PNNL-16343

Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Borehole Summary Report for Waste Treatment Plant Seismic Borehole C4993

C. F. Rust
D. B. Barnett
N. A. Bowles
J. A. Horner

February 2007

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

DISCLAIMER

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161
ph: (800) 553-6847
fax: (703) 605-6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

This document was printed on recycled paper.
(8/00)

PNNL-16343

Borehole Summary Report for Waste Treatment Plant Seismic Borehole C4993

C. F. Rust[(a)]
D. B. Barnett
N. A. Bowles[(b)]
J. A. Horner[(b)]

February 2007

Prepared for
the U.S. Department of Energy
Office of River Protection
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

(a) Freestone Environmental Services, Inc., Richland, Washington
(b) GRAM, Inc., Richland, Washington

Summary

A core hole (C4998) and three boreholes (C4993, C4996, and C4997) were drilled to acquire stratigraphic and downhole seismic data to model potential seismic impacts and to refine design specifications and seismic criteria for the Waste Treatment Plant (WTP) under construction on the Hanford Site. During the months of September through early October 2006, borehole C4993 was completed through the Saddle Mountains Basalt, the upper portion of the Wanapum Basalt, and associated sedimentary interbeds, to provide access to the subsurface for geophysical measurement and for stratigraphic comparison with the other three boreholes.

Presented and compiled in this report are field-generated records for the deep mud rotary borehole C4993 at the WTP site. This report includes borehole logs, lithologic summary, drilling information, and sample collection details.

Borehole C4993 was drilled using direct-circulation, mud rotary methods with a Speedstar 50K drill and tricone button bit (7-7/8-in. outside diameter). Cutting samples were collected primarily from the mud plant every 5 ft or at changes in lithology. A general zoning pattern was recognized within all the basalt units:

1. Upper basal zones generally were fast-drilling (3–7 ft/hr) and fractured, with secondary clay fillings in apparent fracture and/or vesicle fillings.
2. Center zones were slow-drilling (1–3 ft/hr penetration rate), with fewer fractures and much less clay.
3. Basal zones were alternately hard- and slow-drilling in the unit. Penetration rates increased to 3–9 ft/hr. The basal zones directly overlie weathered horizons/clay units at the top of the interbeds.

For sedimentary interbeds, sample returns for the two dominant lithologies (clay and sand) were very poor. Most clay-siltstone samples were disaggregated before being discharged through the mud plant. For sands, sample quality should be considered suspect.

Abbreviations

bgs	below ground surface
DOE	U.S. Department of Energy
ft	foot, feet
in.	inch, inches
OD	outside diameter
PC-3	Performance Category 3
PNNL	Pacific Northwest National Laboratory
SBP	Seismic Boreholes Project
Vp	compressional wave velocity
Vs	shear wave velocity
WTP	Waste Treatment Plant

Contents

Figures

Tables

1.0 Introduction

This report presents field-generated documentation for borehole C4993 constructed with a mud rotary drill rig at the Waste Treatment Plant (WTP) site on the U.S. Department of Energy (DOE) Hanford Site. The documentation for C4993 includes borehole logs, lithologic summary, and record of cutting samples collected during drilling through the months of August through early October 2006.

Initially, four entry holes were drilled by cable tool from the surface to the top of the basalt through the sediment overlying the Saddle Mountains Basalt. These entry boreholes provide access for three deep mud rotary boreholes (C4993, C4996, and C4997) and one core hole (C4998) through the basalt. The one core hole and three boreholes were drilled to acquire stratigraphic and downhole seismic data to model potential seismic impacts and to refine design specifications and seismic criteria for the WTP. The primary purpose of the three boreholes was to provide access to the subsurface for geophysical measurements. The locations of the boreholes and core hole for this study are shown in Figure 1.1. The surveyed locations of the four holes are summarized in Table 1.1.

1.1 Waste Treatment Plant and the Seismic Boreholes Project

The seismic site response analysis for the WTP was reevaluated in 2005, resulting in an increase by up to 40% in the seismic design basis. The original seismic design basis for the WTP was established in 1999 and was based on a probabilistic seismic hazard analysis completed in 1996. The 2005 analysis was performed to address questions raised by the Defense Nuclear Facilities Safety Board about the assumptions used in developing the original seismic criteria and adequacy of the site geotechnical surveys. The updated seismic response analysis used existing and newly acquired seismic velocity data, statistical analysis, expert elicitation, and ground-motion simulation to develop interim design ground-motion response spectra that enveloped the remaining uncertainties. The uncertainties in these response spectra were enveloped at approximately the 84th percentile to produce conservative design spectra, which contributed significantly to the increase in the seismic design basis.

A key uncertainty identified in the 2005 analysis was the velocity contrasts between the basalt flows and the sedimentary interbeds beneath the WTP. The velocity structure of the upper four basalt flows (Saddle Mountains Basalt) and that of the interlayered sedimentary interbeds (Ellensburg Formation) produce strong reductions in modeled earthquake ground motions propagating through them. Uncertainty in the strength of velocity contrasts between these basalts and interbeds resulted primarily from an absence of measured shear wave velocities (Vs) in the interbeds. For the 2005 analysis, Vs in the interbeds was estimated from older limited compressional wave (Vp) data using estimated ranges for the ratio of the two velocities (Vp/Vs) in similar materials. A range of possible Vs for the interbeds and basalts was used and produced additional uncertainty in the resulting response spectra.

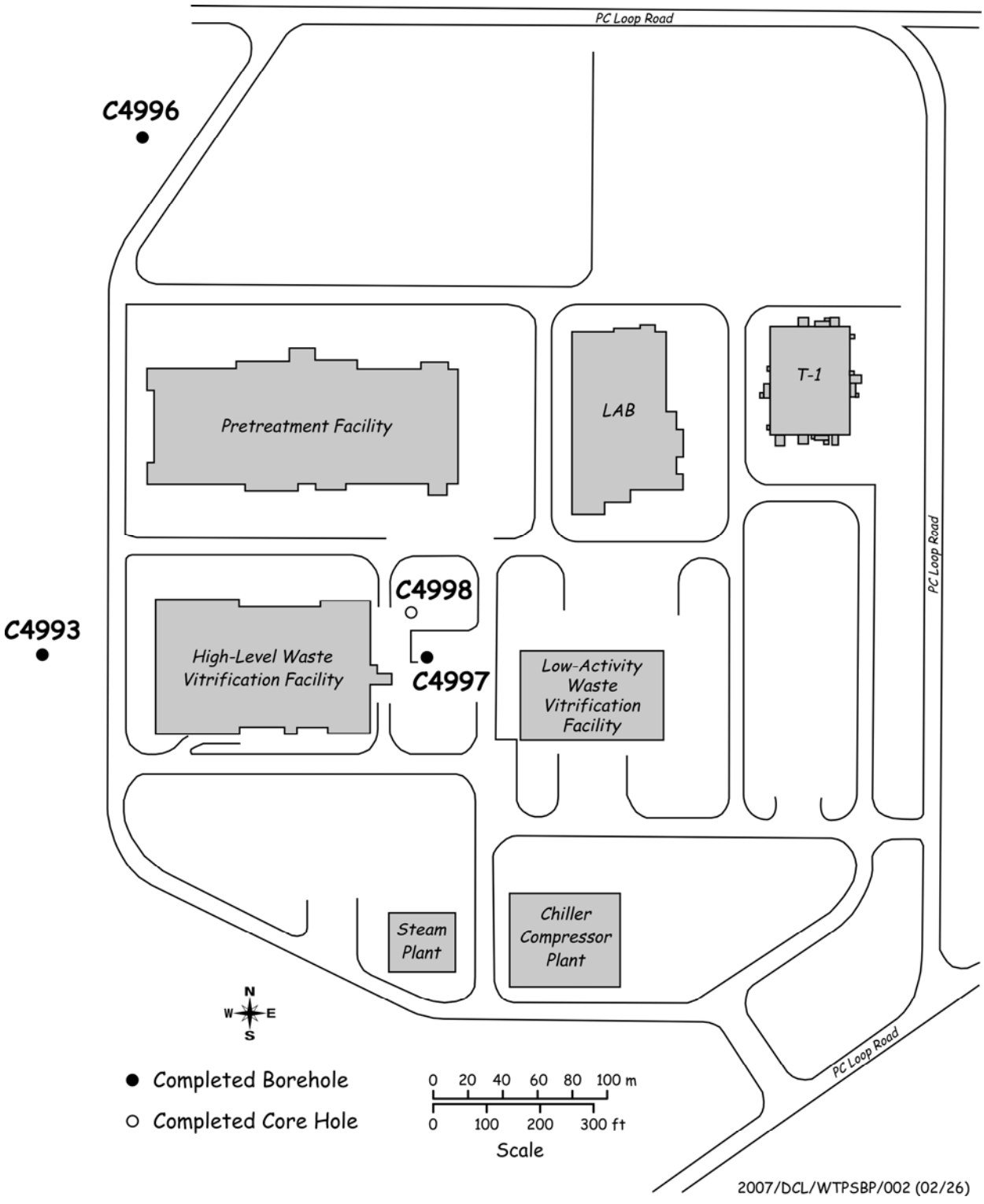


Figure 1.1. Locations of Waste Treatment Plant Boreholes

Table 1.1. Surveyed Horizontal Locations and Elevations of Seismic Boreholes

Hanford Borehole ID	Surveyed WTP Coordinates (ft)		Converted – NAD83 State Plane Coordinates (m)		Elevation (ft) at Ground Surface
C4997	E 10,375.480	N 3,836.210	E 576,309.433	N 135,755.318	676.87
C4998	E 10,345.400	N 3,920.390	E 576,300.266	N 135,780.973	676.87
C4993	E 9,647.070	N 3,840.600	E 576,087.439	N 135,756.656	658.24
C4996	E 9,836.490	N 4,816.880	E 576,145.168	N 136,054.191	670.06

Because of the sensitivity of the calculated response spectra to the velocity contrasts between the basalts and interbedded sediments, DOE initiated the Seismic Boreholes Project (SBP) to emplace additional boreholes at the WTP site and obtain direct Vs measurements and other physical property measurements in these layers. One core hole and three boreholes were installed at the WTP site to a maximum depth of 1468 ft below ground surface. The three boreholes are within 500 ft of the high-level waste vitrification and pretreatment facilities of the WTP, the Performance Category 3 (PC-3) structures affected by the interim design spectra. The new measurements from the seismic boreholes are expected to reduce the uncertainty in the modeled site response caused by the lack of direct knowledge of the Vs contrasts within these layers.

1.2 Scope of Work

The well-site geology support personnel for the C4993 drilling effort included geologists from Freestone Environmental Services, Inc., Pacific Northwest National Laboratory (PNNL), and GRAM, Inc. The scope of work for each subcontractor varied slightly during the drilling of C4993. All geologists supporting the C4993 drilling effort collected, examined, described, and preserved samples of cuttings from 5-ft depth intervals or recognized changes in lithology.

1.3 Procedures, Quality Assurance, and Quality Control Requirements

Organizational responsibilities and actions to be completed were established in *Sampling and Analysis Plan – Waste Treatment Plant Seismic Boreholes Project* (PNNL 2006). That document also specified that geological observations were to be recorded using the Fluor Hanford, Inc., Groundwater Remediation Project Procedure, *Geologic Logging* (Fluor Hanford, Inc. 2006). Documented procedures were strictly followed to ensure the integrity of descriptions and records. All subcontractors were aware of the importance of maintaining depth measurements as accurately as possible. Emphasis also was placed on personnel training, records control, quality control, inspection, approval of records, change control of records, and physical control of duplicate records, as well as physical transfer of the custody of samples and chain-of-custody records.

1.4 Report Scope

This document compiles field records and summarizes observations and measurements made during the drilling of borehole C4993 and visual characterization of the rock cuttings collected during drilling. All data in this report are presented in the English units in which they were measured or recorded onsite. The report includes documentation of the mud rotary drilling, borehole logging, and sample collection.

Completed borehole logs are contained in Appendix A. Field activity and daily drilling reports are provided in Appendix B. The samples collected during drilling are inventoried in Appendix C. In Appendix D, the characteristics of basalt members and sedimentary interbeds are summarized. Appendix E provides an inventory list of photographs of the samples.

2.0 Drilling and Geological Sampling

The primary purpose of drilling borehole C4993 was to provide a conduit for access of geophysical tools. Five basalt layers and five sedimentary interbeds were penetrated by the rotary-drilled portion of the borehole. Drilling of the rotary portion of the hole began on September 8 and ended on October 7, 2006, at a total depth of 1411 ft. Crews alternated 12-hour work shifts to maintain field support on a 24/7 schedule during the entire period. The logs in Appendixes A and B provide details on geology, drilling activities, problems encountered, footages drilled, and the timing of events during drilling, cementing, logging, sampling, and other drilling-related activities.

Borehole C4993 was drilled using direct-circulation, mud rotary methods with a Speedstar 50K drill and tricone button bit (7-7/8-in. outside diameter [OD]). Drilling fluid (also known as mud—combinations of bentonite, polymers, and water) was cleaned of cuttings and recirculated into the borehole using a mud pump and portable mud plant (Figure 2.1). Mud was used to lubricate and cool the drill bit and to return cuttings from depth to ground surface.

Well-site geologists collected, described, and packaged cuttings samples in jars and chip trays as described in the *Sampling and Analysis Plan* (PNNL 2006). Each sample was labeled with borehole number, depth, date collected, and the initials of the well-site geologist who collected the sample. Cuttings samples were then described on the Borehole Log (Appendix A), and additional notes were recorded on Field Activity Reports (Appendix B). Care was taken to correctly identify the source depths for the collected cuttings. The drillers, geologists, and site supervisors also monitored drilling parameters and progress by geolograph.

Cuttings samples were collected primarily from the mud plant every 5 ft or at changes in lithology (Figure 2.1). Cuttings sample collection involved scraping a shovel full of cuttings from the discharge slide coming off the mud plant, which screen-separated the cuttings from the bentonite drilling fluid. Most samples were washed in a handheld screen to remove excess mud and mud additives. Some samples were not washed, to retain finer material typical of interbeds.

Most zones within the sedimentary interbeds did not produce adequate samples from the mud plant. To provide an archival sample in these intervals, samples were collected from the top screens of the mud plant or were screened directly from the surface casing at the borehole. Other samples were bottled from the sand vortex discharge tubes on the mud plant. It was determined later that the bottled sand samples may not be representative of the interbed because of intermixing caused by intermittent operation of the sand pump in the mud plant.

Figure 2.1. Mud Rotary Drill Rig at Borehole C4993 with Mud Plant Alongside

Grab samples were collected by one of the above-mentioned methods and then washed, distributed, and containerized in labeled glass jars, cloth bags, and plastic cuttings trays. The depth range was recorded for each grab sample. A description was made based upon the percentage of each rock type present, color, fracture patterns, mineralogy, crystal forms, and any additional visibly distinguishable characteristics.

Some sampling was coordinated with the driller. Consultation with the driller provided insight on interpreting drilling characteristics, such as drill speed, penetration rate, torque of the drill string, and jarring or vibration of the drill string in fracture zones, to identify when depth errors occurred with the geolograph. The geolograph was nominally recalibrated at the end of each 20-ft drill string.

3.0 Borehole Geology

The Waste Treatment Plant (WTP) is located on the Hanford Site, which is in the Pasco Basin at the center of the Columbia Plateau. The geology of the Hanford Site and the deep subsurface was investigated previously during the Basalt Waste Isolation Project. Those previous investigations are reported in the *Consultation Draft Site Characterization Plan* (DOE 1988) and in *Geologic Studies of the Columbia Plateau* (Myers et al. 1979). The stratigraphic units drilled during the Seismic Borehole Project include the upper Columbia River Basalt Group with sedimentary interbeds and the overlying unconsolidated sediments. The overlying unconsolidated sediments, Hanford and Ringold formations, were drilled using a cable drill rig prior to mud rotary drilling and are not covered in the following sections. Geologic observations for units encountered during drilling of borehole C4993 are presented in the following sections.

3.1 Stratigraphy and Lithology

The Columbia River Basalt Group with alternating sedimentary units drilled during the project included three formations—the Saddle Mountains Basalt, the Wanapum Basalt, and the Ellensburg Formation (Figure 3.1). The Saddle Mountains Basalt includes the Elephant Mountain Member, Pomona Member, Esquatzel Member, and Umatilla Member. The Wanapum Basalt includes the Priest Rapids Member, which is the uppermost member of the Wanapum Basalt and consists of two flows, the Lolo and the Rosalia flows. The Ellensburg Formation sediments are interbedded with the Columbia River Basalt Group and include the Rattlesnake Ridge, Selah, and Cold Creek interbeds within the Saddle Mountains Basalt and the Mabton Interbed between the Saddle Mountains Basalt and Wanapum Basalt. Basalt units and sedimentary interbeds are discussed in Sections 3.1.1 and 3.1.2, respectively. A summary lithologic log derived from the borehole logs is shown in Figure 3.2.

3.1.1 Basalt Units

Elephant Mountain Member of the Saddle Mountains Basalt

The Elephant Mountain Member is the uppermost basalt flow of the Columbia River Basalt Group present in the study area. Beneath the Hanford Site, this single flow has an average thickness of 100 ft with a range of 15 ft. In borehole C4993, the Elephant Mountain Member has a total thickness of 115.5 ft and was encountered between 358 ft and 473.5 ft below ground surface (bgs). This member is medium- to fine-grained, with abundant microphenocrysts of plagioclase. A few spaced fractures occur throughout the basalt flow based on drill rod vibration, increased drill rate, and driller interpretation. The most common secondary mineral was green clay.

The portion of the Elephant Mountain Member flow top in C4993 that had escaped erosion was highly vesicular, amygdaloidal, had clay-filled fractures, showed signs of weathering, and was oxidized to a reddish-brown at the contact with the overlying Ringold Formation sediments. The flow bottom had an overall increase in glassy fragments. Although vesiculation was much less apparent, secondary, fracture-filling clay was present at the contact with Rattlesnake Ridge sediment.

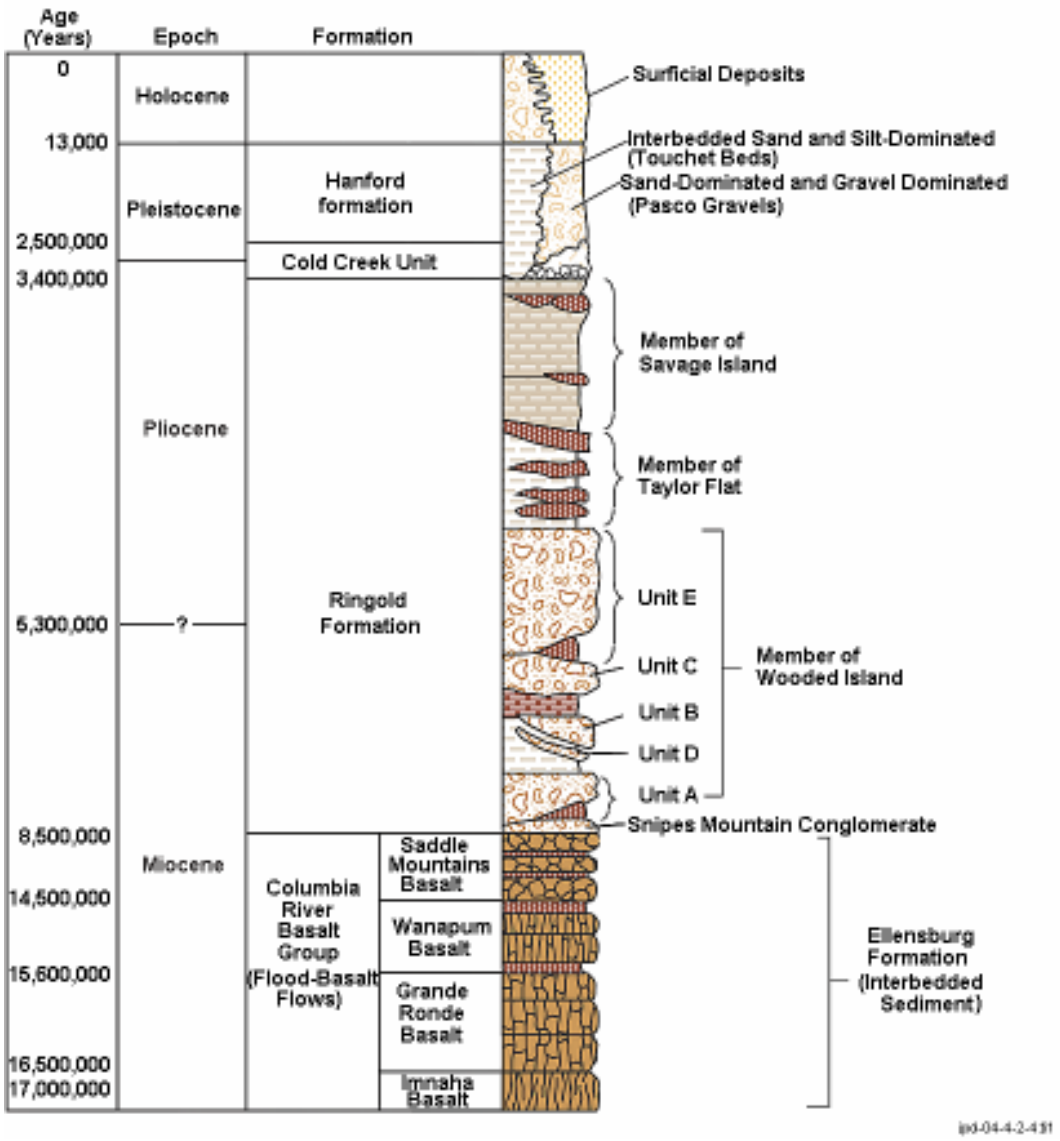


Figure 3.1. General Stratigraphy of the Hanford Site

Pomona Member of the Saddle Mountains Basalt

The Pomona Member overlies the Esquatzel Member and is separated by the Selah Interbed of the Ellensburg Formation. This single flow has an average thickness of 185 ft with a range of 10 ft. In borehole C4993, the Pomona Member has a total thickness of 191.5 ft and was encountered between 532 ft and 723.5 ft bgs. This basalt is fine-grained to glassy and contains plagioclase phenocrysts and rare olivine. Clay, zeolites, and silica, probably as fracture and/or vesicle filling, were observed in the cuttings samples. Blue-green clay was present most often as fracture fill.

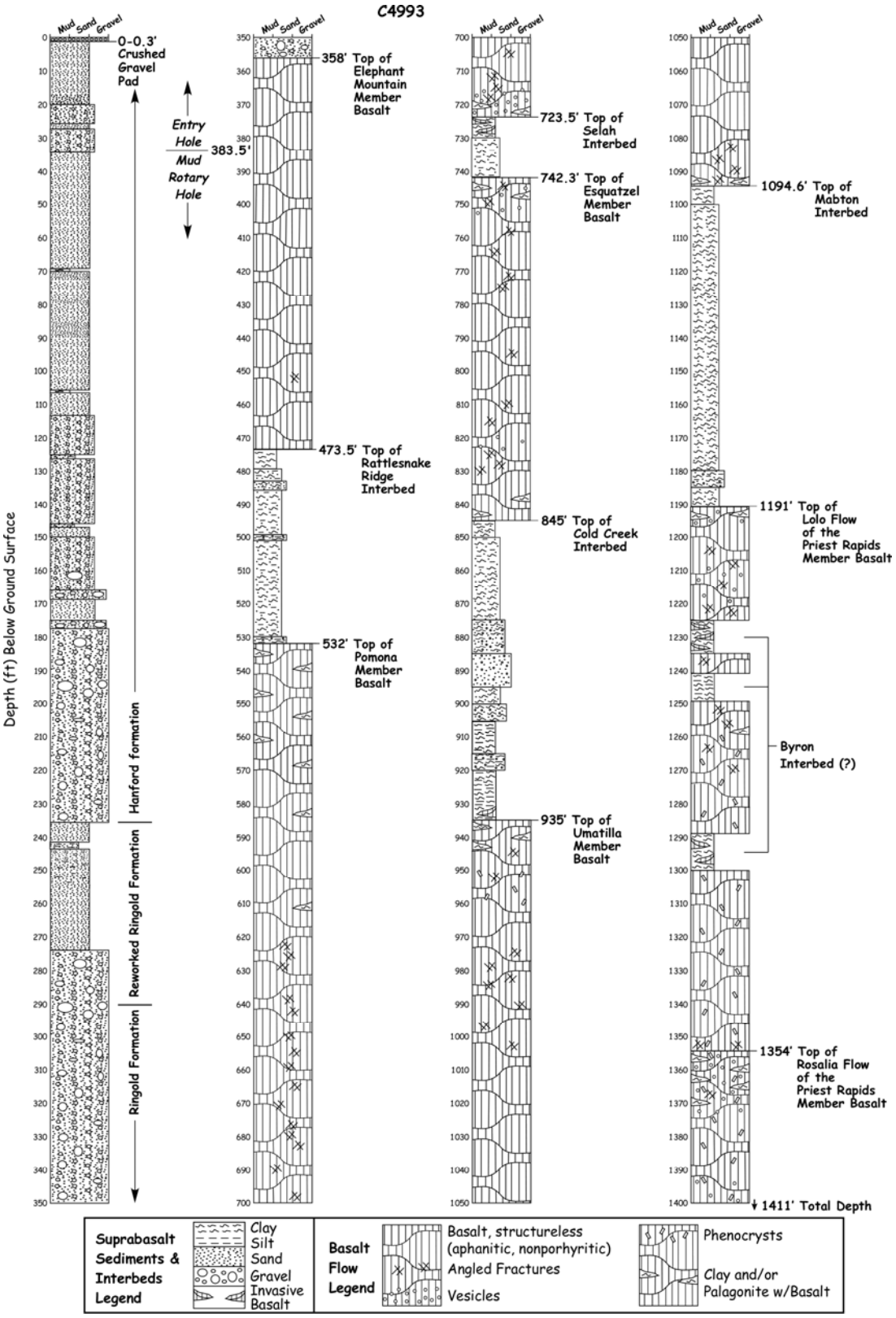


Figure 3.2. Summary Lithologic Log for Borehole C4993

The flow top of the Pomona Member was extremely brecciated and highly fractured and contained palagonite. Palagonite is a tan or brown amorphous material resulting from the hydration of basaltic glass; its presence here indicates that this lava flow probably encountered water while still in a molten state. A high clay and sediment content (between 10 and 40%) was observed in the top 15 feet of the basalt flow, dropping to about 1–5% of green-blue clay downward though most of the thickness of the unit. The blue-green clay is interpreted to be fracture fill (Figure 3.3). Plagioclase phenocrysts are common through the unit. Some features were observed in cutting samples that could be interpreted as slickensides, but these may be drilling-induced striations.

