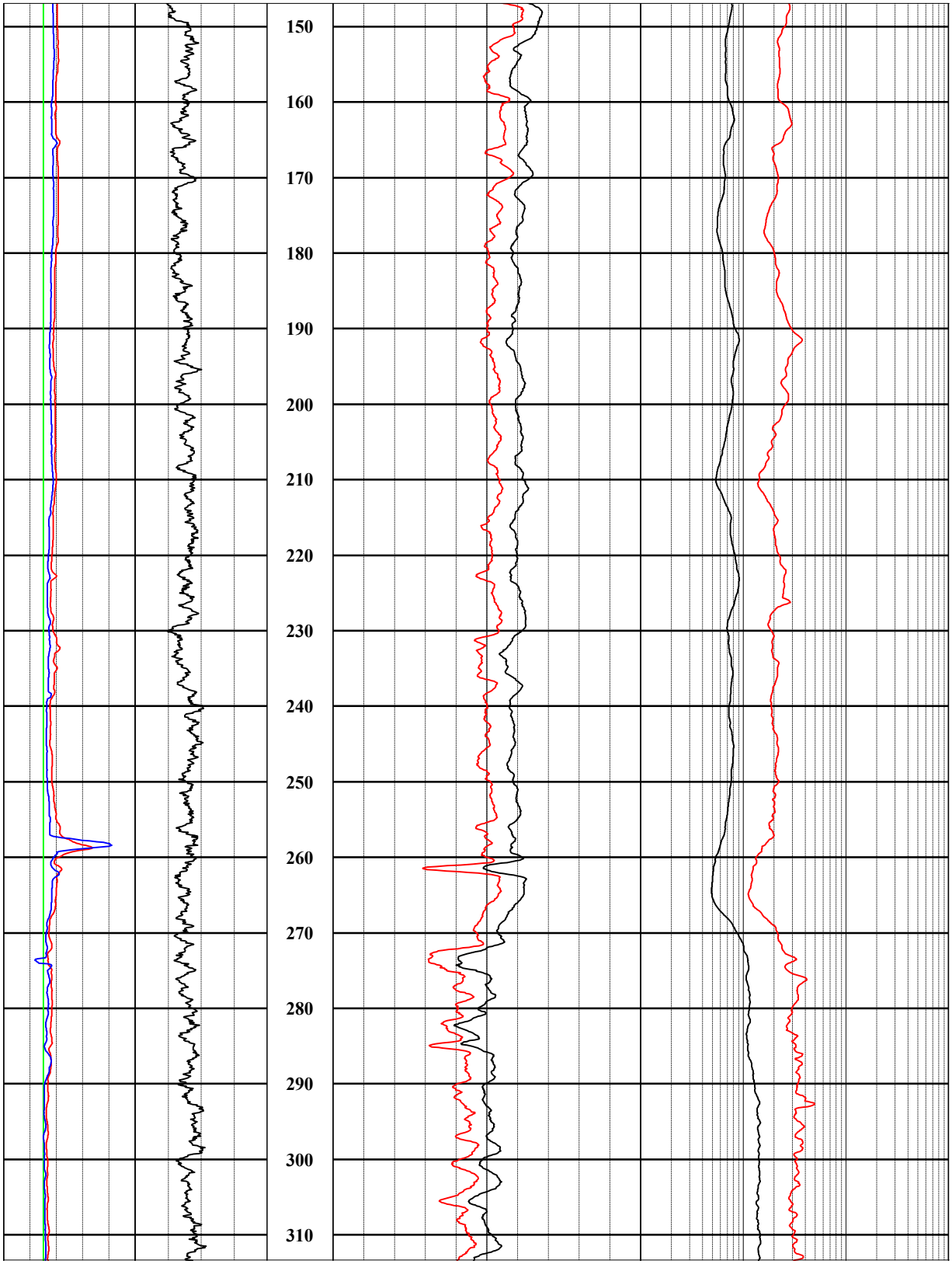

Figure RAI 2.2.1.1.1-004-50 (Sheet 2 of 4)

DTN: MO0801RFGEOLOG.002

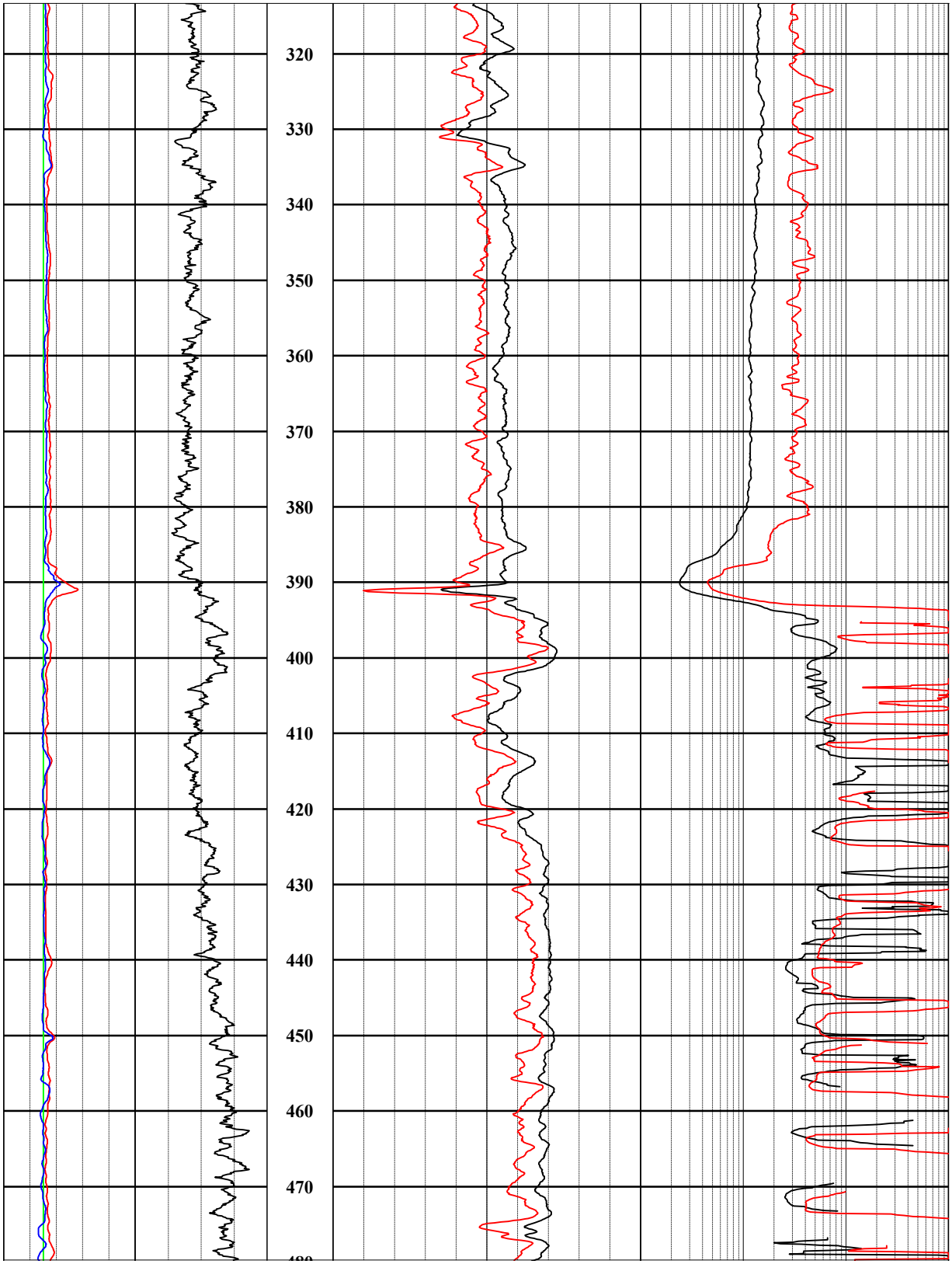

Figure RAI 2.2.1.1.1-004-50 (Sheet 3 of 4)

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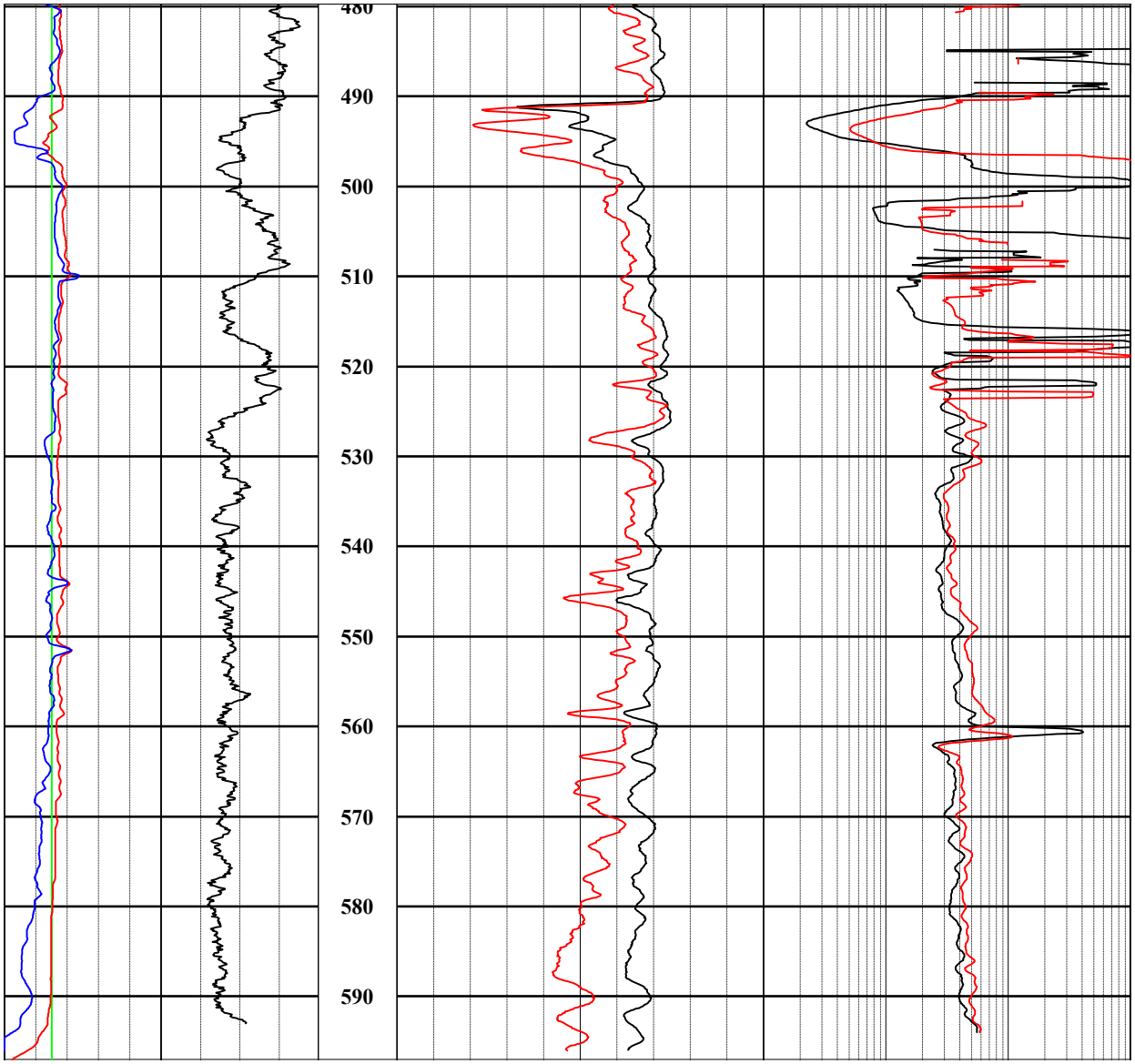

Figure RAI 2.2.1.1.1-004-50 (Sheet 4 of 4)

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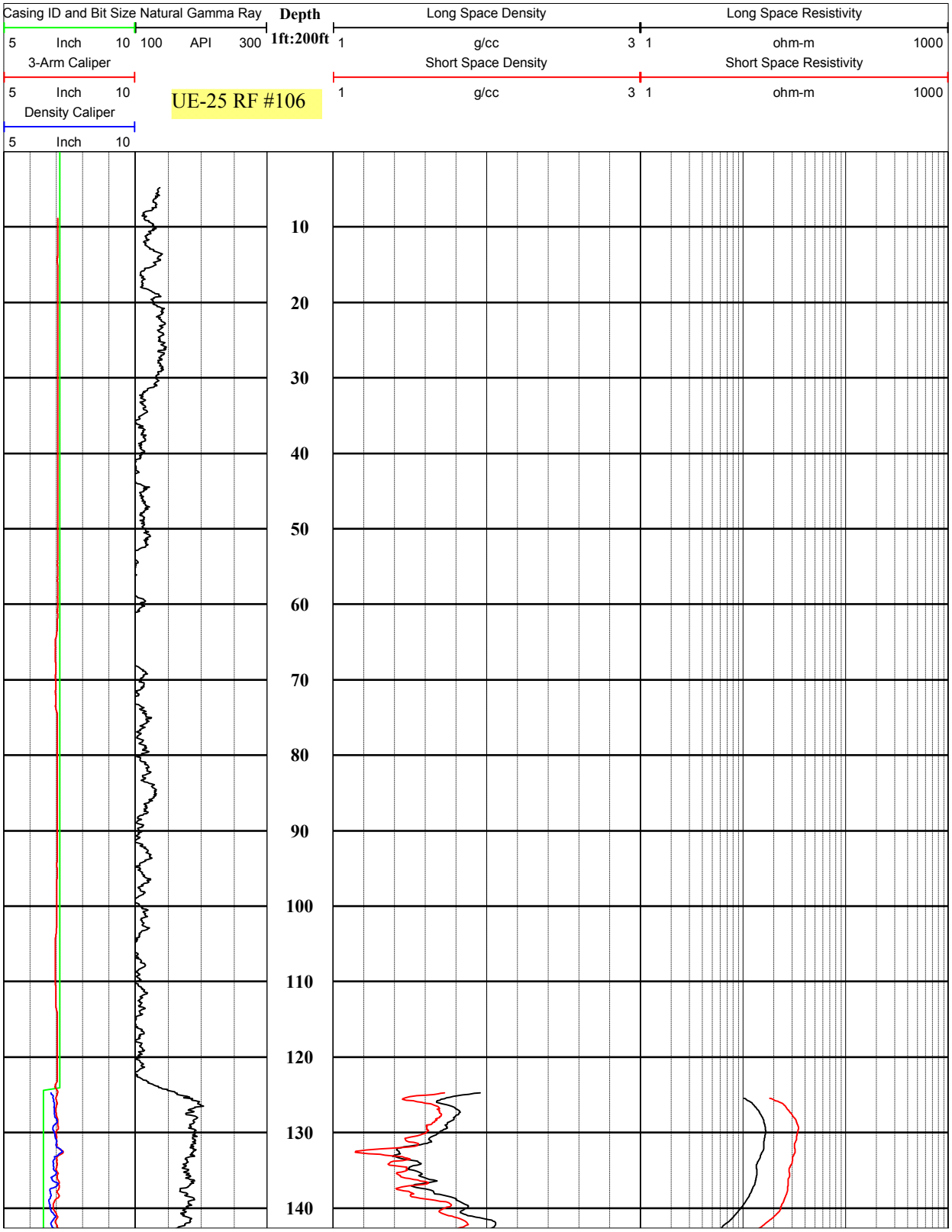

Figure RAI 2.2.1.1.1-004-51 (Sheet 1 of 3)

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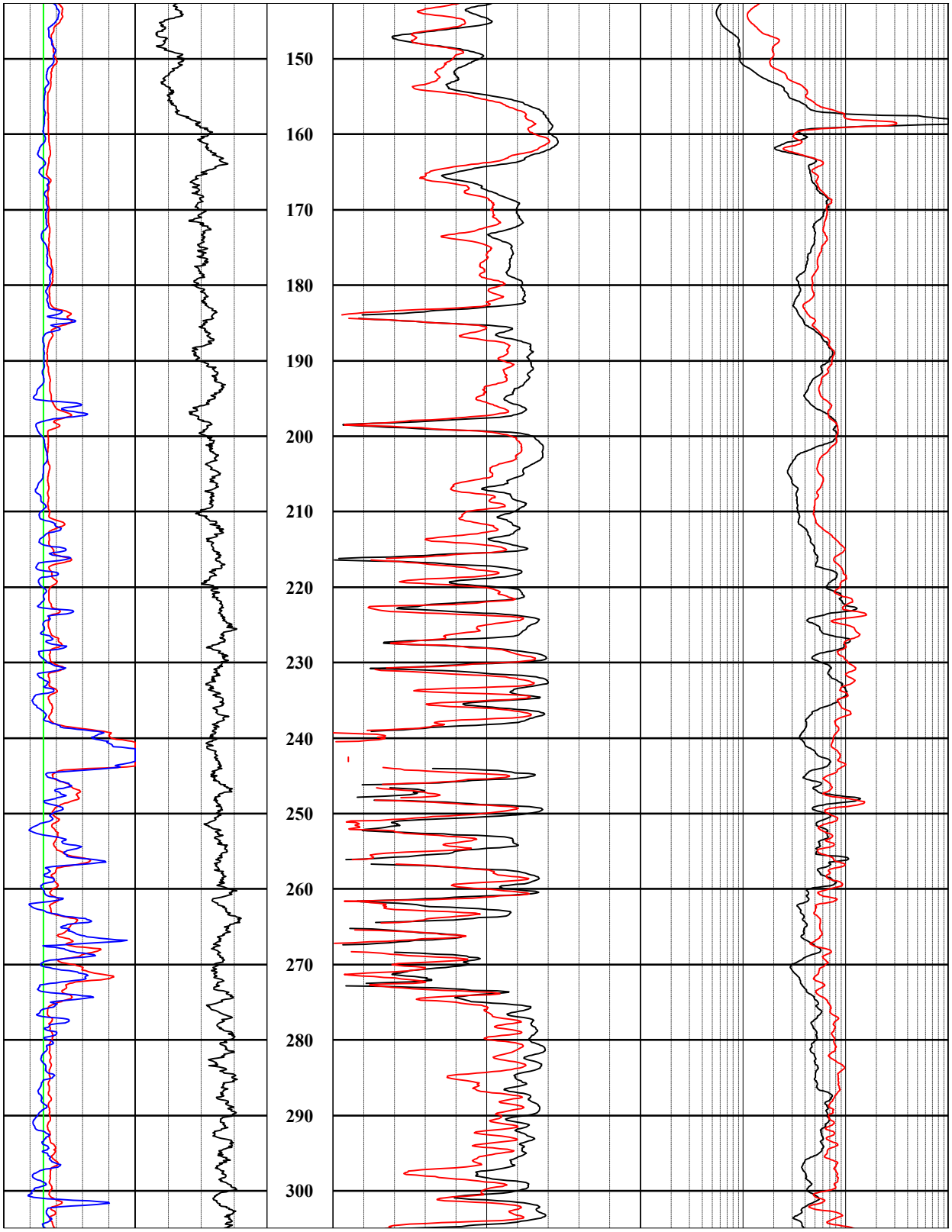

Figure RAI 2.2.1.1.1-004-51 (Sheet 2 of 3)

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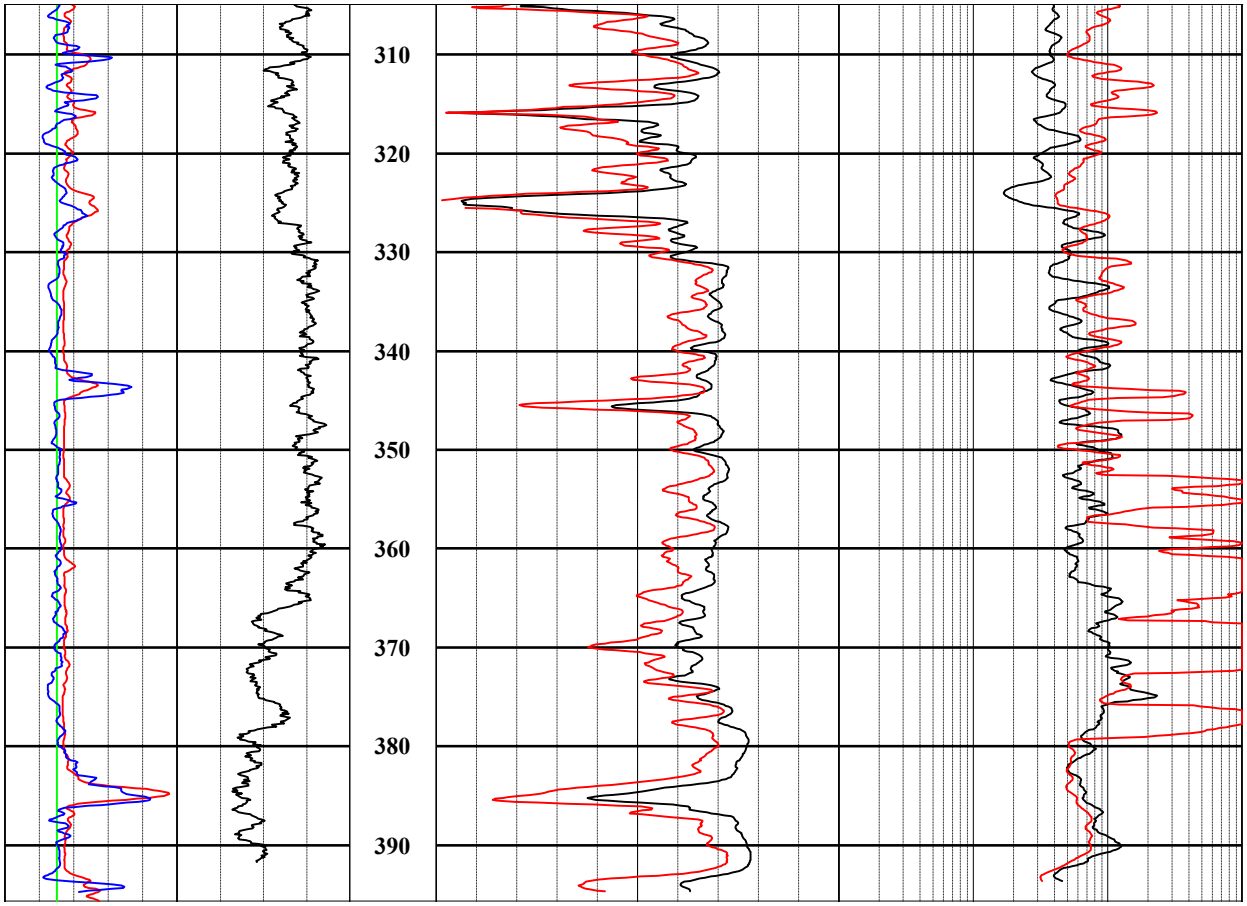