The Pomona flow bottom was determined based on the disappearance of basalt and an increase in clay content from the cutting samples. A few vesicles were present with blue-green clay lining in some of the vesicle walls.

Figure 3.3. Blue-Green Clay on Basalt Surface, Clay Fracture Fill

Esquatzel Member of the Saddle Mountains Basalt

The Esquatzel Member lies above the Umatilla Member and is separated by the Cold Creek Interbed of the Ellensburg Formation. This single flow has an average thickness of 100 ft with a range of 10 ft. In borehole C4993, the Esquatzel Member has a total thickness of 102.7 ft and was encountered between 742.3 ft and 845 ft bgs. This member is fine-grained and plagioclase-phyric, often containing plagioclase glomerocrysts and clinopyroxene microphenocrysts. In cutting samples, only fragments of plagioclase phenocrysts were observed. Clay, pyrite, and iron oxide were observed in the cutting samples are found as fracture and joint fillings.

The flow top of the Esquatzel Member was highly weathered to blue-gray-green clay. Minor fracturing was present at the flow top, based on the presence of blue-green clay fracture fill and vesicles filled with hematite (Figure 3.4). Aggregates of pyrite and magnetite crystals were observed and probably occur as both primary minerals and secondary veins, based on observations in the core at C4998 (Figures 3.5 and 3.6). The flow bottom was moderately fractured, with glassy flow bands (Figure 3.7) typical of a flow bottom.

Umatilla Member of the Saddle Mountains Basalt

The Umatilla Member is the lowermost and oldest member of the Saddle Mountains Basalt and consists of two flows in the study area, the Umatilla and the Sillusi. Geochemical analysis is required to differentiate between the flows. This member has an average thickness on the Hanford Site of 150 ft with a range of 10 ft. In borehole C4993, the Umatilla Member has a total thickness of 159.6 ft and was encountered between 935 ft and 1094.6 ft bgs. This unit is fine-grained and plagioclase-phyric, often extremely glassy. Clay and pyrite, presumably as fracture fillings, were observed in the cuttings, blue-green clay being the most common.

The flow top for this unit begins abruptly with the appearance of hard clay that drilled similar to basalt from 933 ft to 935 ft bgs, followed by basalt and a variety of secondary gray-green clay minerals. Fractures with gray-green clay fill and sparse plagioclase phenocrysts occur throughout the unit. Cuttings from the highly fractured zones exhibit pyrite veins (Figure 3.6). The flow bottom had an increase in fractures and of light gray brittle clay/claystone.

Figure 3.4. Vesicles Filled with Hematite or Similar Iron Oxide Mineral

Figure 3.5. Fragment of Fracture Fill Containing Magnetite and Pyrite Crystals. Fragment is 2 mm at its longest dimension.

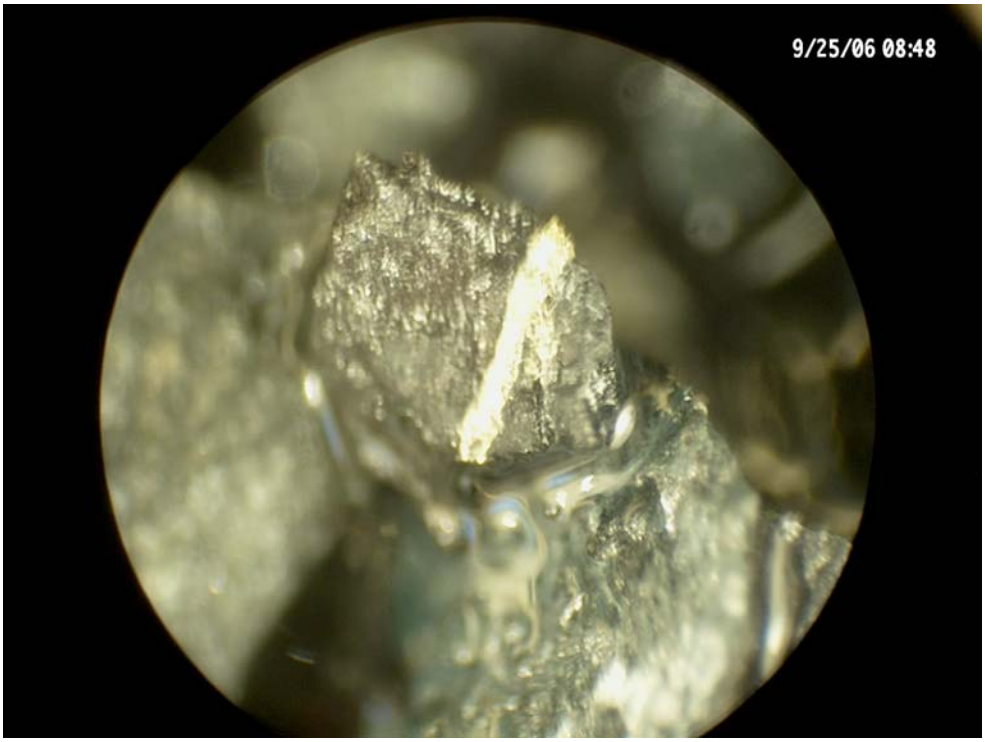


Figure 3.6. Pyrite Vein in Basalt Cuttings (0.5 mm width)

Figure 3.7. Glassy Flow Bands from Bottom of Basalt Flow

Priest Rapids Member of the Wanapum Basalt

The Priest Rapids Member is the uppermost member of the Wanapum Basalt and consists of two flows, the Lolo and the Rosalia flows. This member has an average thickness of 232 ft with a range of 40 ft. In borehole C4993, the Lolo flow has a total thickness of 163 ft and was encountered between 1191 ft and 1354 ft bgs. The Rosalia flow was encountered at approximately 1354 ft until total depth for the borehole, which was reached at 1411 ft bgs. In general, Priest Rapids Member basalt is fine- to medium-grained and glassy and has a high content of plagioclase microphenocrysts. Micropegmatites, coarse centimeter-scale intergrowths of plagioclase and glass, have been observed in this basalt member from other localities, as well as enclaves of quartz and pyroxene intergrowths. However, the younger Lolo flow has less common small olivine phenocrysts (less than 5 mm) and rare glomerocrysts or phenocrysts of plagioclase. In comparison, the older Rosalia flow is typically coarser-grained with rare olivine and plagioclase phenocrysts. The Byron Interbed sometimes separates the two basalt flows, as was observed in borehole C4996, but was not present in borehole C4993. The flow-top designation of the Rosalia flow was based on the appearance of distinctive flow-top features and properties. In borehole C4993, a few plagioclase phenocrysts were found, and none was micropegmatitic. Silica (opal and quartz), iron oxide, and clay have been observed in cutting samples, presumably as fracture/joint/vesicle-filling material.

The flow top of the Lolo flow of the Priest Rapids Member began abruptly with the appearance of soft, weathered altered basalt from 1191 ft to 1195 ft bgs and fracture fill or vesicle fill of soft opal. Roughly 90% of materials in the first 4 ft of the flow top could be crushed easily between fingers. Fractures with blue-green clay, silica (opal and quartz), and iron oxide mineral fill occur throughout the unit. Some basalt cuttings are glassy and some show botryoidal/mammillary texture on sides, probably siderite infilling vesicles or fractures (Figure 3.8). Clear plagioclase phenocrysts, some as large as 3 mm long, increase in abundance downward through the basalt flow.

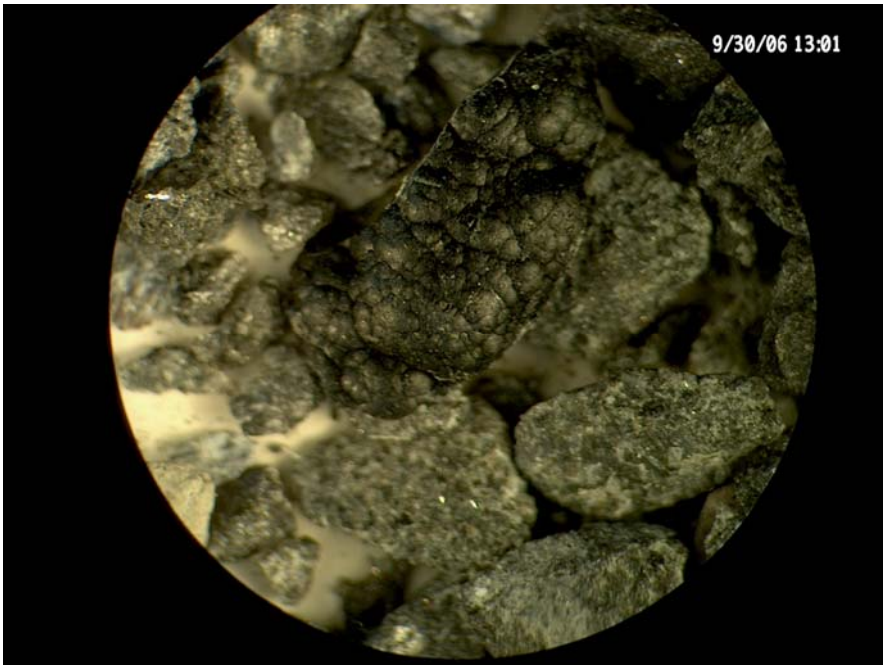


Figure 3.8. Fracture or Vesicle Filling Showing Botryoidal/Mammillary Mineral, Probably Siderite

The flow-top designation of the Rosalia flow of the Priest Rapids Member was based on the appearance of a highly weathered soft flow-top basalt composed of large amounts of green-gray clay (>5–25%) and an increase in drill rate in the interval 1354 ft to 1373 ft bgs. Sparse visible plagioclase phenocrysts (up to 1 mm), limited gray-brown-green clay fracture fill, and vesicles were present until total depth of 1411 ft bgs at 0700 hours on October 8, 2006.

3.1.2 Sedimentary Interbeds

Ellensburg Formation, Including the Rattlesnake Ridge, Selah, Cold Creek, Mabton, and Byron Interbeds

The Ellensburg Formation includes epiclastic and volcaniclastic sedimentary rocks that are interbedded with the Columbia River Basalt Group in the central and western part of the Columbia Plateau (Figure 3.9). The interbeds in the Ellensburg Formation are defined based on the upper and lower bounding basalt flows. The Rattlesnake Ridge, Selah, and Cold Creek interbeds lie within the Saddle Mountains Basalt; the Mabton Interbed lies between the Saddle Mountains Basalt and Wanapum Basalt. The Byron Interbed lies between the Lolo and Rosalia flows of the Priest Rapids Member.

Interbeds are made up of quartzitic to arkosic, micaceous sandstone and mudstone, with minor conglomerate containing abundant metamorphic and plutonic clasts. Paleosols composed of fine-grained, massive silt and clay are common. The provenance of these sediments is believed to be associated with the ancestral Columbia and Snake rivers. Layers of air fall tuff often lie within paleosols, indicating Cascade volcanism was active during Columbia River basaltic volcanism.

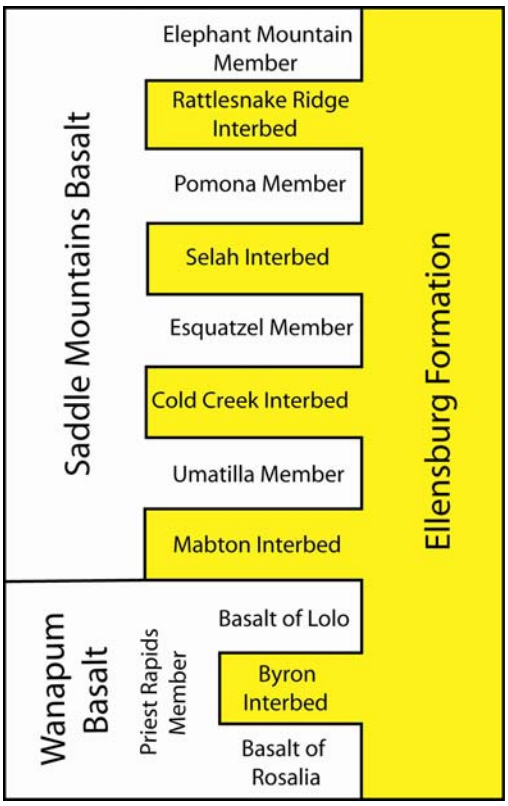


Figure 3.9. Relationship of Saddle Mountains Basalt and Wanapum Basalt to Ellensburg Formation Interbeds in Pasco Basin

Three distinct alternating sedimentary intervals occurred within the Lolo flow of the Priest Rapids Member. These intervals were not expected, based on what was encountered at the three other boreholes (C4996, C4997, and C4998). The first sedimentary interval was encountered between 1225 ft and 1234 ft bgs with a thickness of 9 ft and began abruptly with a green clay and fine- to medium-grained sand and a few muscovite flakes. Then the sedimentary interval gradually transitioned back to basalt with the presence of minor clay and iron oxide minerals. The second sedimentary interval was encountered between 1241.5 ft and 1249 ft bgs with a thickness of 7.5 ft, and was a silty claystone with very minor sand with fossiliferous, carbonaceous debris embedded in clay and siltstone (Figure 3.10). The claystone also contained lignite pieces displaying a woody texture (Figure 3.11) and diatoms (Figure 3.12). A microscopic comparison of a carbonaceous interval in borehole C4998 (~1184–1189 ft) showed some similarities with the exception that no diatoms were observed in the core. The third sedimentary interval was encountered between 1288.5 ft and 1299.5 ft bgs with a thickness of 11 ft and was a gray-black silty claystone, firmer than the second sedimentary interval. The interval has abundant carbonaceous debris, partially coalified, with large (up to 3-cm) lignite fragments, which were combustible after drying (Figure 3.13). It is possible that these three sequences represent the Byron Interbed, with invasive lobes of the Lolo flow separating the sedimentary intervals. Table 3.1 provides a summary description of the interbed sediments within borehole C4993.

3.1.3 General Observations

An erosional surface marks the contact between the overlying sediments and the topmost basalt unit at a depth of 358 ft bgs. Cable drilling stopped at 383.5 ft bgs, and the entry casing was set at 363.7 ft bgs and grouted in place, with the top of the cement grout set at 354.7 ft bgs to 383.5 ft bgs in borehole C4993.

Figure 3.10. Carbonaceous Debris in Claystone

Figure 3.11. Lignite Showing Remnant Plant Textures (~70X magnification)

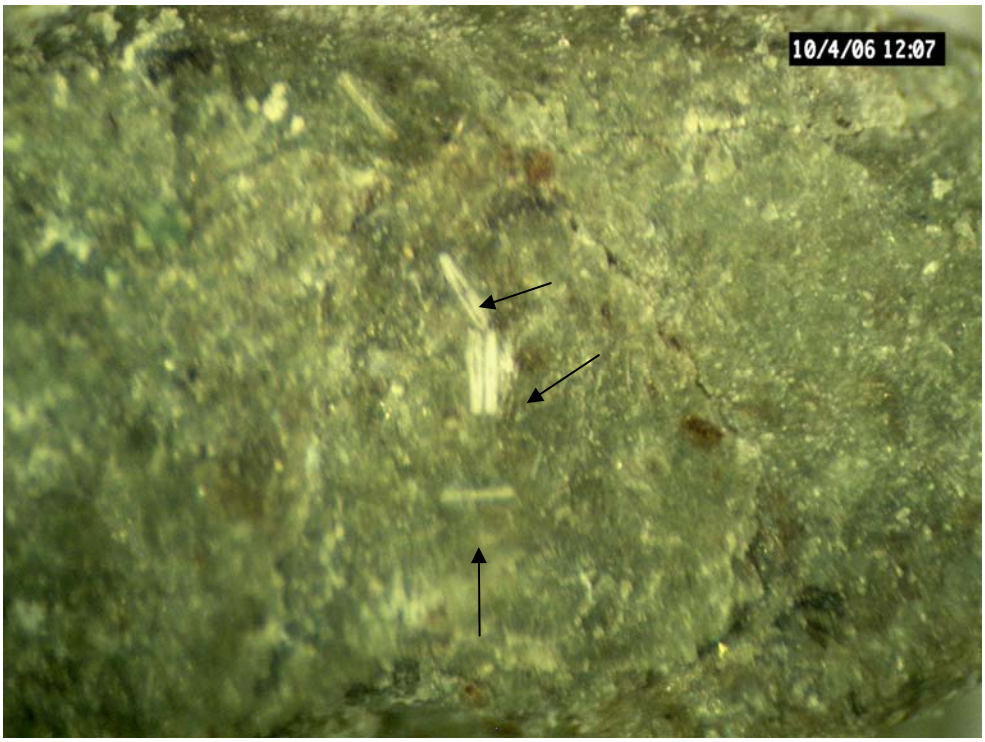


Figure 3.12. Diatoms (arrows) in Claystone from 1248 ft Below Ground Surface

Figure 3.13. Lignite Fragments Selected from Interval 1288.5 to 1290 ft Below Ground Surface

Table 3.1. Generalized Description of Sediments Within Borehole C4993

Unit Name	Rattlesnake Ridge Interbed	Selah Interbed	Cold Creek Interbed	Mabton Interbed	Byron Interbed
Depth interval(s) in feet bgs	473.5–532	723.5–742.3	845–935	1094.6–1191	1225–1234; 1241.5–1249; 1288.5–1299.5
Thickness in feet	58.5	18.8	90	96.4	27.5 (total)
Lithology	Green-gray/dark grayish-brown/light gray/light reddish-brown/dark reddish-brown/medium brown silty-sandy clays. Very fine to medium quartz and mafic sand.	Gray/tan-brown/tan-brown/light tan-off-white/tan-brown/light gray-off-white/light gray silty clays. Very fine to coarse mafic and quartz sand.	Gray-green/green/gray-green/green-white/gray silty clays. Olive green/dark green, very fine to coarse sand.	Dark blue-gray/dark green-gray/dark green/green-gray clays. Dark greenish-grey very fine to very coarse angular-grained sand.	Black to light gray-green. Clay and silt. Light brown to medium gray clay with diatoms and coalified carbonaceous debris. Minor fine- to medium–grained sand in upper horizon.
Mineralogy	Quartz and mafic sand (<5–48%)	Mafic and quartz sand (~5–50%)	Quartz sand (50%), mafic sand (5–40%), mica, feldspar, iron oxide (~10%)	Quartz and mafic sand (<10–70%)	Large muscovite flakes in sand.
Comments	Highly variable sequence of alternating silty clay and sand.	Clay-rich interval, large amounts of mafic sand.	Clay-rich interval at top and bottom, large interval of poorly sorted, micaceous sand in the middle, slightly silty clay green color from 905 ft to 940 ft, almost no sand in samples, with hard clay above basalt.	Top half alternates from clay and fine-grained sands to very fine to very coarse angular-grained sands. Lower half of interval is essentially a clayey poorly sorted sand.	The three horizons are interbedded with the Lolo basalt flow—possible invasive lobes into Byron Interbed.

Basalt flow structures and fractures were poorly represented in cuttings, due in part to the destructive nature of mud rotary drilling (tricone button bit) and the erosion and attrition of these features as cuttings were transported to the surface by heavy bentonite drilling mud and cycled through the mud plant before sample collection. Fracturing or jointing of any kind may be inferred for some intervals by the presence of varying amounts of secondary minerals (e.g., clays and pyrite) as fracture/joint fillings. In some cases, fragments of fractures/veins and vesicles are apparent under magnification (Figures 3.5 and 3.8). The difference between cooling joints and tectonic fracturing, however, cannot be distinguished by cuttings alone. The C4993 borehole log included drillers' notifications of fracture zones, which were identified by observable drill responses, drilling penetration rates, and torque variation.

Identifying secondary minerals in cuttings was extremely difficult due to the destructive nature of mud rotary drilling, shared physical properties with the bulk sample, and the small grain size of the returned sample. All three factors make the simplest deterministic tests difficult. Hence, it is difficult to estimate the amount of a specific mineral present within a specific interval. For example, softer, less-indurated particles have a greater chance of disintegrating within the borehole than do harder lithologies. It follows that more of the harder lithologies would be present in a random sample but may not correctly reflect the lithology at depth. The absolute amount of secondary minerals present in each cuttings sample, therefore, may be interpreted on only a very general scale.

A general zoning pattern was recognized within all the basalt units:

1. Upper basal zones generally were fast-drilling (3–7 ft/hr) and fractured, with secondary clay fillings in apparent fracture and/or vesicle fillings.
2. Center zones were slow-drilling (1–3 ft/hr penetration rate), with fewer fractures and much less clay.

3. Basal zones were alternately hard- and slow-drilling in the unit. Penetration rates increased to 3–9 ft/hr and gave interpretive warnings when weathered horizons/clay units at the top of the interbeds were entered.

For sedimentary interbeds, sample returns for the two dominant lithologies (clay and sand) were very poor. For clays, the only reliable data retrieved were the clay to clay-siltstone-size materials. At times, the only retrievable clay-siltstone samples were taken from the top of the surface casing before the mud plant. Most of the clay-siltstone samples were disaggregated before being discharged through the mud plant. For sands, samples should be considered suspect and unrepresentative. Some jar and chip tray sand samples were collected directly from the sand vortex pump discharges on the back of the mud plant. The sand vortex pump on the mud plant was not running continuously throughout drilling. Sandy samples probably represent a mixture over an unspecified stratigraphic interval rather than representing a specific sand interval or zone. Based on the rapid advance of the drill, generation of sand waste, and loss of drilling mud, sand zones in the interbeds appeared to be relatively unconsolidated. At no time were cemented sands retrieved. Sands appeared to be completely disaggregated by the mud rotary drilling process.

The clay-rich zones appeared to have squeezing and swelling properties, as evidenced by closing or partial closing of the borehole during drilling, reaming, geophysical logging, and redrilling of cement plugs. After drilling through an interbed, the hole was cemented over the interval of the interbed, then the cement plug was redrilled. Cementing schedules and general construction features are shown in Figure 3.14. The remaining cement in the borehole column may have been thin or washed out in some of the intervals, as evidenced by retrieval of clay cuttings in cemented zones. Some of the squeezing/swelling interbed zones had repetitive squeezing/swelling episodes. For portions of the interbeds, drillers reduced weight on the bit to avoid excessive bit advancement and potential for borehole deviation. Drillers tried to limit penetration rates to 15–20 ft/hr. However, drillers noted a decreased rate of drilling in some clay intervals due to enhanced adhesive properties of those zones. The adhesive clay conditions also required the drillers to take extra time to wash out the clay to avoid clogging of the tricone button bit. Overall, very few recognizable cutting samples were retrieved while drilling through the sedimentary interbeds.

Present throughout the borehole were fragments resembling a felsic or intermediate intrusive rock, up to 5% in abundance, as shown in Figure 3.15. These grains were invariably flattened and foliated, with one side concave and striated. The grains also contained well-defined plagioclase phenocrysts. Unidentified, black mineral grains were preferentially aligned with foliation. The fragments are persistent throughout this and the other two rotary boreholes (C4996 and C4997), are infallibly consistent in configuration and composition, are frequently associated with metallic shards on the concave side of the fragments, and are not similar to any lithology observed in the core hole (C4998). All these observations thus suggest the grains are an artifact of drilling, although the mode of formation is unknown.

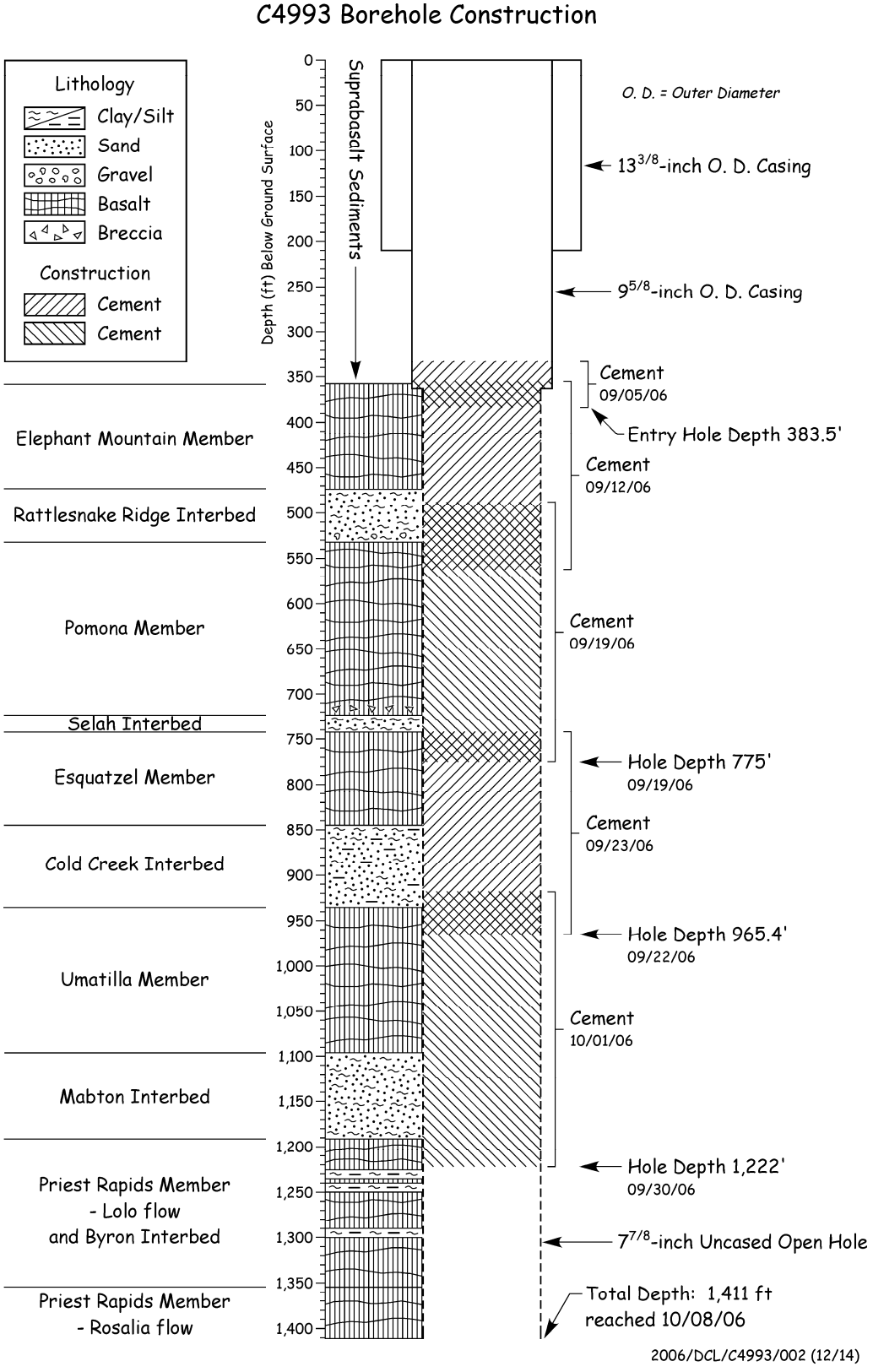


Figure 3.14. General Construction Details of Borehole C4993

Figure 3.15. Felsic-Appearing Cutting Fragment Determined To Be an Artificial Product of Drilling

4.0 References

DOE (U.S. Department of Energy). 1988. *Consultation Draft Site Characterization Plan. Reference Repository Location, Hanford Site, Washington*. DOE/RW-0164, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C.

Fluor Hanford, Inc. 2006. *Geologic Logging*. Groundwater Remediation Project Procedure GRP-EE-01-7.0, Revision 1, Richland, Washington.

Garcia BJ, SC Adams, ST Ahlquist, CF Rust, and JR Fetters. 2006. *Borehole Summary Report for Waste Treatment Plant Seismic Borehole C4996*. Freestone Environmental Services, Inc., Richland, Washington.

Gardner MG, KD Reynolds, and DE Skoglie. 2006. *Drilling Plan for the Waste Treatment Plant Seismic Test Borehole Project*. FS-RW-SWS-PN-005, Rev. 0, Duratek Federal Services, Richland, Washington.

Myers CW, SM Price, JA Caggiano, MP Cochran, WJ Czimer, NJ Davidson, RC Edwards, KR Fecht, GE Holmes, MG Jones, JR Kunk, RD Landon, RK Ledgerwood, JT Lillie, PE Long, TH Mitchell, EH Price, SP Reidel, and AM Tallman. 1979. *Geologic Studies of the Columbia Plateau—A Status Repor*t. RHO-BWI-ST-4, Rockwell Hanford Operations, Richland, Washington.

PNNL (Pacific Northwest National Laboratory). 2006. *Sampling and Analysis Plan – Waste Treatment Plant Seismic Boreholes Project.* PNNL-15848 Revision 2, Richland, Washington.

Appendix A

Borehole Logs for Borehole C4993

49647/T5.2.5
LOG-06-151

BOREHOLE LOG (Using GRP-EE-01-7.0, Rev. 1) Page 1 of 27 Date: 9/8/06 start

Well ID: C4993 | Well Name: | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows/Recovery	Graphic Log 10/20/06	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
380		DOES NOT Apply in this Borehole Log (All 27 pages)		355'-383.5': Grout seal • Basalt present @ 380' bgs (likely cuttings from cable-tool rig & caving from driving casing after grouting)	Mud-Rotary Drilling w/ 7 7/8" O.D. Tri-cone bit. *Entry B.H. drilled from ∅ → 383.5' bgs
385	G.S.	DB 9/9/06		383.5'-473.5': Basalt, Blk. to dk. gray (wet), lt. gray to dk. gray (dry; GLEY1 3/N, 4/N, 5/N); V. hard (V. slow drilling).	Grab Sample (G.S.) @ 385' bgs DB 9/9/06 392' bgs
390	G.S.	DB 9/9/06			G.S. @ 390' bgs 9/9/06
	G.S.			• Drilling speed picked up between 427'-431', Driller noted that he lost ~100 to 200 gallons fluid.	397' bgs
395	G.S.				*Note: Determined that Depth was off by 7' ⇒ 395' sample became 402' bgs (changes depth @ 0815, 9/9/06)
400	G.S.				DB 9/9/06 G.S. @ 402' bgs; 9/9/06 (0815 am) @ 50 rpm; Drill rate @ ~0.9 ft/hr. (404.4')
405	G.S.				G.S. @ 405' bgs; 9/9/06, (1200) @ 30 rpm; Drill rate @ ~0.6 ft/hr (405'); Drill rate @ ~1.2 ft/hr (406.2'); " " @ ~1.4 ft/hr (407.6', 409')
410	G.S.				G.S. @ 410' bgs; 9/9/06, (1545) @ 28 rpm, ~1.6 ft/hr. ~1.8'/hr @ 412.4' ~1.5'/hr @ 413.9'
415	G.S.				G.S. @ 415' bgs, 9/9/06 (1855) @ 25 rpm, ~1.4'/hr

Reported By: J. Horner / N. Bowles | Reviewed By: SP Reidel

Title: Geologist | Title: Staff Geologist

Signature: [signature] Date: 9/9/06 | Signature: SP Reidel Date: 10/20/06

A-6003-642 (03/03)

COPIED FOR RECORDS

BOREHOLE LOG (using GRP-EE-01-7.0, Rev. 1)

Date: 9/9/06 start 9/9/06 Finish

Well ID: C4993	Well Name:	Location: WTP Seismic Borehole #4
Project: WTP Seismic Boreholes Project		Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
420	G.S.				Mud-Rotary Drilling w/ 7 7/8" O.D. Tri-cone bit
					G.S. @ 430' bgs
425	G.S.			DBB 10/20/06	G.S. @ 425' bgs
					G.S. @ 430' bgs
430	G.S.				
				(NS) 9/10/06	
				→@ 435' bgs V. high (LCM) "Lost Circulation Mat." in cuttings (also in 435' unwashed G.S.)	G.S. @ 435' bgs, 9/10/06
435	G.S.			→Driller notes possible fracture encountered @ 436' bgs.	(0745) @ ~35 rpm. Drill rate @ ~ 2.3 Ft/hr (438.1')
					G.S. @ 440' bgs, 9/10/06 (NS)
440	G.S.				(1005) @ 27 rpm, ~1.8'/hr. ~1.9'/hr @ 442.5' (NS) 9/10/06
					~1.9'/hr @ 444.4'
				DBB 10/20/06	G.S. @ 445' bgs, 9/10/06
445	G.S.				(1215) (NS) 9/10/06
					~1.2'/hr @ 447.3'
450	G.S.				G.S. @ 450' bgs, 9/10/06 (1555) @ 26 RPM, ~1.9'/hr.
					~1.7'/hr @ 452.1'
				→@ 453.5': likely fracture present.	~2.4'/hr @ 454.5'
455	G.S.				G.S. @ 455' bgs, 9/10/06
				DBB 10/20/06	(1810) (NS) 9/10/06

Reported By: J. Horner / N. Bowles	Reviewed By: SP Reidel
Title: Geologist	Title: Staff Geologist
Signature: [signature] Date: 9/9/06	Signature: SP Reidel Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (Using GRP-EE-01-7.0, Rev. 1)

Date: 9/10/06 start 9/11/06 - Finish

Well ID: C4993	Well Name:	Location: WTP Seismic Borehole #4
Project: WTP Seismic Boreholes Project		Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
460	G.S.				Mud Rotary Drilling w/ 7 7/8" O.D. Tricone bit
					G.S. @ 460' bgs
465	G.S.			DBB 10/20/06	G.S. @ 465' bgs
470	G.S.				G.S. @ 470' bgs
				473.5' @ 9/10/06	
				~~474'~~ overall increase in glassy fragments, with v. fine stale & slightly darker color. Minor gen- ken fragments of clay are present	
475	G.S.				G.S. @ 475' bgs., 9/11/06 v. fast drilling!
				→ Bottom of Elephant Mtn. Member (Basalt) @ 474' bgs. (NB) 9/11/06	
				474' → 479: Clay @ 9-10-06 (M) Greenish gray (5/5BG, 10BG, Gley 2)	
480	G.S.			479' → 485': Sandy Silt/Clay (SM)	G.S. @ 480' bgs., 9/11/06 v. fast
				→ @ 480': v. fn to md. sand present ~~(~20%)~~ (NB) 9/11/06 ~25%	
				→ @ 483': color changes to lt. gray (2.5Y 5/1). Sand to ~40%, mostly basalt/mafic.	
485	G.S.			→ @ 485': sand cont. down to <10% ⇒ M	G.S. @ 485' bgs., 9/11/06 v. fast
				485' → 532': Clay/silt (M) <10% mafic sand, lt. gray (2.5Y 5/1), plastic	
490	G.S.				G.S. @ 490' bgs., 9/11/06 v. fast
				(NB) 9/11/06	
495	G.S.			→ @ 495': ~~color~~ color changes to dk. grayish brown (7.5YR 5/1)	G.S. @ 495' bgs, 9/11/06 v. fast
				~~p.3~~ p.4 (NB) 9/11/06	~~p.3~~ p.4 (NB) 9/11/06

Reported By: J. Horner / N. Bowles	Reviewed By: SP Reidel
Title: Geologist	Title: Staff Geologist
Signature: [signature] / [signature] Date: 9/11/06	Signature: [signature] Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (using GRP-EE-01-7.0, Rev. 1)

Date: 9/11/06 - Start/Finish.

Well ID: C4993 | Well Name: | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
500	G.S.				Mud-Rotary Drilling w/ 7 7/8" O.D. Tri-Cone bit.
				@ 500': Color change to lt. gray (10YR 6/1) w/ inc. in sand/chip content (basalt) ⇒ likely from earlier basalt drilling!?? (not representative of formation) NB 9/11/06	G.S. @ 500' bgs, 9/11/06
505	G.S.			@ 505': Sand cont. returns to <10%	G.S. @ 505' bgs, 9/11/06
510	G.S.			@ 510': Major color change to lt. reddish brown (10YR 6/3), <5% sand. NB 9/11/06	G.S. @ 510' bgs, 9/11/06
515	G.S.			@ 515': color darkens to md. reddish brown (10YR 4/3).	G.S. @ 515' bgs, 9/11/06
520	G.S.			@ 520': color darkens to dk. reddish brown (7.5YR 4/3).	G.S. @ 520' bgs, 9/11/06
525	G.S.			@ 525': Color is md. brown (10YR 5/2)	G.S. @ 525' bgs, 9/11/06
530	G.S.			@ 530': Sand NB 9/11/06 signs of inc. basalt content (as chips) ~10 to 20% 15%	G.S. @ 530' bgs, 9/11/06 NB 9/11/06
	Chip Tray Sample				Chip Tray sample @ 530' bgs (Top of Pomona Basalt).
				532'-723.5': Basalt (Pomona) Breccia/Flowtop, likely highly fractured w/ various sediments in fractures (reddish & yellowish silts/clays) ~60% basalt chips/ ~40% sediments.	
535	G.S.				G.S. @ 535' bgs, 9/11/06

Reported By: N. Bowles | Reviewed By: SP Reidel

Title: Geologist | Title: Staff Geologist

Signature: [signature] Date: 9/11/06 | Signature: SP Reidel Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (using GRP-EE-01-7.0, Rv.1)

Page 5 of 27
Date: 9/11/06 - Start

Well ID: C4993 | Well Name: | Location: WTP Seismic Borehole #4 9/13/06 - Finish

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
540	G.S.			→ @ 540': Basalt content inc. to ~85% (Sed. <15%).	Mud-Rotary Drilling w/ 7 7/8" O.D. Tri-Cone bit.
					G.S. @ 540' bgs, 9/11/06
545	G.S.			→ @ 545': Basalt cont. inc. to ~90% (Sed. < 10%).	G.S. @ 545' bgs, 9/11/06
					Deviation Survey @ ~547.8' bgs. #1.0 Deg, 10.4 ft off.
550	G.S.			→ @ 550': <5% (clay cont. >95% basalt.	G.S. @ 550' bgs, 9/11/06
555	G.S.				G.S. @ 555' bgs, 9/11/06
				→ @ 557': harder, more competent basalt. Drilling slows significantly.	
560	G.S.			→ @ 560': <5% clays, likely that min. fractures persist.	G.S. @ 560' bgs, 9/11/06
565	G.S.			→ @ 565': Samples collected still contain residual cement from drilling of grout to 562.5' bgs. Drilling is v. slow, ⇒ v. competent basalt, v. sparse clay content ⇒ Much less fractured.	G.S. @ 565' bgs, 9/13/06, w/ XRF ~1.5'/hr @ 567.7' bgs. ~1.7'/hr @ 569.4' bgs.
570	G.S.			→ @ 568.4': likely v. hard basalt area (observed by drill jumping around while drilling).	G.S. @ 570' bgs, 9/13/06, w/ XRF.
				→ @ 570': <1% non basalts ⇒ 99% basalt, v. competent/hard, dk grayish blk (GLEY1 3/N).	~2.7'/hr @ 574.7' bgs.
575	G.S.				G.S. @ 575' bgs, 9/13/06 ~1.4'/hr @ 576.1' bgs. ~1.2'/hr @ 577.3' bgs.
				→ P. 6	→ P. 6

Reported By: N. Bowles
Title: Geologist
Signature: [signature] Date: 9/13/06

Reviewed By: SP Reidel
Title: Staff Geologist
Signature: SP Reidel Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (Hanford GRP - EE-01-7.0, Rv. 1)

Page 6 of 27

Date: 9/13/06 - start 9/14/06 Finish

Well ID: C4993 | Well Name: | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
580	G.S.			→ (basalt cont'd) @ 575': 100% basalt (same as for 570' w/out other materials).	Mud-Rotary Drilling w/ 7 7/8" o.d. Tri-cone bit.
				→ @ 580': ~ 5% to 10% non-basalt material (pale yellow [2.5Y 8/4] soft deposit [possibly opal], & lt. blue/gray	G.S. @ 580' bgs, 9/13/06
585	G.S.			→ @ ~ 9/13/06 [GLEY 2 7/5B] silty deposit), likely in fractures w/in basalt. Continuing to ~595' bgs (lt. blue gray silt) & decreasing to	~ 2.1'/hr @ 580.7' bgs. G.S. @ 585' bgs
590	G.S.			≤ 2% @ 600' bgs	G.S. @ 590' bgs
				DBB 10/20/06	
595	G.S.				G.S. @ 595' bgs
600	G.S.			-601': Likely fractured	G.S. @ 600' bgs
				.	~ 1.5'/hr @ 604.3' bgs.
605	G.S.			→ @ 605': cuttings returned are v. fine; v. slow but steady drilling	G.S. @ 605' bgs, 9/14/06 ~ 1.4'/hr @ 605.7' bgs. ~ 1.1'/hr @ 606.8' bgs.
				→ @ 607.2': likely fracture encountered	~ 1.0'/hr @ 607.9' bgs. ~ 1.0'/hr @ 608.5' bgs.
610	G.S.			→ @ ~ 609.5': v. rough drilling.	~ 1.1'/hr @ 609.9' bgs. G.S. @ 610' bgs, 9/14/06 ~ 1.0'/hr @ 610.9' bgs.
				DBB 10/20/06	~ 1.2'/hr @ 612.1' bgs. ~ 1.5'/hr @ 613.6' bgs.
615	G.S.				G.S. @ 615' bgs, 9/14/06

Reported By: J. Bowles / J. Horner | Reviewed By: SP Reidel

Title: Geologist | Title: Staff Geologist

Signature: [signature] Date: 9/14/06 | Signature: [signature] Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (Using GRP-EE-01-7.0, Rev. 1)

Page 7 of 27
Date: 9/15/06

Well ID: C4993 | Well Name: NA | Location: WTP Seismic Borehole #4

Project: WTP Seismic Borehole Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
620	G.S.			Pomona Member cont...	Mud-Rotary Drilling
				~620': Up to 98% blk-gray basalt,	with a 7 7/8" O.D. Tri-
				mostly aphyric w/ very sparse plag.	cone bit.
				phenos up to 3 mm. Minor (~2%)	
				fragments of hard lt. yellowish brn.	G.S. @ 620' bgs
625	G.S.			clay & a lt green mineral, likely	G.S. @ 625' bgs
				fracture fill but a few half rounded	~1.0'/hr : 617.3 - 623.8' bgs
				fragments (mostly grn) indicate potential	~1.5'/hr : 623.8 - 627.1' bgs
				vesicular fill (?). Drilling as though	~1.7'/hr : 627.1 - 628.8' bgs
				multiple fractures are present	~1.5'/hr : 628.8' - 630.5' bgs
630	G.S.			from 623' - 627' bgs.	
				At ~633 ft (geolograph) vibration	~1.1 ft/hr @ ~ 09:00
				of rods indicate significant fracture zone.	(630 ft - 635 ft)
				DBB 9/16/06	(Driller slowed rotation
					rate after few minutes in
					fracture zone.
635	G.S.				633.7 - 637 ft ~ 1.3 ft/hr.
					~1.6 ft/hr : 637 ft - 638 ft
				+637.5: Rod vibration indicates fracturing to	~ 1.3 ft/hr 638 - 640
				~637.6 (Geolograph). Also @ 638.5 - 638.6,	XRF sample taken for DBB 9/15/06
				and 638.8 - 639.5, sample @ 640 has plag	middle Pomona @ 640'.
640	G.S.			xtals up to 2 mm long in basalt frags. Green,	DBB 9/15/06
				soft fracture-fill clays (?) still attached to some	~1.56 ft/hr @ ~ 646'-647'
				basalt frags. Some observed w/ slickensides	Stopped drilling @ 18:17
				(See photos 5900 - 5902)	to prepare for gyroscopic
				640-645: Appears to contain more	alignment test. (Randy
				grn-brn clay and speckled material	Price). Geolograph @ 648.1
645	G.S.			like sandstone (lt. gray w/ blk specks)	
				much fracturing in first 1/2 this interval	
				(~640 - 642.5) as indicated by vibrations/	
				spasmodic turning of drill. Photos 5903 - 5907	
				are photos of speckled material showing indications	
				of slickensides in upper extremity of image	~2.5 ft/hr ~ 2100 (648.4' to 651.1')
650	G.S.			closeup (5906 - 5907) Between 645 - 647 blue-grn	
				clay frags increase. Based on drill vibration, fracts	~2.14 ft/hr ~ 2200 (652.9' - 651.1')
				at ~647.5	
				650': ~95% black-gray basalt, aphanitic,	
				~4% salt + peppers material (5% blk, 95% white), 1%	
655	G.S.			green-blue clay likely fracture fill, (poss. slickensides (pic. 5908 - 5911))	~2.6 ft/hr ~ 2257 (652.9' to 655.2')
				651.7': Rod vibration indicates fracturing	DBB 9/16/06
				655': Same, though basalt w/ sparse plag. phenos.	
				Rig jumping due to possible fractures	

NA DBB 9/16/06

Reported By: J. Horner, D. B. Barnett, C. Rust | Reviewed By: S P Reidel

Title: Geologists | Title: Staff Geologist

Signature: J. Horner C. Rust | Date: 9/15/06 | Signature: S P Reidel | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (USW GRP-EE-01-7.0, Rv. 1)

Date: 9/16/06

Well ID: C4993 | Well Name: NA | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
660	G.S.			660: 98% black-gray basalt with sparse pheno-crysts, ~1% green-blue clay mineral on basalt faces (see photo 5912-5913) indicates fractures	~2.1 ft/hr @ 0107 (659.4 to 655.2)
					slow and steady drilling
665	G.S.			665: 95% black-gray aphanitic basalt, ~4% salt + pepper material, possible fracture fill 1% brown-tan mineral NOTE: slow drilling is producing small chips	~1.6 ft/hr @ 0140 (662.4 to 660.1)
					Sample @ 670 taken over estimated interval 668.5'-670'
	G.S.				DBB 9/16/06
670				Geolograph rotational press. indicates fracts @ 670.5 possible (erratic rotation of rods also observed). Also @ 674, 674'-677.5', 679.5-681.5, 683.5-684.5	~1.5 ft/hr. @ 669.8'
					~1.7 ft/hr. @ 671.5'
					~1.4 ft/hr @ 672.9'
675	G.S.			Clay in cuttings 670-675, gry-grn, causing cuttings to stick to mud trough. Could be fract fill (?) 670', 675' X10-15% chips	~1.5 ft/hr @ 674'
					Driller says drill acted like clay was present
				appear to be a felsic tuff — lt. gray to white w/dark, (blk) elongate phenos. Nearly all of these	~470-472'
	G.S.			grains are flattened and most are striated as	~1.5 ft/hr @, 674.5'
680				with mullion/slicks - may be altered basalt or	~1.5 ft/hr @ 677.3'
				micropeg? (see photos 5914-5915, 5916-5918) Black min.	~1.5 ft/hr @ 678.8'
				laths are preferentially aligned w/foliation, if present,	(@ ~14:00)
				(see photos 5920-5923) Much of the foliation or	~2.1 ft/hr. @ ~682.6
				structure may be artifact of drilling.	~1.7 ft/hr @, ~684.3
685	G.S.			680-685': large (up to 0.75 cm) flakes of	~~0.3 ft/hr @ ~684.9~~ DBB 9/16/06
				blue-grn clay ~ 1-5% - prdo. fracture fill in	~0.9 ft/hr @, 685.2
				basalt. Also chalcedony frag 1 cm long (clear & milky)	
690	G.S.			690: 95% black-gray aphanitic basalt, ~3% large (1 to 5 mm) pieces of green-blue clay, ~2% salt + pepper material	~1.4 ft/hr @ ~689.4'
695	G.S.			695: 98% black-gray aphanitic basalt, ~2% salt + pepper material	~1.4 ft/hr @ 695.0'

Reported By: Colleen Rust / D.B. Barnett | Reviewed By: S P Reidel

Title: Geologists | Title: Staff Geologist

Signature: [signature] | Date: 9/16/06 | Signature: S P Reidel | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG

(USWG GRP-EE-07-7.0, Rv. 1)