Figure RAI 2.2.1.1.1-004-51 (Sheet 3 of 3)

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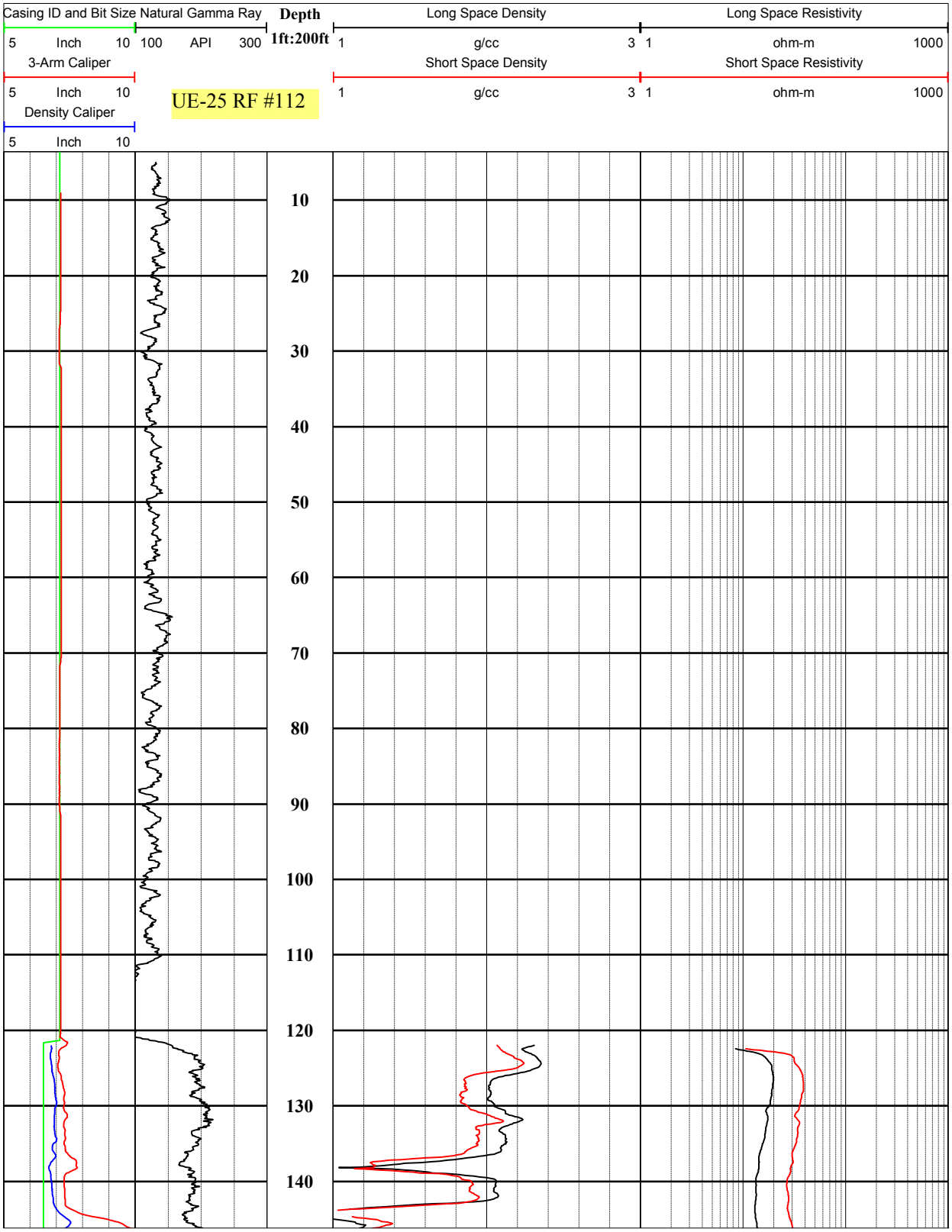

Figure RAI 2.2.1.1.1-004-52 (Sheet 1 of 3)

DTN: MO0801RFGEOLOG.002

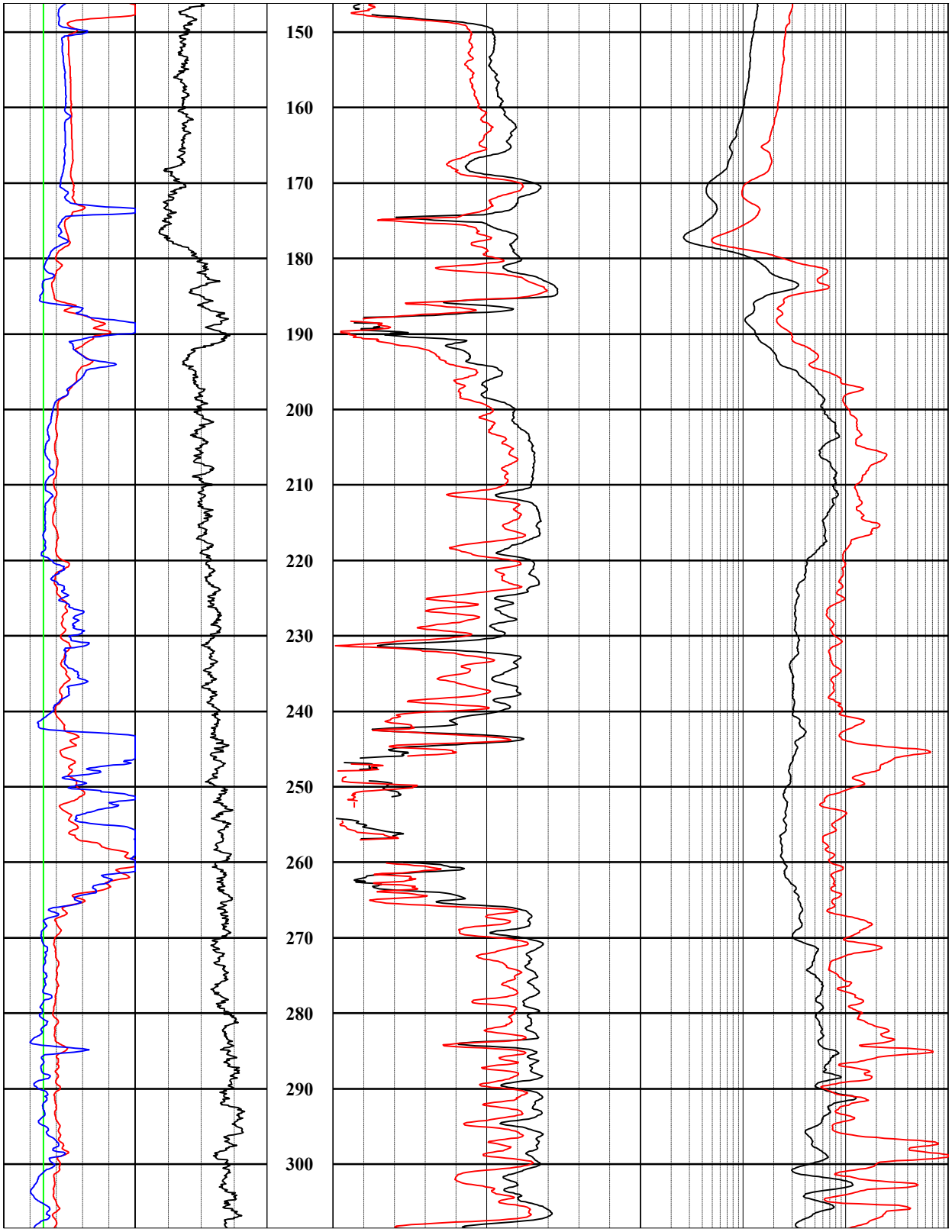

Figure RAI 2.2.1.1.1-004-52 (Sheet 2 of 3)

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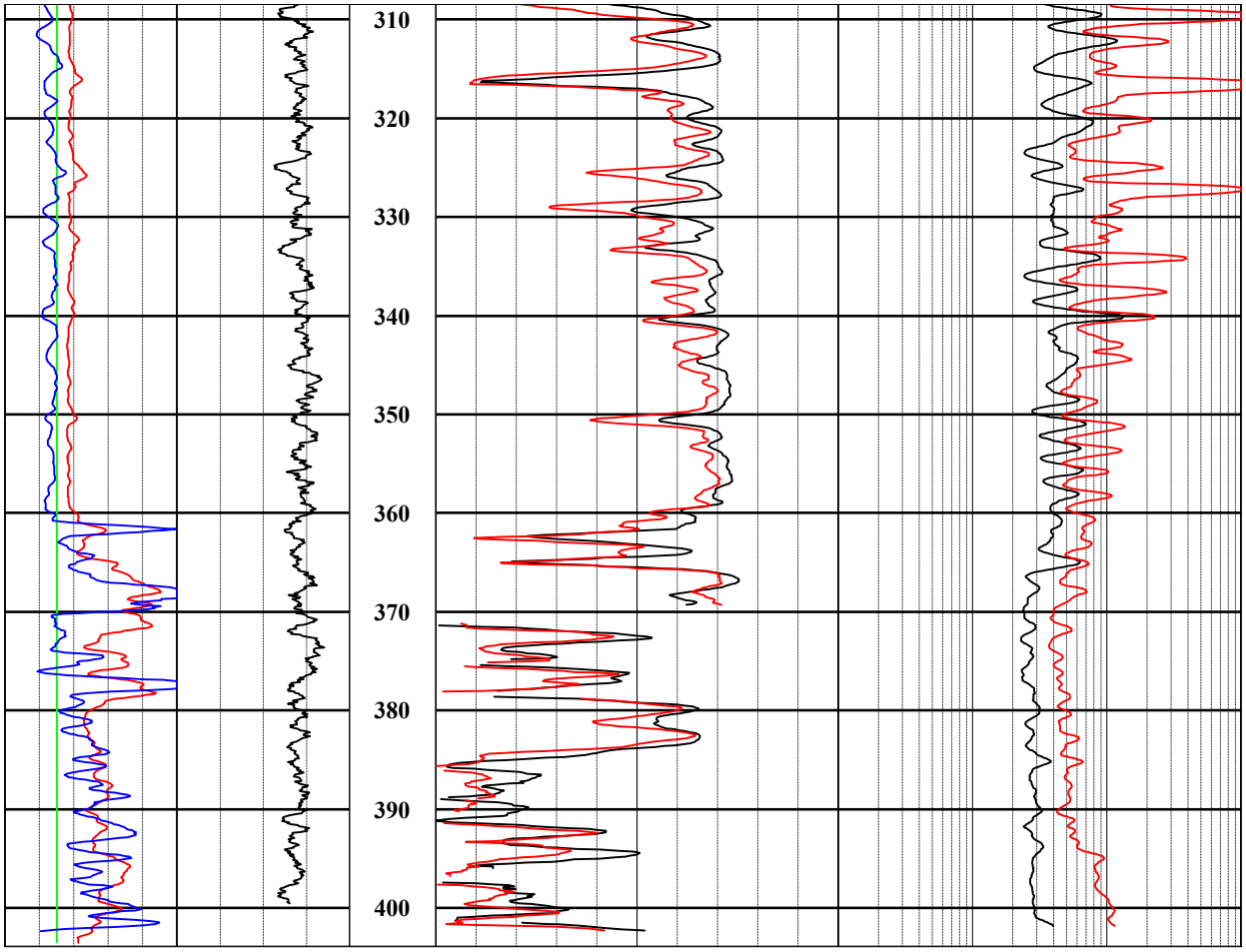

Figure RAI 2.2.1.1.1-004-52 (Sheet 3 of 3)

DTN: MO0801RFGEOLOG.002

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 5: Provide additional technical bases to support the conclusion in SAR Section 1.1.5.2.7.2 that the thirteen profiles used to model shear wave (V_S) and compression wave (V_P) velocities in the subsurface strata beneath Midway Valley account for the full range of variability and uncertainty in subsurface material properties of the tuff and alluvium layers underlying the GROA. This information should include additional technical bases to justify that impedance contrasts between densely welded and weakly to moderately welded tuffs, and between tuff and alluvium, are accounted for in the site response analysis (SAR Section 1.1.5.2.5.2).

In SAR Section 1.1.5.2.7.2 (pages 1.1-97-1.1-99), the applicant states that thirteen shear wave velocity profiles were developed for site response modeling to represent the variability of subsurface conditions beneath the GROA. From these base case profiles, the applicant developed a suite of sixty randomized site response V_S and V_P profiles that were used in the site response modeling (BSC 2008[c] – SAR Section 1.1.10). The applicant concludes that these sixty randomized site response V_S and V_P profiles represent the full variability and uncertainty of V_S and V_P in near subsurface of Midway Valley. It is not clear, from the information presented in the SAR and in BSC 2008, whether the changes in the site response ground motions due to impedance contrast between densely welded and weakly to moderately welded tuffs layers is fully accounted for by the applicant's approach. The information is required to verify compliance with 10 CFR 63.21(c)(1)(ii), 10 CFR 63.112(c) and 10 CFR 63.114(a), (b).

1. RESPONSE

This response clarifies the technical basis supporting the conclusion that the 13 base-case velocity profiles for the surface geologic repository operations area (GROA), used to model shear-wave velocity (V_S) and compression-wave velocity (V_P) profiles for site-response analysis, account for the full range of uncertainty and variability in site properties. Also included in this response is the technical basis that the site-response analysis adequately accounts for impedance contrasts between densely and weakly-to-moderately welded tuffs and between alluvium and tuff.

1.1 VARIABILITY AND UNCERTAINTY IN ALLUVIUM AND TUFF

The technical bases to support the conclusion in SAR Section 1.1.5.2.7.2 that the 13 profiles used to model V_S and V_P account for the full range of variability and uncertainty in the alluvium and tuff underlying the surface GROA are provided below.

As described in Section 6.4.2 of BSC 2008c in SAR 1.1.10[1], the objective of the site response analyses is to incorporate the effects of the site materials (tuff and alluvium) on ground motions at (1) the depth of the waste emplacement drifts in the repository block and at (2) the ground surface of the surface GROA. For each of these sites, a single set of ground motion hazard curves and related ground motion inputs are developed. These products are developed such that

they are applicable at any location within the overall repository block site or the overall surface GROA site, respectively.

1.1.1 Treatment of Uncertainty and Variability

Major inputs into the site response model are the V_S and V_P profiles for each site. Profiles are developed that appropriately represent the uncertainty and variability in velocities. Three types of uncertainty and variability are addressed:

- Epistemic (knowledge) uncertainty
- Deterministic variability
- Aleatory (random) variability

The term "epistemic uncertainty" is used for the case in which available data allow alternate interpretations of the mean velocity profile. For the surface GROA, this situation occurs in the area south of the Exile Hill Fault splay.[2] For this area, different velocity measurement techniques indicate different mean V_S values over some depth ranges. Thus, alternate base-case V_S profiles are developed to represent this uncertainty in the actual in situ properties. Based on the degree to which each alternate interpretation is supported by the available data, weights are assigned.[3] For the repository block, available velocity data do not lead to the incorporation of epistemic uncertainty in the development of base-case velocity profiles.[4]

The term "deterministic variability" is used for the case in which the mean velocity profile varies spatially in a systematic and known manner. For the surface GROA, this situation occurs for velocities on each side of the Exile Hill Fault splay.[5] The mean velocity profile to the northeast of the splay differs systematically from the one to the south. In addition, the varying thickness of alluvium underlying the surface GROA represents deterministic variability. This is also the case for the repository block.[6] The V_S at the approximate depth of the waste emplacement level varies systematically resulting in two velocity areas. One area is subdivided into three zones based on geology and is characterized by a relatively "stiff" mean velocity profile; the other area consists of a single zone and is characterized by a relatively "soft" velocity profile.[7]

Aleatory variability results from the random variation of velocity properties that is observed in situ. Even for spatial regions that exhibit a consistent mean velocity profile, variability exists from location to location.

Each type of variability and uncertainty is treated differently in the development of site-specific ground motions.

- Aleatory variability is accommodated in site-response modeling by using each base-case profile as the basis for stochastically generating 60 profiles that are random, but consistent with the mean profile.[8] In stochastically generating the profiles, site-specific information on the correlation between velocity and layer thickness is used.[9] The site-response model is run for each of the 60 velocity profiles and the resulting response spectra or amplification factors (transfer functions) are averaged taking the results as lognormally distributed.

- Epistemic uncertainty is accommodated by first developing site-specific mean ground motion hazard curves for each alternate interpretation. Development of these hazard curves makes use of the transfer functions that accommodate aleatory variability. Then, for a given level of ground motion, the mean probabilities of exceedance for the alternate hazard curves are averaged using the weights assigned to the different interpretations to produce the final hazard curve.

- For deterministic variability, site-specific hazard results are enveloped to develop a single set of ground motions for the repository block site and the surface GROA site. That is, first site-specific hazard curves are developed for cases based on the mean velocity profiles for the different spatial areas (repository block and surface GROA) and different alluvium thickness values (surface GROA only), taking into account aleatory variability and epistemic uncertainty. Then, for each value of ground motion, the mean probability of exceedance associated with the repository block or surface GROA hazard curves is examined and the larger value is chosen for the site-wide repository block and site-wide surface GROA hazard curve, respectively.

This treatment of epistemic uncertainty and aleatory variability is appropriate for the determination of mean seismic hazard and associated ground motion inputs. Enveloping of mean probabilities of exceedance for hazard curves representing deterministic variability provides results that are applicable at any location within each site. Because enveloping is used to obtain a site-wide result, the site-wide hazard is conservative (higher probability of exceedance) for portions of each site.

1.1.2 Base-Case Velocity Profiles for the Surface GROA

Based on the available velocity data and the geologic framework of the site, 13 base-case velocity profiles for the surface GROA are developed: a base case for tuff northeast of the Exile Hill Fault splay combined with four representative values for alluvium thickness (30, 70, 100, and 200 ft) and three base cases for tuff south of the Exile Hill Fault splay, each combined with three representative values of alluvium thickness (30, 70, and 100 ft).[10] The different base-case tuff profiles across the Exile Hill Fault splay and the alluvium thickness values represent deterministic variability. South of the Exile Hill Fault splay, alternate interpretations of the mean tuff V_S profile represent epistemic uncertainty. Aleatory variability is accommodated for each base-case profile by using the profile to stochastically generate 60 profiles that are used in site-response modeling. The resulting transfer functions are used to develop the site-specific hazard curves for each combination of epistemic uncertainty and deterministic variability.

Velocity data for the site, which forms the basis for the developed velocity profiles, were acquired using a range of techniques: spectral analysis of surface waves (SASW) surveys, downhole seismic velocity surveys, suspension logging surveys, sonic velocity logging, and vertical seismic profiling. SASW surveys provide information on the average velocity along the length of the survey line. Borehole-based techniques complement the SASW data and provide information on velocities in the immediate vicinity of the borehole. Geologic data are used to provide insights on the areas or zones in which various representative mean velocity profiles apply. Thus, the base-case profiles accommodate alternate interpretations (epistemic uncertainty)

that result from measurement techniques having different resolution and averaging properties. Base-case profiles also accommodate deterministic spatial variability in velocity properties and alluvium thickness. Randomness (aleatory variability) in the geology and non-uniqueness in the geophysical interpretation are accommodated in the aleatory component of the site response. The same principles used to address variability and uncertainty in velocity profiles for the surface GROA are also applied in developing site-specific hazard curves and ground motion inputs for the repository block.

1.2 IMPEDANCE CONTRASTS

The impedance contrasts between the densely welded and weakly-to-moderately welded tuffs and between the tuff and alluvium are appropriately accounted for in the site-response analysis. This conclusion is reached because contrasts based on velocity data are variable in amplitude, vary spatially, and generally show a poor correlation to lithostratigraphic contacts.

An impedance contrast at an interface is a function of the velocity and density of the two adjacent layers. Impedance contrasts are examined to first-order in terms of seismic velocity contrasts. The examination is focused on two important layer boundaries identified in *Preliminary Evaluation and Analysis of the U.S. Department of Energy Geotechnical Data for the Waste Handling Building Site at the Potential Yucca Mountain Repository*[11] for the surface GROA. One boundary is between the alluvium (Qal) and underlying nonwelded tuff (Timber Mountain Group, pre-Rainier Mesa Tuff bedded tuff, Tmbt1). The other is between the moderately welded Tiva Canyon Tuff–crystal-poor upper lithophysal zone (Tpcpul) and the densely welded Tiva Canyon Tuff–crystal-poor middle nonlithophysal zone (Tpcpmn).

Examination of the 2000 to 2001 downhole and suspension V_S profiles for northeast of the Exile Hill Fault splay[12] shows no evidence for a stable and uniformly distributed impedance contrast between densely welded and weakly-to-moderately welded tuffs (taken as the contact between the Tiva Canyon Tuff–crystal-poor upper lithophysal unit and the Tiva Canyon Tuff–crystal-poor middle nonlithophysal unit). (Note that not all boreholes and none of the SASW surveys from this data set sample the target contact.) Velocity contrasts are observed in the profiles, but their correlation with lithostratigraphic contacts is inconsistent. South of the fault splay, a velocity contrast at the target contact is also not observed consistently.[13] (Note again that not all boreholes and SASW surveys from this area sample the target lithostratigraphic contact.) Velocity data from borehole and SASW surveys in this area do show velocity contrasts as a function of depth, but the contrasts do not show a consistent correlation with lithostratigraphic boundaries. Rather, they vary laterally in depth and amplitude on the scale of borehole separation distances (hundreds of feet). Thus, for the surface GROA, a stable and laterally coherent impedance contrast between the densely and weakly-to-moderately welded tuffs is not supported by the available velocity data.