Date: 9/17/06

Well ID: C4993 | Well Name: | Location: WTP SEISMIC BOREHOLE #4

Project: WTP SEISMIC BOREHOLE PROJECT | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
700	G.S.	OTHER NOTES/ PICKS		700: 98% black-gray aphanitic basalt, ~2% salt and pepper material, no clay minerals, though drilling has slowed down to ~0.65 ft/hr due to fracturing. Also, @ 703.5-704, based on geolograph.	Drill rig is shaking & torqueing indicates fractures ~1.4 ft/hr @ 699.4' ~0.65 ft/hr @ 701.3'
705	G.S.			Most of the "salt & pepper" or "felsic tuff" discussed here and on p. 8 appears throughout samples up to 2-5% and is actually blue-grn clay when wet (some of these grains are not clay - affinity unknown) (Photos 5924-5926)	penetration rate = 1 ft/hr. @ 10:05 (~707.5 ft) = 2.0 ft/hr from 713'-714' @ 14:04-14:34
710	G.S.			Minor fracturing @ ~709.8-710.1 based on geolograph	
		This may be top of interbed (selah)		Much fracturing ~713-716.5 or vesicles?)	Drilling much faster in fracts or vesiculation
715	G.S.			Clay content increasing @ ~719 Numerous fragment (basalt) w/small vesicles 715-720 interval. Some vesicles have blue-grn mineral lining of walls.	Geolograph indicating fracturing or other heterogeneities beginning @ 713' to ~716.5' Dramatic increase in drilling rate to ~6 ft/hr. @ ~717-718 ft @ ~15:20 until @ 721.5' slowed again 16:00 DBB 9/17/06
720	G.S.				
723.5	G.S.	Top of Interbed (Selah)		723.5: 50% black-gray basalt, 45% gray clay pieces ranging from 1cm to 1mm to background mush 4% tan-brown clay, 4% slightly friable green-blue clay, small amounts of silt	Stopped drilling @ 721.8' to circulate and wait for logger (gyro). Gyro going into hole @ 18:00
725	G.S.	Selah 3rd Possible?		725: 25% black-gray basalt, 70% gray clay and silt mixture, ~5% tan-brown clay, V. fine sand mostly basalt	Driller says he reduced bit weight to cause this to avoid penetrating clay too rapidly DBB 9/17/06
730	G.S.			730: Color of clays change to mostly tan-brown clay with mafic basalt sand (sample from top of pipe + hooked shaker sample 50/50 in tray)	Samples 703.5-735 unwashed for interpretation in trays
735	G.S.			735: Color of clays become a lighter tan to off white with ~25% mafic sand	Drilling through interbed ranged from ~7 to 21 ft/hr

Reported By: C. Heanrust / D.B. Barnett | Reviewed By: S.P. Reidel

Title: Geologists | Title: Staff Geologist

Signature: [signature] Date: 9/17/06 | Signature: [signature] Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (USING GRP-07-7.0, Rv. 1)

Page 10 of 27
Date: 9/18/06

Well ID: C4993 | Well Name: | Location: WTP SEISMIC BOREHOLE #4

Project: WTP SEISMIC BOREHOLE PROJECT | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
740	G.S.	Picks samples		740: ~90% clays tan-brown to light gray to off white with silt present and mafic sand (~5% for both)	~21 ft/hr @ 739.3'
		Bottom of Interbed / Flow Top			Samples 740 to 742.3 were unwashed for description
742.3	G.S.			742.3: 45% black-gray basalt, 30% gray to light gray clay, 20% green-blue clay, 5% silt + sand mostly mafic	
745	G.S.			745: 55% black-gray basalt, 20% green-blue clay indicating fractures, 20% gray clay, 5% tan-brown clay, green-blue clay semi resistant to breaking	Drill rates slowed down to ~ 14.5 ft/hr @ 745'
					Drill rates continued to slow down to ~ 9.3 ft/hr
750	G.S.	XRF sample		750: 95% black-gray basalt with sparse vesicles filled with a red-brown iron oxide, 4% gray to tan clay, 1% green-blue clay	→ see photo #5928
					XRF sample C4993-9-18-06 750 ft, Top of Esquatzel Mbr. DBB 9/19/06
755	G.S.			755: 98% black-gray aphanitic basalt, 1% blue-green clay, 1% iron oxide mineral + presence of tan-pink mineral w/ black spots on one side face (1mm) see photo #5929+5930	Drill rate ~ 6.4 ft/hr
760	G.S.			760: 95% black-gray aphanitic basalt, 1% blue-green clay indicating fractures, 2% iron oxide mineral on basalt surfaces, 2% light gray-white and black felsic looking rock chips	Drill rate ~ 2.8 ft/hr
765	G.S.			765: 90% black-gray aphanitic basalt, 5% blue-green clay, 5% light/black felsic looking material	Drill rate ~ 2.8 ft/hr
770	G.S.			770: 95% black basalt, 4% blue-green clay, 1% iron oxide on surfaces of basalt	Drill rate ~ 1.78 ft/hr
				Geologgraph indicates fracts @ ~ 773.5 - 774.4 further examination of "felsite" chips in 775' sample indicates that	
775	G.S.			→ 775.3 these are in fact a distinct	STOPPED DRILLING @ 775.3 @ ~ 07:50
		see P.11 DBB 9/18/06		lithology - (see photos 5933 - 5937) and contains plagioclase phenos.	preparing to circulate, trip out & perform televiewer/sonic logging

Reported By: Colleen Rust / D. B. Barnett | Reviewed By: SP Reidel

Title: Geologists | Title: Staff Geologist

Signature: [signature] | Date: 9/18/06 | Signature: SP Reidel | Date: 9/20/06

A-6003-642 (03/03)

BOREHOLE LOG

Date: 9/20/06

Well ID: C4993 | Well Name: NA | Location: Next to Grout Plant/facility

Project: WTP Seismic – Borehole #4 | Reference Measuring Point:

Depth (Ft.)	Sample Type No.	Sample Other Blows/6" Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
775	see p. 10	DBB 9/18/06		← 775' started here on 9/20/06	08:30 – circulating & changing out mud @ 778.8
					11:30 – first grab sample
				780–785: overall chip sample color (aggregate) is med gray due to percentage of light gray to white fract fill material or interbed material (?) Fragments consisted of ~60% basalt and 40% leucocratic components. Leucocratic components appear to consist of felsic tuff (prob. rhyolitic) cement fragments, fracture or vesicle fill opal. Basalt chips are glassy to plag/mafic phyric w/dense pop. of vesicles in some frags (see photos 5951–5952)	11:30–12:05 – drilling rate ~ 2.0 ft/hr @ 781.2 ft.
780	G.S.				~ 2.0 ft/hr @ 13:50
					~ 1.2 ft/hr. 787' to 788' @ ~ 15:20.
					~ 2.0 @ 17:21 – 17:52 (791'–792').
785	G.S.				(see photos 5940–5946) & 5955–5956
				785–790: fewer light-colored chips than above (probably from less cement chips); some fragments w/ marcasite x tals and magnetite xtals ~ 30–40% of grains are attracted to magnet.	
790	G.S.				→ (see photos 5953–5954)
				XRF sample C4993-9-21-06 middle Esquatzel – 795' DBB 9/21/06	
795	G.S.	XRF sample @ 795		795: 90% aphanitic gray-black basalt, ~9% light grains that look felsic with light colored phenocryst (pics 5957–5958), remaining 1% mixture of green-blue clay, iron oxide grains (pics 5960–5961), appearance of pyrite on the surface of a piece of basalt (pic 5959)	Drilling rate ~ 1.96 ft/hr
800	G.S.			800: ~94% gray-black basalt, 5% green light colored felsic pieces, 1% green-blue clay, one piece of muscv. mica (pic 5962) CR 9/20/06	Drill rate ~1.87 ft/hr
805	G.S.			805: black-gray basalt with sparse phenos appearance of tan-brown clay	Drill rate ~1.8 ft/hr
810	G.S.			810: 95% black-gray basalt with sparse phenos, ~3% felsic material, 2% green-blue clay typical of fractures	Drill rate ~1.2 ft/hr. Slow and steady drill rates

Reported By: D.B. Barnett, Colleen Rust | Reviewed By: SP Reidel

Title: Geologist | Title: Staff Geologist

Signature: D.B. Barnett / Colleen Rust | Date: 9/20/06 | Signature: SP Reidel | Date: 9/20/06

A-6003-642 (03/03)

BOREHOLE LOG (USWG GRP-02-7.0, Rv. 1)

Page 12 of 27
Date: 9/21/06

Well ID: C4993 | Well Name: | Location: WTP SEISMIC BOREHOLE #4

Project: WTP SEISMIC BOREHOLE PROJECT | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
815	G.S.			815: 90% black-gray basalt with sparse phenocrysts, ~7% felsic material, 3% green-blue clay fracture fill	Drill rate ~1.5 ft/hr
				820'–830' v. aphanitic, aphyric basalt, med gray to blk, in glossy frags, v. few vesicular frags, cuttings are ~40% lt-colored frags, w/ felsics and cement frags	Drilling rate @ 08:30 ~2.0 ft/hr
820	G.S.			Photos 5464-5465 - Apparent contact basalt/intermed.	Drilling rate @ 09:14 2.0 ft/hr v. @ 820'
				Fractures ~824–827' (Geograph)	
825	G.S.			very rough drilling (fracts) @ 829'-830'	Drilling stopped @ 10:00 @ 822.2 ft to allow gyro logging
				830' – Aphanitic, aphyric basalt light-to-med gray. 80-90% of chips now basalt – much fewer felsics/intermed., misc cement etc. Opaques and or pyrox.	Grab samples @ 820' (09:20) and 825' (13:40)
830	G.S.			constitute up to ~10% of basalt (texture microscopically) – fragments are very magnetic.	Drilling rate = ~2 ft/hr. @ 831.1 ft (16:30)
					Grab sample @ 830' taken 15:50
835	G.S.			835: aphanitic black-gray basalt (95%), ~5% felsic material, Pic 5468 glass blocks typical & flows at the bottom	
		DBB 10/18/06 Top cold Cr upper pick			
840	G.S.			840: ~50% basalt, ~50% dark gray clay with little sand sized particles (unwashed sample)	
843	G.S.	TOP OF OLD CREEK INTERBED		843: ~30% basalt, ~70% dark gray clay w/ some sand sized particles	
845	G.S.			845: Gray-green clay with a few fine pieces of sand, <5% basalt in sample coarse grains	Drill rate ~12 ft/hr clays are sticking to the drill bit (2005)
850	G.S.			850: Green-gray silty clay, color change from 845' which was more gray than green, very few grains of sand	Drill rate ~20.3 ft/hr

Reported By: Colleen Rust | Title: Geologist | Signature: C. F. Rust | Date: 9/21/06

Reviewed By: SP Reidel | Title: Staff Geologist | Signature: SP Reidel | Date: 9/20/06

A-6003-642 (03/03)

BOREHOLE LOG (USING GRP-GI-7.0, Rv. 1)

Page 13 of 27
Date: 9/21/06

Well ID: C4993 | Well Name: | Location: WTP SEISMIC BOREHOLE #4

Project: WTP SEISMIC BOREHOLE PROJECT | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
855	G.S.			855: 50% light green clay with 50% very fine grained sand (mixture of materials including basalt) and some silt	Very low sample return
					Samples 850 to 870 were undershed to keep sand sized particles within sample
860	G.S.			860: Sandy Clay, dominated by green clay (95%) with quartz sand grains (vf)	
865	G.S.			865: Sandy Clay, 50% green clay and 50% sand predominantly quartz, coarse size	drill rate ~16.3 ft/hr
870	G.S.			870: Same as 865' though some grains of sand are feldspars, mica, and basalt	drill rate ~ 15.4 ft/hr
875	G.S.			875: Very course grained Sandy Clay, 75% sand grains (50% quartz, 40% basalt, 10% mica, + feldspars), 25% green clay	
880	G.S.			880: Course grained sand (50% quartz, 50% basalt) with some green clay (5%)	drill rate ~24 ft/hr
885	G.S.			885: Sand, poorly sorted (vf to c grained), grains predominantly quartz with some basalt, feldspars, and iron oxide coated material)	drill rate ~21 ft/hr
					All sands have a green color due to green clay in interbed, present in all samples.
890	G.S.			890: Sand, medium size, predominantly quartz with green grains and basalt	

Reported By: Colleen Rust | Reviewed By: S P Reidel

Title: Geologists | Title: Staff Geologist

Signature: C. J. Rust | Date: 9/21/06 | Signature: S P Reidel | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (USING GRP-01, 7.0, Rv. I)

Page 14 of 27

Date: 9/22/06

Well ID: C4993 | Well Name: | Location: WTP SEISMIC BOREHOLE #4

Project: WTP SEISMIC BOREHOLE PROJECT | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
895	G.S.			895: Sandy Clay, 50% green and white clay, white clay is more plastic, 50% fine grained sand, mostly quartz with some basalt, feldspar, and iron oxide	drill rate 16.7 ft/hr
900	G.S.			900: Very coarse Sand, poorly sorted grains that range from silt to ves, largest grains are of white quartz and gray basalt, with some clay (~10%)	drill rate 13.2 ft/hr
905	G.S.			905: Slightly silty clay, green in color	drill rate ~15 ft/hr
910	G.S.			910: Slightly silty clay, green in color	drill rate ~ 16.5 ft/hr
915	G.S.			915: Silty Clay with a few course grains of sand, mainly quartz, green in color	Fast and steady drilling through entire interbed until the last few feet.
920	G.S.			920: Silty Clay, green in color	
925	G.S.			925: Silty Clay, gray-green in color	drill rate ~25 ft/hr
930	G.S.			930: Silty Clay, gray in color, with sparse pieces of basalt present, drilling rate slowed down drastically due to hard clays, believe basalt is from above walls (contamination)	2458 to 0118 drill started to jump around 932-933', rate drastically slowed down

Reported By: Colleen Rust | Title: Geologist | Signature: C. Rust | Date: 9/22/06

Reviewed By: S P REIDEL | Title: Staff Geologist | Signature: S P Reidel | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (USING GRP-01 7.0, Rv. 1)

Date: 9/22/06 start 9/25/06 finish

Well ID: C4993 | Well Name: | Location: WTP SEISMIC BOREHOLE #4

Project: WTP SEISMIC BOREHOLE PROJECT | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
935	G.S.	TOP OF BASALT		935: 75% aphanitic basalt from Umatilla flow top, 25% slightly silty clay gray-green in color	933'-935': Was a layer of hard clay that drilled similar to basalt
940	G.S.			940: 90% aphanitic black basalt, with ~9% green-blue clay, ~1% large grains of a white mineral (off-white) and quartz grains	Drill rate has dropped down to ~2.5 ft/hr out of flow top.
945	G.S.			945: 95% aphanitic black basalt, 5% green-blue clay typical of fractures	Drill rate ~25 ft/hr
950	G.S.			950: 95% gray-blk aphanitic basalt w/ <5% blue/grn to lt brown clay fragments & <2% felsic phenos up to 1mm (qtz, feldspar) 953' drilling as though fractured	G.S. @ 950' bgs Drill rate ~2.5 ft/hr from 948'-953.1'. 4.2'/hr: 953.1'-955.2 0.6'/hr: 955.2-955.8' G.S @ 955' bgs 1.6'/hr: 955.8'-957.4'
955	G.S.				
960	G.S.			960': decrease in clay fragments	G.S. @ 960' bgs 1.4'/hr @ 962' bgs Drill rate slows to 1.1'-1.4'/hr from 960'-965'.
965	G.S.			965': 98% dk. gray-blk aphanitic basalt w/ ~2% lt. brn clay & v. sparse green clays.	G.S @ 965'
970	G.S.	XRF sample @970'		970': 79% gray-dk. gray aphanitic basalt with <5% multicolored (gray, brn, yellows, grn) clay/siltstone fragments, typical of fract. till	G.S. @ 970' bgs, 9/25/06 + XRF Sample ~1.1 to 0.9'/hrs

Reported By: Colleen Rust / J. Horner / N. Bowles | Reviewed By: SP Reidel

Title: Geologists | Title: Staff Geologist

Signature: [signature] Date: 9/22/06 | Signature: [signature] Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (using HRR-EE-01-7.0, Rv. 1)

Date: 9/25/06

Well ID: C4993 | Well Name: — | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
975	G.S.			975: Black aphanitic basalt w/ slight increase in clay-stone fracture fill material, mostly (790%) dk gray & brn. • Geologograph indicates multiple fractures from ~970'→ with an increase in drill rate	Drill rate increases: @ 970' ~1.1'/hr @ 975' ~3.5'/hr @ 980' ~6.2'/hr @ 985' ~6.3'/hr
980	G.S.			980: >90% black aphanitic basalt w/ <10% tan, brn & increased gnn clay/ clay-stone fill material. cuttings are much larger, up to 1 cm. Some clay fragments are beaded with alternating lt/dk. tan & brn colors. Multiple basalt fragments are speckled with pyrite. Pictures 5969 & 5970 show vermon vein of pyrite.	G.S. @ 975' bgs G.S. @ 980' bgs
985	G.S.				G.S. @ 985.8' bgs
990	G.S.			985: Same as above, with the addition of more gray clay, still <10% overall.	G.S. @ 990' bgs 2.8'/hr - drill rate
995	G.S.			990: clay fraction reduces, drilling seems to smooth out a little	G.S. @ 995' bgs drill rate - 2.9'/hr
1000	G.S.			995: clay fraction up to 10%, multicolored.	G.S. @ 1000.5' bgs drill rate - 2.8'/hr
1005	G.S.				G.S. @ 1005' bgs drill rate - 3.0'/hr
1010	G.S.			1010: Clay fraction down to <5% (v. sparse), much harder material / slower drilling. → p. 17	G.S. @ 1010' bgs, 9/25/06 ~2.0'/hr. → p. 17.

Reported By: J. Horner / N. Bowles | Title: Geologist | Signature: John Horner / Nathan Bowles | Date: 9/25/06

Reviewed By: SP Reidel | Title: Staff Geologist | Signature: SP Reidel | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (using GRP-EE-01-7.0, Rv.1)

Page 17 of 27

Date: 9/25/06 - start 9/26/06 - Finish

Well ID: C4993 | Well Name: — | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1015	G.S.	XRF sample @ 1015'		1015: Consistent w/ 1010 sample, black basalt, no phenos & <5% clay fragments.	Mud-Rotary Drilling w/ 7 7/8" tri. cone bit.
					G.S. @ 1015' bgs, 9/25/06 ~1.8'/hr. (+ XRX Sample @ 1015')
1020	G.S.				G.S. @ 1020' bgs, 9/26/06 ~1.9'/hr.
1025	G.S.				G.S. @ 1025' bgs, 9/26/06 ~2.0'/hr.
1030	G.S.				G.S. @ 1030' bgs ~2.0'/hr
1035	G.S.				G.S. @ 1035' bgs ~2.1'/hr
1040	G.S.				@ 9/26/06 ~~1040~~ G.S. @ 1040' bgs ~2.1'/hr
1045	G.S.				G.S. @ 1045' ~2.1'/hr
1050	G.S.			1050: Basalt appears more competent, drilling slows, ~no more clays present (<1%), v dk. grey to black, (GLEY 1 3/N - 2.5/N) PP.18	G.S. @ 1050.' bgs. ~1.7'/hr. ~1.4'/hr @ 1052.5' bgs PP.18

Reported By: J. Bowles / J. Horner | Title: Geologists | Signature: [signature] | Date: 9/26/06

Reviewed By: SP Reidel | Title: Staff Geologist | Signature: [signature] | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG

(using GRP-EE-01-7.0, Rv.1)

Page 18 of 27

Date: 9/26/06 - Start 9/28/06 - Finish

Well ID: C4993 | Well Name: — | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows/Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1055	G.S.	Samples		Cont. from 1050'.	Mud-Rotary Drilling w/ 7 7/8" Tri-Cone Bit.
					G.S. @ 1055' bgs, 9/26/06 ~1.5'/hr.
1060	G.S.	XRF Sample @ 1060'			G.S. @ 1060' bgs, 9/27/06 ~1.4'/hr.
1065	G.S.			DBB 10/20/06	G.S. @ 1065' bgs, 9/27/06 ~1.4'/hr
1070	G.S.				G.S. @ 1070' bgs ~1.0'/hr
1075	G.S.			1075': ~95% black aphanitic basalt with ~5% soft to brittle multi-colored clay fragments, mostly lt. green & brown.	G.S. @ 1075' bgs ~1.3'/hr
					@ 1078.5' ~1.5'/hr
1080	G.S.			1080: Clay fraction decreases to ≤1%	G.S. @ 1080' bgs ~1.8'/hr
				DBB 10/20/06	~1.0'/hr @ 1082' bgs
					" 1083 "
					" 1084 "
1085	G.S.				G.S. @ 1085' bgs
				1088.5': Apparent fractures in basalt. ~1/5 to 10% brittle clay/ claystone chips present, mostly lt. gray w/ v. sparse green grains.	9/28/06
1090	G.S.			1090': Clay content increases to ~15%, fractures cont, remains v. competent (slow drilling).	G.S. @ 1090' bgs. ~1.1'/hr. ~1.3'/hr. @ 1091.3' bgs. 9/28/06

→ p. 19

Reported By: N. Bowles / J. Horner | Reviewed By: SP Reidel

Title: Geologist | Title: Staff Geologist

Signature: [signature] | Date: 9/28/06 | Signature: SP Reidel | Date: 9/20/06

A-6003-642 (03/03)

BOREHOLE LOG

Page 19 of 27
Date: 9/28/06 - Start/Finish

Well ID: C4993 | Well Name: — | Location: WTP Seismic Borehole #4
Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1095	G.S.			1094.6' → Clay (m) Mabton Interbed.	Mud-Rotary Drilling w/ 7 7/8" Tri-Cone bit.
				• Dark bluish gray (Gley 2, 4/10B) clay, w/ <10% v. fine sand	G.S. @ 1095', 9/28/06
1100	G.S.			1100: color changes to dark greenish gray (Gley 1, 5/5GY) @ 9/28/06 (Gley 1, 5/GY)	G.S. @ 1100, 9/28/06
1105	G.S.				G.S. @ 1105, 9/28/06
1110	G.S.				G.S. @ 1110, 9/28/06
1115	G.S.			1115: dark greenish gray clay with 5-20% v. fine - fine angular sand (60-70% basalt, 30-40% felsic).	G.S. @ 1115', 9/28/06
1120	G.S.			1119': Drilling with less flow constriction, driller notes that sand was likely encountered @ 1119'.	G.S. @ 1120', 9/28/06
1125	G.S.			1120: Clay/Sand ratio difficult to determine. Unrinsed sample is ~70-80% dk gray clay (Gley 1, 5/5GY) & 20-30% VF-C sub-ang felsic sand with >70% felsics & <30% basalt. Most of basalt appears to be residual flakes from overlying Umatilla member.	G.S. @ 1125', 9/28/06 (Gley 1, 5/GY)
1130	G.S.				G.S. @ 1130', 9/28/06

Reported By: W. Bowles / J. Horner
Title: Geologist
Signature: [signature] Date: 9/28/06

Reviewed By: SP Reidel
Title: Staff Geologist
Signature: [signature] Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG

(using GRP-EE-01-7.0, Rv.1)

Date: 9/28/06 start 9/29/06-Finish

Well ID: C4993 | Well Name: — | Location: WTP Seismic Borehole #4

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1135	G.S.			1135: >60% greenish gray (5GY 5/1 – 5/1GY) clay with <40% v.f.-v.c. sub-ang. Sand (m-vc S is >70% felsic v.f.-f S is ~50% felsic) → to 1191 DBB 10/5/06	Mud-Rotary Drilling with 7 7/8" o.d. Tri-cone bit.
					G.S. @ 1135', 9/28/06
1140	G.S.				G.S. @ 1140', 9/28/06 ~10'/hr drill rate
1145	G.S.				G.S. @ 1145', 9/28/06 ~10'/hr
1150	G.S.			DBB 10/5/06	G.S. @ 1150', 9/28/06
1155	G.S.				G.S. @ 1155', 9/28/06
1160	G.S.				G.S. @ 1160', 9/28/06
1165	G.S.			1165: Notice inc. cont. of basalt drill cuttings ⇒ likely from above basalt members not fully washed out??	G.S. @ 1165', 9/28/06
1170	G.S.				G.S. @ 1170', 9/29/06
				→ p.21	→ p.21

Reported By: J. Horner / N. Bowles | Reviewed By: SP REIDEL

Title: Geologist | Title: Staff Geologist

Signature: J. Horner / N. Bowles Date: 9/29/06 | Signature: S P Reidel Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (using GRP-EE-01-7.0, Rv.1)

Date: 9/29/06 – Start

Well ID: C4993	Well Name: —	Location: WTP Seismic Borehole #4	
Project: WTP Seismic Boreholes Project.		Reference Measuring Point: Ground Surface	

Depth (Ft.)	Sample Type No.	Sample Blows/6" Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1175		contact picks samples		1175: Continue w/ sandy Clay (SM) as described @ 1135' bgs.	Mud-Rotary drilling w/ 7 7/8" Tri-Cone bit.
1180	G.S.			1185' – Basalt cuttings comprise ~15% of total. Qtz and felsic grains are ~60% of total – these are angular to subrded. Chalcopy. frags (rare) (photo 5987) Some (<1% cement frags) Becomes coarse, but poorly sorted + clay @ ~1183	Grab sample @ 1180' drilling rate ~1.0 ft/hr Clay is clogging bit at 1183' ft rotation of drill becomes rough as if in fractured basalt
1185	G.S.				Between 1180' and 1185' drill rate was ~3.3 ft/hr. Grab sample @ 1185' Both 1180' 1185 samples contain minute fragments of drill steel – driller was
1190	G.S.	1191' – top of Priest Rapids Mbr.		1191-1225' Basalt (weathered?) (at start of interval) Clay and and/or altered basalt, Black, most chips can be crushed w/fingers – comprises ~90%. 10% is harder basalt frags (from higher in hole?) and fracture fill/vesicle fill(?) opal (soft). Based on geolograph, formation changed @ ~1190.5 – began torque variations. Chips @ 1195 more competent – harder A few vesicles.	informed of this. Steel frags are 0.5-1.0 mm dia. (see photo 5986) Driller says drill began to "jerk" ~1190-1191. Drill rate increased ~1189 to ~5 ft/hr. Grab sample not taken @ 1190 due to no cuttings coming to surface – 1191 instead.
1195	G.S.				Grab sample 1195' Slow rate due to flow top
1200	G.S.	XRF Sample for top of P.R.		1200: Black aphanitic basalt (98%) ~1% green-blue clay typical & fractures, <1% clear white mineral/qtz of flow top of Priest Rapids Member	
1205	G.S.			1205: Black aphanitic basalt (97%), 2% green-blue clay, 1% salt + pepper material, sparse clear white + iron oxide minerals.	Drill rate ~1.9 ft/hr
1210	G.S.			1210': Black aphanitic basalt (95%), 4% light to medium green-blue clay, 1% salt + pepper material, Pic #5991-5992 occurrence of clear white quartz void fill, in either a fracture or vesicle	Picture #5991-5992 Drill rate ~2 ft/hr

Reported By: N. Bowles / D.B. Barnett / Colleen Rust		Reviewed By: S.P. Reidel	
Title: Geologist		Title: Staff Geologist	
Signature:	Date: 9/29/06	Signature:	Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG

Date: 9/30/06 (start)

Well ID: C4993	Well Name: NA	Location: Seismic Borehole (Rotary)	
Project: WTP Seismic Borehole		Reference Measuring Point: Ground Surface	

Depth (Ft.)	Sample Type No.	Blow Counts / Recovery (Additional notes)	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1210		See p. 21 DBB 9/30/06		CR 10/4/06	Grab sample @ 1215' @ 08:35
1215	G.S.			1215': Basalt = 90+ % of grains, is extrem plagioclase phyric - some chips contain such qty of plag that appear at least 50% or more plag - the rest is opaque and pyrox. Felsic/Intermed. chips are still present to ~1-2%. Much opaline (blk to dk grn) like obsidian w/ conch. ~~choidal fract. Some of these chips show~~	Grab sample taken @ 1221 instead of 1220 due to error in geolograph - this was adjusted by the driller, so subsequent samples/levels should be accurate.
1220	G.S.	Dominant lithology is clay		Grab sample at 1220-1221 ← botryoidal/mammilary texture on reverse sides, so probably vesicle or fract fill. (see photos 5993-5994)	Stopped drilling @ ~10:45 - circulated while waiting for loggers - logger arrive ~12:25.
1225	G.S.			1220-1221: "Felsic/Intermed." chips are more abundant. These are invariably smoothed and striated on one side. In one case, @ 1215 ft., at least three steel filings were attached to one of these grains and appeared to be embedded within it (see photos 5995-5997). Could these be an "artificial lithology" created by abrasion w/ drill string? If so, why the apparent regular composition and texture?	Clay description - also contains fine-med. sand. Minor carbonaceous debris, large muscovite flakes - 1225.
1230	G.S.				1230 - more tuffaceous less muscov. and carbonac. debris - more basalt.
1235	G.S.	See p. 6		Most basalt grains @ 1220-1221 have ophitic texture, consisting almost entirely of an assemblage of pyrox + plag.	STARTED DRILLING AFTER CEMENT AT 2438 ON 10/4/06
				1225: Lighter gray basalt (50%), green clay (45%), felsic (salt + pepper) material (~5%)	Drill rate ~2 ft/hr
1240		CR 10/4/06 SEE PAGE 23		1230: Light gray basalt (~40%), large pieces of green clay (1-5 mm) Some more resistence to breaking and others can be easily flattened (55%), ~~felsic/intermed.~~ Andesol felsic/interm. material (salt/pepper) (~5%)	CR 10/4/06
1245				1235: More light gray basalt with occurences of small pieces of metal oxides within grain (~80%), much less green clay (~5%), with increasing felsic salt + pepper material (~15%)	DRILL RATE ~2.2 ft/hr
		See p. 23 DBB 10/2/06		SEE PAGE 23 CR 10/4/06	SEE SUPPLEMENTAL DRILL LOG PAGE #1 (1215' to 1240')

Reported By: D. B. Barnett / Colleen Rust		Reviewed By: S P Reidel
Title: Geologist		Title: Staff Geologist
Signature: [signature] [signature]	Date: 9/30/06	Signature: [signature] Date: 10/20/06

[See also supplemental Log p. 1 of 1 for this date.]

A-6003-642 (03/03)

SUPPLEMENTAL DRILL LOG

This log is supplemental to page 22 of Borehole Log for well C4993 dated 9/30/06

DBB 10/5/06

HOLE NO. C4993

PROJECT WTP SEISMIC BOREHOLE #4
CONTRACTOR WDC
DATE STARTED 10/4/06 COMPLETED 10/4/06
LOGGED BY COLLEEN RUST

TOTAL DEPTH NA LAND SURFACE ELEV. NA
INCLINATION VERT. BEARING NA
COORDINATES T NA R NA S NA OTHER
SURVEY REFERENCES NA

Revised SP/Cadd 10/20/06

Footage	Hole Condition: Run/Box #	Hole Condition: Water (gpm)	Hole Condition: Pit Loss (gpm)	Formation Condition: Fracture Orientation	Formation Condition: Fracture Filling	Formation Condition: RQD (%)	Casing Schedule	Footage	Graphic Log (Scale 1in = 5ft; Basic Geology: rock types, structures, alteration, (Relative Competence))	Lithologic Descriptions, Drilling Notes
								1215		SEE NOTES ON PAGE 22 OF THE BOREHOLE LOG.
								1220		
								1225		ABRUPT CONTACT, BASED ON DOMINANCE OF CLAY 1225: mostly green clay with some fine to medium sand, with muscovite flakes
								1230		1230: increasing basalt with decreasing green clay, appearance of felsite (black & white) 1235: back to dominated basalt with limited green clay, felsite material & iron minerals
								1235		TRANSITIONAL CONTACT, BASED ON THE DOMINANCE OF BASALT
								1240		

DBB 10/20/06

BOREHOLE LOG

Date: 10/4/06

Well ID: C4993	Well Name: NA	Location: Near GTF
Project: WTP Seismic Borehole #4		Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	~~Blows~~ Recovery (10/4/06)	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
	See p. 22				
1236		contact picks/notes/samples		DBB 10/4/06 (no hole)	Geolograph indicates possible fract. beginning @ ~ 1231.5'
					photos 6000-6003 – fossils (diatoms prob.) in clay/silt
1240	G.S.				from 1248' photos 6004–07
		1241.5		~ 1241⁵ – 1249: Claystone, silty w/ v. minor fine sand, light gray-grn to dark gray-grn & black. Fossiliferous w/ abundant carbonaceous clay & lignite, diatoms. 50–60% clay/clayst., 10–25% basalt, ~5% tuff, 5% felsite + ~~cement frags~~ (DBB 10/4/06). Wood texture visible on some lignite frags/carbonaceous debris. Microscopic comparison of carbonaceous interval in C4998 (~1184–1189 ft) shows some similarities to the above description (no diatoms). This interval (1241.5 – 1249) may be a bifurcation of Mabton?	carbonaceous debris embedded in clay/siltstone. Photos 6008 – 6011: Diatoms in clay 0.3 mm long. Photos 6012–6013: Frag of lignite and closeup showing texture.
1245	G.S.				12:00–12:60 1.7 ft/hr @ 1251' 1253.1 (12:00 – 13:00) @ 2.0 ft/hr.
1250	G.S.	1249			photos 6014-15 – more felsite, 6016 = dark veinlets in felsite.
1255	G.S. + XRF sample			1249 – 1288.5: Basalt (60–70%) clay and felsite frags comprise up to 30–40%. Basalt is dark gray – blk. Increase to ~80% basalt frags @ 1260. Temporary increase in clay content ~ 1258.	DBB 10/4/06 Drilling and geolograph indicate fractures 1249–1255
1260	G.S.			1260: 80% basalt – plagioclase xtals/phenos up to 3 mm long – clear. A few basalt frags appear to have a fabric/foliation – could be large glomerocrysts (?) Felsite comprises ~ 15% of total grains. The rest is clay frags and other seds. from other intervals.	
1265	G.S.			1265: Gray-black basalt (80%) with plag. phenos, ~15% felsite material, ~5% green clay	Drill rate ~ 1.3 ft/hr
1270	G.S.		DBB 10/4/06 CR 10/4/06	1270: Black basalt (85%) with some pheno cysts, <5% green clay, 10% felsite, with large flakes of muscov. mica (1 to 2 mm in size) possibly from previous clay layer (1241.5 to 1249')	Drill rate ~ 1.4 ft/hr

Reported By: D.B. Barnett / Colleen Rust	Reviewed By: S P Reidel
Title: Geologists	Title: Staff Geologist
Signature: [signatures] Date: 10/4/06	Signature: [signature] Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG

Page 24 of 27
Date: 10/4/06

Well ID: C4993 | Well Name: NA | Location: ~~NA~~ CR 10/11/06 NEAR GTF
Project: NTP SEISMIC BOREHOLE #4 | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows/ Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1270	SEE PG. 23	OTHER NOTES/ picks			Additional Descript. and Comments
				1275: Black basalt (~70-80%), Felsite material increased to ~15%, 5% green clay, presence of muscov. mica flakes within the sample.	Drill rate has decreased to ~1 ft/hr
1275	G.S.				
				1280: ~80% basalt, 10% each of clay and felsite. Basalt dark gray to blk, mostly aphyric - some glassy - other basalt is extremely plag. phyric, occasional phenos of pyrox up to 2mm long. Phyric basalt dominates.	> and porphyritic
1280	G.S.				
				1285: ~70% Basalt, 15% felsite, 15% clay. Basalt in same proportions as in 1280 sample. Fractures around 1287.5 (geolograph).	Grab sample @ 1285' @ 09:25 ~1.4 ft/hr
1285	G.S.	XRF sample also			
				1288.5 - 1299? Claystone/clay, ~~up to 50 to~~ 70% clay/ claystone, 30% basalt, 10% Felsite & other. Claystone is soft, but ~~firmer~~ harder than clay in 1241'-1249' interbed	DBB 10/5/06
1290	G.S.				
				Clay is med. gray to black (wet). Abundant organic/carbonaceous debris partially coalified - large (up to 3 cm-long) lignite frags (see photos 6023-6025) Clay is slightly silty, med gray upon drying.	comments on clay - may have interacalated basalt (see geolographs)
1295	G.S.				
				1290 - Same dx as 1288.5	
				1295' - Clay ~60-70%, basalt ~30-40% "Felsite" ~10% - Trace of v. micaceous sand. 1299.5 - 1354': Basalt (wet) 0%	
1300	G.S.				
				1300': 60-70% Basalt, med-dk gray, Plagioclase and pyrox phyric; clay & "felsic" 25-30%	See geolograph for 1299.5 pick
				1305: 90-95% Basalt, dark gray, with pheno crysts, 5% green clay and Felsite, clay pieces are half the size as in 1300' sample, smaller pieces of muscov. mica	Grab sample @ 1305' @ 1957 ~2 ft/hr
1305	G.S.				

Reported By: Colleen Rust / D.B. Barnett
Title: GEOLOGISTS
Signature: [signature] Date: 10/4/06

Reviewed By: SP Reidel
Title: Staff Geologist
Signature: [signature] Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG

Page 25 of 27
Date: 10/5/06

Well ID: C4993 | Well Name: NA | Location: NEAR GTF
Project: WTP SEISMIC BOREHOLE #4 | Reference Measuring Point: GROUND SURFACE

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1310	G.S.			1310': 90-95% Basalt, dark gray with pheno crysts, ~5% felsite, <1% green clay with muscov. mica flakes	GRAB sample collected at 1310' @ 2219 ~2ft/hr
1315	G.S.			1315: same, no muscov. mica	GRAB sample collected at 0125 @ 1315' ~ 1.3ft/hr
1320	G.S.			1320': ~90% dark gray basalt w/ pheno crysts, ~5% felsite, ~2% green clay	GRAB sample collected at 1320' @ 0529 ~ 1ft/hr
1325	G.S.			1325': Same as above.	G.S. @ 1325' @ 0830, 10/6/06, ~1.7'/hr.
1330	G.S.			1330': Same w/ clay cont @ <1%.	G.S. @ 1330' @ 1400, 10/6/06, ~1.3'/hr.
1335	G.S.			1335' Same.	G.S. @ 1335' @ 1700, 10/6/06, ~1.7'/hr.
1340	G.S.			PBB 10/20/06	G.S. @ 1340' @ 2030 10/6/06, ~1.3'/hr
1345	G.S.				G.S. @ 1345' @ 0010 10/7/06, ~1.2'/hr

Reported By: Colleen Rust / N. Bowles / J. Horner | Reviewed By: SP Reidel
Title: Geologists | Title: Staff Geologist
Signature: [signature] | Date: 10/6/06 | Signature: [signature] | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG (Using GRP-EE-01-7.0, Rev 1)

Well ID: c4993 | Well Name: N/A | Location: Near GTF | Date: 10/6/06 start @ 1400 hrs 10/7/06 - Finish

Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1350	G.S.			1350: Basalt continues w/ ~90% black - dk gray basalt ~5% "felsite" & 1-3% lt. green clay/claystone. phenocrysts are still present. DBD 10/20/06	G.S. @ 1350' @ 0400, 10/7/06, ~1.2'/hr
1355	G.S.			1354 - 1355: Highly weathered, soft flow-top basalt (~90%) >5% felsite & ~5% lt. green clay/claystone. Likely new basalt flow section	G.S. @ 1355' @ 0755, 10/7/06, ~1.6'/hr. Overall drill speed from 1354 - 1356.7 ⇒ 5.4'/hr.
1360	G.S.			1356: Same w/ ~25% dk gray/blk (carbonaceous) clay mixed in w/ basalt cuttings. 1357: Highly weathered basalt flow-top, same as for 1354 w/ increased felsite (~10%) & lt. green clay (~10%) & no more blk/gry clay content.	G.S. @ 1360' @ 0855, 10/7/06, ~5.3'/hr. @ 1357 10/7/06
1365	G.S.			1359: felsite down to ~5% & grn. clay down to 3 to 5%, ~3 to 5% brn/gray clay/claystone showing up. 1360: Same as above w/ ~1 to 2% dk gry/blk. clay 1362: felsite <5%, 90% basalt. ~5% grn. clay	G.S. @ 1365 @ 0940, 10/7/06, ~6.7'/hr.
1370	G.S.			1365: Increase in clay cont: ~5 to 10% dk gray/blk. clay & ~5% lt grn clay. 1370: Decrease clays: <5% dk. gry/blk clay, ~3% lt. grn clay. Appears to be getting harder (slower drilling).	G.S. @ 1370 @ 1040, 10/7/06, ~4'/hr (from 1367 - 1371) ~3.3'/hr @ 1373.5' (from 1371') ~2.6'/hr @ 1374.8' (from 1373.5').
1375	G.S.			1373: felsite cont: 5 to 10% lt. grn clay to 1 to 3%, no dk gray/blk clays; Harder formation @ 1373 (much slower drilling). 1375': felsite <5%, lt. grn clay 1 to 3% appears more consistent	G.S. @ 1375' @ 1240, 10/7/06, ~3.'/hr (@ 1376.3') ~3.0'/hr @ 1377.8' bgs.
1380	G.S.			1380': Same as @ 1375' but more comp. @ 10/7/06	G.S. @ 1380' @ 1430, 10/7/06, ~2.5'/hr.
1385	G.S.			1385': Same, but w/ faster drilling * Bottom of flow top was est @ ~1373' bgs.	G.S. @ 1385' @ 1545, 10/7/06, ~4.1'/hr.

Reported By: J. Horner/N. Bowles | Title: Geologist | Signature: John Horner | Date: 10/7/06

Reviewed By: SP Reidel | Title: Staff Geologist | Signature: SP Reidel | Date: 10/20/06

A-6003-642 (03/03)

BOREHOLE LOG

Page 27 of 27
Date: 10/7/06 - start

Well ID: C4993 | Well Name: n/a | Location: Near GTF
Project: WTP Seismic Boreholes Project | Reference Measuring Point: Ground Surface.

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
1390	G.S.			@ 10/7/06	G.S. @ 1390' bgs @ 1655, 10/7/06, ~3.5'/hr.
1395	G.S.			>95% 1395: ≥90% dk gray-black basalt w/ sparse visible phenos up to 1 mm. Small (<1mm) vesicles are present in chip samples. Dark grey/brn/green clay/claystone are present. dk. gray claystone fragments up to 1.5 cm X 1 mm. clay fraction is <5% bulk. Drilling is st. rough as trough fractures are present.	G.S. @ 1395' bgs @ 1930, 10/7/06, ~3.7'/hr
1400	G.S.			1400: Drilling as trough multiple fractures are present, drill rate increases up to 5'/hr b/w 1400'-1405'	G.S. @ 1400' bgs @ 2100, 10/7/06, ~2.6'/hr
1405	G.S.			1405': >97% basalt, <3% clay still present, mostly gray/brn, less grn.	G.S. @ 1405' bgs @ 2200, 10/7/06, ~5.0'/hr
1410	G.S.			1405-1407: drilling smoothes out (minimal fractures) & rate decreases to 1.4'/hr	G.S. @ 1410' bgs @
1415				1407'-1411': drill rate slows to a steady 1.0'/hr, very competent bottom of flow top may extent to as deep as 1405' bgs.	
1420				1410: basalt is darker with v. fine xtals. grn/brn/gray clay/claystone fragments are still present (<5%)	
1425				Total depth = 1411' bgs @ 0700, 10/8/06	
1430					
1435					

DBB 10/20/06

DBB 10/20/06

Reported By: N. Bowles / J. Horner		Reviewed By: SP Reidel	
Title: Geologist		Title: Staff Geologist	
Signature:	Date: 10/8/06	Signature: SP Reidel	Date: 10/20/06

A-6003-642 (03/03)

Appendix B

Field Activity Reports for Borehole C4993

49647/T4.2.5
Log-06-152

FIELD ACTIVITY REPORT NO. 1 - DRILLING PLAN

Page 1 of 2

Date: 9/8/06 → DBB 10/20/06

Purpose: WTP Seismic Boreholes Project
Location: GTF pit
Well ID: C4993
Well Name: NA
Drilling Co.: Water Development Corp. (WDC)
Rig No.: 122
Rig Make/Mod.: Gefco / Speedstar 50K

Casing String No. 1 2 3 4	Drilling Method	Circulation	D.H. Hammer
Casing Size —N/A—	Auger	Air ___ Water/Mud ✓	Make
Grade	Rotary ✓ (mud)	Reverse ___ Direct ✓	Model
Lbs.Per Ft. —	Tubex	Vol: cfm	Choke
Material —	Cable Tool	gpm	Casing Hammer
Type:	Sonic	Pressure ___ psi	Make
Welded — Thd.	A.R. w/Sonic	Drill Pipe O.D.	Model
Planned / Actual	Geoprobe	Tool Joint Size	Bit Size
Set At: — / —	Other:	Additives Sodium Bicarb.	Type Tri-Cone (F59YS)
Shoe OD/ID —			~~Nozzles~~ 7 7/8" O.D.
Reference Measuring Point:			Rod Size
GROUND LEVEL			~20.' L

Drlg. Co. | Rig No.: | Rig Make/Mod.:

Casing String No. 1 2 3 4	Drilling Method	Circulation	D.H. Hammer
Casing Size	Auger	Air ___ Water/Mud ___	Make
Grade	Rotary	Reverse ___ Direct ___	Model
Lbs.Per Ft.	Tubex	Vol: cfm	Choke
Material	Cable Tool	gpm	Casing Hammer
Type:	Sonic	Pressure ___ psi	Make
Welded ___ Thd.	A.R. w/Sonic	Drill Pipe O.D.	Model
Planned / Actual	Geoprobe	Tool Joint Size	Bit Size
Set /	Other:	Additives	Type
Shoe OD/ID			Nozzles
Reference Measuring Point:			Rod Size
GROUND LEVEL			

D&B 10/20/06

Comments/Remarks:
Note: this borehole is a continuation/deepening of an "Entry Borehole" (#4) drilled w/a cable-tool rig w/ 9 5/8" O.D. casing set @ ~~363.5'~~ 363.7' bgs (9/8/06); Borehole to 383.5' bgs. Initial grout level in borehole @ 354.7' bgs.

Estimated Depth to Water
~ NA
DBB 10/20/06

Reported By: N. Bowles
Name/Title: Geologist
Signature:
Date: 9/8/06

A-6003-650 (04/03)

COPIED FOR RECORDS

FIELD ACTIVITY REPORT - DAILY DRILLING

Date: 9/8/06 → 9/9/06

Well ID: C4993	Well Name: Deep Mud Rotary #3
Location: WTP Seismic Borehole #4	Report No.: 1

Start	Finish	Total
Time 1700 (9/8/06)	Time 0730 (9/9/06)	Time 15.5 hrs
Hole Depth/Csg 354.7' / -N/A-	Hole Depth/Csg 394.5' / -N/A-	Hole Depth/Csg 39.8' / -N/A-

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 _____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1700		Geo to site. Sign-off on HASP, JHA, Site Security
	1730	Plan, etc. Gathering supplies for sample collection.
1730		To site. Drillers already tripping in w/ drill, ~~rod~~
	1825	bit. 10 collars w/ bit&sub => 207'. collars @ 9/8/06
1825	1845	Drill rod in, 8 joints (460') => To bottom @ ~355' bgs.
1845	1900	Preparations for drilling (mixing mud, etc...).
1900	1945	POD for Night Shift. Drillers cont. w/ preparations.
1945		Switch out drillers. Drilling grout w/ Sodium
	~~002~~	Bicarb./Water mix circulating.
	0025	Drill depth = 383.5' bgs (Total ~~Entry~~ B.H. depth)
	0100	G.S. @ 385' bgs
	0415	G.S. @ 390' bgs
	0725	Drill depth = 394.5' bgs
	0730	End shift

"G.S." is "Grab Sample"
DBB 10/20/06

not used @ 9/9/06

Reported By: N. Bowles / J. Horner
Title: Geologist Date: 9/9/06
Signature:

Reviewed By: D.B. Barnett
Title: Geologist Date: 10/20/06
Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/9/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole # 4 | Report No.: 2

Start	Finish	Total
Time 0730	Time 1930	Time 12.0 hrs
Hole Depth/Csg 394.5' / 401.5' (RB) 9/9/06 / -N/A-	Hole Depth/Csg 415 / -N/A-	Hole Depth/Csg 13.5 / -N/A-

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0730		Day shift Geo to site. Sign off on POD. Meet w/ Night-Shift Geo ⇒ Transition.
	0800	
0800	0815	To site. Prepare to collect sample @ 395' bgs.
0815		Notified by driller that Geolograph depth reading off by 7' (Should be @ 402' bgs instead of 395' bgs. ⇒ Collect G.S. (chip tray, Pint. jar, & XRF Bag sample.)
	0830	@ ~~395' bgs.~~ 402' bgs (RB) 9/9/06 (RB) 9/9/06
0830	1200	Drilling ~~cont.~~ continues beyond 402' bgs. → To 405' bgs.
1200	1205	G.S. @ 405' bgs (will resume 5' intervals).
1205	1545	Cont. drilling → To 410' bgs
1545	1550	G.S. @ 410' bgs.
1550	1855	Cont. drilling. → To 415' bgs.
1855	1900	G.S. @ 415' bgs.
1900		Cont. drilling. Geo & Site Sup. to Night Shift POD.
	1930	POD.
1930		End of day Shift.