The lack of stable and laterally persistent velocity contrasts in the Tiva Canyon Tuff units beneath the surface GROA is reasonable. Faulting of the tuff units and variable distribution of fractures are geologic factors that contribute to the deterministic and random components of velocity variability.

The potential existence of an impedance contrast between alluvium and the underlying tuff at the surface GROA, is addressed through examination of the velocity data collected in 2000 to 2001. These data show a velocity contrast of varying amplitude at a range of depths beneath the surface GROA.[14]

Table RAI 2.2.1.1.1-005-1 lists the boreholes where downhole velocity data were collected in 2000 to 2001. The tuff/alluvium shear-wave velocity ratio was calculated for each borehole at a depth within 10 ft of the tuff/alluvium contact as identified in the borehole logs. Values of 1.0 indicate that a velocity contrast was not observed in the downhole data. The mean velocity ratio is 1.14 ± 0.21 (Table RAI 2.2.1.1.1-005-1). There is about a ± 10 ft uncertainty in identifying the tuff/alluvium contact from drill cuttings for those holes where core was not collected and similarly a ± 10 to 15 ft uncertainty in the interpretation of velocity contrasts from the downhole transit time data. Given those uncertainties, the shear-wave velocity ratio of the nearest velocity contrast to the tuff/alluvium contact was also calculated. The differences in depths between observed velocity contrasts and the estimated tuff/alluvium contact ranges up to 30 ft (Table RAI 2.2.1.1.1-005-1). Thus the velocity contrast represents the tuff/alluvium boundary in most cases but may also define a velocity contrast of other origins such as between uncemented and cemented alluvium. The mean ratio is 1.37 ± 0.24.

In most areas of the surface GROA, the alluvium overlies the ignimbrite of Comb Peak (also known as Tuff "X") or bedded tuffs (pre-Rainier Mesa Tuff bedded tuffs and pre-Tuff unit "x" bedded tuffs (also known as post-Tiva Canyon Tuff bedded tuffs)). These units have similar velocities as the alluvium. Thus, the velocity contrast is generally close to 1. In no case does the tuff/alluvium velocity contrast exceed a value of 2 beneath the surface GROA based on the available velocity data. The thickness of the alluvium at the surface GROA also varies from less than about 30 ft south of the Exile Hill Fault splay to about 200 ft north of the fault splay. Thus the tuff/alluvium contact varies with depth across the surface GROA.

The effects of random impedance contrasts are incorporated into the site response as evidenced by a sample of the randomized velocity profiles.[15] Because stable and uniform impedance contrasts beneath the surface GROA are absent, a probabilistic treatment in the site-response analysis is appropriate. One-dimensional deterministic site-response analysis using velocity profiles derived from average unit velocities and a geologic model are not representative of the variable velocity structure beneath the surface GROA, which has both deterministic and random components.

The site-response analysis is performed for the range of site conditions beneath the areal extent of the surface GROA, which includes impedance contrasts of variable amplitudes and depths. Thus the consideration of 13 base-case velocity profiles to address epistemic uncertainty and deterministic variability and randomization of the profiles to address aleatory variability is the appropriate approach in developing the design ground motions based on mean hazard.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company, ACC: DOC.20080221.0001.

[2] Ibid., Section 6.4.2.5.1

[3] Ibid., Section 6.4.5.1.

[4]Ibid., Sections 6.4.2.6 and 6.4.2.9.

[5] Ibid., Section 6.4.2.5.1

[6] Ibid., Section 6.4.2.6.

[7] Ibid.

[8] Ibid., Section 6.4.2.9.

[9] Ibid., Section 6.4.2.10.

[10] Ibid., Table 6.4-13 and Figures 6.4.2-44 to 6.4.2-56 and 6.4.2-64 to 6.4.2-76.

[11] Gonzalez, S.H., Stamatakos, J.A., Murphy, K.R., and McKague, H.L., 2004. *Preliminary Evaluation and Analysis of the U.S. Department of Energy Geotechnical Data for the Waste Handling Building Site at the Potential Yucca Mountain Repository*. San Antonio, Texas: Center for Nuclear Waste Regulatory Analysis, Section 3.3, page 3-11.

[12] BSC 2002. *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project*. ANL-MGR-GE-000003 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021004.0078, Figures 8, 10, VII-5 and VII-7.

[13] Ibid., Figures 4, 5, 7, 9, VII-1, VII-2, VII-4, and VII-6.

[14] Ibid., Figures 4 to 19.

[15] BSC 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-95.

Table RAI 2.2.1.1.1-005-1. Tuff/Alluvium Shear-Wave Velocity Ratio from 2000 to 2001 Downhole Velocity Data

Borehole	Shear-Wave Velocity Ratio within 10 Feet of the Contact	Shear-Wave Velocity Ratio Closest to Contact	Approximate Difference in Depth (ft)
UE-25 RF#13	1.00	1.35	-15
UE-25 RF#14	1.00	1.43	10
UE-25 RF#15	1.00	1.40	30
UE-25 RF#16	1.00	1.71	-25
UE-25 RF#17	1.27	1.27	5
UE-25 RF#18	1.00	1.74	-10
UE-25 RF#19	1.00	1.19	-20
UE-25 RF#20	1.00	1.39	-25
UE-25 RF#21	1.00	1.30	-30
UE-25 RF#22	1.61	1.61	5
UE-25 RF#23	1.36	1.36	-5
UE-25 RF#24	1.35	1.35	-10
UE-25 RF#25	1.00	0.71	20
UE-25 RF#26	1.00	1.48	15
UE-25 RF#28	1.52	1.52	-5
UE-25 RF#29	1.18	1.18	-5
Mean and Sigma	1.14 ± 0.21	1.37 ± 0.24	14.7 ± 9

NOTE: The mean for the “Approximate Difference in Depth” is calculated from the absolute values of the data listed.

Source: BSC 2002, *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project* (Figures 4 to 19).

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 6: Explain how the two reference rock outcrop conditioned seismic hazard curves, one based on the shear-strain-threshold approach, and the other based on the extreme-stress-drop approach, are combined to produce hazard curves shown in SAR Figures 1.1-79 and 1.1-80.

In Appendix A4.5.3 of BSC 2008[c] (SAR Section 1.1.10 General References), the applicant states that the final conditioned mean seismic hazard curves are developed by combining the conditioned hazard curves using both the shear-strain-threshold approach and the extreme-stress-approach. However, the applicant has not explained the method used to combine these hazard curves to develop SAR Figures 1.1-79 and 1.1-80. The information is needed to verify compliance with §10 CFR 63.21(c)(1)(ii), 10 CFR 63.112(c), and 10 CFR 63.114(g).

1. RESPONSE

Combined conditioning of seismic hazard curves for the probabilistic seismic hazard analysis reference rock outcrop is accomplished by applying the two conditioning approaches in series (BSC 2008c in SAR 1.1.10[1]). First, the probabilistic seismic hazard analysis reference rock outcrop hazard is conditioned using the extreme-stress-drop approach. Next, the extreme-stress-drop-conditioned hazard curve is conditioned using the shear-strain-threshold approach. Thus, conditioning related to the seismic source is applied first, followed by conditioning related to site characteristics. The output of the second step provides the final conditioned seismic hazard curves (e.g., SAR Figures 1.1-79 and 1.1-80) used in developing site-specific ground motions.

Details regarding implementation of the two conditioning approaches are provided in the response to RAI 2.2.1.1.1-008.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20080221.0001; DOC.20080314.0001; DOC.20080328.0001, pp. D-30 to D-32.

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 7: Provide an updated probability distribution of threshold shear strain, similar to Fig. 6-7 of BSC 2005a, SAR Section 1.1.10 General References, used to develop SAR Figures 1.1-79 and 1.1-80 (SAR Section 1.1.5.2.5.1 and SAR Section 1.1.10, BSC 2008c Appendix A). Also, provide the updated geotechnical data (shear wave velocity and strain dependent material properties) used for conditioning reference rock-outcrop hazard curves (BSC 2008c, Section A4.5.2).

In BSC 2008c, Section A4.5.2, the applicant states that an updated approach and material properties were used for conditioning reference rock outcrop hazard curves based on the shear-strain-threshold approach. However, the applicant has not provided details of the updated approach. The information is needed to assess compliance with 10 CFR 63.21(c)(1)(ii), 10 CFR 63.112(c) and 10 CFR 63.114(g).

1. RESPONSE

This response presents information on the shear-strain-threshold probability distribution used in the updated shear-strain-threshold approach described in Section A2.2 of BSC 2008c in SAR 1.1.10.[1] It also clarifies that the updated geotechnical data forming the basis for site-response model results used to implement the conditioning approach are those described and provided in Sections 6.4.2 and 6.4.4 of BSC 2008c.

1.1 UPDATED SHEAR-STRAIN-THRESHOLD PROBABILITY DISTRIBUTION

The shear-strain-threshold approach to conditioning seismic hazard curves for Yucca Mountain recognizes that, if the level of ground motion propagating through the rock mass is high enough, the associated shear-strain increment generated in the rock would have caused it to fracture. As the type of deformation expected from such high levels of ground motion is not observed, it is concluded that the level of ground motion experienced at Yucca Mountain is limited. This level of ground motion that has not been exceeded in over 10 million years is taken as a reasonable bound to ground motion that can occur within the geologic setting of Yucca Mountain. During this time, based on the range of earthquake recurrence interval for the Solitario Canyon Fault that was assessed during the probabilistic seismic hazard analysis for Yucca Mountain (SAR Table 1.1-66), from 50 to 285 large earthquakes have occurred.

In Section 6.4.1 and Figure 6-5 of BSC 2005a in SAR 1.1.10,[2] uniaxial compression test results for 288-mm diameter samples from the Topopah Spring Tuff were interpreted in terms of the shear-strain increment from in situ conditions that is required to produce fracturing. Shear-strain increments for samples with a height-to-diameter ratio greater than 1.5 fell within the range 0.09% to 0.25%. Numerical modeling of lithophysal tuff deformation[3] corroborated the laboratory results. Based on this information, the shear-strain-increment threshold required to produce fracturing was characterized as a triangular probability distribution ranging from 0.09% to 0.25% with a mode of 0.16%.[4] The distribution represents uncertainty in the threshold value.

For the updated implementation of the shear-strain-threshold approach, a uniform distribution shown in Figure RAI 2.2.1.1.1-007-1 is used to characterize the shear-strain-increment threshold and its uncertainty.[5] The range of the distribution is maintained at 0.09% to 0.25%, but each value within the range is considered equally likely. For implementation, a two-point discrete distribution is used. Conditioning is carried out for shear-strain-increment thresholds of 0.09% and 0.25% and the resulting hazard curves are averaged using equal weights.[6]

1.2 UPDATED GEOTECHNICAL DATA INCORPORATED INTO SITE-RESPONSE MODELING

Implementation of the updated shear-strain-threshold approach uses site-response modeling to compute the shear strains that would be generated at the nominal depth of the Topopah Spring crystal-poor lower lithophysal zone for different levels of input ground motion at the probabilistic seismic hazard analysis reference rock outcrop.[7] For the updated approach, site-response modeling described in BSC 2008c[8] provides the needed shear strain and ground motion information. Site-response modeling in BSC 2008c[9] uses velocity profile and dynamic property curve inputs that differ from those used in a 2004 report.[10] The update in model inputs derives from consideration of additional geotechnical data that are discussed and provided in BSC 2008c[11] as well as the use of Approach 3 rather than Approach 2B described in Section 6.1 of NUREG/CR-6728.[12]

Two mean velocity profiles are used in BSC 2008c to characterize the repository block (SAR Figure 1.1-135).[13] Spectral analysis of surface wave (SASW) data collected in 2004 and 2005,[14] combined with SASW data collected earlier,[15] indicate that different portions of the repository block are characterized by different mean profiles. These different spatial areas are termed “soft” and “stiff” zones reflecting the velocity attained at a depth of about 600 to 1,000 ft. Zones with a shear-wave velocity of about 4,000 ft/s are designated “soft” zones and zones with a shear-wave velocity of about 6,000 ft/s are designated “stiff” zones.[16] Sonic velocity compressional-wave and shear-wave data from the vicinity of Yucca Mountain form the basis for the velocity profiles of deeper units that cannot be imaged using the SASW technique.[17] Because the two base-case velocity profiles represent spatial differences in mean velocity characteristics, site-response modeling results using the different profiles are weighted equally in conditioning.

Dynamic material property curve sets for tuff that are used in BSC 2008c (SAR Figure 1.1-131)[18] are similar to those used in the 2004 report.[19] They differ only in that, for the updated curve sets, the effect of confining pressure (i.e., depth) is taken into account. In both cases, two sets of curves are used to represent epistemic uncertainty in properties. Because NUREG/CR-6728 Approach 2B[20] was used in the 2004 report,[21] site response results representing epistemic uncertainty were enveloped and thus depth effects on properties did not affect calculated ground motions. Approach 3 of NUREG/CR-6728[22] is employed in BSC 2008c[23] and, in developing site-specific ground motions, results for alternative dynamic material property curve sets are averaged using weights.[24] The same weights are used in combining conditioned hazard curves for the different base-case properties. Data considered in developing the base-case sets of curves are described and provided.[25]

Details regarding implementation of approaches to conditioning extreme ground motion are provided in the response to RAI 2.2.1.1.1-008.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000007 REV 00 ACN 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20080221.0001; DOC.20080314.0001; DOC.20080328.0001.

[2] BSC 2005. *Peak Ground Velocities for Seismic Events at Yucca Mountain, Nevada*. ANL-MGR-GS-000004 REV 00 ACN 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20050223.0002; DOC.20050725.0002; DOC.20061002.0010.

[3] Ibid., Section 6.4.2 and Figure 6-6.

[4] Ibid., Section 6.4.2 and Figure 6-7.

[5] BSC 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section A2.2.

[6] Ibid., p. D-32.

[7] Ibid., Section A2.2.

[8] Ibid., Section 6.5.

[9] Ibid.

[10] BSC 2004. *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000003 REV 01 ACN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041111.0006; DOC.20051130.0003. Section 6.3.

[11] BSC 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.4.2.4.2.

[12] McGuire, R.K.; Silva, W.J.; and Costantino, C.J. 2001. *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion*

Spectra Guidelines. NUREG/CR-6728. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 251294.

[13] BSC 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.4.2.6 and Figures 6.4.2-85 and 6.4.2-86.

[14] Ibid., Section 6.4.2.4.2 and Appendix C Electronic Attachment.

[15] Ibid., Section 6.4.2.2 and Appendix C Electronic Attachment.

[16] Ibid., Section 6.4.2-80.

[17] Ibid., Section 6.4.2.4.3 and Appendix C Electronic Attachment.

[18] Ibid., Section 6.4.4.2 and Figure 6.4.4-10.

[19] BSC 2004, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*, Section 6.2.4 and Figure 6.2-139.

[20] McGuire et al. 2001, *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines*, Approach 2B.

[21] BSC 2004, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*, Section 6.3.

[22] McGuire et al. 2001, *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines*, Approach 3.

[23] BSC 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.5.

[24] Ibid., Section 6.4.2.5.

[25] Ibid., Section 6.4.4.1.

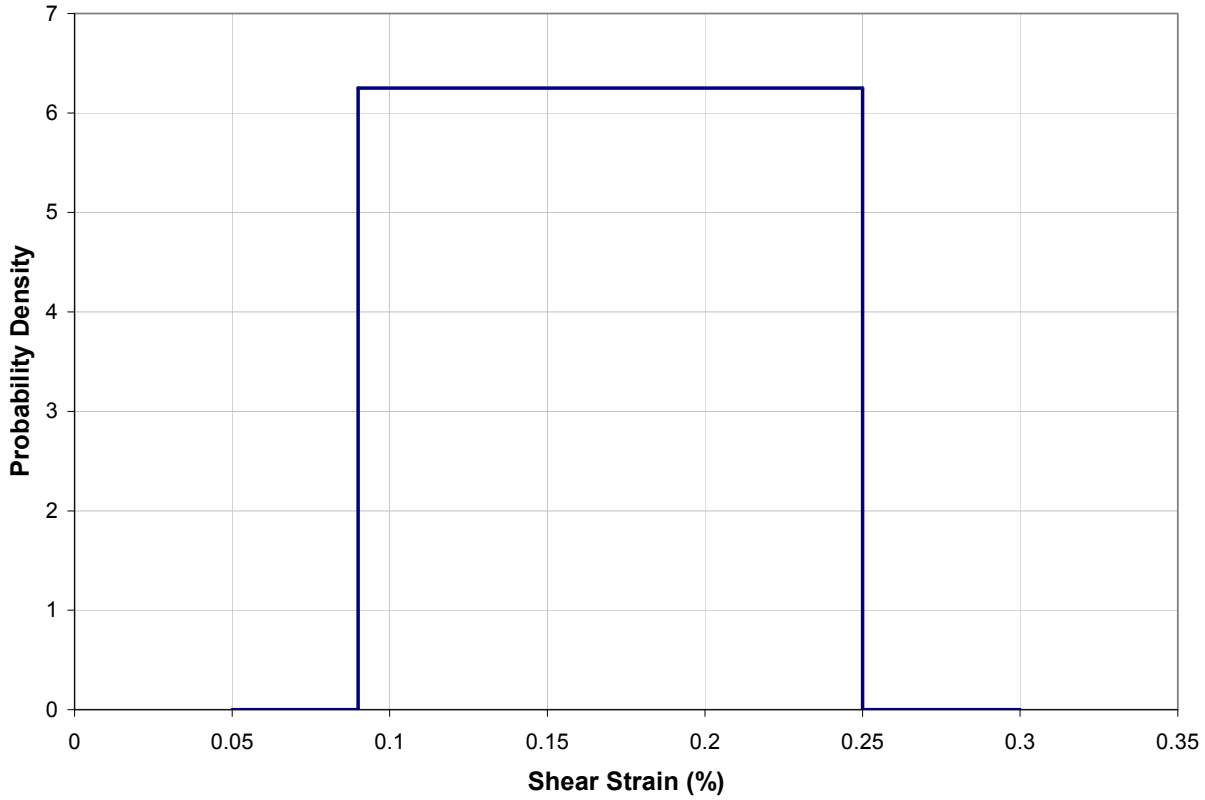

Figure RAI 2.2.1.1.1-007-1. Uniform Probability Distribution for Shear-Strain Threshold

NOTE: In implementing shear-strain-threshold conditioning, the uniform probability distribution is treated as a discrete distribution consisting of two values (0.09% and 0.25%) that are weighted equally.

Source: BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section A2.2.

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 8: Explain how the updated probability distribution of threshold shear strain and the updated probability distribution (density) of bounding horizontal Peak Ground Velocity (PGV) developed in BSC 2008c (SAR Section 1.1.10) are used in Equation A-4.2 (BSC 2008c).

In BSC 2008c, Section A4.5.2, the applicant states that an updated approach and material properties were used for conditioning reference rock outcrop hazard curves based on the shear-strain-threshold approach. However, the applicant has not provided details of the updated approach. The information is needed to assess compliance with 10 CFR 63.21(c)(1)(ii), 10 CFR 63.112(c) and 10 CFR 63.114(g).

1. RESPONSE

This response provides an explanation of how the updated probability distribution of threshold shear strain and the updated probability distribution (density) of bounding horizontal PGV are developed and used in Equation 4, Section A4.2 of BSC 2008c in SAR 1.1.10.[1] The response explains that the updated probability distribution of threshold shear strain, which is a uniform distribution, is implemented through a discrete representation (γ_m in Equation 4) consisting of two values. This section also explains that the updated shear-strain-threshold conditioning approach in BSC 2008c[2] is generalized such that conditioning can be applied to multiple ground motion measures (not just PGV). It explains further that the conditioning probability is determined on the basis of site-response modeling that establishes a relation between shear strain at the nominal depth of the Topopah Spring crystal-poor, lower lithophysal zone (Tptpll) and ground motion at the probabilistic seismic hazard analysis (PSHA) reference rock outcrop.

Equation 4 of BSC 2008c[3] mathematically represents the updated shear-strain-threshold approach:

$$P[x > x']^C = \sum_i P[\gamma_m > \gamma \mid x_i] P[x_i]$$

in which $P[x > x']^C$ is the shear-strain conditioned ground motion hazard at the PSHA reference rock outcrop for ground motion x, $P[\gamma_m > \gamma \mid x_i]$, is the complementary cumulative distribution function for shear strains at the repository waste emplacement level (γ) given ground motion x_i at the PSHA reference rock outcrop with γ_m, the non-exceeded shear-strain-threshold value $P[x_i]$ is the probability of ground motion x_i at the PSHA reference rock outcrop, and the summation is over the range (i) of ground motion values defining the hazard curve.

The term $P[\gamma_m > \gamma \mid x_i]$ is evaluated on the basis of site-response modeling results.[4] The site-response modeling results provide the lognormal distribution of shear strain and shear strain standard deviation ($\sigma_{\ln}$) at the nominal depth of the Tptpll (γ) as a function of ground motion level at the PSHA reference rock outcrop (x_i). To obtain results for the needed range of ground motion level (x_i), the modeling is carried out for a suite of 21 input control motion levels ranging

from horizontal peak ground acceleration (PGA) of 0.01 to 10 g.[5] Appropriate reference earthquake response spectra are scaled to the target PGA level[6] for the 1-to-2 and 5-to-10 Hz response frequency range to provide input ground motion for the site-response model. Because mean velocity properties of the repository block vary spatially and mean tuff dynamic material properties are uncertain, two base-case inputs are used for each in site-response modeling.[7] Thus, site response modeling is carried out for 168 combinations of ground motion input level (21), response frequency range (2), base-case velocity profile (2), and base-case tuff dynamic material property curve set (2). For each combination, aleatory variabilities in velocity profile and tuff dynamic material property curve set are taken into account by stochastically developing 60 profiles and curve sets based on the base cases and determining site response for each. The shear strain results for the 60 realizations are used to determine the geometric mean and σ_{ln} for each combination taking the results as lognormally distributed. This provides the information that is used to evaluate the term $P[\gamma_m > \gamma \mid x_i]$.