Not used (NB)

Reported By: N. Bowles

Title: Geologist | Date: 9/9/06

Signature:

Reviewed By: D. B. Barnett

Title: Geologist | Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/9/06 → 9/10/06

Well ID: C4993 | Well Name:

Location: WTP | Report No.: 3

Start	Finish	Total
Time 1900	Time 0715	Time ~~9-10-06 07~~ 12:15 ~~10:15~~
Hole Depth/Csg 415 / N/A	Hole Depth/Csg 433 / N/A	Hole Depth/Csg 18 / N/A

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1905	POD meeting
1905		Shift change @ 415' bgs
	~~1850~~ 2258	Grab sample @ 420' bgs
	0310	Grab sample @ 425' bgs
	0400	Added 20' of drill pipe Talley = 447'
	0500	Grab Sample @ 430' bgs
		• Speed picked up between 427' & 430', driller noted that he lost 100-200 gallons fluid
0630	0650	Current depth = 433', drillers raise bit & circulate mud, flushing ~~happen~~ 9-10-06 ?, Driller said he's still loosing fluid.
0650	→	Resume drilling
	0715	Day shift drillers on site

not used GW 9/10/06

Reported By: J. Horner

Title: Geologist Date: 9/10/06

Signature: Julie Horner

Reviewed By: D. B. Barnett

Title: Geologist Date: 10/20/06

Signature: D B Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/10/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Boreholes Project. | Report No.: 4

Start	Finish	Total
Time 0730	Time 1930	Time 12.0 hrs
Hole Depth/Csg 433' / -N/A-	Hole Depth/Csg 457' / -N/A-	Hole Depth/Csg 24' / -N/A-

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0730	0745	Geo to site. Changeover w/ Night Shift. Sign off on POD
0745	0750	To site. Sample collected from ~~7~~ 435' (G.S.) (MB).
0750	1005	Drilling cont. → To 440' bgs. G.S. @ 440' bgs.
1005	1215	Cont. drilling. → To 445' bgs. G.S. @ 445' bgs.
1215	1340	Cont. drilling. → To 447.3' bgs
1340	1420	lower derrick for rig maintenance/safety check.
1420	1555	Cont. drilling. → To 450.' G.S. @ 450.' bgs.
1555	1810	Cont. drilling. → To 455.' G.S. @ 455' bgs.
1810	1855	Cont. drilling. → To 457.'
1855	1900	To POD for 2nd Shift. Drillers cont. drilling.
1900	1930	2nd Shift POD.
1930		Done w/ day Shift.
		Not used (MB)

Reported By: N. Bowles | Title: Geologist | Date: 9/10/06 | Signature:

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/10/06 → 9/11/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole # 4 | Report No.: 5

Start	Finish	Total
Time: 1900	Time: 0715	Time: @ 9/11/06 12:15
Hole Depth/Csg: ~~457'~~ / N/A DBB 10/20/06	Hole Depth/Csg: ~~475'~~ 477' @ 9/11/06 / N/A	Hole Depth/Csg: 20' / N/A

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	POD meeting
1910	→	Continue drilling →
	2045	G.S. @ 460' bgs
	2120	461' bgs
	2200	461.5' bgs
	2300	463.0' bgs
	2350	463.5' bgs
2350	2400	Adding ~20' of drill pipe Total = 457'
	2400	Resume drilling
	0100	G.S. @ 465' bgs
	0200	467.5' bgs
	0230	468.3' bgs
	0400	470' bgs collect G.S.
	0500	471.4' bgs
	0550	472.8' bgs
	0630	474' bgs Encountered Rattlesnake Ridge Tuff @ 474' bgs
	0700	G.S. @ 475' bgs
	0715	Geo shift change @ 477' bgs
		not used @ 9/11/06

Reported By: J. Horner

Title: Geologist | Date: 9/11/06

Signature: John Horner

Reviewed By: D.B. Barnett

Title: Geologist | Date: 10/20/06

Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/11/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 6

Start	Finish	Total
Time 0700	Time ~~0730~~ 1930 (WB 9/11/06)	Time 12.5 hrs
Hole Depth/Csg ~477 / -N/A-	Hole Depth/Csg 561 / -N/A-	Hole Depth/Csg 84' / -N/A-

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: ____ See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0700	0730	POD
0730		To site. Geo Changeover. In Rattlesnake Ridge Interbed (@ 474' bgs).
		⇒ Drilling in Interbed. V. fast drilling & V. Frequent Grab Sampling: ⇒ @ 480', 485', 490', 495', 500', 505', 510', 515', 520', 525', 530', (chiptray @ 532'), 535', 540', & 545' bgs.
		Drilled to depth of 547.8' bgs. Also, top of Pomona Basalt (WB 9/11/06) encountered @ 547.8' bgs. Note: Drilling suspended from 0825 - 0950 due to mud pumping problems
	1320	
1320		Stop drilling to perform Gyroscopic deviation Survey. Waiting on logging rig / crew. Cont. turning tools & circulating mud.
	1525	
1525		Gyro. crew/rig to site, begin (WB 9/11/06) performing deviation survey. ⇒ 1.0 Deg per 100, 10.4 ft off.
	1630	
1630		Resume drilling. ⇒ To 561' bgs
		G.S.S @ 550', 555', & 560' bgs
(WB 9/11/06 0705)	~~0705~~ 1905 (WB 9/11/06)	Drilling cont.
	~~0730~~ 1930 (WB 9/11/06)	Head to Night Shift POD. Also, Geo Changeover.

Not used (TR)

Reported By: N. Douglas | Title: Geologist | Date: 9/11/06 | Signature: [signature]

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature: [signature]

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/11/06 → 9/12/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 7

Start	Finish DBB 10/20/06	Total
Time 1900	Time 06:00	Time 11 hrs. DBB 10/20/06
Hole Depth/Csg 561 / N/A	Hole Depth/Csg 562 / N/A	Hole Depth/Csg 1 / N/A

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	POD meeting
1910	→	Driller change over, resume drilling from 561' →
9-11-06	1945	562' bgs.
1945	2030	Circulating mud while preparing to trip out drillpipe.
2030	2230	Trip out drill pipe
2230	2245	Waiting for logging crew
2245	2300	Logging crew on site setting up
2300	0030	Performing Acoustic visual imaging logging
0030	0330	Geovision on site for suspension logging Vs & Vp
0330	0440	Prepare to trip in tremie for pouring grout seal
	0430	RCT survey ≤ BKG
0440	0530	Tripping in 2" tremie down to ~553' bgs
0530	→	Mixing & pumping grout + prep Fine
	0600	Geologist left site

Not used 9/12/06

Reported By: J. Horner | Title: Geologist | Date: 9/12/06 | Signature: John Horner

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/12/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 8

Start	Finish	Total
Time 0700	Time 1700	Time 10.0
Hole Depth/Csg 562 / -N/A-	Hole Depth/Csg 562 / -N/A-	Hole Depth/Csg Ø / -N/A-

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0700	0730	POD & Site Security Plan Review.
0730		To site. Drillers Finished grouting borehole @ ~0630 am.
	0830	Currently tripping out w/ tremie pipe.
0830		All tremie out of borehole. Cleaning up grouting
	1030	equip.; Staging equip., etc...
1030		To project trailers for general site supplies &
	1100	sampling supplies. Meet w/ F.H. Geo STR.
1100		Moving all G.S. jars & chip trays to conex storage
	1115	(only samples from entry-hole drilling.).
1115	1145	To C4998/C4997 site to deliver supplies to C4997 Geo.
1145	1245	To site. Mechanic working on equipment (shaker engine).
1245		~~Mechanic leave site~~ (NB) 9/12/06 waiting on parts for mech.
	1530	Driller to town for parts.
1530		Driller returns to site. Waiting on parts & mech.
	1620	Driller & helper working on rig.
1620	1700	Mech. to WTP site. Begin working on repairs.
1700		Geo leave site due to repairs being conducted. Driller
		& Site Sup. say that no drilling will begin
		before 1900 (7pm), when next shift starts. ⇒
		Done for day

Not used (NB)

Reported By: N. Bowles | Title: Geologist | Date: 9/12/06 | Signature:

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/12/06 - 9/13/06

Well ID: C 4993 | Well Name: NA

Location: NTP Seismic Borehole #4 | Report No.: 9

Start	Finish	Total
Time 1900	Time 0700	Time 12 hrs. DBB 10/20/06
Hole Depth/Csg 332' (grout 532 - 562) / n/a	Hole Depth/Csg 563 / n/a	Hole Depth/Csg 1' (new hole) / n/a

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1945	Waiting for drillers to arrive
1944	2000	POD meeting
2000	2045	Prepare to resume drilling (grout from 332' - 562')
		• Mixing Sodium Bicarbonate solution for drilling
2045	2125	Begin drilling out grout (cure time 14 hrs 15 min)
2125	→	The mud shaker started to malfunction. Drillers troubleshoot & notify supervisor & discuss options. Current depth = ~355' (23' in 40 min.)
→	2215	Drillers changed the filters & started it back up
2215	2240	Seems to be running better, letting the mud rig run a while to see how it acts before drilling.
2240	→	Resume drilling from 355' to ...
	2315	368' bgs
	0030	422' bgs (43'/hr from 2315 - 0030)
	0130	455' bgs 33'/hr from (0030 - 0130) ~~422 - 455~~
	0300	504' bgs 34'/hr (455' - 504')
	0400	532' bgs 28'/hr (504' - 532')
	0500	545' bgs 13'/hr (532 - 545)
	0518	562' bgs encountered Pomona basalt
0518	0550	Drilling from 562' to ~563' bgs
0550	→	Dumping mud & mixing a new batch
		not used JH 9/13/06

Reported By: J. Horner | Title: Geologist | Date: 9/13/06 | Signature: John Horner

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/13/06

Well ID: C4993

Well Name: NA

Location: WIPP Seismic Borehole #4

Report No.: 10

Start	Finish	Total
Time 0700	Time ~~0730~~ 1930 (NB) 9/13/06	Time 12.5 hrs
Hole Depth/Csg 563. / -N/A-	Hole Depth/Csg 584.2 / -N/A-	Hole Depth/Csg 21.2' / -N/A-

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: —

See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0700	0715	POD
0715	0730	To site. Recondition/mix mud.
0730	0740	Begin circulating mud.
0740	0745	Add on 1 x 20' drill rod. ~587' total tally.
0745		Begin drilling @ ~563.5 → ~~10~~ (NB) 9/13/06
		G.S. @ 565' bgs @ 0755.
		G.S. @ 570' bgs @ 1120.
		G.S. @ 575' bgs @ 1310.
		G.S. @ ~~590~~ 580' bgs @ 1650'.
	(NB) 9/13/06 @ 1930	Final to 584.2' bgs. Almost ready for sample @ 585' bgs.
1900	(NB) 9/13/06 @ 1900	Head to 2nd shift (Nights) POD. & Changeover w/ Geo.
	1930	

Not used (NB)

Reported By: N. Bowles

Title: Geologist

Date: 9/13/06

Signature: [signature]

Reviewed By: D.B. Barnett

Title: Geologist

Date: 10/20/06

Signature: [signature]

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/13/06 - 9/14/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 11

Start	Finish	Total
Time 1900 (9/13/06)	Time 0700 (9/14/06)	Time 12 hrs
Hole Depth/Csg 584.2 / n/a	Hole Depth/Csg 602 / n/a	Hole Depth/Csg 17.8' / n/a

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	POD meeting
1910	→	Drillers shift change, continue drilling from ~~584.2'~~ @ 9/13/06
	1930	Collect G.S. @ 585' bgs
1950	2010	Stop drilling to make adjusments on drill rig
2010	2015	Adding 20' drill pipe Total = 607'
2015	→	Resume drilling
	2100	587.6'
	2200	588.6' 1.0'/hr
	2230	589.2 1.2'/hr
	2300	590' collected G.S. 1.6'/hr
	2400	591.8 1.8'/hr
	0100	593.5 1.7'/hr
	0200	595' 1.5'/hr Collected G.S. @ 595'
	0300	596.5' 1.5'/hr
	0400	598.5 2.0'/hr
	0500	599.7 1.2'/hr
	0515	G.S. @ 600' bgs
	0600	601'
	0700	End of shift, depth = ~602' bgs
		not used @ 9/14/06

Reported By: J. Horner | Title: Geologist | Date: 9/14/06 | Signature: John Horner

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/14/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 12

Start	Finish	Total
Time 0700	Time 1930	Time 12.5
Hole Depth/Csg 602' / -N/A-	Hole Depth/Csg 617.3' / -N/A-	Hole Depth/Csg 15.3' / -N/A-

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size: —

See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0700	0715	POD meeting.
0715		To site. Cont. Drilling. → Initial Depth @ 603.4 @ 0730
		Grab Sampling @ ~~0605~~ SB 9/14/06 605.' bgs (@ 0830).
		Added on 1 x 20' drill rod → 627' total tally (@ 1025).
		G.S. @ 610' bgs (1305).
		G.S. @ 615' bgs (1715).
	1845	To 617.3. Head to POD.
1845	1900	To project trailers for POD.
1900	1930	POD & Changeover w/ Night shift Geo.
1930		Done for day

Not Used x3

Reported By: J. Bowles

Title: Geologist | Date: 9/14/06

Signature:

Reviewed By: D.B. Barnett

Title: Geologist | Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of ___

Date: 9/14/06 → 9/15/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 13

Start	Finish	Total
Time 1900 (9/14/06)	Time 0700 (9/15/06)	Time 12 hrs
Hole Depth/Csg 617.3 / n/a	Hole Depth/Csg 632 / n/a	Hole Depth/Csg 14.7' / n/a

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900		Geologist on site POD over
1910	→	Driller shift change, continue drilling →
	2105	Collect grab sample @ 620' bgs
	2200	620.9' ~1.0'/hr
	2400	622.9 ~1.0'/hr
	0100	623.8 0.9'/hr
	0200	625.3 1.5'/hr G.S. @ 625.3' bgs
	0300	626.8 1.5'/hr
0350	0355	Adding 20' drill pipe Total = 647'
	0400	627.9' Geolograph was off, # from the string.
	0500	628.8' ~1.7'/hr
	0550	G.S. @ 630' bgs
	0600	630.3' ~1.5'/hr
	0700	~632' End of shift

not used GW 9/15/06

Reported By: J. Horner | Title: Geologist | Date: 9/15/06 | Signature: [signature]

Reviewed By: D. B. Barnett | Title: Geologist | Date: 9/20/06 | Signature: [signature]

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/15/06

Well ID: C4-993	Well Name: NA
Location: WTP Seismic	Report No.: 12

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs
Hole Depth/Csg 632.7' / NA	Hole Depth/Csg 648.1 / NA	Hole Depth/Csg 16.1' / NA

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:25	P.O.D.
07:25	08:00	Depth = 632.7' rate = ~1 ft/hr.
08:00	09:00	Depth = 633.8' rate = 1.1 ft/hr. – slow rotation in fractures
09:00	10:00	Depth = 634.8' rate = 1 ft/hr.
10:00	11:00	Depth = 635.7' rate = 0.9 ft/hr.
11:00	12:00	Depth = 637.0' rate = 1.3 ft/hr.
12:00	13:00	Depth = 638.6' rate = 1.1 ft/hr.
13:00	14:00	Depth = 639.9 rate = 1.3 ft/hr.
14:00	15:00	Depth = 641.4 rate = 1.5 ft/hr.
15:00	16:00	Depth = 643.1 rate = 1.7 ft/hr.
16:00	17:00	Depth = 645.7 rate = 2.6 ft/hr.
17:00	18:00	Pull up rods, circulate, prep for deviation test. Drilled to 648.1 @ 1.5 ft/hr.
18:00	18:45	Loggers on site for straightness test (gyroscope)
18:45	19:00	P.O.D

DBB 9/16/06

Reported By: D. B. Barnett	Reviewed By: S P Reidel
Title: Geologist	Title: Sr Geologist
Date: 9/15/06	Date: 10/20/06
Signature:	Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/15/06 PM

Well ID: C4993 | Well Name:

Location: WTP Seismic Borehole #4 | Report No.: 13

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 648.1' /	Hole Depth/Csg 668.0' /	Hole Depth/Csg 19.9' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	Pod meeting: Cold weather and possible rain
1900	1930	GEOPHYSICAL LOGGING STARTED, hit bottom at @ 1930 at 635'
1930	1949	Logging completed, inclination 0.5°, 9.5' distance
1949	2005	Geophysical logging crew off site
2005		Drilling continued @ 648.1'
2007		new geograph was placed and machine was recalibrated
2134		651.7': rod vibrated indicating fracturing, drilling speed slowed down
2215		Drill started to jump really hard possible fractures
0300		at 662.4' drilling at roughly 2-2.5 ft/hr
0606		added an additional pipe string, and recalibrated geograph
0700		End of shift at depth ~668.0' bgs

CP 9/16/06

Reported By: Colleen Rust

Title: Geologist | Date: 9/15/06

Signature:

Reviewed By: SP Reidel

Title: Staff Geologist | Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/16/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic borehole | Report No.: 16

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs
Hole Depth/Csg 668.5 / NA	Hole Depth/Csg 686.5 /	Hole Depth/Csg 18.16' /

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:15	P.O.D. Temperature upper 40's F
07:45	08:00	First sample this shift @ 668.5'-670.5' (see below)
08:00	09:00	"Some fractures"
09:00	10:00	"Some fractures" - less frequent
10:00	19:00	drilling rate varies between 0.9 to 2.1 ft/hr.
	18:35 →	Added on new drill rod
		Grab samples:
		670' @ 07:55
		675' @ 11:25
		680' @ 14:45
		685' @ 17:35

DBB 9/16/06

Reported By: D. B. Barnett

Title: Geologist | Date: 9/16/06

Signature: D. B. Barnett

Reviewed By: S.P. Reidel

Title: Staff Geologist | Date: 9/20/06

Signature: S.P. Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/16/06 PM

Well ID: C4993

Well Name:

Location: WTP Seismic Borehole #4

Report No.: 17

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg ~~648.4'~~ 686.6' / CR 9/16/06	Hole Depth/Csg 703.0' /	Hole Depth/Csg 16.4' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	POD meeting: Warning about fatigue and cold temperatures
2055		690' sample taken, drill ~~rate~~ CR 9/16/06 rate ~ 1.4 ft/hr
2400		695' sample taken, drill rate ~ 1.4 ft/hr
0400		700' sample taken, drill rate ~ 0.65 ft/hr drastic slow down
0700		shift change @ 703.0'

CR 9/17/06

Reported By: Colleen Rust

Title: Geologist Date: 9/17/06

Signature: Colleen Rust

Reviewed By: SP Rendel

Title: Staff Geologist Date: 10/20/06

Signature: SP Rendel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/17/06

Well ID: CA993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 18

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs.
Hole Depth/Csg 703.5' / NA	Hole Depth/Csg 721.8' / NA	Hole Depth/Csg 18.3' / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 _____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:15	P.O.D. – wear seat belts when in Gators. Rick Norton - site Rep.
08:15	0:9:15	Drilling rate 1.2 ft/hr. 705'-706' (geograph)
/	09:30	New 20' rod started.
09:05	10:04	Drilling rate = 1.0 ft/hr. (leading @ ~707.5') (geograph)
/	08:15	Grab sample @ 705'
10:48	11:34	Drilling rate from 708'-709' = 1.3 ft/hr (geograph)
/	12:15	Grab sample @ 710'
/	12:17	Drilling rate for past hour = 1.3 ft/hr - Rick Norton
14:04	14:34	Drilling rate = ~~1.3 ft/hr~~ DBB 9/17/06 2.0 ft/hr from 713'-714'
/	14:55	Grab sample @ 715
	~~15:20~~	DBB 9/17/06 Lower torque noticeable on geograph @ 717'
/	16:00	Grab sample @ 720' @ 16:00
15:04	16:04	Drilling rate averaged 6 ft/hr. (geograph)
/	16:10	Site Supervisor had called for loggers to run deviation
DBB	9/17/06	on hole – nearing interbed and want to gyro the hole
/	/	before this is intercepted – Drillers stopped drilling and
/	/	began circulating while waiting for logger. Depth ~721.8 ft
/	17:15	Logger (Randy Price) showed up
/	18:00	Gyroscope warmed up and going into hole.
	18:45	Survey (Gyro) complete

DBB 9/17/06

Reported By: D.B. Barnett | Title: Geologist | Date: 9/17/06 | Signature: D.B. Barnett

Reviewed By: SP Reidel | Title: Staff Geologist | Date: 10/20/06 | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/17/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 19

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 721.8' /	Hole Depth/Csg 774.0' /	Hole Depth/Csg 52.2' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	POA meeting: trip hazards
1910	1918	Arrival on site: Gyro crew were off site and drilling was
		in progress at 722.8'
1929		723.5' sample taken, believe contact is at 723.5'
1929	2000	723.5' to 727.0' ~7.0 ft/hr drill rate
2000	2019	727.0' to 733.6' ~19.8 ft/hr drill rate
2019	2026	733.6' to 735.4 CR 9/17/06 ~15.4 ft/hr drill rate
2026	2032	735.4 to 736.5' ~11 ft/hr drill rate
2032	2040	736.5' to 739.3' ~21 ft/hr drill rate CR 9/17/06
2046		742.3' sample taken, bottom contact of R. Selah Sediment
2057		745' sample taken, drill rate ~ 14.5 ft/hr
2130		750' sample taken, drill rate ~ 9.3 ft/hr
2220		755' sample taken, drill rate ~ 6.4 ft/hr
2209		Rig jumped 3 inches due to a fracture, rough drilling
2409		760' sample taken, drill rate ~ 2.8 ft/hr
0202		765' sample taken, drill rate ~ 2.8 ft/hr
0447		770' sample taken, drill rate ~ 1.78 ft/hr
0700		End of shift @ 774.0

CR 9/18/06

Reported By: Colleen Rust

Title: Geologist Date: 9/17/06

Signature: Colleen F. Rust

Reviewed By: SP Reidel

Title: Staff Geologist Date: 10/20/06

Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of ___

Date: 9/18/06

Well ID: C4993

Well Name: NA

Location: WTP Seismic Borehole #4

Report No.: 20

Start	Finish	Total
Time 07:00	Time 1900	Time 12 hrs. DBB 9/19/06
Hole Depth/Csg 774' / NA	Hole Depth/Csg 775' / NA	Hole Depth/Csg ~~775'~~ 1.3 ft / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ See Report No. 1

Rod Size:

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:15	P.O.D. — Rain & wind possible today
/	07:35	Sample taken @ 775' (sprinkling rain - v. light)
/	07:50	Stopped drilling — circulating
/	11:40	Drill bit is now out of hole - Smith bit - still usuable - drillers will keep using it.
/	12:20	Began televiewer logging
/	14:05	Logging (televiewer) complete
/	14:20	Rig engine restart
/	15:00	Rig shut down, drillers go to C4996
/	16:15	Rick Garrison arrives @ well site
/	16:30	Geovision loggers arrive - Doug McFarland from PNNL

DBB 9/18/06

Reported By: D. B. Barnett

Title: Geologist Date: 9/18/06

Signature: D.B. Barnett

Reviewed By: S P Reidel

Title: Staff Geologist Date: 10/20/06

Signature: S P Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/18/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 21

Start	Finish	Total
Time 1900	Time 0700	Time 12 HRS
Hole Depth/Csg 775.3 /	Hole Depth/Csg 775.3 /	Hole Depth/Csg 0' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	Pod meeting: Concern voiced about sleeping on the job
	1930	Geovision loggers finished up and left site
1930		Tripping of trim pipe started to lay grout
	2015	Finished tripping in trim pipe, started to set up for cement
2113		started to mix the first batch of cement (760 gallons of cement) ~300ft
	2340	Finished pumping cement into hole
	0130	pulled out trimming pipe and waiting to have cement set, trimming pipe is 80 ft above cement plug
0130	0247	Pulled remaining pipe out to wait
0247	0700	started to put in the collars and piping, had some issues with fittings, and changed out mud
0700		shift change @ 775.3

9/19/06 CR

Reported By: Colleen Rust

Title: Geologist | Date: 9/18/06

Signature: C. F. Rust

Reviewed By: SP Reidel

Title: Staff Geologist | Date: 10/20/06

Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

DBB 9/20/06

Page 1 of 2

Date: 9/19/06

Well ID: C49983 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 22

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs
Hole Depth/Csg 775 ~~3~~ / NA	Hole Depth/Csg 775 ~~3~~ / NA	Hole Depth/Csg 775 ~~3~~ / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 _____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:15	P.O.D. Drillers cautioned to stay clear of rods while tripping out - laying down rods on service truck - Sweesy
07:15	11:25	Waiting for cement to cure. - disposing of old mud
11:25	11:45	Tripping back into hole from 227' - ~~530~~ ~~488~~ DBB 9/19/06
	11:45	Driller advises that cement is still too soft to drill out - Samples in jars still soft - need to wait longer - pull one rod back out. Stopped @ 488' - could be cement or boot.
	14:25	Start drilling cement
	16:20	Drilling cement @ ~ 20 ft/hr. - cement top @ 488 ft. this places top of cement 74 ft above the bottom of the cement emplaced on 9/12/06 (see p. 2 this report)
	18:05	Site Supervisor reports that HMS has issued T-storm advisory until 10:00 pm (22:00) - Storm (no lightning observed) arrived @ drill site @ ~ 18:10 - Just moderate rain
	18:30	Drilling cement @ ~ 520 bgs @ ~ 20 ft/hr.