In the updated shear-strain-threshold approach, conditioning is carried out for 9 ground motion measures addressed in the PSHA for Yucca Mountain (PGA, PGV, spectral acceleration at response oscillator frequencies of 0.3, 0.5, 1, 2, 5, 10, and 20 Hz).[8] For each ground motion measure, conditioning is carried out for the four combinations of base-case velocity profile and tuff dynamic material property curve set. The site-response modeling results for 20 of the 21 input ground motion levels and reference earthquake response frequency ranges provide the relation between ground motion at the PSHA reference rock outcrop and shear strain and shear strain σ_{ln} at the nominal depth of the Tptpll. In developing this relation, site-response modeling results for either the 1-to-2 Hz reference earthquake or the 5-to-10 Hz reference earthquake are used, depending on the ground motion measure and on the annual probability of exceedance (i.e., ground motion level) considered in light of hazard deaggregation results.[9] Thus, for each combination of base-case velocity profile, tuff dynamic material property curve set, and ground motion measure, 20 pairs of ground motion at the PSHA reference rock outcrop and shear strain and shear strain σ_{ln} at the nominal depth of the Tptpll are obtained from the site-response modeling results. For implementation of the conditioning equation, interpolation is used between points to obtain shear strain and shear strain σ_{ln} values for the x_i values at which the hazard curve is defined. For ground motion values greater than those associated with the maximum calculated shear strain value, the maximum shear strain and associated shear strain σ_{ln} values are used. This is conservative in that it provides higher ground motion (less reduction from conditioning) than if the ground motion–shear strain relation were to be extrapolated at higher ground motion values. The conditioning equation for the updated shear-strain-threshold approach is implemented for two shear-strain-threshold values (0.09% and 0.25%) to represent the uncertainty in the shear-strain threshold.

The output of the above process consists of eight shear-strain-threshold conditioned hazard curves for each ground motion measure, representing the combinations of base-case velocity profile, base-case tuff dynamic material property curve set, and shear-strain-threshold value. To obtain the final shear-strain-threshold conditioned hazard curve for each ground motion measure, the probabilities associated with each hazard curve are averaged with appropriate weights. Each shear-strain-threshold value and base-case velocity profile is given equal weight. Equal weights for shear-strain-threshold value are used because the probability distribution is taken as uniform.

Equal weights are used for base-case velocity profile because the profiles represent known spatial variability. Weights for the base-case dynamic property curve sets are assessed to represent their assessed probability of representing in situ conditions. [10]

Details on the implementation of the combined conditioning process using the extreme-stress-drop and shear-strain-threshold approaches, which provides context for the use of the shear-strain-threshold probability distribution,[11] are provided in the sections below. Responses to RAI 2.2.1.1.1-006 and RAI 2.2.1.1.1-007 refer to these sections for details on the overall implementation of the conditioning approaches.

1.1 EXTREME-STRESS-DROP CONDITIONING

The first step in applying the combined conditioning approaches is to implement the extreme-stress-drop approach. Extreme stress drop is characterized as a lognormal distribution with a median of 400 bars and a standard deviation (σ_{ln}) of 0.6.[12] This distribution is assumed in the context of the point-source stochastic ground motion model[13] using a single-corner-frequency source representation. For the conditioning calculations, the extreme-stress-drop distribution is represented by three discrete values: 150, 400, and 1,100 bars with weights of 0.2, 0.6, and 0.2, respectively.[14] In Section 6.2.2.4 and Figures 6.2-22 and 6.2-28 of *Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*,[15] modeling of extreme ground motion is carried out for moment magnitude (**M**) 6.0 and 6.5, consistent with the range of magnitude that dominates seismic hazard at mean annual probabilities of exceedance less than about 10^{-4}. Results for each magnitude are weighted equally. Other model inputs used in ground motion modeling for extreme-stress-drop conditioning are described.[16] To characterize ground motion from an extreme-stress-drop earthquake, for each combination of extreme stress drop and moment magnitude, 60 ground motion realizations are computed. In each realization, stress drop, source depth, crustal attenuation parameter Q_0, site attenuation parameter kappa, site velocity profile, and tuff dynamic material model curves are randomized. The resulting suite of 5% damped[a] response spectra are taken to follow a lognormal distribution and their geometric mean is calculated.

The resulting distribution of response spectra for the six combinations of extreme stress drop and moment magnitude are used to condition the results from the PSHA for Yucca Mountain:[17]

$$P[x > x']^C = P[x_m > x' | \Delta\sigma_m] P[x > x'] \qquad \text{(Equation 1)}$$

in which $P[x > x']^C$ is the extreme-stress-drop-conditioned hazard for the PSHA reference rock outcrop for ground motion x, $P[x_m > x' | \Delta\sigma_m]$ is the complementary cumulative distribution function for extreme ground motion x_m given extreme stress drop $\Delta\sigma_m$, and $P[x > x']$ is the unconditioned hazard for the PSHA reference rock outcrop. Conditioning is carried out for the

[a] Unless otherwise indicated, all response spectra mentioned in this document are determined for 5% damping.

PGA hazard curve. $P[x_m > x' | \Delta\sigma_m]$ is calculated based on a lognormal distribution using the geometric mean value of PGA determined from the point-source ground motion modeling and a σ_{ln} of 0.15. A σ_{ln} of 0.15 is used rather than the modeled value of σ_{ln} to avoid double counting the effects of variability, which are already included in the unconditioned PSHA results.[18]

An example of $P[x_m > x' | \Delta\sigma_m]$ is shown in Figure RAI 2.2.1.1.1-008-1. For an extreme stress drop of 1,100 bars and a moment magnitude of 6.5, the geometric mean for PGA at the PSHA reference rock outcrop from the 60 realizations of the response spectrum is about 3.79 g.[19] For a σ_{ln} of 0.15, the complementary cumulative probability distribution goes from 1 for PGA less than about 2 g to near 0 for PGA greater than about 6 g (Figure RAI 2.2.1.1.1-008-1). Thus, for this case, extreme-stress-drop conditioning has no effect on PGA hazard exceedance probabilities for PGA less than about 2 g and has a very large effect on hazard exceedance probabilities for PGA greater than about 6 g, effectively limiting probabilistic PGA to a maximum of about 6 g.

Extreme-stress-drop conditioning is carried out based on the geometric mean for the modeled PGA distribution for each of the six combinations of moment magnitude (**M** 6.0, **M** 6.5) and extreme stress drop (150, 400, and 1,100 bars). The resulting conditioned PGA hazard curves are then combined using the weight associated with each combination to produce a final extreme-stress-drop conditioned horizontal PGA hazard curve as shown in Figure RAI 2.2.1.1.1-008-2.[20]

Based on the ratio of final conditioned to unconditioned PGA hazard as a function of mean annual exceedance probability, unconditioned uniform hazard spectra from the PSHA are scaled to reflect extreme-stress-drop conditioning as shown in Figure RAI 2.2.1.1.1-008-3.[21] Using this method, the shape of the uniform hazard spectrum determined in the PSHA is maintained, while its level of spectral acceleration reflects extreme-stress-drop conditioning. The same scaling approach is applied to PGV hazard. Finally, the conditioned uniform hazard spectra are used to construct conditioned hazard curves for the ground motion measures addressed in the PSHA (0.3, 0.5, 1, 2, 5, 10, and 20 Hz response spectral acceleration; PGA; and PGV). For PGV, in addition to conditioning the mean hazard curve, conditioning is also carried out for the 5th, 15th, 50th, 85th, and 95th fractile hazard curves.

Figure RAI 2.2.1.1.1-008-4 summarizes the extreme-stress-drop conditioning process.

1.2 SHEAR-STRAIN-THRESHOLD CONDITIONING

Implementation of combined shear-strain-threshold and extreme-stress-drop conditioning is accomplished by applying the shear-strain-threshold approach to hazard curves that have been previously conditioned using the extreme-stress-drop approach.[22] This section describes the details of the shear-strain-threshold conditioning component of the implementation.

As described in Section 6.2 of *Peak Ground Velocities for Seismic Events at Yucca Mountain, Nevada*,[23] the conceptual basis for the shear-strain-threshold approach is that if high enough levels of horizontal PGV affected the entirety of the repository block, they would produce shear

strain levels that would cause inter-lithophysal fractures to form pervasively throughout the Tptpll. Because geologic investigations do not yield evidence of such damage, it is inferred that sufficiently high levels of PGV have not occurred at Yucca Mountain since the tuff was deposited approximately 12.8 million years ago. Ground motion site response modeling is used to determine the level of horizontal PGV that would be required to generate shear strains exceeding the damage threshold, and this level of ground motion is taken as a reasonable bound, consistent with the geologic setting of Yucca Mountain.

In BSC 2008c in SAR 1.1.10,[24] the shear-strain-threshold approach implemented in *Peak Ground Velocities for Seismic Events at Yucca Mountain, Nevada*[25] is updated to take into account additional geotechnical data and enhanced to incorporate aleatory variability in shear strain. The approach is also generalized to address the full suite of ground motion measures included in the PSHA. Furthermore, the geologic observations for the Tptpll are used to condition hazard curves at the PSHA reference rock outcrop rather than at the repository waste emplacement level. This allows the shear-strain-threshold-conditioned hazard curves to form the basis for development of site-specific ground motions at the surface facilities area as well as at the repository waste emplacement level.

Laboratory uniaxial compression testing of 288-mm-diameter tuff specimens, corroborated by numerical simulation of lithophysal tuff deformation, led to the determination of a shear-strain-increment threshold beyond which the tuff would exhibit geologically observable fracturing. [26] Given uncertainty in the evaluation, this threshold was characterized by a triangular probability distribution ranging from 0.09% to 0.25% shear strain with a mode of 0.16%. In the updated implementation of the shear-strain-threshold conditioning approach, a uniform probability distribution is used,[27] maintaining the original 0.09% to 0.25% range (Figure RAI 2.2.1.1.1-008-5). Implementation using the uniform distribution is carried out by conditioning using two discrete shear-strain threshold values (0.09% and 0.25%) and weighting the resulting conditioned hazard curves equally.

Shear-strain-threshold conditioning is carried out using Equation A-4 from BSC 2008c:[28]

$$P[x > x']^C = \sum_i P[\gamma_m > \gamma \mid x_i] P[x_i] \qquad \text{(Equation 2)}$$

in which $P[x > x']^C$ is the shear-strain conditioned ground motion hazard at the PSHA reference rock outcrop for ground motion x, $P[\gamma_m > \gamma \mid x_i]$, is the complementary cumulative distribution function for shear strains at the repository waste emplacement level (γ) given ground motion x_i at the PSHA reference rock outcrop with γ_m, the non-exceeded shear strain threshold value $P[x_i]$ is the probability of ground motion x_i at the PSHA reference rock outcrop, and the summation is over the range (i) of ground motion values defining the hazard curve. In the case for which shear-strain-threshold conditioning is applied by itself (i.e., not in conjunction with extreme-stress-drop conditioning), $P[x_i]$ is the probability of unconditioned ground motion and is determined from the unconditioned PSHA hazard curves by differencing. In the case for which both the shear-strain-threshold and extreme-stress-drop approaches are applied, $P[x_i]$ is the

probability of extreme-stress-drop-conditioned ground motion and is determined from the extreme-stress-drop-conditioned hazard curve by differencing. The term $P[\gamma_m > \gamma \mid x_i]$ is evaluated using the results from site-response modeling. Note that the 2008 implementation of the shear-strain-threshold conditioning approach is an update and differs from the original 2005 implementation.

1.2.1 Development of Ground Motions Supporting the Original Shear-Strain-Threshold Conditioning Approach

In the original implementation of the shear-strain-threshold conditioning approach,[29] site-response modeling results from *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*[30] were used. Site-response modeling was accomplished using a random-vibration-theory-based equivalent-linear approach.[31] That phase of site-response modeling and development of site-specific ground motions used Approach 2B described in Section 6.1 of NUREG/CR-6728.[32] Site-specific ground motions were determined for a suite of mean annual probabilities of exceedance. For shear-strain-threshold conditioning, PGV and shear strain results for the nominal depth of the Tptpll for mean annual probabilities of exceedance of 10^{-4}, 10^{-5}, 10^{-6}, and 10^{-7} were used.

In site-response modeling supporting the original implementation, ground motion input to the site-response model (control motion) consisted of scaled deaggregation earthquake response spectra[33] for each mean annual probability of exceedance of interest. For response oscillator frequency ranges of 1-to-2 Hz and 5-to-10 Hz, deaggregation earthquakes (magnitude, distance combination) were based on the earthquakes controlling the seismic hazard at a particular mean annual probability of exceedance. For each response oscillator frequency range, three deaggregation earthquakes were developed to represent the distribution of magnitudes contributing to ground motion hazard. The deaggregation earthquake response spectra were then scaled to match the uniform hazard spectrum from the PSHA in the appropriate frequency range. The scaled deaggregation earthquake response spectra, thus, are a representation of the PSHA ground motion hazard results. This representation is appropriate for input to the site-response model.

Other key inputs to the site-response modeling are velocity profiles and tuff dynamic material property curves that characterize the site materials, including uncertainty in that characterization. Development of velocity profiles and sets of tuff dynamic material property curves relied on geotechnical information available for the 2004 phase of site-response modeling.[34] The seismic velocity of the repository block tuff was represented by two mean profiles to characterize the site material and its epistemic uncertainty.[35] Two sets of tuff dynamic material property curves were also developed to characterize the tuff and uncertainty in its properties.[36]

Based on the characterization of the repository block tuff and control ground motions, site-response modeling was carried out for the various combinations of inputs.[37] For each mean annual probability of exceedance, combinations were based on the two response oscillator frequency ranges, three deaggregation earthquakes for each oscillator frequency range, two tuff velocity profiles, and two sets of tuff dynamic material property curves. In addition, for each

combination, horizontal site response was calculated for two wave propagator types: inclined incident waves and vertically incident waves. For each of the combinations, aleatory variability in site properties was taken into account by stochastically generating 60 velocity profiles and sets of dynamic property curves based on the mean base-case profiles and sets of curves. Site response was calculated for each of the 60 profiles and sets of curves for each combination.

In the original implementation of the shear-strain-threshold approach, site-response modeling based on the above inputs provided the basis for relating horizontal PGV at the repository waste emplacement level to seismically produced shear strain at the nominal depth of the Tptpll.[38] For a given hazard level, PGV and shear strain results, as a function of depth, were aggregated for each combination of velocity profile, dynamic property curves, response oscillator range, and wave propagator type. Taking the results as lognormally distributed, the geometric mean was determined for PGV and shear strain for each combination. Results for PGV and shear strain were then arithmetically averaged over the nominal depth range of the Tptpll. Results for the two wave propagator types were then averaged. This process was carried out for 4 mean annual probabilities of exceedance (10^{-4}, 10^{-5}, 10^{-6}, and 10^{-7}) and resulted in 4 PGV shear-strain pairs for each of the 8 combinations of velocity profile, tuff dynamic material property curve set, and response oscillator frequency range.[39]

Based on these results relating horizontal PGV to shear strain, and using linear interpolation between calculated results, the triangular shear-strain-threshold probability distribution was transformed to a corresponding distribution for bounding horizontal PGV for each combination.[40] Each of these distributions was then converted to a corresponding complementary cumulative distribution function that was used to condition the site-specific horizontal PGV hazard curve for the repository waste emplacement level using:

$$P[y > y']^C = P[y_m > y \mid \gamma_m]P[y > y'] \qquad \text{(Equation 3)}$$

in which y is horizontal PGV at the repository waste emplacement level (taken as equivalent to PGV at the nominal depth of the Tptpll), $P[y > y']^C$ is conditioned horizontal PGV hazard, $P[y_m > y \mid \gamma_m]$ is the complementary cumulative distribution function for the probability that the bounding horizontal PGV value is greater than y, given the shear-strain-threshold distribution γ_m, and $P[y > y']$ is the unconditioned horizontal PGV hazard at the repository waste emplacement level.[41] The unconditioned hazard curve for the repository waste emplacement level was developed using linear interpolation and extrapolation of the logarithm of mean annual probability of exceedance and the logarithm of horizontal PGV values for the four hazard levels evaluated. For each value of PGV, the final conditioned horizontal PGV hazard curve is determined by averaging the probabilities for the 8 conditioned hazard curves associated with the 8 combinations of velocity profile, tuff dynamic material property curve set, and response oscillator frequency range using equal weight.[42]

1.2.2 Development of Ground Motions Supporting the Updated Shear-Strain-Threshold Conditioning Approach

In the updated implementation of the shear-strain-threshold conditioning approach, site-response modeling results from BSC 2008c in SAR 1.1.10[43] were used to establish the relation between shear strain at the nominal depth of the Tptpll and PGV at the PSHA reference rock outcrop. In the updated approach other measures of ground motion are also addressed (i.e., PGA, 0.3 Hz, 0.5 Hz, 1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz spectral acceleration). Similar to the original approach, site-response modeling was accomplished using a random-vibration-theory-based equivalent-linear approach.[44] For this updated phase of site-response modeling and development of site-specific ground motions, Approach 3 from NUREG/CR-6728[45] was employed.[46] As part of the implementation of Approach 3, site-response modeling is used to develop a catalog of transfer functions (also called amplification factors) relating ground motion at the PSHA reference rock outcrop to ground motion and shear strain at the repository waste emplacement level.[47]

The catalog of transfer functions is developed for a range of control motion amplitudes.[48] Control motion inputs are based on results of the Yucca Mountain PSHA and are developed such that they exhibit PGAs ranging from 0.01 to 10 g.[49] This range of inputs provides transfer functions appropriate for ground motion levels associated with mean annual probabilities of exceedance from 10^{-2} to 10^{-8} at the PSHA reference rock outcrop. Reference earthquake response spectra derived from the PSHA results[50] are scaled such that their PGA values match the intended target level.[51] Site response is calculated using two scaled reference earthquake response spectra for each PGA level: one for the response oscillator frequency range of 1-to-2 Hz and one for the range of 5-to-10 Hz. Thus, site response is calculated for earthquakes dominating both low and high response oscillator frequency ranges for a wide range of input PGA amplitudes.

For the updated approach, updated velocity profiles and dynamic property curve sets were used, taking into account geotechnical data collected through 2006. The repository block was again represented by two base-case velocity profiles reflecting spatial differences in the observed mean velocity of the tuff.[52] Tuff dynamic material property curves were updated to incorporate effects of confining pressure (i.e., depth). Two base-case sets of curves were again employed to represent the epistemic uncertainty in property characteristics.[53] In addition, weights were developed for the two sets of curves to reflect their assessed likelihood of representing the in situ conditions at Yucca Mountain.[54] Site-response modeling was carried out for each combination of base-case velocity profile (2 cases), tuff dynamic material property curve set (2 cases), response oscillator frequency range (2 cases), and control motion PGA level (21 cases).[b] In addition, for each combination, aleatory variability was taken into account by computing the site-response for

[b] For PGA level, while site response was calculated for 21 control motion PGA levels (i.e., 0.01 g, 0.05 g, 0.1 g, 0.2 g, 0.3 g, 0.4 g, 0.5 g, 0.75 g, 1 g, 1.25 g, 1.5 g, 2 g, 2.5 g, 3 g, 4 g, 5 g, 6 g, 7 g, 8 g, 9 g, 10 g), results from only 20 levels were used in conditioning. Results for control motion with PGA of 6 g were omitted (e.g., file SAT.07\EHCS15E3.M12\MSTR10G.009\003\AM1P02B1.IN) as it was judged the density of results was sufficient at that level with the remaining results.

60 stochastic realizations of velocity profile and tuff dynamic material property curves based on the base-case profiles and curves.

Results of the site-response modeling are used to evaluate the term $P[\gamma_m > \gamma \mid x_i]$ in Equation 2. Because the updated shear-strain-threshold probability distribution is taken as uniform with a range of 0.09% to 0.25%, the evaluation is carried out for the two end values: 0.09% and 0.25%. For each ground motion measure and shear-strain-threshold combination, $P[\gamma_m > \gamma \mid x_i]$ is evaluated for each of the four combinations of tuff velocity profile and tuff dynamic material property curves. Results for either the 1-to-2 Hz response frequency range or the 5-to-10 Hz response frequency range are used depending on the ground motion measure and the annual probability of exceedance.[55] The choice of which result to use is based on which is the dominant contributor to seismic hazard for the combination of ground motion measure and mean annual probability of exceedance. This is assessed from hazard deaggregation results. For each combination of velocity profile and dynamic material property curve, the $P[\gamma_m > \gamma \mid x_i]$ term is evaluated using the results from 20 of the PGA level control motion cases. For values of x_i, the geometric mean of the shear strain at the nominal depth of the Tptpll from the site-response modeling, and the associated shear strain $\sigma_{\ln}$, are tabulated. Results for either the 1-to-2 Hz or 5-to-10 Hz response frequency range are used depending on the ground motion measure and annual probability of exceedance.[56] The results are then resampled to a common set of ground motion values using interpolation and extrapolation. For ground motion values exceeding the maximum for which site response modeling was carried out, the calculated shear strain associated with that maximum ground motion input is conservatively used. If shear strains were extrapolated to higher levels, the probability of exceeding the shear-strain threshold would increase and the amount of conditioning reduction in the hazard curves would be greater. A generic illustration of the relation between shear strain and ground motion is shown in Figure 2.2.1.1.1-008-6.

For each combination of ground motion measure and shear-strain-threshold value, conditioned hazard curves are developed for the four combinations of velocity profile and dynamic material property curve set. If the results of only shear-strain-threshold conditioning are desired, Equation 2 is evaluated determining $P[x_i]$ from the unconditioned hazard curve for the PSHA reference rock outcrop. If results of combined extreme-stress-drop and shear-strain-threshold conditioning are desired, Equation 2 is evaluated determining $P[x_i]$ from the extreme-stress-drop conditioned hazard curve for the PSHA reference rock outcrop. Once the conditioned hazard curves for the four combinations of velocity profile and dynamic material property curves are determined, the final conditioned hazard curve is calculated by taking the weighted average, for a given ground motion measure value, of the probabilities from the four conditioned hazard curves for each of the shear-strain-threshold values (eight hazard curves).[57] Results for the two shear-strain-threshold values and the two base-case velocity profiles are weighted equally; results using the different base-case sets of tuff dynamic material property curves are weighted as described in BSC 2008c in SAR 1.1.10.[58] Figure RAI 2.2.1.1.1-008-7 shows a generic illustration of a final conditioned hazard curve and the eight intermediate hazard curves whose weighted average is its basis. For PGV, in addition to conditioning the mean hazard curve, conditioning is also carried out for the 5th, 15th, 50th, 85th, and 95th fractile hazard curves.

Figure RAI 2.2.1.1.1-008-8 summarizes the updated shear-strain-threshold conditioning process.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000007 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20080221.0001; DOC.20080314.0001; DOC.20080328.0001.

[2] Ibid., Section A4.2.

[3] Ibid.

[4] Ibid., Section 6.5.3, Appendix D.

[5] Ibid., Section 6.5.2.1.1.

[6] Ibid., Section 6.4.1 and Tables 6.4-3, D-3, and D-4.

[7] Ibid., Sections 6.4.2.6 and 6.4.4.2.

[8] CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1998. *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada*. Milestone SP32IM3, September 23, 1998. Three volumes. Las Vegas, Nevada: Civilian Radioactive Waste Management System Management and Operating Contractor. ACC: MOL.19981207.0393.

[9] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.5.2.1.1 and Table 6.5-1.

[10] Ibid., Section 6.4.5.2.

[11] Ibid., Equation 4, Section A4.2.

[12] Ibid., Sections 5.4 and A3.2.1.3.

[13] Ibid., Section 6.3.

[14] Ibid., Sections 5.4 and A3.2.1.3.

[15] BSC 2004. *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000003 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041111.0006; DOC.20051130.0003.

[16] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.4.7 and Table 6.4-24.

[17] Ibid., Equation A-3 in Section A4.1.

[18] Ibid., Section A4.4.

[19] Ibid., Appendix D, Electronic Attachment file: Y06.D\RASCALS\PT.A\EX.6\M65\ D01H08\SD1100\LOGN\SA.LOG.

[20] Ibid., p. D-31.

[21] Ibid.

[22] Ibid., pp. D-30 to D-32.

[23] BSC 2005. *Peak Ground Velocities for Seismic Events at Yucca Mountain, Nevada*. ANL-MGR-GS-000004 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20050223.0002; DOC.20050725.0002; DOC.20061002.0010.

[24] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Sections 6.5.1.1, A2, A4.2, A4.5.2, and p. D-32.

[25] BSC 2005, *Peak Ground Velocities for Seismic Events at Yucca Mountain, Nevada*.

[26] Ibid., Section 6.4.

[27] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section A2.2.

[28] Ibid., Section A4.2.

[29] BSC 2005, *Peak Ground Velocities for Seismic Events at Yucca Mountain, Nevada*, Appendix C.

[30] BSC 2004, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*, Section 6.3.4.

[31] Ibid., Sections 6.1 and 7.

[32] McGuire, R.K.; Silva, W.J.; and Costantino, C.J. 2001. *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines*. NUREG/CR-6728. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 251294.

[33] BSC 2004, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*, Section 6.2.2.5.

[34] Ibid., Sections 6.2.3 and 6.2.4.

[35] Ibid., Sections 6.2.3.3 and Figure 6.2-118.

[36] Ibid., Sections 6.2.4.2 and Figure 6.2-139.

[37] Ibid., Section 6.3.1.1 and Figures 6.3-1 and 6.3-2.

[38] BSC 2005, *Peak Ground Velocities for Seismic Events at Yucca Mountain, Nevada*, Section 6.5 and Appendix C.

[39] Ibid., Table 6-3.

[40] Ibid., Section 6.6.

[41] Ibid., Section 6.8.

[42] Ibid., Figure 6-9.

[43] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.5.3.

[44] BSC 2004, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*, Sections 6.1 and 7.

[45] McGuire et al. 2001, *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines*.

[46] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.1.3.1.

[47] Ibid., Sections 6.5.3 and 6.5.2.1.1.

[48] Ibid., Section 6.5.2.1.1.

[49] Ibid., Section 6.4.1.

[50] BSC 2004, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*, Section 6.2.2.4.

[51] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.4.1, Table 6.4-3, and Figure 6.4.1-17.

[52] Ibid., Section 6.4.2.6 and Figure 6.4.2-93.

[53] Ibid., Section 6.4.4.2 and Figure 6.4.4-10.

[54] Ibid., Section 6.4.5.2.

[55] Ibid., Section 6.5.2.1.1 and Table 6.5-1.

[56] Ibid.

[57] Ibid., p. D-32, Table D-9.

[58] Ibid.

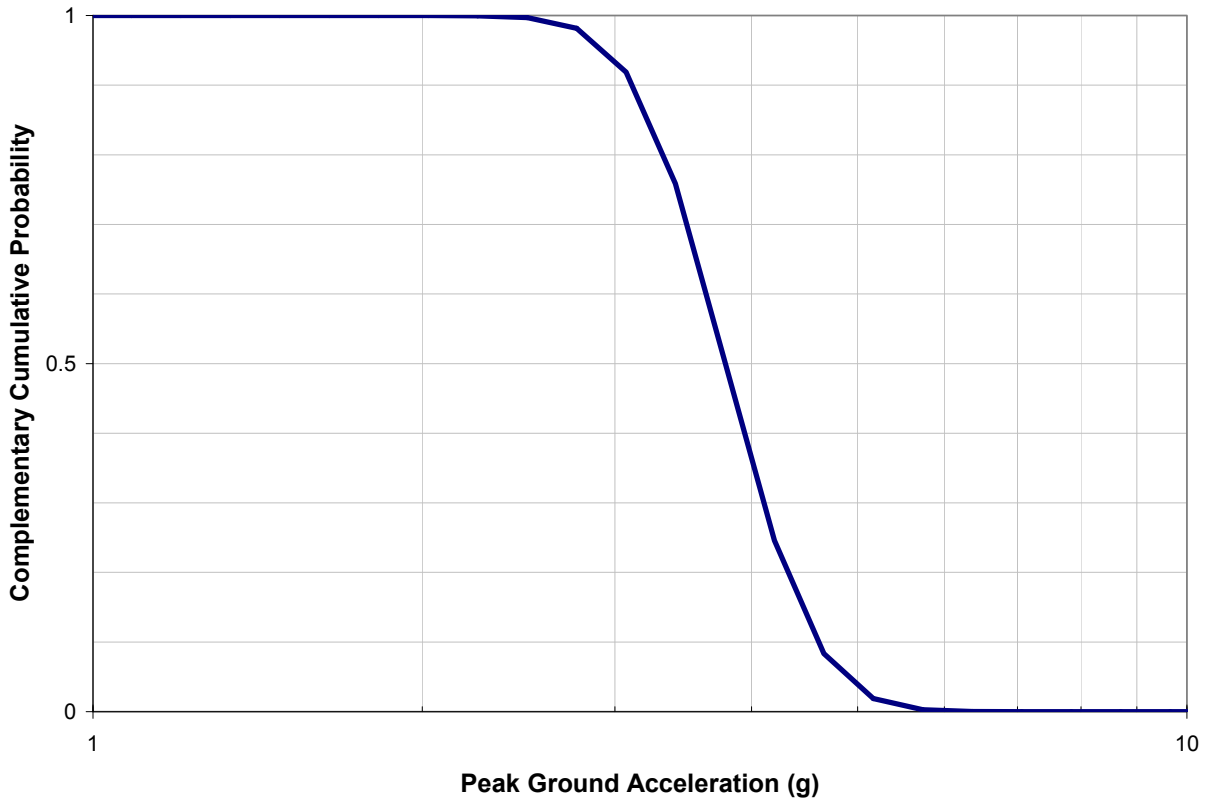

Figure RAI 2.2.1.1.1-008-1. Complementary Cumulative Distribution for the Extreme-Stress-Drop Conditioning Case with Moment Magnitude 6.5 and Stress Drop of 1,100 Bars

Source: BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*. Appendix D Electronic Attachment,
File Y06.D\RASCALS\PT.A\EX.6\M65\D01H08\SD1100\LOGN\SA.LOG

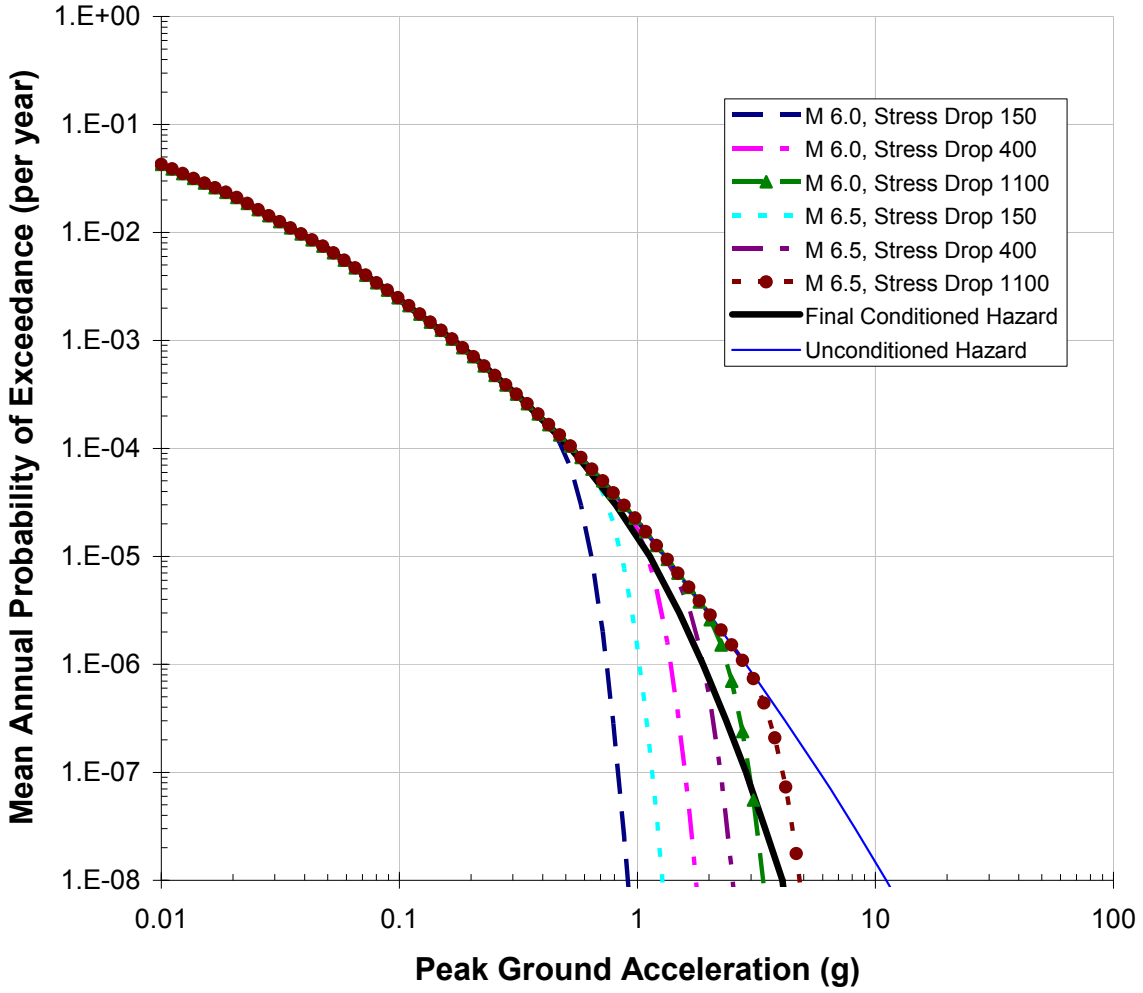

Figure RAI 2.2.1.1.1-008-2. Extreme-Stress-Drop Conditioned Mean Hazard for Horizontal Peak Ground Acceleration

NOTE: M is moment magnitude; stress drop is the stress parameter for the stochastic point-source ground motion model in bars.

Source: BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Appendix D Electronic Attachment,
Files Y.06\EHCS15E2.MD1\EX.6\M60\D01H08\SD0150\H1000.OUT,
Y.06\EHCS15E2.MD1\EX.6\M60\D01H08\SD0400\H1000.OUT,
Y.06\EHCS15E2.MD1\EX.6\M60\D01H08\SD1100\H1000.OUT,
Y.06\EHCS15E2.MD1\EX.6\M65\D01H08\SD0150\H1000.OUT,
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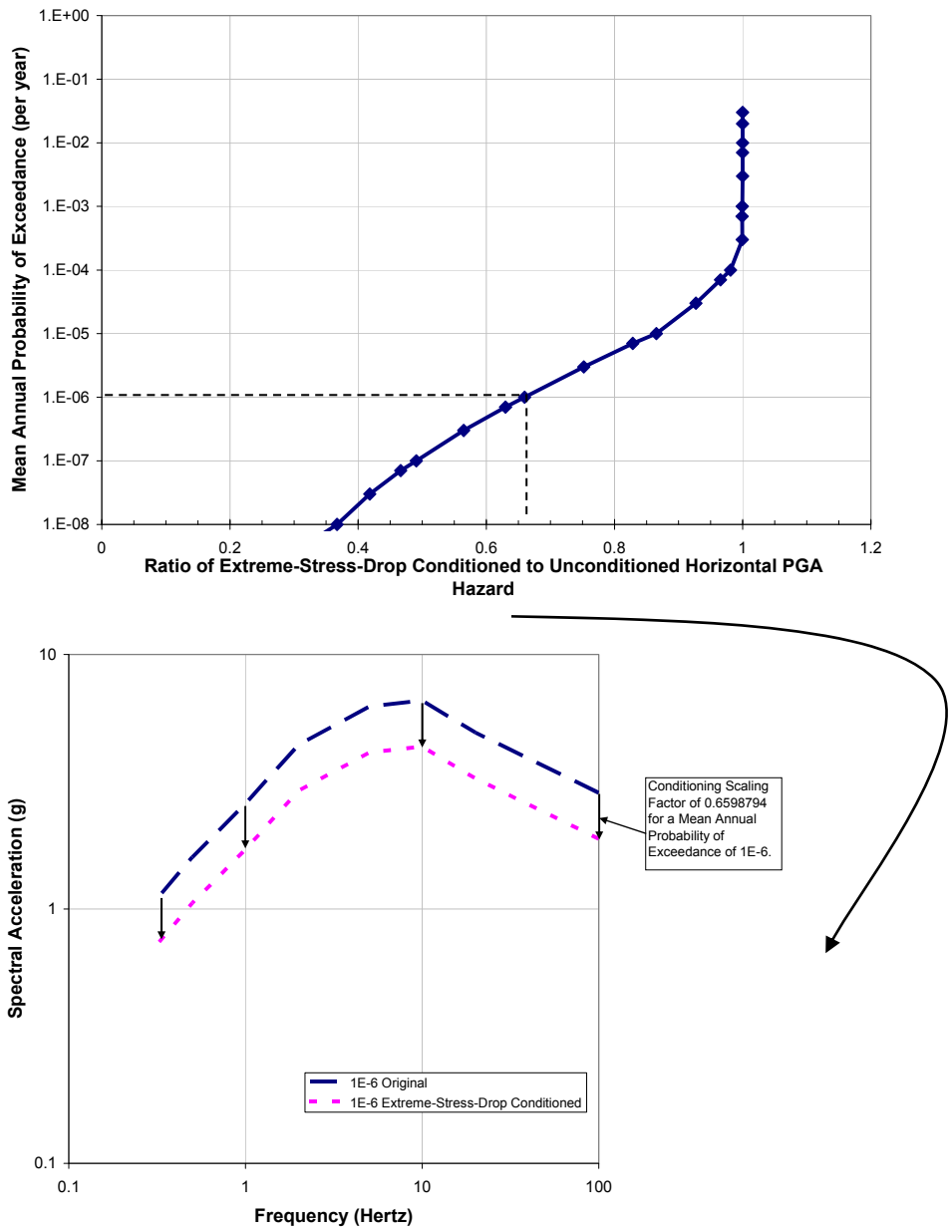

Figure RAI 2.2.1.1.1-008-3. Scaling to Obtain Extreme-Stress-Drop Conditioned Uniform Hazard Spectra

NOTE: Top: Ratio between extreme-stress-drop conditioned mean horizontal PGA hazard and unconditioned mean horizontal PGA hazard for an extreme stress drop of 1100 bars and **M** 6.5. Bottom: Example of scaling to obtain extreme-stress-drop conditioned uniform hazard spectra for a mean annual probability of exceedance of 1^{-6}.

Source: BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Appendix D Electronic Attachment, File Y06.D\EHCS15E2.MD1\FRACTILE.PGA\SMRAT\H1000.RAT and Y06.D\EHCS15E2.MD1\FRACTILE.PGA\SCALE\SCALE.XLS

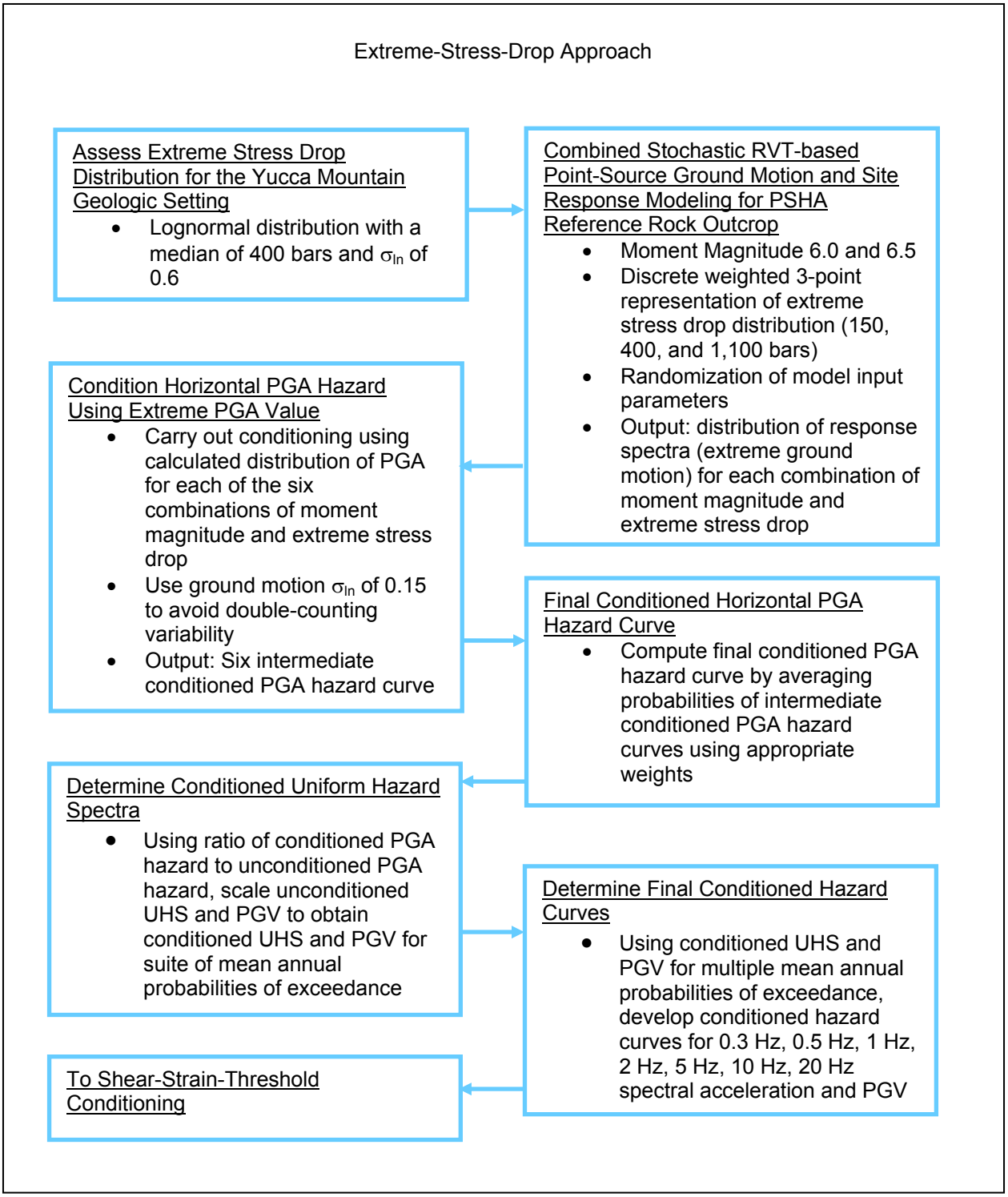

Figure RAI 2.2.1.1.1-008-4. Flow Diagram for Extreme-Stress-Drop Conditioning

NOTE: RVT = random vibration theory; UHS = uniform hazard spectra.