DBB 9/19/06

Reported By: D. B. Barnett | Title: Geologist | Date: 9/19/06 | Signature:

Reviewed By: SP Reidel | Title: Staff Geologist | Date: 10/20/06 | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Continuation Page

Page 2 of 2

Date: 9/19/06

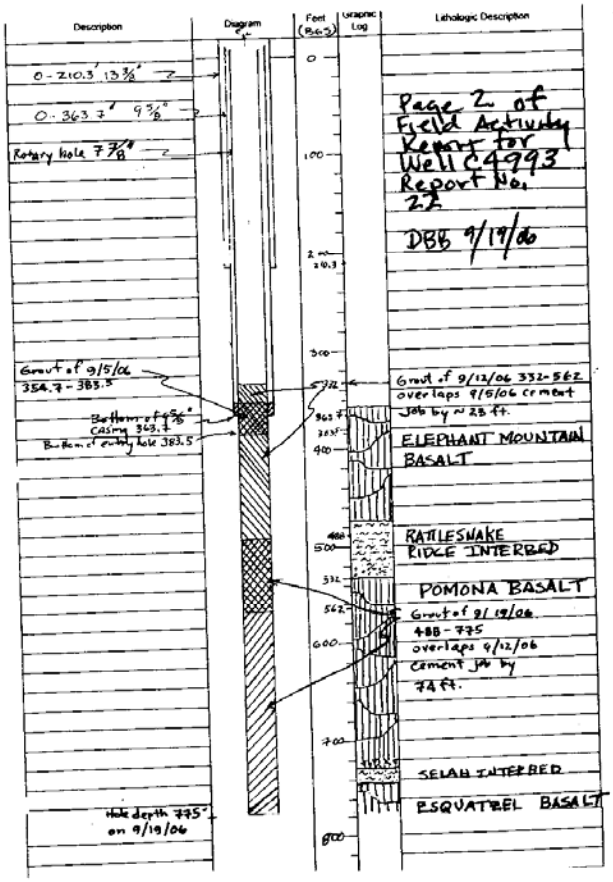
Well Name: C4993

Well ID: C4993

Location: WTP Seismic

Continuation of Report No.: 22

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth
		Graphical Summary of Hole construction C4993 as of 9/19/06



DBB 9/19/06

Reported By: D.B. Barnett

Title: Geologist

Date: 9/19/06

Signature: DBBarnett

Reviewed By: SP Reidel

Title: Staff Geologist

Date: 10/20/06

Signature: SP Reidel

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/19/06 PM

Well ID: C 4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 23

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 775.3 /	Hole Depth/Csg /	Hole Depth/Csg /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	PoD meeting: slick surfaces due to rain shower
2008		Placed ~~9/18/06~~ rod into hole, roughly 200ft off bottom at 629.0'
2103		drill bit at ~646.6', drill rate ~20 ft/hr (Geograph has been
2401		Drill bit at ~674', drill rate ~18 ft/hr giving bad readings)
0417		at ~745', bit is catching the side of the Selah
		Interbed + basalt, clay and basalt chip return in a
		catch sample from the top of the casing pipe, drill rate
		has been slowed down to ensure no more variation from cement
0540		at ~759', 50% basalt + 50% cement present in chips
0630		at ~765', 50% basalt + 50% cement present in chips
0700		shift change

CR 9/20/06

Reported By: Colleen Rust | Title: Geologist | Date: 9/19/06 | Signature: C. Rust

Reviewed By: SP Reidel | Title: Staff Geologist | Date: 10/2/06 | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/20/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 (next to Grout facility) | Report No.: 24

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs
Hole Depth/Csg 775' / NA	Hole Depth/Csg 795.0' / NA	Hole Depth/Csg 20 ft. / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 _____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:30	P.O.D. – Relief drilling crew for day shift did
07:30	07:45	not arrive until 07:45 due to misplaced security badge
	08:00	Drilling in basalt @ 778' – Left last of cement @
		775' @ ~07:40 – changing out mud while drilling
		@ 08:05
	08:30	Begin circulating and continue to change mud – drilling
		stopped @ 778.0'
08:30	10:45	Prepare New mud, circulate, remove old tailings/cuttings
10:45		Begin Drilling again @ 778.0'
11:30	12:05	Drilling rate is ~ 2.0 ft/hr. – depth 781.2'
	11:30	Grab sample @ 780'
13:18	13:47	Drilling rate = ~2.0 ft/hr.
	13:55	Grab sample @ 785' (raining)
	15:00	Grab Sample @ 790'
17:21	17:52	Drilling rate = 2.0 ft/hr. (Previous rate @ 15:20 was 1.3 ft/hr.)
	18:45	Grab sample @ 795'

DBB 9/20/06

Reported By: D.B. Barnett | Reviewed By: S.P. Reidel

Title: Geologist | Date: 9/20/06 | Title: Staff Geologist | Date: 9/20/06

Signature: | Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/20/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 25

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 795.0' / NA	Hole Depth/Csg 815' / NA	Hole Depth/Csg 20 / NA

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	PoD meeting ppb 9/21/06 slip hazards + staying warm and dry
1918		at 795.0', Brent Barnett took the 795.0' sample, description
		Was done by Colleen Rust, sample was taken at shift
		change ~1900. prior to DBS 9/21/06
2104		at 799.4', drill rate 1.96 ft/hr
2129		800' sample taken ~2 ft/hr
2300		at 802.9', drill rate 1.87 ft/hr
2400		at 804.7', drill rate 1.8 ft/hr
2414		805' sample taken
0255		810' sample taken, drill rate ~1.2 ft/hr
0622		815' sample taken, drill rate ~1.5 ft/hr
0700		shift change

CR 9/21/06

Reported By: Colleen Rust | Reviewed By: SP Reidel

Title: Geologist | Date: 9/21/06 | Title: Staff Geologist | Date: 10/20/06

Signature: Colleen F. Rust | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/21/06

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 26

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs.
Hole Depth/Csg 815' / NA	Hole Depth/Csg 835' / NA	Hole Depth/Csg 20' / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:15	P.O.D. - "everyone getting tired" - be careful
	09:14	Drill rate = 2.0 ft/hr @ 817'-818'
	09:20	Grab sample @ 820'
	09:25	Sample for XRF taken from 795' washed sample bag.
	10:00	Loggers arrive for gyro survey — drilling stopped @ 822.2' for logging.
	12:00	Logging complete - drilling resumes
	13:40	Grab samples @ 825'
	15:11	Drill rate @ ~3ft/hr during past hour
	15:50	Grab sample @ 830'
	17:00	Drill rate for past 2 hrs = 1.6 ft/hr. — depth = 831.8'
	18:40	Grab sample @ 835' — rate increasing
	19:00	Shift change

DBB 9/21/06

Reported By: D. B. Barnett

Title: Geologist | Date: 9/21/06

Signature: D Barnett

Reviewed By: SP Reidel

Title: Staff Geologist | Date: 10/20/06

Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of +2 CR-9/22/06

Date: 9/21/06 PM

Well ID: C 4993 | Well Name: NA

Location: NTS SEISMIC BOREHOLE #4 | Report No.: 27

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 835' /	Hole Depth/Csg 948.6' /	Hole Depth/Csg 113.6' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1907	POD meeting: slip hazards and cold weather
1907		at 838.7' drill rate ~12.8 ft/hr
1922	1932	Contact either at 843' or 845' will determine by samples
		drill rate ~12ft/hr
2005		clays are starting to stick or clagh up the bit
2027		850' sample collected, lots of clay with some sand, drill rate ~20.8ft/hr
2042		855' sample collected, almost all sand & silt, very low return
2057		860' sample collected, mostly sand w/ little clay
2118		865' sample collected, drill rate 16.3ft/hr
2135		870' sample collected, drill rate 15.4ft/hr
2149		875' sample collected, mostly sand w/ very little clay
2155		880' sample collected, all sand, ~24ft/hr
2209		885' sample collected, all sand, ~21ft/hr
2250		890' sample collected, all sand
2308		895' sample collected, drill rate ~16.7ft/hr
2330		900' sample collected, drill rate ~ 13.6ft/hr
2350		905' sample collected, drill rate ~ 15ft/hr
2413		910' sample collected, drill rate ~ 16.5ft/hr
2420		915' sample collected
2428		920' sample collected
2440		925' sample collected, drill rate ~ 25ft/hr
2455	0118	Drill jumped around, was drilling tough clays (green-gray) @ 932'-933'
0118		930' sample collected
0146		Drill was slowing down more, very little basalt (from walls)

Reported By: Colleen Rust | Reviewed By: SP Reidel

Title: Geologist | Date: 9/21/06 | Title: Staff Geologist | Date: 10/20/06

Signature: C. F. Rust | Signature: S P Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 2 of 2

Date: 9/21/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 27

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 835' /	Hole Depth/Csg 948.6' /	Hole Depth/Csg 113.6' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0158		935' sample collected, contact of Umatilla Basalt
0306		940' sample collected
0511		945' sample collected
0700		Shift Change @ ~948.6'

CR 9/22/06

Reported By: Colleen Rust
Title: Geologist | Date: 9/21/06
Signature: C. F. Rust

Reviewed By: D.B. Barnett
Title: Geologist | Date: 10/20/06
Signature: D B Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/22/06

Well ID: C4993 | Well Name: ~/A

Location: NTP Seismic Borehole #4 | Report No.: 28

Start	Finish	Total
Time 0700	Time 1900	Time 12 hrs
Hole Depth/Csg 948.6 (@ 9/21/06) / 948.2 / ~/A	Hole Depth/Csg 965.4' / ~/A	Hole Depth/Csg 17.2' / ~/A

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0700	0715	POD meeting
0715	0730	Driller shift change, continue setting up for gyro
0730	0850	Performing gyro survey down to 935.5' bgs (off 12.4', ~½°)
0850	→	Resume drilling
	0900	948.6' bgs
	0945	950.1' bgs collect G.S.
	1000	950.6' bgs
	1100	953.1' bgs 2.5'/hr
	1130	955.2' bgs collect G.S. 4.2'/hr last ½ hr
	1200	955.8' bgs 0.6'/hr last ½ hr avg = 2.6'/hr (last hr)
	1300	957.4' bgs 1.6'/hr
	1350	960' bgs collect G.S.
	1400	960.8' bgs 3.4'/hr
	1500	962.2' bgs 1.4'/hr
	1600	963.3' bgs 1.1'/hr
	1700	964.6' bgs 1.3'/hr
	1720	965' bgs collect G.S.
	1730	Stop drilling & circulate mud to clean borehole. Final depth is 965.4' bgs. Plan to circulate for a couple hours then trip out in preparation for logging.
1730	→	circulating
1830	1900	Geologist up to POD trailer for shift change & meeting. not used @ 9-22-06

Reported By: J. Horner | Reviewed By: D.B. Barnett

Title: Geologist | Date: 9/22/06 | Title: Geologist | Date: 10/20/06

Signature: Josh Horner | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/22/06 → 9/23/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole #4 | Report No.: 29

Start	Finish	Total
Time 1900 (9/22/06)	Time 0430 (9/23/06)	Time 9.5
Hole Depth/Csg 965.4' / -N/A-	Hole Depth/Csg 965.4' / -N/A-	Hole Depth/Csg 0 / -N/A-

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1915	POD and Geo changeover.
1915	1930	Preparing to pull drill. Circulating mud.
1930	0100	Begin pulling drill rod from hole in prep. for logging.
0100	0125	Loggers to site, setting up. Drillers cont. to pull rods.
0125		All drill tools out of hole. Prepare to log w/
	0145	tele Viewer logging system.
0145	0200	Sending logging unit down hole.
0200	0345	To bottom. Begin logging w/ Televiewer.
0345	0400	Logging Completed. Preparing to leave site.
0400	0430	Loggers off site. Geo prepares to leave site
0430		Done for shift. Waiting for Geo-Vision loggers
		(expected @ ~700 am)) Geo leave site @ 0430

Not used (25) 9/22/06

Reported By: N. Bowles | Title: Geologist | Date: 9/23/06 | Signature:

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/23/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole #4 | Report No.: 30

Start	Finish	Total
Time 0545	Time 1700	Time 11.25 hrs
Hole Depth/Csg 965.4 / —	Hole Depth/Csg 977.42' / — (cement)	Hole Depth/Csg 223.4' / — (cement tiff)

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0545	→	Geologist on site for shift change & nobody present. Night shift left @ 0400, waiting on suspension logging crew.
0700	0715	~~TBT~~ meeting (logging crew present)
0715	1030	Setup & perform suspension logging
1030	1110	STR collects 5-gallon mud sample for VCO to sample from & then drillers recondition mud.
1110	1305	Prep for grout operation / trip in tremie • ~2.5 gal/ft x 185' + 20% = ~555 gallons needed • est. 62 bags cement, yielding ~9 gal./bag
1305	1510	Tremie in, mixing & pumping grout (tremie @ 953'bgs) • 1st batch 190 gallons • 2nd batch 210 gallons (570 gallons: 56, 96# bags) • 3rd batch 170 gallons
1510	1630	Clean up from grouting & trip out tremie
1630	→	Drillers left site, prob. went to other rig (?) tremie is ~½ out.
	1700	Geologist left site
		not used 9/23/06

Reported By: J. Horner | Title: Geologist | Date: 9/23/06 | Signature: Jeb Horner

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/24/06

Well ID: C4993 | Well Name: n/a

Location: WTP | Report No.: 3

Start	Finish	Total
Time 0600	Time 1800	Time 12 hrs
Hole Depth/Csg 742' (cement) / n/A	Hole Depth/Csg 930' cement /	Hole Depth/Csg 188' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
	0600	Geologist on site
		*Notes: Started drilling cement @ 0400 (tagged @ 742' bgs)
0645	→	Geologist up to POD meeting (drill depth ~ 815' bgs)
0700	0710	POD meeting ~223' cement
	0715	Drill depth ~ 830' bgs
		*Note: with a start time @ 0400 & a tag @ ~~9/24/06~~ 742'
		the avg. drill rate 27'/hr (88' ÷ 3.25 hrs = 27'/hr)
	0720	Stop drilling @ ~831' bgs for drill rig maintenance
	0835	Resume drilling from 831' to →
	0900	834.7' bgs
	0930	847' bgs ~24.6'/hr Cold ck. Intaked @ 845' bgs
	1000	853.2' bgs ~18'/hr (made connection: 930-0940)
	1100	862.6' bgs ~9.4'/hr (target intaked rate is ~10'/hr)
	1200	872.8' bgs ~10.2'/hr
	1255	Adding 20' drill rod
	1400	892.5' ~10'/hr last 2 hrs
	1500	903' bgs 10.5'/hr
	1600	910' bgs 7'/hr (adjusted geolograph ~6")
	1700	920.4' bgs 10.4'/hr
	1800	930' bgs 9.6'/hr
	1800	Geologist heads up to trailer for Geo shift change.
		not used @ 9/24/06

Reported By: Jake Horner

Title: Geologist Date: 9/24/06

Signature: Jake Horner

Reviewed By: D.B. Barnett

Title: Geologist Date: 10/20/06

Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/24/06 → 9/25/06

Well ID: CA993 | Well Name: —

Location: WTP Seismic Borehole Project. | Report No.: 32

Start	Finish	Total
Time 1800	Time 0630	Time 12.5
Hole Depth/Csg 930 (cement) / -N/A-	Hole Depth/Csg 971.5' / -N/A-	Hole Depth/Csg 41.5 / -N/A-

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1800	1815	Geo to site. Geo changeover
1815	1845	To site. Drilling cement grout.
1845		Depth @ 937.3' bgs. Out of Interbed (@ 935')
	1900	→ Cont. to drill. Geo & STR head to POD.
1900	1915	POD
1915	2030	Return to site. Cont. to drill grout.
2030		Hit basalt @ ~965' bgs (965.4'). Begin circulating
	2440 (1240)	through system/shaker to remove grout cuttings. Also, changing mud out.
2440 (1240)	0500	Resume drilling from 965.4' bgs. → 970' bgs
0500	0530	To 970'. Collect G.S. & XRF sample.
0530	0615	Cont. drilling. To → 971.5 @ 0615
0615	0630	Geo changeover. To project offices.
0630		Down/Night Shift. Geo leave site

Not used (NB)

Reported By: N. Bowles

Title: Geologist | Date: 9/25/06

Signature:

Reviewed By: D.B. Barnett

Title: Geologist | Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/25/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole | Report No.: 33

Start	Finish	Total
Time 0600	Time 1800	Time 12 hours
Hole Depth/Csg 971.5' / N/A	Hole Depth/Csg 1006.4 / N/A	Hole Depth/Csg 34.9 / N/A

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0600	0630	Geologist shift change
/	0615	971.5' bgs continue drilling
/	0700	974.3' bgs
0700	0710	Geologist up to POD meeting
0710	0715	"Tailgate" POD on site (Drillers, STC & Geo.)
/	0720	collect G.S. @ 975.3' bgs ~3.5'/hr
/	0805	collect G.S. @ 980' bgs ~6.2'/hr
/	0900	collect G.S. @ ~~980.8'~~ 985.3' bgs per 9/26/06 ~6.3'/hr
/	/	• Geograph indicated extensive fracturing from ~970'-
0945	1010	Stop advancing & ream borehole from ~970 - 987' bgs & circulate mud to clean borehole. Added 20' pipe 407' total.
	0945	987' bgs ~1.6'/hr
	1100	989.3' bgs
	1115	Collect G.S. @ 990' bgs
	1200	992.5' ~~Lost Rec~~ 3.2'/hr
	1250	Collect G.S. @ 995'
	1300	995.4' ~2.9'/hr
	1400	997.4' 2.0'/hr
	1500	1000.2' 2.8'/hr
	1505	1000.5' collected G.S.
	1600	1002.8' 2.6'/hr
1705	~~1700~~	1005.0' collect G.S. ~3.0'/hr
	1800	Geologist leaves site
		not used per 9/25/06

Reported By: J. Horner

Title: Geologist Date: 9/26/06

Signature: J. Horner

Reviewed By: D.B. Barnett

Title: Geologist Date: 10/20/06

Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/25/06 →

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole H24 | Report No.: 34

Start	Finish	Total
Time 1800	Time 0630	Time 12.5
Hole Depth/Csg 1006.4 / -N/A-	Hole Depth/Csg 1029 / —	Hole Depth/Csg 22.6' / —

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: —

See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1800	1815	To site. Geo shift change. Starting depth @ 1006.4' bgs.
1815	1900	Drilling to 1007' bgs. Circ. mud for add. of stick.
1900		POP meeting. Drillers add on 20' of drill rod
	1915	⇒ 1027' total string.
1915		Drilling. → To 1010' bgs. G.S. @ 1010' bgs.
	~~2025~~ 0821	@ 9/25/06 Drill rate ~ 2.0'/hr.
2025		Cont. Drilling. → To 1015' bgs. G.S. @ 1015' bgs
	2310	Drill rate ~ 1.8'/hr. XRF Sample @ 1015' bgs.
2310		Cont. Drilling. → To 1020' bgs. G.S. @ 1020' bgs.
	0145	Drill rate ~ 1.9'/hr.
0140		Cont. Drilling. → To 1025' bgs. G.S @ 1025' bgs
	0415	Drill rate ~ 2'/hr
0415	0505	Cont. Drilling. → To ~ 1027.
0505	0510	Add on 20' of drill rod. ⇒ 1047' total string.
0510	0600	Cont. drilling. → To 1029 (Cont. drilling).
0600	0630	Done @ site meet w/ day shift Geo.
0630		Done for day. leave site.
		Not Used (NP)

Reported By: N. Bowles

Title: Geologist | Date:

Signature:

Reviewed By: D.B. Barnett

Title: Geologist | Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/26/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole | Report No.: 35

Start	Finish	Total
Time 0600	Time 1800	Time 12 hrs
Hole Depth/Csg 1029 / N/A	Hole Depth/Csg 1048.7 / N/A	Hole Depth/Csg 19.7' / N/A

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0600	0630	Geologist shift transition
	0650	Collect G.S. @ 1030'
0655	0715	Geologist up to TOD meeting
	0800	1032.7' bgs 2.3'/hr
	0900	1034.8' bgs 2.1'/hr
	0910	1035' collected G.S.
	0930	NCO on site to collect mud sample from bucket of mud collected by STR on a previous shift.
	1000	1037' bgs 2.2'/hr
	1100	1038.8 bgs 1.8'/hr
	1135	1040' collected G.S. (@ 1200-1040.6' bgs) 1.2'/hr
	1300	1041.9' 1.3'/hr
	1400	1044.2' 2.3'/hr
	1425	G.S. @ 1045' bgs
	1500	1046.3 2.1'/hr
	7505	Gyro crew on site
	7515	Stop drilling @ 1047' & begin setup for survey
→	1650	Performing gyro survey
1650	1700	Add 20' drill pipe Tallcy = 1067' cont. drilling
	1800	
	1800	Geologist leaves site, end of shift
		not used @ 9/26/06

Reported By: J. Horner | Title: Geologist | Date: 9/26/06 | Signature: J. Horner

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/26/06 → 9/27/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole | Report No.: 36

Start	Finish	Total
Time 1800	Time 0630	Time 12.5
Hole Depth/Csg 1048.7 / -N/A-	Hole Depth/Csg 1066.3 / -N/A-	Hole Depth/Csg 17.6' / -N/A-

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ See Report No. 1 | Rod Size: —

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1800	1815	To site. Geo transition.
1815	1840	Cont. Drilling. → To 1050. G.S. @ 1050. ~1.7'/hr.
1840	1845	Drilling cont. Geo & STR head to POD.
1845 NB 9/26/06	1930	Cont. NB 9/26/06 POD
1930	1005	Drilling cont. → To 1055'. G.S. @ 1055' bgs ~1.5'/hr. @ 1055' bgs.
1005	0130	Cont. to drill. → To 1060'. GS. @ 1060' bgs & XRF Sample @ 1060' bgs. ~ 1.4'/hr.
0130	0500	Cont. to drill. → To 1065'. G.S. @ 1065' bgs. ~ 1.4'/hr.
0500	0515	Add on ~20' of drill rod
0515	0600	Cont. to drill. → To 1066.3'.
0600	0630	Cont. drilling. Geo change out.
0630		Done for day. Leave site

Not used NB

Reported By: N. Bowles | Title: Geologist | Date: 9/27/06 | Signature: N. Bowles

Reviewed By: D.B. Barnett | Title: Geologist | Date: 10/20/06 | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/27/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole #4 | Report No.: 37

Start	Finish	Total
Time 0600	Time 1800	Time 12 hrs
Hole Depth/Csg 1066.3' / n/a	Hole Depth/Csg 1081 / n/a	Hole Depth/Csg 14.7' / n/a

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0600	0630	Geologist transition
0700	~~0700~~ 0720	POD / weekly safety meeting (hearing protection)
	0730	1068' bgs
	0830	1069' bgs 1.0'/hr
	0930	1070' bgs 1.0'/hr collected G.S.
	1030	1070.5' bgs 0.5'/hr
	1130	1071.6' bgs 1.1'/hr
	1230	1072.9' bgs 1.3'/hr
	1330	1074.3' bgs 1.4'/hr
	1405	1075' bgs collected G.S.
	1430	1075.6' bgs 1.3'/hr
	1530	1077' bgs 1.4'/hr
	1630	1078.5' bgs 1.5'/hr
	1720	1080' bgs collect G.S. 1.8'/hr
	1860	1081' bgs 1.5'/hr

not used JH 9/27/06

Reported By: J. Horner

Title: Geologist | Date: 9/27/06

Signature: John Horner

Reviewed By: D.B. Barnett

Title: Geologist | Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/27/06 - 9/28/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole #4 | Report No.: 38

Start	Finish	Total
Time 1800	Time 0700	Time 13.0 hrs
Hole Depth/Csg 1081' / —	Hole Depth/Csg 1107' / —	Hole Depth/Csg 26' /

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size: —

See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1800	1815	To site. Geo changeover. NJB 9/28/06
1815	1000	Drilling. → To ~~1084~~ 1084.8' bgs.
1000		Temp. stop drilling for changing mud out partially. (Thinning out).
	1015	
1015		Cont. drilling. To → 1085' bgs. G.S. @ 1085' bgs.
	1045	v. slow drilling.
1045	1245	Cont. to drill. → To 1087' bgs. NJB 9/27/06
1245	1250	Add on ~ 20' of drill rod. → to 1107' total tally NJB 9/28/06
1250	0330	Cont. to drill. → To 1090' bgs. ~~0330~~
		G.S. @ 1090' bgs, ~ 1.1'/hr.
0330	0525	Drill to 1094.6' bgs → Hit Interbed (Mabton)
0525		Cont. to drill. → G.S. @ ~~8~~ NJB 9/28/06 1095'.
		" " 1100
		" " 1105
	0620	To 1107'.
0620	0630	Add on 20' of drill rod. → 1127' tot. tally
0630	0700	Geo changeover.
0700		Done for day, leave site.
		Not used NJB

Reported By: N. Bowles

Title: Geologist. Date: 9/28/06

Signature:

Reviewed By: D.B. Barnett

Title: Geologist Date: 10/20/06

Signature: DBBarnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Date: 9/28/06

Well ID: C4993 | Well Name: —

Location: WTP Seismic Borehole #4 | Report No.: 39

Start	Finish	Total
Time 0600	Time 1900	Time 13 hrs
Hole Depth/Csg 1107' / N/A	Hole Depth/Csg 1152' / N/A	Hole Depth/Csg 45' / N/A