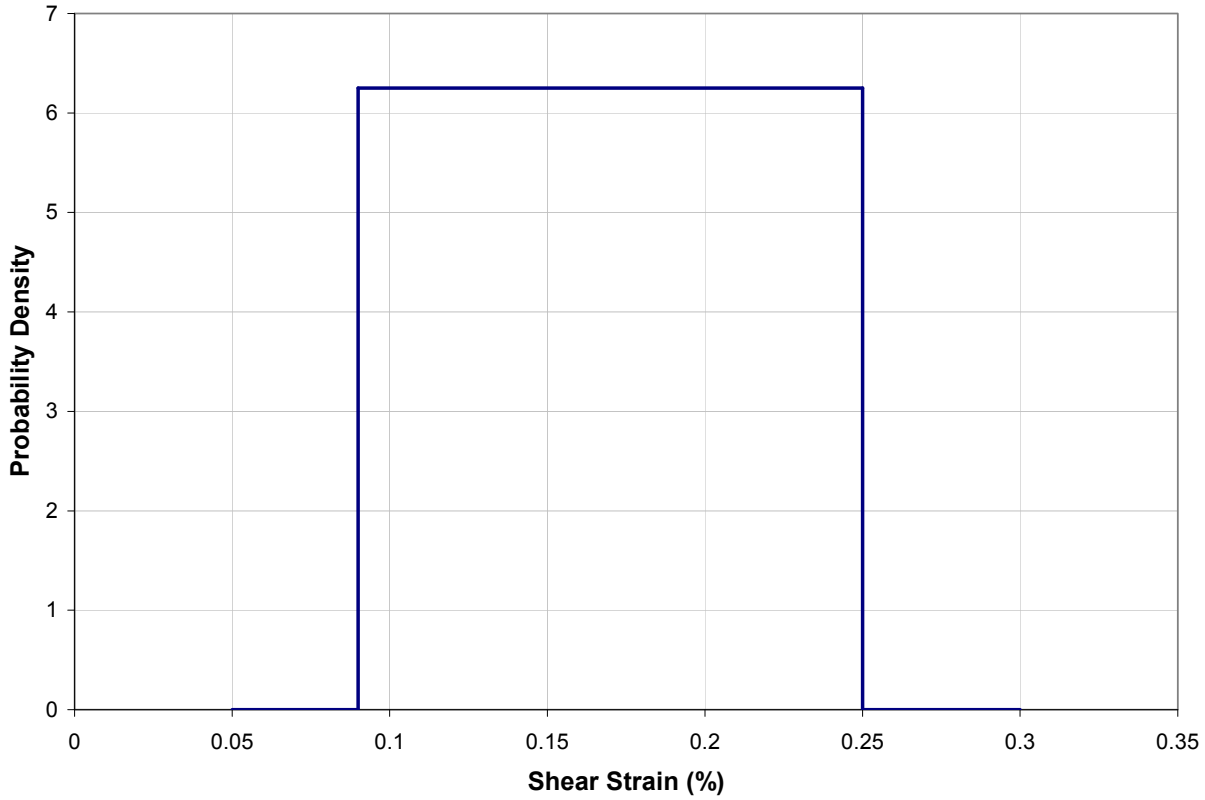

Figure RAI 2.2.1.1.1-008-5. Uniform Probability Distribution for Shear-Strain Threshold

NOTE: In implementing shear-strain-threshold conditioning, the uniform probability distribution is treated as a discrete distribution consisting of two values (0.09 and 0.25) that are weighted equally.

Source: BSC 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section A2.2

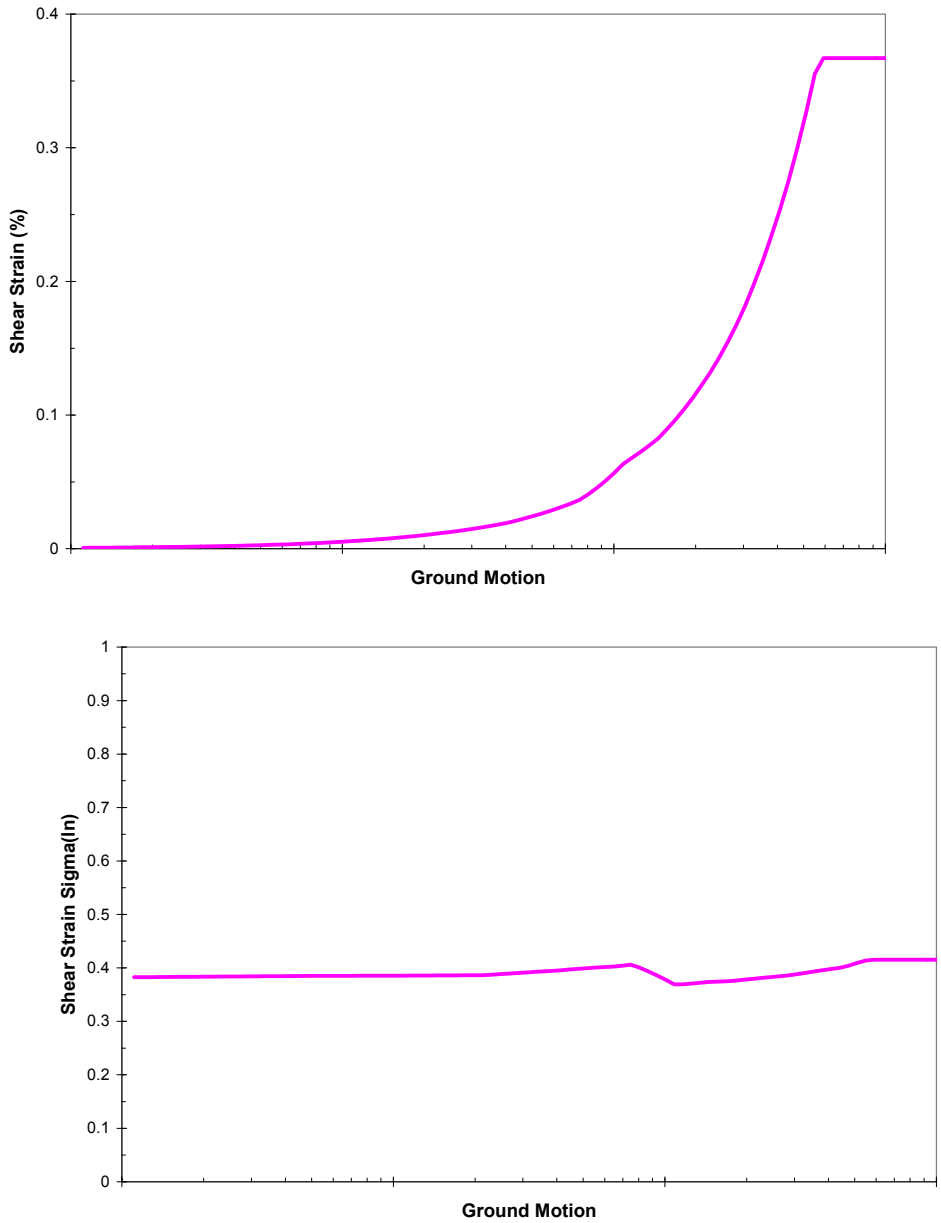

Figure RAI 2.2.1.1.1-008-6. Generic Illustration of the Use of Site Response Modeling Results for Shear-Strain-Threshold Hazard Conditioning

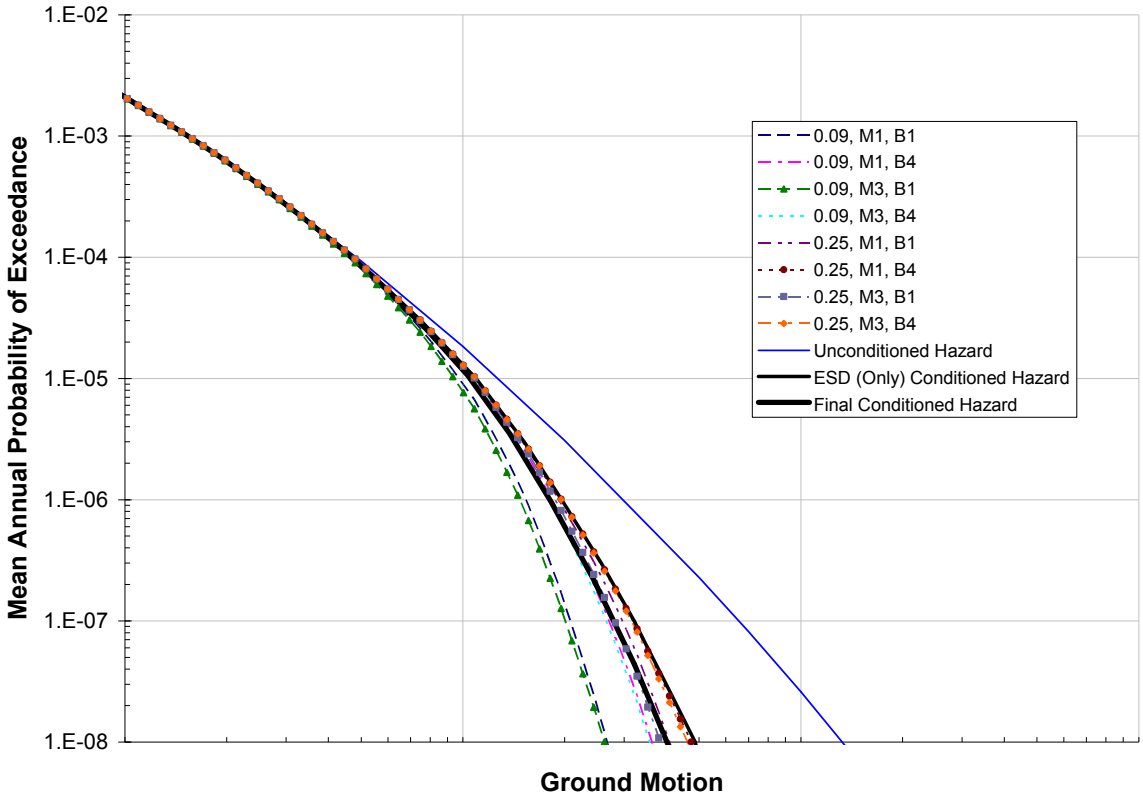

Figure RAI 2.2.1.1.1-008-7. Generic Illustration of Ground Motion Hazard Conditioned Using the Combined Shear-Strain-Threshold and Extreme-Stress-Drop Approaches

NOTE: In the legend, M1 and M3 refer to the "Upper Mean Tuff" and "Lower Mean Tuff" dynamic material property curve sets, respectively; B1 and B4 refer to the "soft" and "stiff" base-case velocity profiles for the repository block, respectively, 0.09 and 0.25 refer to the discrete shear-strain-threshold values used to represent the shear-strain-threshold uniform distribution.
ESD = extreme-stress-drop.

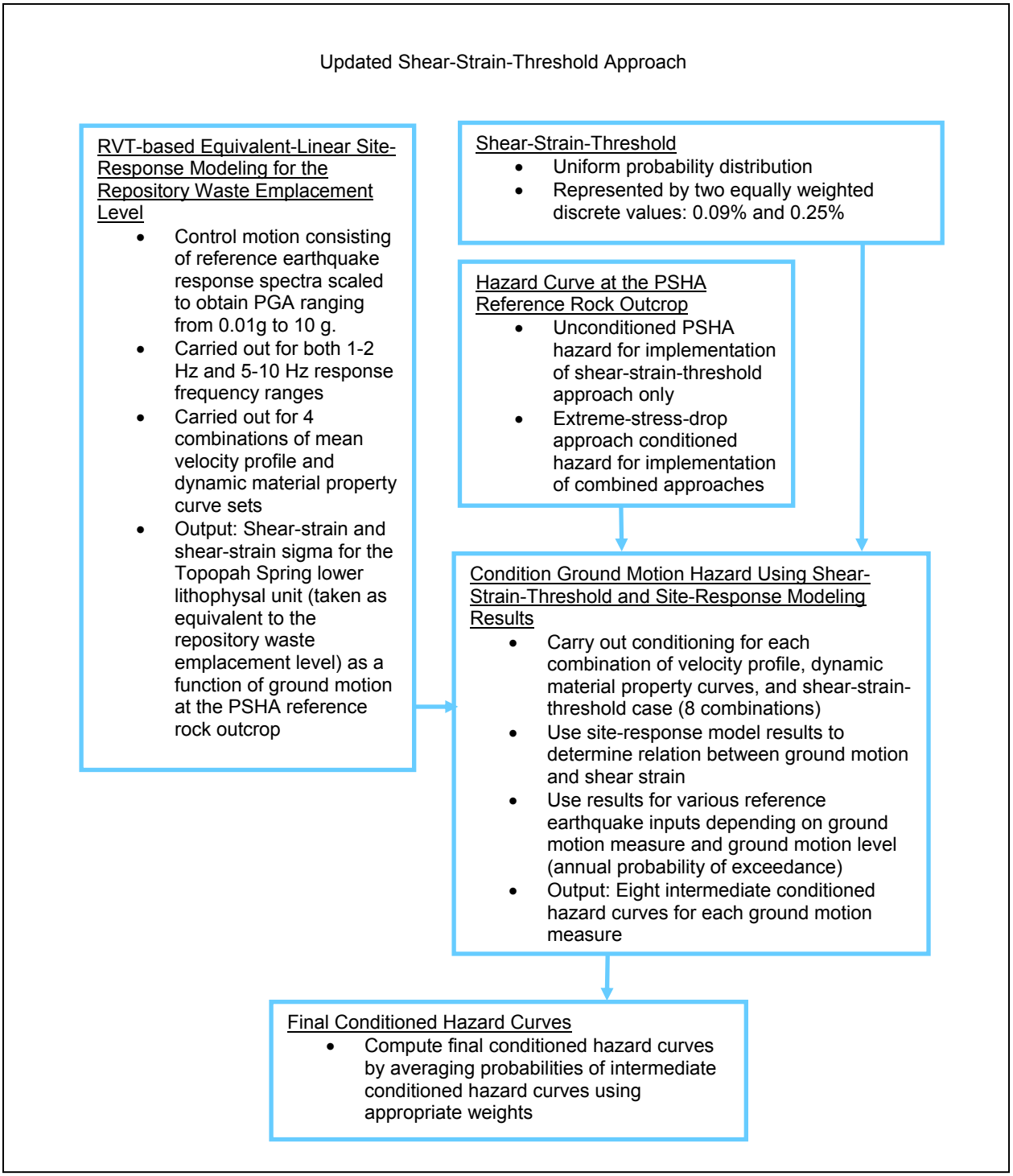

Figure RAI 2.2.1.1.1-008-8. Flow Diagram for Updated Shear-Strain-Threshold Conditioning

NOTE: RVT = random vibration theory.

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 9: Clarify the technical bases for development of compression wave (V_P) velocity profiles for the surface facilities and repository block discussed in SAR Section 1.1.5.2.7.2. (Pages 1.1-98 and 1.1-100). Explain why the directly measured V_P values were not used for the V_P profiles, in contrast to section 6.4.2.5.2 of BSC 2008c (SAR Section 1.1.10 General references) that seems to include directly measured V_P data from boreholes drilled in 2000 and 2001.

In the SAR Section 1.1.5.2.7.2, the applicant states that the V_P profiles were derived from the V_S profiles and smoothed and extrapolated Poisson Ratio curves. In contrast, the applicant states in BSC 2008c that the measured V_P profiles from fifteen boreholes drilled in 2000 and 2001 were used to first generate the smoothed Poisson Ratio curves. The Poisson Ratio curves were extrapolated to greater depths based on vertical seismic profiling (VSP) data. The smoothed and extrapolated Poisson Ratio curves were then combined with V_S profiles to recompute V_P profiles. These recomputed V_P profiles were used in the site response analysis and to support average Poisson Ratio values for the Calico Hills Formation and Prow Pass Tuff. The applicant has not provided rationale to show why the directly measured V_P measurements were not used for the V_P profiles. Moreover, the applicant states that sensitivity calculations show that uncertainty in the V_P profiles did not significantly alter their modeled results (BSC, 2008c, page 6-53). Yet, the applicant has not provided supporting information to substantiate this claim. The information is needed to verify compliance with 10 CFR 63.21(c)(1)(ii) and 10 CFR 63.112(c).

1. RESPONSE

This response clarifies the technical basis for development of base-case compression-wave velocity (V_P) profiles used in vertical site-response modeling. It addresses the use of Poisson's ratio to determine V_P profiles based on base-case shear-wave velocity (V_S) profiles. The response also provides supporting information to examine the sensitivity of ground motions to values of Poisson's ratio used to determine V_P profiles for stratigraphic units below the Paintbrush Group.

1.1 TECHNICAL BASIS FOR DEVELOPMENT OF BASE-CASE V_P PROFILES

The technical bases for development of V_P profiles for the surface geologic repository operations area (GROA) and repository block are provided below. Specifically, the response explains why directly measured V_P values were not used for V_P profiles in Section 6.4.2.5.2 of BSC 2008c from SAR 1.1.10.[1]

In BSC 2008c, base-case V_P profiles for site-response modeling were determined from the base-case V_S profiles and Poisson's ratio.[2] This approach is similar to that used in Section 6.2.3.3.2 of the 2004 report, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*,[3] for the repository block. For the surface GROA, however, the 2004 report used downhole

and suspension logging V_P data to develop base-case P-wave profiles.[4] In the current analysis, the Poisson's ratio approach is also applied to the surface GROA. This change is made because, with the evolution of the surface facilities layout to cover a larger area than considered in the 2004 report,[5] greater reliance is made on spectral analysis of surface wave (SASW) data to characterize the velocity of the site. Interpretations of SASW data provide only S-wave profiles. This necessitates the use of Poisson's ratio to develop V_P profiles corresponding to mean base-case V_S profiles.

The velocity profiles for the surface GROA and the repository block are developed on the basis of available velocity data and the geologic framework of the sites.[6] Velocity data for the sites were acquired using a range of techniques: SASW, downhole seismic velocity surveys, suspension logging surveys, sonic velocity logging, and vertical seismic profiling (VSP). These techniques can measure V_P and V_S except SASW, which only measures V_S. Borehole-based techniques provide information on velocities in the immediate vicinity of the borehole. SASW surveys complement the borehole-based measurements and provide information on the average velocity along the length of the survey line.

Final profiles for site response modeling are developed by combining, as appropriate, the component profiles for alluvium, the tuffs of the Timber Mountain and Paintbrush Groups, and the V_S values for the Calico Hills Formation and Prow Pass Tuff. For the repository block, the base-case V_P profiles are determined using the base-case V_S profiles, which are derived from SASW data, and V_P/V_S ratios calculated from Poisson's ratio data. There are no directly measured V_P profiles to determine the base-case V_P profiles with the exception of a few shallow downhole velocity profiles (< 100 ft) that were measured in 2000 on the crest of Yucca Mountain. Eight borehole surveys were performed but the P-wave data are generally unusable because of interference from seismic waves that traveled along the steel casing in these boreholes.[7] The V_P/V_S ratios applied to base-case V_S profiles over depths nominally corresponding to tuffs of the Paintbrush Group are derived from Poisson's ratio values determined from VSP data (0.3). The V_P/V_S ratios applied over depths nominally corresponding to the Calico Hills Formation and the Prow Pass Tuff are derived from Poisson's ratio values determined from sonic velocity data (0.25).

At the surface GROA, V_P profiles for tuffs of the lower Timber Mountain Group and upper Paintbrush Group are available for 16 downhole surveys and 16 suspension surveys performed in 2000 to 2001. A total of 38 SASW surveys were also performed at the surface GROA in 2000 to 2001. In the 2004 to 2005 geotechnical investigation program, 41 SASW surveys at 24 locations were performed at the surface GROA to enhance the characterization of the subsurface velocity structures in the areas of important-to-safety buildings. No directly measured V_P data were collected in 2004 to 2005. The 2000 to 2001 and 2004 to 2005 data formed the bases for the V_S and V_P profiles above the Calico Hills Formation (top ~1,300 ft) used in the development of design ground motions.[8]

Because the SASW survey results are more abundant and cover a significantly greater area than the downhole and suspension surveys, the base-case V_P profiles for the surface GROA are developed based on the base-case V_S profiles and an estimate of the mean Poisson's ratios as a function of depth. Poisson's ratios are calculated based on the 2000 to 2001 downhole and

suspension V_S and V_P data at the surface GROA for tuffs of the lower Timber Mountain Group and upper Paintbrush Group and the sonic V_S and V_P data for the Calico Hills Formation and Prow Pass Tuff.[9]

1.2 SENSITIVITY ANALYSES

Figures RAI 2.2.1.1.1-009-1 through RAI 2.2.1.1.1-009-13 show that uncertainty in the Poisson's ratio used to develop V_P profiles for the Calico Hills Formation and the Prow Pass Tuff does not significantly alter the site-wide ground motion results.

Base-case V_P profiles were calculated from base-case V_S profiles on the basis of mean Poisson's ratio values determined from site data.[10] For the Calico Hills Formation and the Prow Pass Tuff, a Poisson's ratio value of 0.25 was used based on sonic velocity data.[11] VSP data in the vicinity of the repository block indicated a constant 0.3 value for Poisson's ratio at depth.[12] Sensitivity analyses were carried out to evaluate the impact on ground motion if a Poisson's ratio value of 0.3 had been used for the Calico Hills Formation and the Prow Pass Tuff, rather than 0.25.[13] For the surface GROA, to evaluate sensitivity, two cases were run with the alternate V_P profile values for the Calico Hills Formation and Prow Pass Tuff (depths below 1,100 ft). The velocity profile for the area northeast of the Exile Hill fault splay was used with alluvium thickness values of 30 and 200 ft. For the repository block, both base cases were run with the alternate V_P profile values for the Calico Hills Formation and Prow Pass Tuff (depths below 1,300 ft).

Comparisons of the vertical 5% damped response spectra for the sensitivity cases to the site-wide vertical uniform hazard spectrum (UHS) are shown in Figures RAI 2.2.1.1.1-009-1 to RAI 2.2.1.1.1-009-6 for the surface GROA and in Figures RAI 2.2.1.1.1-009-7 to RAI 2.2.1.1.1-009-13 for the repository block. For the surface GROA, results are compared for ground motion with mean annual probabilities of exceedance of 10^{-3}, 5×10^{-4}, 10^{-4}, 10^{-5}, 10^{-6}, and 10^{-7}. For the repository block, comparisons are shown for mean annual probabilities of exceedance of 10^{-3}, 5×10^{-4}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, and 10^{-8}. For both sites, the comparisons show that the sensitivity results are comparable to or slightly less than the respective site-wide UHS based on the alternate value of Poisson's ratio. Thus, the use of 0.3 or 0.25 as the value of Poisson's ratio to convert base-case V_S profiles to base-case V_P profiles for the Calico Hills Formation and Prow Pass Tuff has a negligible impact on site-specific vertical ground motion.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] BSC (Bechtel SAIC Company) 2008. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000007 REV 00 ACN 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20080221.0001; DOC.20080314.0001; DOC.20080328.0001.

[2] Ibid., Sections 6.4.2.5.3 and 6.4.2.6.2.

[3] BSC 2004. *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*. MDL-MGR-GS-000003 REV 01 ACN 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041111.0006; DOC.20051130.0003.

[4] Ibid., Section 6.2.3.4.2.

[5] Ibid., Section 6.2.3 and Figure 6.2-89.

[6] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.4.2.

[7] BSC 2002. *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project*. ANL-MGR-GE-000003 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021004.0078. Section 6.4.3.

[8] BSC 2008, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Section 6.4.2.

[9] Ibid., Section 6.4.2.5.2.

[10] Ibid., Sections 6.4.2.5.3 and 6.4.2.6.2.

[11] Ibid., Section 6.4.2.5.2.

[12] BSC 2004, *Development of Earthquake Ground Motion Input for Preclosure Seismic Design and Postclosure Performance Assessment of a Geologic Repository at Yucca Mountain, NV*, Section 6.2.3.2.5 and Figure 6.2-117.

[13] BSC 2009. *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV.* MDL-MGR-GS-000007 REV 00 ACN 02 ADD 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20080221.0001; DOC.20080314.0001; DOC.20080328.0001; DOC.20090108.0015. Section 6.4.2.5.2[a].

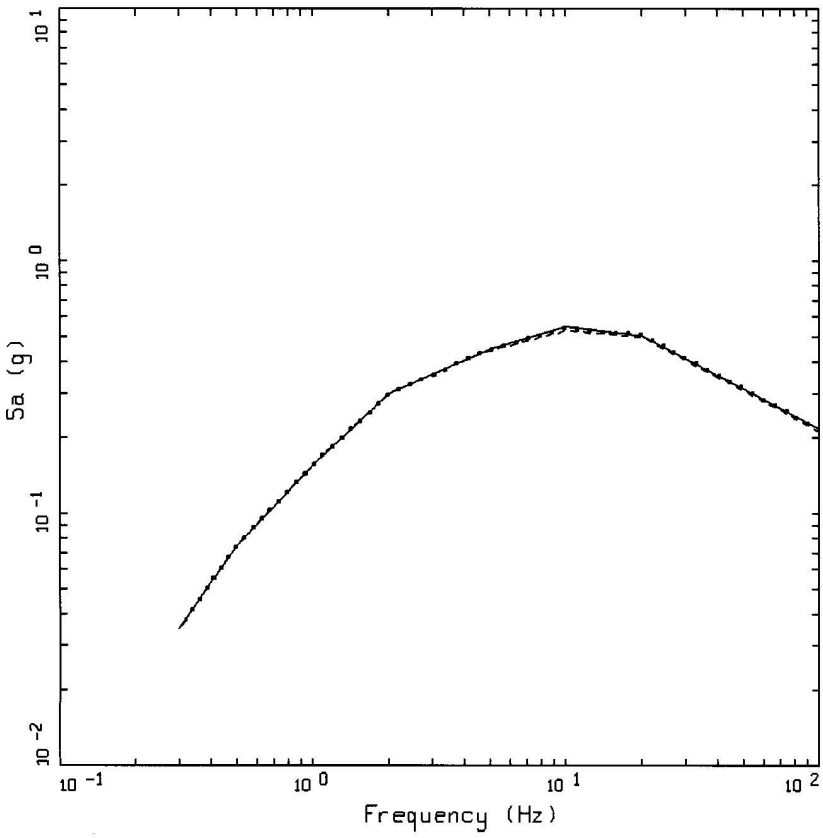

Figure RAI 2.2.1.1.1-009-1. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Surface GROA Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-3} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the surface GROA with a 10^{-3} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line and the dashed line are the sensitivity results for the V_P profile for northeast of the Exile Hill fault splay, with 30 and 200 ft of alluvium, respectively, using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-97[a].

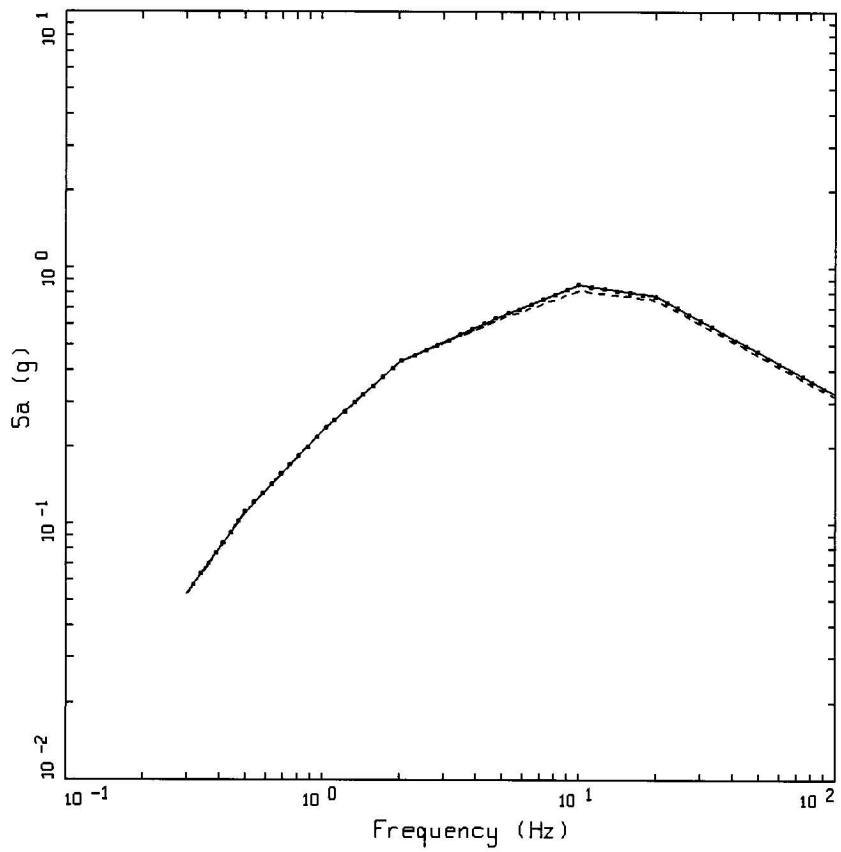

Figure RAI 2.2.1.1.1-009-2. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Surface GROA Site-Wide Vertical Uniform Hazard Spectrum with a 5×10^{-4} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the surface GROA with a 5×10^{-4} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line and the dashed line are the sensitivity results for the V_P profile for northeast of the Exile Hill fault splay, with 30 and 200 ft of alluvium, respectively, using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-98[a].

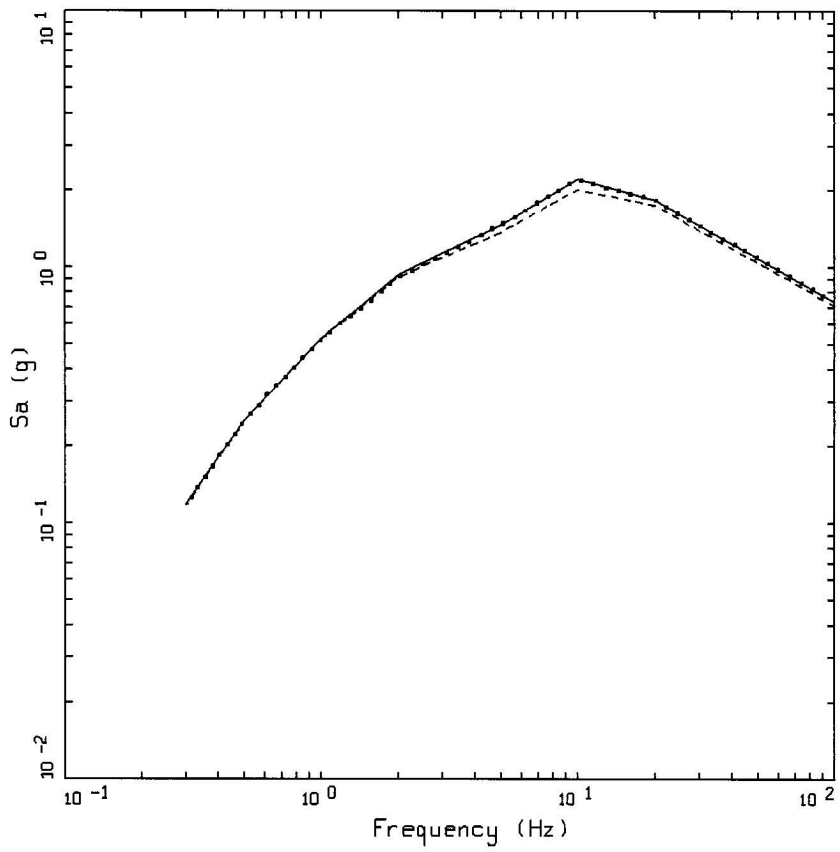

Figure RAI 2.2.1.1.1-009-3. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Surface GROA Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-4} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the surface GROA with a 10^{-4} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line and the dashed line are the sensitivity results for the V_P profile for northeast of the Exile Hill fault splay, with 30 and 200 ft of alluvium, respectively, using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-99[a].

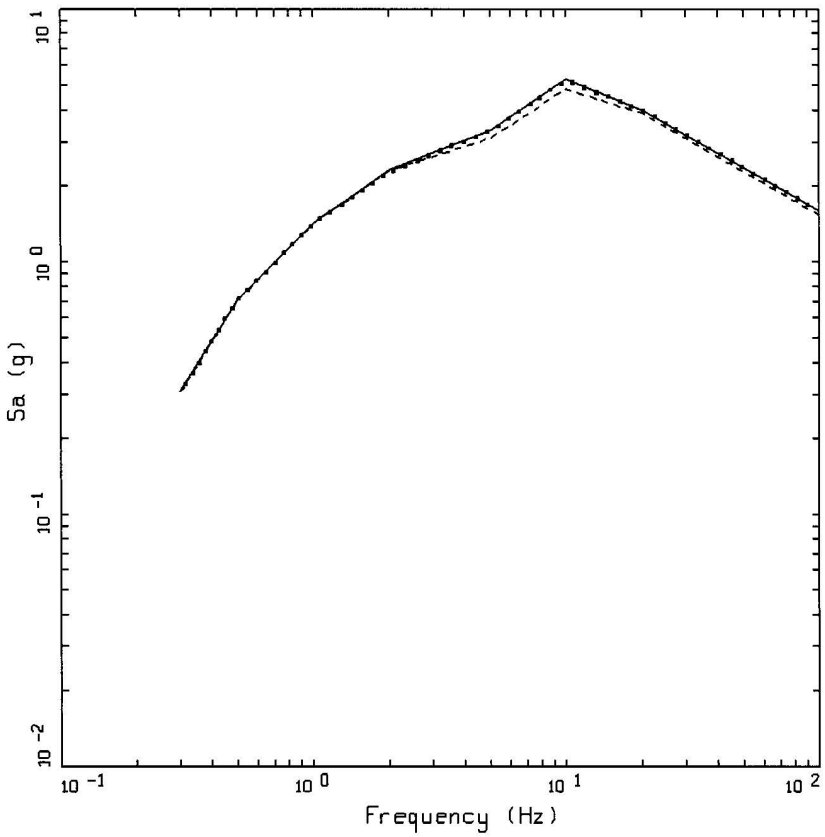

Figure RAI 2.2.1.1.1-009-4. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Surface GROA Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-5} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the surface GROA with a 10^{-5} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line and the dashed line are the sensitivity results for the V_P profile for northeast of the Exile Hill fault splay, with 30 and 200 ft of alluvium, respectively, using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-100[a].

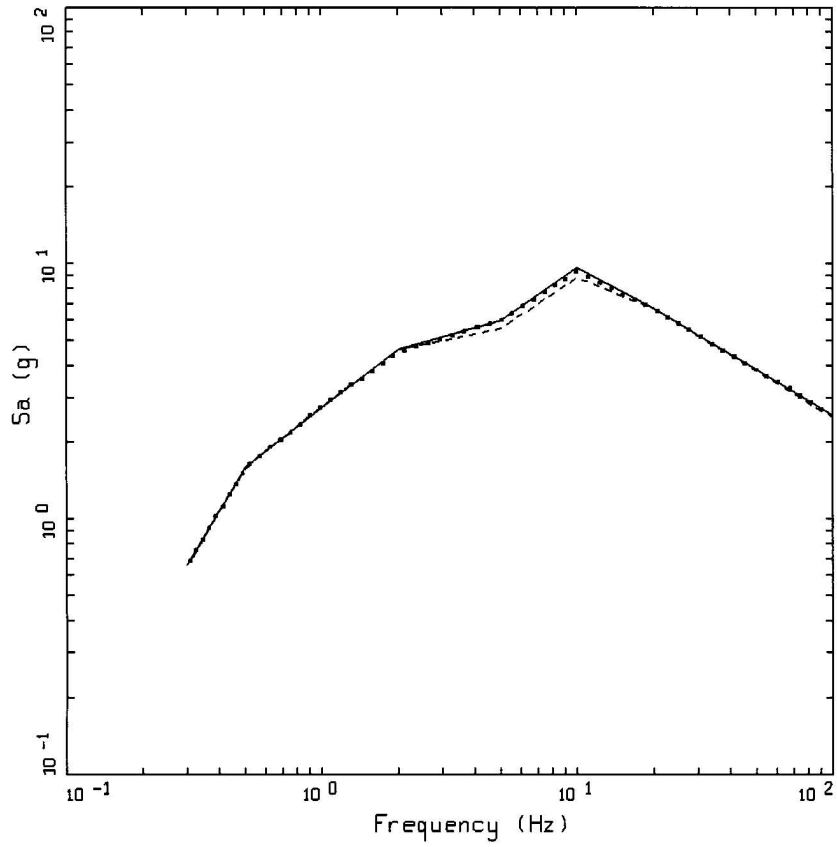

Figure RAI 2.2.1.1.1-009-5. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Surface GROA Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-6} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the surface GROA with a 10^{-6} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line and the dashed line are the sensitivity results for the V_P profile for northeast of the Exile Hill fault splay, with 30 and 200 ft of alluvium, respectively, using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-101[a].

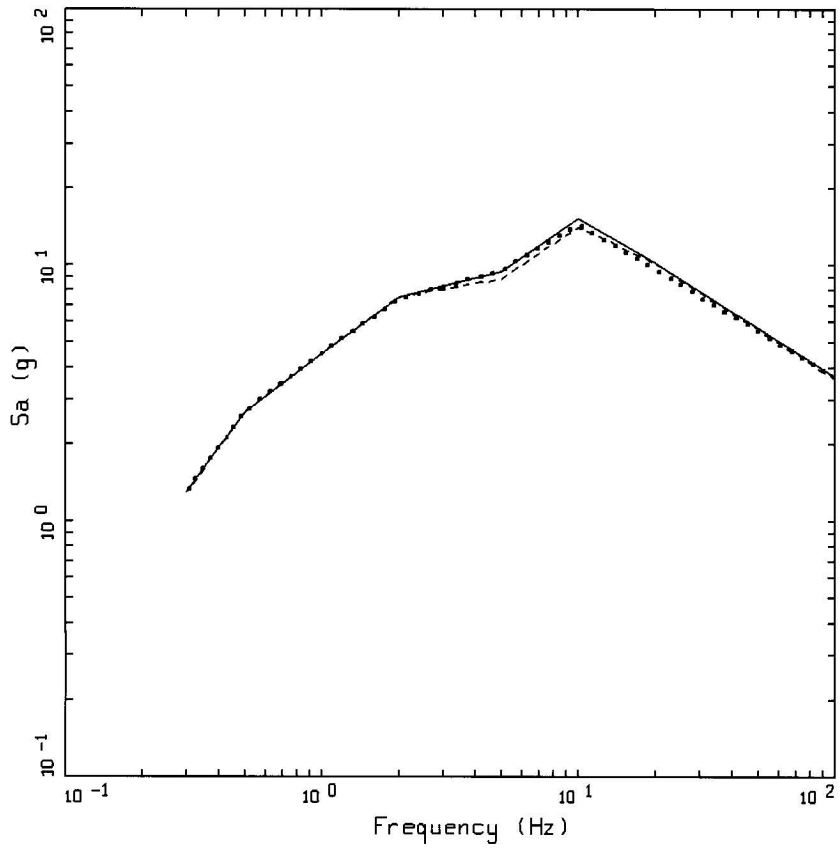

Figure RAI 2.2.1.1.1-009-6. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Surface GROA Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-7} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the surface GROA with a 10^{-7} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line and the dashed line are the sensitivity results for the V_P profile for northeast of the Exile Hill fault splay, with 30 and 200 ft of alluvium, respectively, using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-102[a].

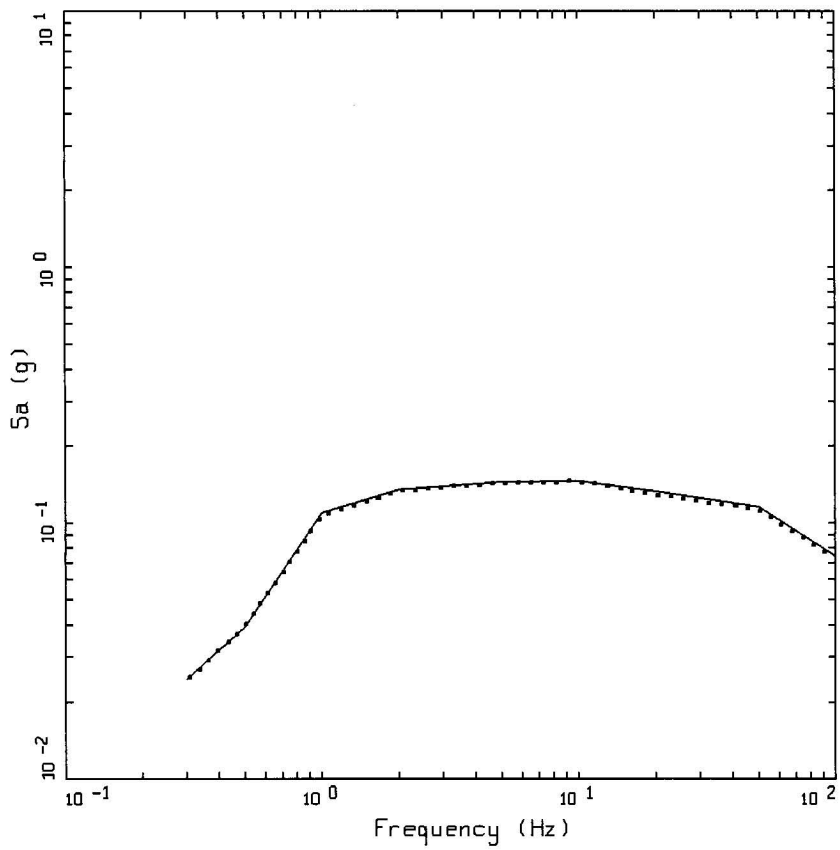

Figure RAI 2.2.1.1.1-009-7. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Repository Block Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-3} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the repository block waste emplacement level with a 10^{-3} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line shows the sensitivity results for the repository block using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-103[a].

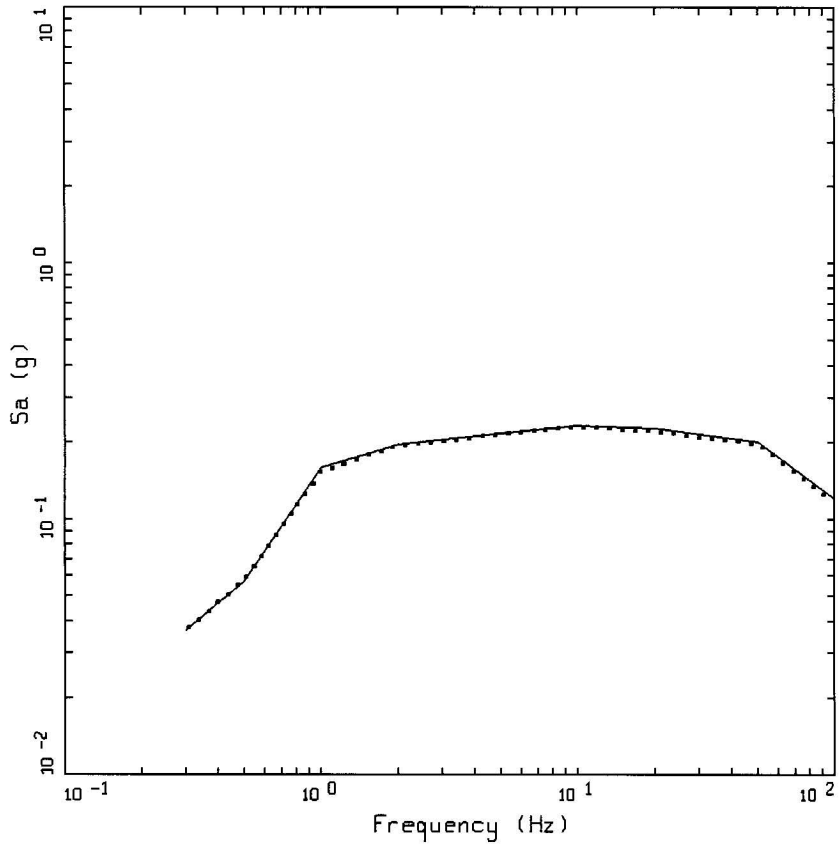

Figure RAI 2.2.1.1.1-009-8. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Repository Block Site-Wide Vertical Uniform Hazard Spectrum with a 5×10^{-4} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the repository block waste emplacement level with a 5×10^{-4} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line shows the sensitivity results for the repository block using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-104[a].

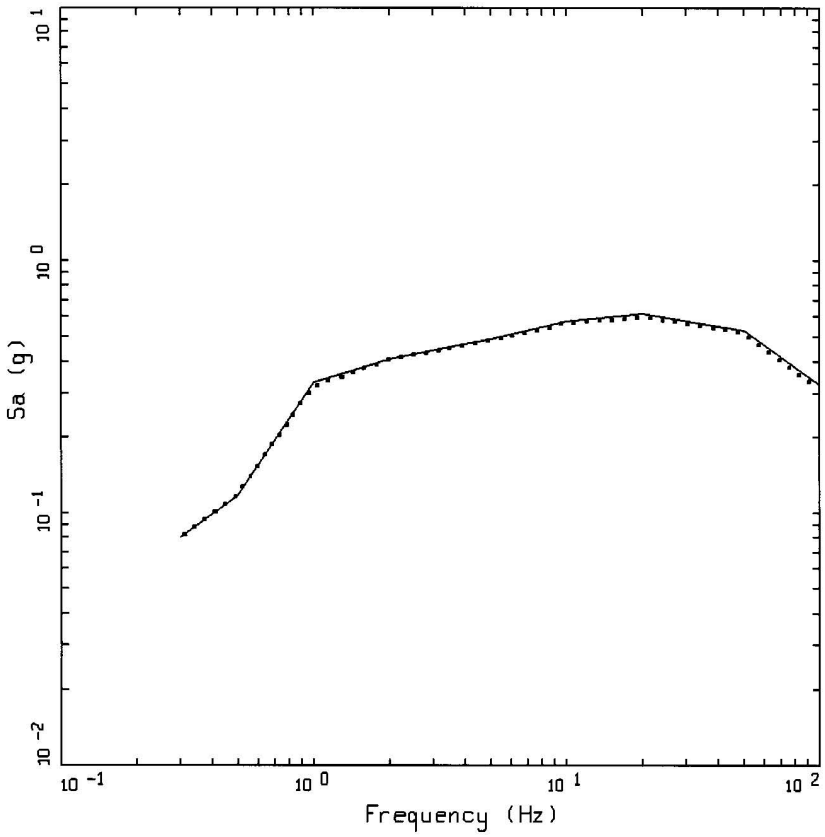

Figure RAI 2.2.1.1.1-009-9. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Repository Block Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-4} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the repository block waste emplacement level with a 10^{-4} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line shows the sensitivity results for the repository block using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-105[a].

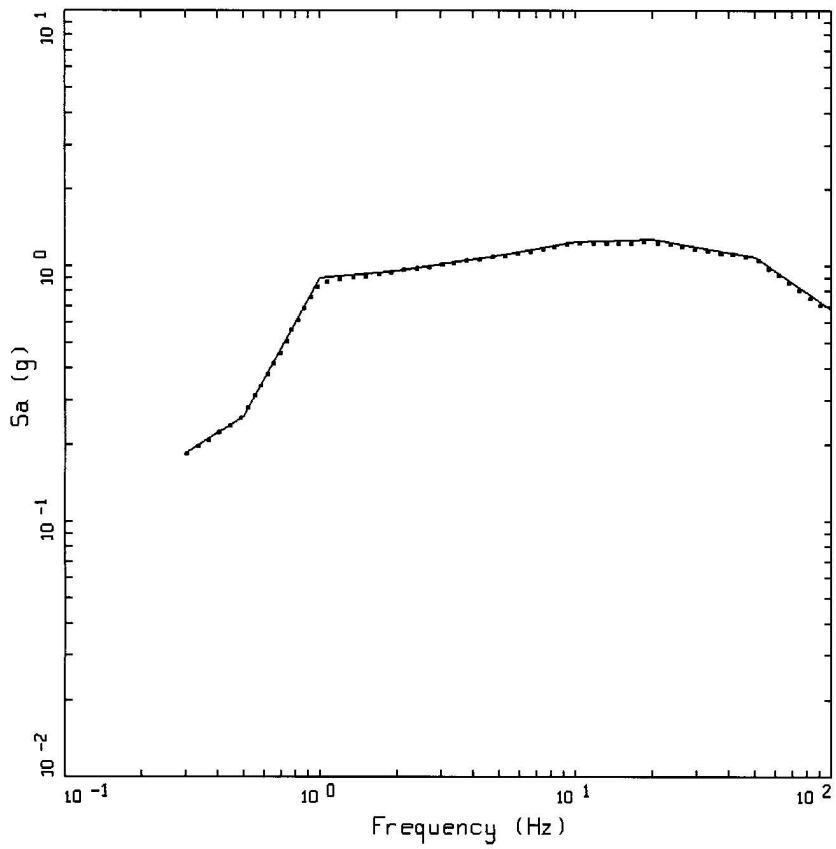

Figure RAI 2.2.1.1.1-009-10. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Repository Block Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-5} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the repository block waste emplacement level with a 10^{-5} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line shows the sensitivity results for the repository block using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-106[a].

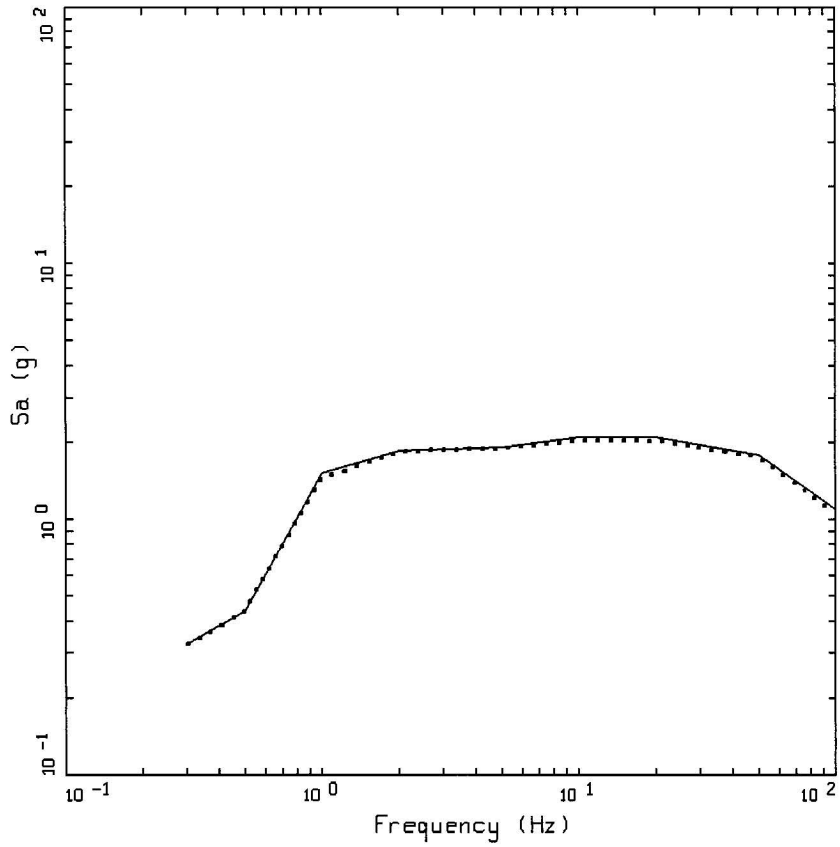

Figure RAI 2.2.1.1.1-009-11. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Repository Block Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-6} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the repository block waste emplacement level with a 10^{-6} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line shows the sensitivity results for the repository block using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-107[a].

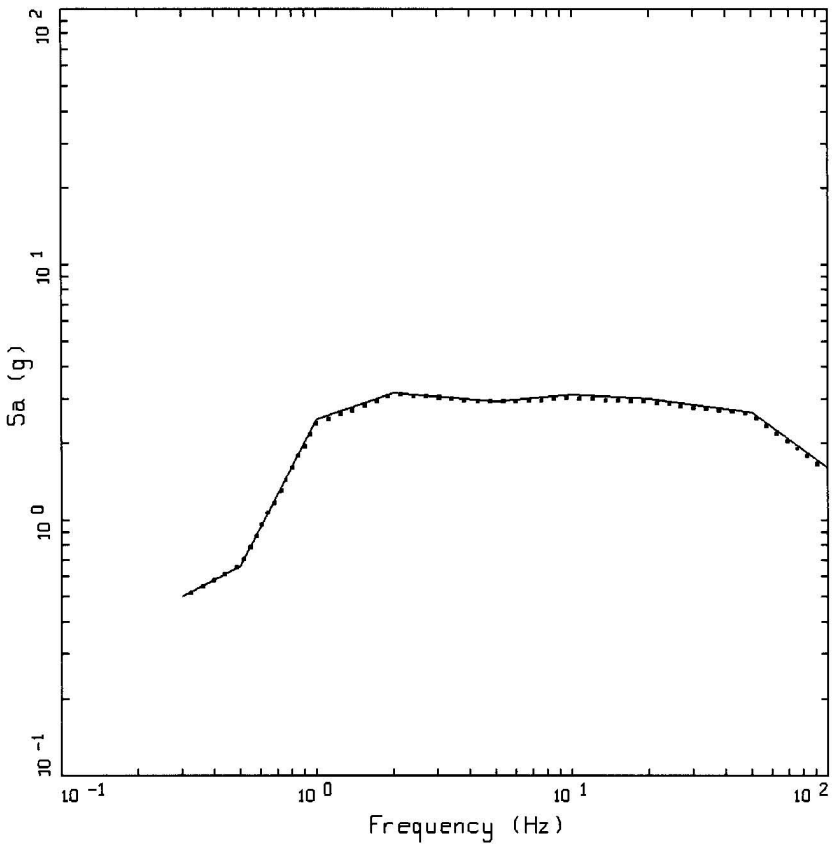

Figure RAI 2.2.1.1.1-009-12. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Repository Block Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-7} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the repository block waste emplacement level with a 10^{-7} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line shows the sensitivity results for the repository block using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-108[a].

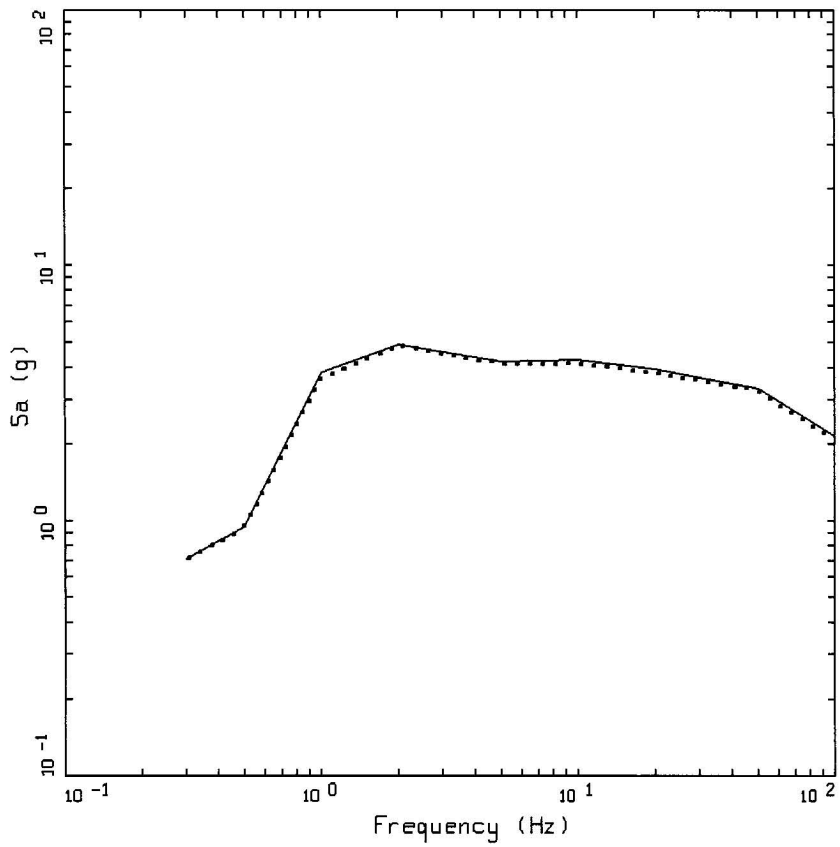

Figure RAI 2.2.1.1.1-009-13. Comparison of Vertical Uniform Hazard Spectrum for Sensitivity Cases to the Repository Block Site-Wide Vertical Uniform Hazard Spectrum with a 10^{-8} Mean Annual Probability of Exceedance

NOTE: The solid curve is the site-wide uniform hazard spectrum for the repository block waste emplacement level with a 10^{-8} mean annual probability of exceedance using a Poisson's ratio of 0.25 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff. The dotted line shows the sensitivity results for the repository block using a Poisson's ratio of 0.3 to determine the base-case V_P profile from the base-case V_S profile for the Calico Hills Formation and the Prow Pass Tuff.

Source: BSC 2009, *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain, NV*, Figure 6.4.2-109[a].

RAI Volume 2, Chapter 2.1.1.1, First Set, Number 10: Justify the location and characteristics of faults in Midway Valley within the Geological Repository Operations Area (GROA) zone of influence of fault-displacement (SAR Section 1.1.5.1.4; Figures 1.1-59, 1.1-61, 1.1-64). In particular, address the results of the 43 additional boreholes drilled during 2006 and 2007 and structural-geologic interpretations (Orrell, 2007, SAR Section 1.1.10) about relationships between, and potential Quaternary slip on, the Bow Ridge block-bounding fault and splays, the Exile Hill fault and splays, and the Midway Valley faults and splays, and potential effects on the seismic hazard. Additionally, explain how the fault maps provided in figures 1.1-59, 1.1-61 and 1.1-64 and the exposed and buried faults in cross sections of the GROA figures 1.1-65, 1.1-66, and 1.1-67 are consistent with each other and with the most recent interpretations of the boreholes data.

In SAR Section 1.1.5.1.4, the location and characteristics of faults in Midway Valley are discussed, and Section 1.1.10 includes a reference (Orrell 2007) about a preliminary reinterpretation of the 43 additional boreholes drilled during 2006 and 2007 and effects on location of the Bow Ridge fault and adjacent faults near proposed aging pads. However, the SAR discussion does not discuss the data and its effects on the fault locations and potential seismic hazard. Apparent inconsistencies in SAR maps and cross sections of the GROA, and the incomplete use of existing potentially relevant data, make the characterization of faults relevant to design considerations for GROA structures and facilities unclear. Staff needs this information to verify compliance with 10 CFR 63.21(c)(1)(ii) and 10 CFR 63.112(b), (c) and (d).

1. RESPONSE

The locations and characteristics of the faults in Midway Valley have been derived from a number of data sources (*Geologic Map of the Yucca Mountain Region, Nye County, Nevada*, [1] the bedrock geologic map of the Yucca Mountain area,[2] *Geologic Framework Model (GFM 2000)*, [3] Orrell 2007 in SAR 1.1.10[4]). Drilling conducted from 2006 through 2007 contributed to the updated interpretation of the Bow Ridge Fault as shown in SAR Figure 1.1-59.

This discussion addresses potential impacts to seismic hazard results related to updated geologic interpretations for Midway Valley presented in the SAR (Section 1.1.5.2.7.2, p. 1.1-96; Figure 1.1-59). Geotechnical boreholes in Midway Valley drilled in 2006 through 2007 form the basis for an updated interpretation of the buried location of the Bow Ridge Fault north of Exile Hill shown on SAR Figure 1.1-59 and documented by Orrell.[5] Based on data from boreholes UE-25 RF#75, UE-25 RF#76, UE-25 RF#78, UE-25 RF#79, and UE-25 RF#80, the main trace of the Bow Ridge Fault is interpreted to lie several hundred feet east of its previously interpreted location and is shown as such on SAR Figure 1.1-59. Buesch and Lung[6] considered data from 18 boreholes drilled in 2005, depth to bedrock data for 23 boreholes drilled in 2006–2007, and a more detailed evaluation of 12 additional boreholes drilled in 2006 through 2007, which are located in the vicinity of important to safety (ITS) facilities and aging pads. Based on their evaluation, Buesch and Lung observed that, with respect to the locations of faults, results are "consistent with the locations of previously identified faults with a few additional minor faults."[7]

The updated borehole information for the location of the Exile Hill Fault and splays and Midway Valley Fault and splays does not significantly impact the seismic hazard analysis. Thus, the evaluation of potential impact to seismic hazard provided below only addresses the updated interpretation of the Bow Ridge Fault.

Fault displacement hazard was evaluated in the probabilistic seismic hazard analysis (PSHA) for Yucca Mountain in the *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada,* Sections 4.2 and 8.2.[8] Fault displacement hazard (i.e., the annual probability that a given level of fault displacement will be exceeded) was evaluated for nine demonstration sites, some of which were characterized by multiple hypothetical conditions.[9] These sites represent the range of faulting conditions found within the GROA. Demonstration site #1 is a location along the Bow Ridge Fault west of Exile Hill.[10] Paleoseismic results, observations of faulting in the Basin and Range province, and seismic characterization of seismic sources formed the basis for the assessed fault displacement hazard.[11]

The expert teams who characterized fault displacement for the PSHA used two approaches: the displacement approach and the earthquake approach. The displacement approach relates fault displacement hazard to information on recurrence interval or slip rate for a given demonstration site (fault) of interest.[12] Contributions to hazard from principal and distributed faulting are not discriminated. The earthquake approach[13] related fault displacement hazard to the occurrence of earthquakes on seismic sources. Contributions to hazard from principal faulting due to earthquakes on the fault being evaluated and distributed faulting due to earthquakes on nearby faults are assessed explicitly. For both approaches, the revised location of the Bow Ridge Fault does not affect the calculation of fault displacement hazard for demonstration site #1. For the displacement approach, the spatial relation between the location of demonstration site #1 and other seismic sources is not relevant. For the earthquake approach, the distance between demonstration site #1 and other seismic sources is unaffected by the change in location of the Bow Ridge Fault to the north of demonstration site #1.

The approach to mitigation of fault displacement hazard is described in Section 5 of *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report*.[14] The primary design approach is to locate ITS structures, systems, and components away from Quaternary faults with a potential for significant displacement. The layout of surface facilities shown in the SAR achieves this result. The ITS surface facilities avoid the Bow Ridge Fault and the Paintbrush Canyon Fault, the two faults in the vicinity of Midway Valley with a potential for significant displacement. The change in the location of the Bow Ridge Fault to the north of Exile Hill does not alter this fact.

In addition to fault displacement hazard, the vibratory ground motion hazard is also evaluated in the probabilistic seismic hazard analysis for Yucca Mountain.[15] The Bow Ridge Fault is considered as an active seismic source by the expert teams involved in the evaluation. In the PSHA, the vibratory ground motion hazard is calculated for a point at Easting 547,953 meters and Northing 4,077,750 meters[16] in the repository block. This location is almost identical to fault displacement hazard demonstration site #8.[17] The change in location of the Bow Ridge Fault to the north of Exile Hill moves the fault farther from the ground motion calculation point. This would result in a lower calculated ground motion. However, given the short distance from the

ground motion calculation point (less than 5 km), the generally slow change in ground motion attenuation for distances less than 10 km,[18] and the generally minor contribution to ground motion hazard from the Bow Ridge Fault source,[19] any change will be negligible.

Given the above assessment of potential effects on fault displacement hazard and vibratory ground motion hazard related to the revised location of the Bow Ridge Fault north of Exile Hill, there is no impact to information presented in the SAR.

The geologic and geophysical logs provided in RAI 2.2.1.1.1-004 show the additional data relied upon for determination of the site geology as described in the SAR.

This request for additional information is related to the request for a geologic map and geologic cross sections for the surface portions of the GROA (RAI 2.2.1.1.1, 2nd, #1). When the interpretations of the 2006 and 2007 investigations in Midway Valley are completed, an updated geologic map and the updated cross sections for the surface portions of the GROA, including an updated interpretation of fault locations and characteristics, will be prepared. The plan for the updated geologic map and geologic cross sections will be discussed in response to RAI 2.2.1.1.1, 2nd, #1. While there may be some local, minor changes in the interpretations, it is expected that the results will confirm the locations and characteristics of the faults considered in the design of the surface facilities.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

[1] Potter, C.J.; Dickerson, R.P.; Sweetkind, D.S.; Drake, R.M., II; Taylor, E.M.; Fridrich, C.J.; San Juan, C.A.; and Day, W.C. 2002. *Geologic Map of the Yucca Mountain Region, Nye County, Nevada*. Geologic Investigations Series I-2755. Denver, Colorado: U.S. Geological Survey. TIC: 253945.

[2] Day, W.C.; Dickerson, R.P.; Potter, C.J.; Sweetkind, D.S.; San Juan, C.A.; Drake, R.M., II; and Fridrich, C.J. 1998, *Bedrock Geologic Map of the Yucca Mountain Area, Nye County, Nevada.* Geologic Investigations Series I-2627. Denver, Colorado: U.S. Geological Survey. ACC: MOL.19981014.0301.

[3] BSC (Bechtel SAIC Company) 2004. *Geologic Framework Model (GFM2000).* MDL-NBS-GS-000002 REV 02. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040827.0008.

[4] Orrell, S.A. 2007. "Preliminary 2007 Geotechnical Drilling Results from the U.S.G.S. for the Waste Handling Buildings and Aging Pad Areas." Letter from S.A. Orrell (SNL) to R.J. Tosetti

(BSC), May 29, 2007, 07_631_YMP-LL_05-29-2007, with enclosure.
ACC: LLR.20070531.0001.

[5] Ibid.

[6] Buesch, D.C. and Lung, R.C., 2008, *Update of Geotechnical Borehole and Test Pit Program through 2007 in Midway Valley, Nevada*. Denver, Colorado: U.S. Geological Survey. ACC: LLR.20080121.0080. p. 7.

[7] Ibid.

[8] CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1998. *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada.* Milestone SP32IM3, September 23, 1998. Three volumes. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981207.0393.

[9] Ibid., Section 4.3.2.

[10] Ibid., Figure 4-9.

[11] Ibid., Section 4.2 and Appendix E.

[12] Ibid., Section 4.2.4.1.

[13] Ibid., Section 4.2.4.2.

[14] DOE (U.S. Department of Energy) 2007. *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report*. YMP/TR-003-NP, Rev. 5. Las Vegas, Nevada: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: DOC.20070625.0013.

[15] CRWMS M&O 1998. *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada,* Sections 4.1, 5, 6, and 7.2.

[16] MO0401MWDRPSHA.000. Results of the Yucca Mountain Probabilistic Seismic Hazard Analysis (PSHA). Submittal date: 03/13/2008.

[17] CRWMS M&O 1998. *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada,* Figure 4-9.

[18] Ibid., Figures 6-1 to 6-4.

[19] Ibid., Figures 7-23, 7-24, 7-55, 7-56, 7-83, 7-84, 7-107, 7-108, 7-135, 7-136, 7-161, 7-162.