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0600	0630	Geologist transition
0620	0630	Adding 20' drill pipe
/	0630	Resume drilling
/	0700	Depth = 1109' bgs
/	0715	Stop drilling (1109.5' bgs), Return hose for drilling mud slipped off @ the connection to the drill rig spilling several gallons of mud on the plastic & over onto the gravel pad.
0715	0800	Reconnect hose & circulate mud while cleanning mess up
0800	→	Resume drilling
/	0815	Collect G.S. @ 1110' bgs
/	1100	collect G.S. @ 1115' bgs
/	1210	collect G.S. @ 1120' bgs
/	1300	collect G.S. @ 1125' bgs
1345	1350	Add 20' drill pipe, Tallley = 1147'
/	1430	collect G.S. @ 1130' bgs
/	1500	collect G.S. @ 1135' bgs ~10'/hr
/	1530	collect G.S. @ 1140' bgs ~10'/hr
/	1600	collect G.S. @ 1145' bgs ~10'/hr
1620	1625	Circulate mud in preparation to add drill pipe (1048.4' bgs)
1625	1628	Adding 20' drill pipe Tallley = 1167'
1628	→	Resume drilling from 1148.4' to → 1151.1' bgs
1625		Gyro crew on site setting up equipment
/	1645	collect G.S. @ Gyrodata 1150' bgs

Reported By: J. Horner | Reviewed By: D.B. Barnett

Title: Geologist | Date: 9/28/06 | Title: Geologist | Date: 10/20/06

Signature: J. Horner | Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Continuation Page

Page 2 of 2

Date: 9/28/06

Well Name: —

Well ID: C4993 DBB 10/2/06

Location: WTP Seismic Borehole #4

Continuation of Report No.: 39

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth
1650	1700	Stop drilling @ 1151.1' bgs & circulate.
1700	~~1715~~	Stop circulating & prep to trip in gyro tool.
~~1715~~	1805 ~~1805~~	Trip in gyro tool.
1805 ~~1805~~	1820 ~~1820~~	Logging complete, trip out tool. @ 9/28/06
		• 19.5' deviation @ ~1150' bgs (~~1.25°~~) (1.7°)
1820 ~~1820~~	1835 ~~00~~	Store tools & logging crew leaves site
1830	1840	Refueling equipment
1840	1900	Resume drilling from 1151.1' bgs → 1152' bgs
1840	1850	Just circulating
~~1850~~	1900	Driller & Geologist transition

9/28/06

not used 9/28/06

Reported By: J. Horner

Title: Geologist Date: 9/23/06

Signature: J. Horner

Reviewed By: D. B. Barnett

Title: Geologist Date: 10/20/06

Signature: D. B. Barnett

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/28/06 → 9/29/06

Well ID: C4993 (NB 9/28/06) Well Name: —

Location: WTP Seismic Boreholes #4 Report No.: 40

Start	Finish	Total
Time 1900	Time 0730	Time 12.5 hrs.
Hole Depth/Csg 1152' / —	Hole Depth/Csg 1179.6' / —	Hole Depth/Csg 27.6' / —

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: —

See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1930	To site. Geo Changeover, sign off on POD.
1930		Drilling → ~~1155~~ (NB 9/28/06) G.S. @ 1155' bgs.
		" @ 1160' bgs.
		" @ 1165' bgs.
	2030 (NB 9/28/06)	To 1167'
~~2030~~	~~(NB 9/28/06)~~	~~Add on ~ 20' of drill rod → 1187' tot. tally~~ (NB 9/28/06)
		Have mud leak on drill-string head fittings/seals.
		Attempting to repair. Remove 20' stick → 1147' tot.
		4 (NB 9/28/06) more sticks removed → tot. of 100' out.
	0015 (NB 9/29/06)	Fixing leak. → Tripped back to bottom, 1187' drill string.
0015 (NB 9/29/06)	0150	Cont. to drill. → G.S. @ 1170' bgs; To ~ 1171.8'
0150		Suspend drillind Temp. ~~1147~~ (NB 9/29/06)
	0200	due to mud leak on rig's centrifugal pump.
0200		Cont. to drill. Pump cont. to leak (minor/controlled).
		G.S. @ 1175' bgs.
	0400	To ~ 1177
0400		Stop/suspend drilling again to deal w/ pump leak.
	0540	→ Fixed
0540	0705	Cont./Resume drilling → To 1179.6' bgs
0705		Again, suspend drilling due to pump leak on rig.
	0715	→ Fixing leak./Pull up String, Temp.
0715	0730	Geo Changeover.
0730		Done for day. leave site.
		Not used (NB 9/29/06)

Reported By: N. Bowles

Title: Geologist Date: 9/29/06

Signature:

Reviewed By: D. B. Barnett

Title: Geologist Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 2

Date: 9/29/06

Well ID: C4993 | Well Name: NA

Location: Seismic Borehole #4 | Report No.: 41

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs.
Hole Depth/Csg 1179.6' / NA	Hole Depth/Csg 1196 / NA	Hole Depth/Csg 15.4 / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 _____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:15	P.O.D. — C4997 has twisted off last joint — need to fish out; C4993 has pump problems - will replace packing & continue to drill Molton. Relieved Nathan Bowles @ 07:15
07:15	12:15	Rig crew fixing mud pump Chad to scavenge parts from another pump)
	12:45	Grab sample @ 1180 ft - slow drilling due to v. adhesive clay.
	14:19	Grab sample @ 1185 ft - drilling rate between 1180' and 1185' was ~3.3 ft/hr. Both of these samples contained steel fragments - driller says probably off of bit fragments are ~0.5 to 1 mm dia. (photo #5986).
	17:15	Grab sample @ 1190 ft (approx.) — this was actually ~1191' No returns - driller increased flow to get returns. ~~Also~~ DBB 9/29/06
	18:20	Toby came by with magnet — we examined cuttings
	↓↑	from 1190-1195 and found abundant steel shavings.
	18:15	Grab sample @ 1195'
	18:45	Driller had us pull the sample from 1175' and check for metal filings — there were many (see photos 5988-5990) after running/swiping magnet through cuttings, Drillers contemplating bit change but would rather wait until sump is ready for logging tools — (This would be at ~1211 ft.)
		DBB 9/29/06

Reported By: D.B. Barnett | Reviewed By: SP Reidel

Title: Geologist | Date: 9/29/06 | Title: Staff Geologist | Date: 10/20/06

Signature: | Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Continuation Page

Page 2 of 2

Date: 9/29/06

Well Name: C4993

Well ID: NA

Location: Seismic Borehole #4

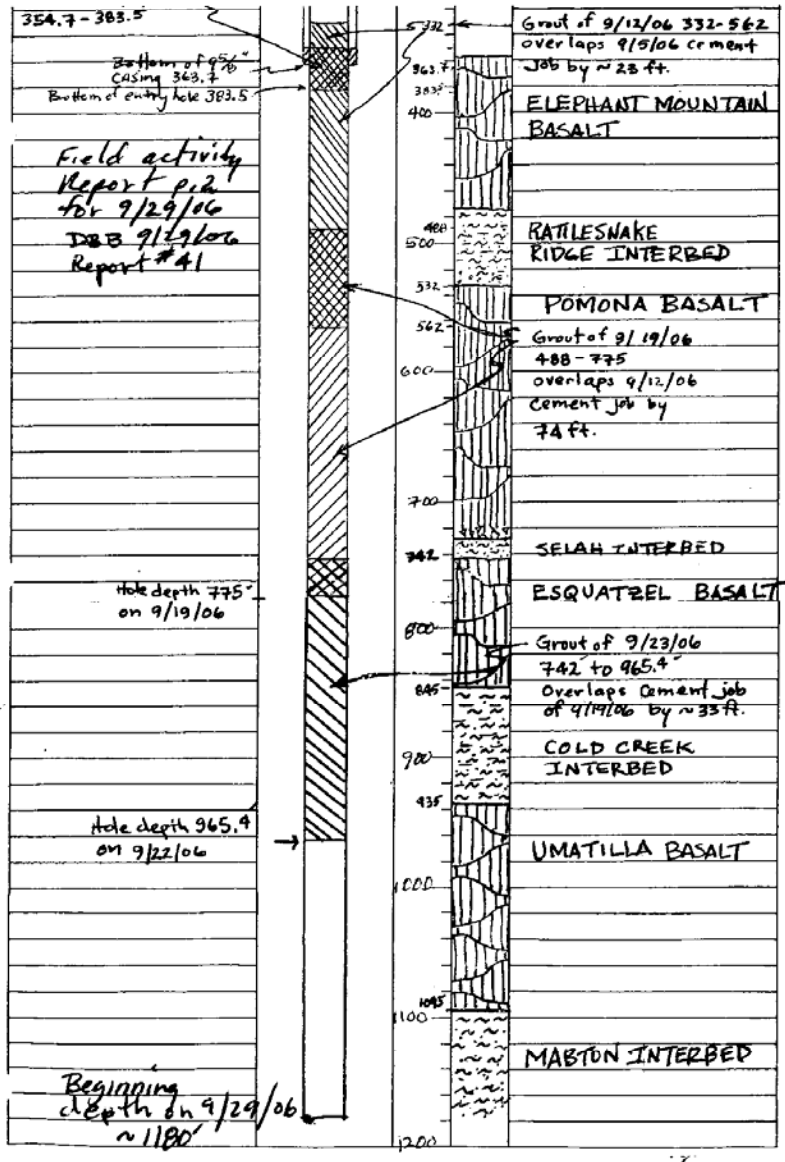
Continuation of Report No.: 41

~~Time/Depth~~ ~~DBB 9/29/06~~ ~~From~~ ~~To~~

Description of Activities/Operations with Depth

Details of hole construction as of 9/29/06 following cementing of Cold Creek Interbed on 9/23/06

For upper portion of hole see p. 2 of Report # 22.



Reported By: D. B. Barnett

Title: Geologist

Date: 9/29/06

Signature: D B Barnett

Reviewed By: S P Reidel

Title: Staff Geologist

Date: 10/20/06

Signature: S P Reidel

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of ___

Date: 9/29/06 PM

Well ID: C4993 | Well Name: NA

Location: SEISMIC BOREHOLE #4 | Report No.: 42

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 1196.0' / ___	Hole Depth/Csg 1211.0' / ___	Hole Depth/Csg 15' / ___

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ___ Rod Size: See Report No. 1

Time/Depth From	To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900		Contact with Priest Rapids Member at 1191', presently at 1196' in basalt
1900	1910	PoD meeting: drive slowly on roads
2000		at 1197.7' ~ 0.8 ft/hr
2104		at 1198.4' ~ 0.7 ft/hr
2200		at 1199.7' ~ 1.3 ft/hr
2214		1200' sample collected ~ 1.28 ft/hr
2400		at 1203.1 ~ 1.7 ft/hr
0101		1205' sample collected ~ 1.9 ft/hr
0245	0300	Motor on mud truck was leaking oil, needs to be changed out
0500		Changed out mud truck and restarted drilling
0600		at 1209.0'
0626		1210' sample collected ~ 2ft/hr
0700		shift change at 1211.0

9/30/06

Reported By: Colleen Rust | Reviewed By: SP Reidel

Title: Geologist | Date: 9/29/06 | Title: Staff Geologist | Date: 10/2/06

Signature: C. F. Rust | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of ____

Date: 9/30/06

Well ID: C4993 | Well Name: Seismic Borehole (Rotary)

Location: Borehole #4 (near Grout Facility) | Report No.: 43

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs
Hole Depth/Csg 1211' / NA	Hole Depth/Csg 1222' / NA	Hole Depth/Csg 11 ft. / NA

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:30	P.O.D. and monthly safety mtg.
	08:35	Grab sample @ 1215'
	10:45	Grab sample taken @ 1221' Drillers reports that geolograph was off by ~1 ft. He adjusted for this error, but the 1220 ft ~~sample~~ level was already past.
	11:10	XRF sample for Top of Priest Rapids basalt taken from 1200 ft grab sample. "XRF SAMPLE NO. C4993-9-30-06, TOP of Priest Rapids"
	10:45	(continued) Drillers stopped @ 1222' and began circulating while waiting for loggers.
	~~12:25~~	~~Loggers arrive for deviation testing~~
	12:25	DBB 9/30/06
	13:50	Placed bagged samples in core boxes and stored in CONEX box. Footages 605' to 1160'.
	1430	Loggers finish gyro logging results = 1.25° deviation from vertical
	1435	Drillers began tripping out of hole & cleaning hole as they withdraw.

Reported By: D. B. Barnett
Title: Geologist | Date: 9/30/06
Signature: D B Barnett

Reviewed By: SP Roidel
Title: Staff Geologist | Date: 10/20/06
Signature: S P Roidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 9/30/06 PM

Well ID: C4993	Well Name: NA
Location: SEISMIC BOREHOLE #4	Report No.: 44

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 1222.0' /	Hole Depth/Csg 1222.0' /	Hole Depth/Csg 0' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1915	PoD Meeting: Seatbelts talk + Monthly Safety Meeting
	2056	Drill bit out of hole
2056		Gyro team on site, had problems at 1183', were unable to get lower, started logging from this point up
2354	2405	Gyro team out of hole and later off site
2405		Geovision group on site and into hole, got hung up at 1185' and started logging from this point up
	0342	Geovision group out of hole and later off site
0342	0700	Started to trip back into hole to perform a wiper pass and will rerun logging instruments
	0700	Shift Change

CR 9/30/06 CR

Reported By: Colleen Rust		Reviewed By: SP Reidel	
Title: Geologist	Date: 10/1/06	Title: Staff Geologist	Date: 10/2/06
Signature: Colleen F. Rust		Signature: SP Reidel	

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/1/06 DBB

Well ID: C4993 | Well Name: NA

Location: WTP Seismic Borehole #4 | Report No.: 45

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs
Hole Depth/Csg 1222' / NA	Hole Depth/Csg 1222' / NA	Hole Depth/Csg 0 / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:15	P.O.D. — C4993 drilling in basalt; C4993 is tripping in for wiper pass — couldn't get logging tools past 1185' (Mabton interbed).
07:15	10:15	Drillers trip back to bottom for wiper pass — then circulate in prep for loggers.
11:35	13:45	Stopped rotating and began tripping out rods onto fork lift and service truck
	13:40	Loggers arrive to conduct televiewer survey - Randy Price
13:50	14:25	Remove boxes/jars of samples to conex box
	15:40	Logging w/ televiewer complete
	16:25	Kent Reynolds on site
	16:35	Geovision arrives - Doug Metarland, John Deal
	~17:00	Geovision began logging
	18:25	Logging complete — tool out of hole
	19:00	Shift end

DBB 10/1/06

Reported By: D. B. Barnett | Title: Geologist | Date: 10/1/06 | Signature: DBB 6

Reviewed By: SP Reidel | Title: Staff Geologist | Date: 10/2/06 | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/11/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 46

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 1222' /	Hole Depth/Csg 1222' /	Hole Depth/Csg 0' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	POD Meeting
	2230	Finished tripping in trim pipe for grout
2400		Pumped in first batch of grout
	2445	Finished pumping in forth batch of grout
		Batch 1, 2, 3, 4: 210 gallons each totaling 840 gallons
	0320	Finished taking out trim pipe
	0700	Shift Change => should be able to tag Noon on 10/12/06

CR 10/12/06

Reported By: Colleen Rust

Title: Geologist | Date: 10/12/06

Signature: Colleen T. Rust

Reviewed By: SP Reidel

Title: Staff Geologist | Date: 10/20/06

Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 3

Date: 10/2/06

Well ID: C4993 | Well Name: NA

Location: Seismic Borehole # | Report No.: 47

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs.
Hole Depth/Csg 1222' / NA	Hole Depth/Csg 1222' / NA	Hole Depth/Csg 0 /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	~~07:00~~ DBB 10/2/06	P.O.D. - Blue Star back on site on C4996 then over to pull casing @ C4998 - C4997 preparing to cement C4993 waiting for cement to cure.
	07:15	
	10:45	New drill rods arrive on site
		P.O.D (continued from above 07:15): No one at meeting was sure what the T.D. for C4993 & C4997 was supposed to be. Page 2 of this report clarifies this.
	12:10	Lifted collar and checked bit - will go with same bit as before. Cement is not yet firm - will wait longer.
	15:30	Les Walker (Fluor) showed up - brought sample jars & trays up @ T-5A bldg.
	17:00	Cement tagged @ 918 ft bgs - begin preparing mud contents to drill cement (see p. 3 of this report for details of cement job).
	19:00	Shift change

DBB 10/3/06

Reported By: D. B. Barnett | Reviewed By: SP Reidel

Title: Geologist | Date: 10/2/06 | Title: Stgr Geologist | Date: 10/20/06

Signature: DBB | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Continuation Page

Page 2 of 8

Date: 10/2/06

Well Name: C4993	Well ID: NA
Location: Seismic Borehole #4	Continuation of Report No.: 47

Description of Activities/Operations with Depth

Time/Depth		
~~From~~	~~To~~	

Instructions from Steve Reidel and Alan Rohay on final target depths of C4993 and C4997

~~Page 1 of 2~~ DBB 10/2/06

P. 2 of Report #47 "Field Activity Report - Daily Drilling"

Barnett, D B (Brent)

From: Rohay, Alan C
To: Rohay, Alan C
Cc: Barnett, D B (Brent)
Subject: RE: Final depths for C4997 and C4993
Attachments:

Sent: Mon 10/2/2006 9:33 AM

here is another email but does not give a quick estimate of what the depth will be

From: Reidel, Stephen P
Sent: Thu 9/28/2006 12:35 PM
To: Brouns, Thomas M; Wright, Christopher S; Rohay, Alan C; Gardner, Martin G (Marty)
Cc: 'CKimmel@landauinc.com'; Barnett, D B (Brent); Reidel, Stephen P
Subject: Final depths for C4997 and C4993

Based on the seismic testing objectives, it has been decided to follow the plan used for C4996.

The test object at the base of the boreholes is to collect data from the Byron interbed and the flow top of the Rosalia flow (lowest of the Priest Rapids flows).

Therefore, drilling should proceed through the Byron interbed and the Rosalia flow top. Once the Rosalia flow top has been completely penetrated, an additional 30 feet of the massive interior will be drilled. This will allow the Rosalia flow top and Byron interbed to be tested.

The well-site geologists will inform the drillers when the Rosalia flow top has been penetrated; this of course will be after they have been drilling massive basalt. This then will form the basis for the final depth of the borehole (s).

Stephen Reidel PhD
Pacific Northwest National Laboratory
and Battelle-Pacific Northwest Division
MS K6-75; PO Box 999
Richland, WA 99352
sp.reidel@pnl.gov
(509) 376-9932
http://www.pnl.gov
Street Address: 3110 Port of Benton Blvd.

From: Brouns, Thomas M
Sent: Thursday, September 28, 2006 12:19 PM
To: Wright, Christopher S; Reidel, Stephen P
Cc: CKimmel@landauinc.com
Subject: RE: September 27, 2006 Well C4997 WTP Seismic Boreholes Project Status Update

Steve will be putting guidance out on this. We are going to a depth a little more than 1400, to the base of the Rosalia flow. Steve will clarify where we expect that to be exactly.

Tom

From: Wright, Christopher S
Sent: Thursday, September 28, 2006 11:50 AM
To: Brouns, Thomas M; Reidel, Stephen P
Cc: CKimmel@landauinc.com
Subject: FW: September 27, 2006 Well C4997 WTP Seismic Boreholes Project Status Update

https://webma...:%20Final%20depths%20for%20C4997%20and%20C4993.EML?Cmd=ope 10/2/2006

DBB 10/2/06

DBB 10/2/06

Reported By: D.B. Barnett	Reviewed By: S P Reidel
Title: Geologist Date: 10/2/06	Title: Staff Geologist Date: 10/20/06
Signature: [signature]	Signature: [signature]

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Continuation Page

Page 3 of 3

Date: 10/2/06

Well Name: C4-993

Well ID: NA

Location: Seismic Borehole # 4

Continuation of Report No.: 47

~~Time/Depth~~ DBB 10/2/06

~~From~~ ~~To~~

Description of Activities/Operations with Depth

P. 3 of Report # 47 "Field Activity Report - Daily Drilling"

Hole depth 775' on 9/19/06

Hole depth 965.4' on 9/22/06

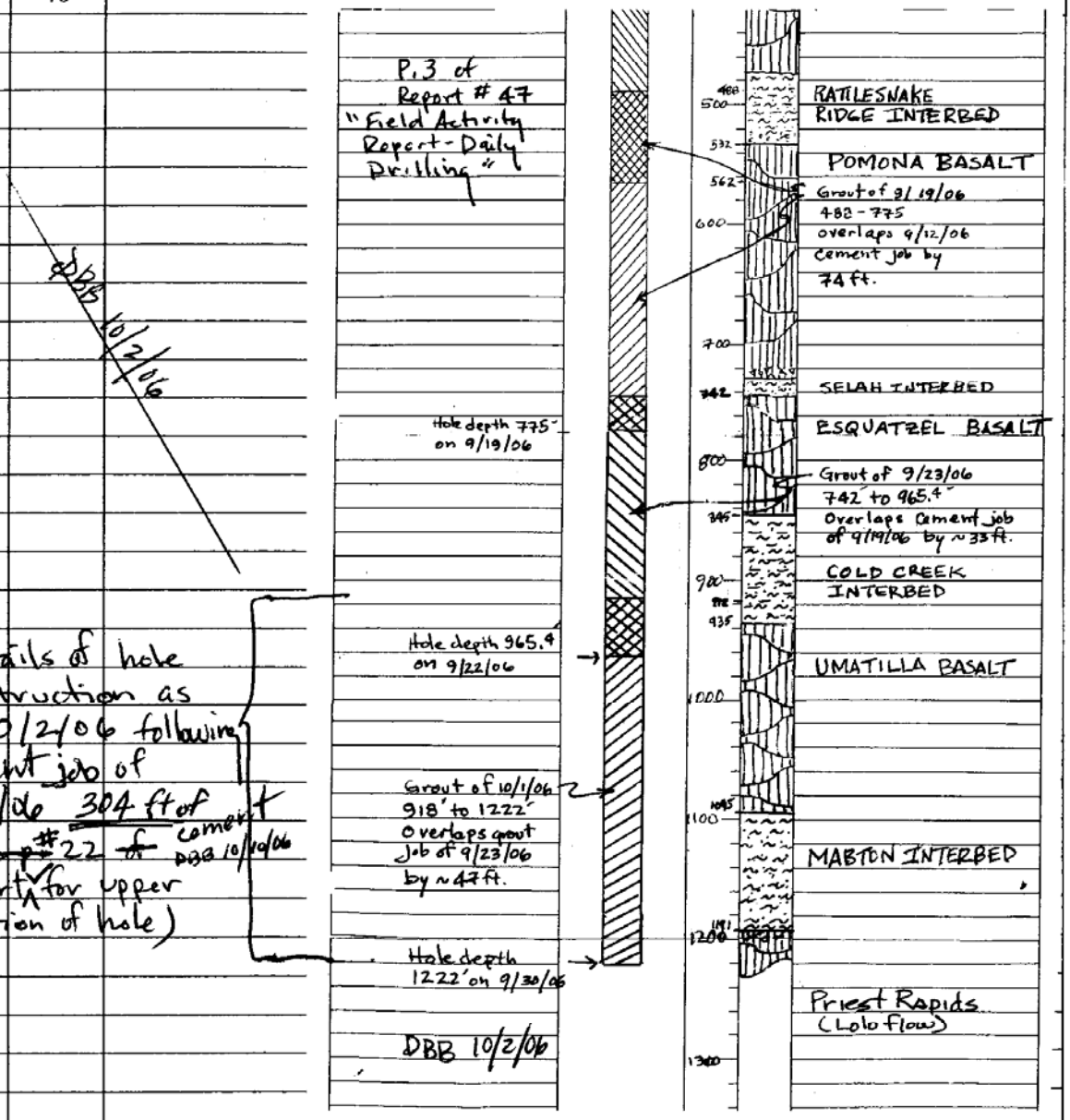
Grout of 10/1/06 918' to 1222' Overlaps grout Job of 9/23/06 by ~47 ft.

Hole depth 1222' on 9/30/06

DBB 10/2/06

DBB 10/2/06

Details of hole Construction as of 10/2/06 following cement job of 10/1/06 304 ft of cement ~~(see p# 22 of~~ DBB 10/10/06 Report for upper portion of hole)



Reported By: D.B. Barnett

Title: Geologist Date: 10/2/06

Signature: DBB

Reviewed By: SP Reidel

Title: Staff Geologist Date: 10/10/06

Signature: SP Reidel

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/2/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 48

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 1222' /	Hole Depth/Csg 1222' /	Hole Depth/Csg 0' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	PoD Meeting: slip, trip, and fall warning
	1930	started drilling grout, 10 ft/hr in sediment & 20 ft/hr in basalt
		→ tagged at 918' @ 1700 during day shift
	0700	Continued drilling through cement
	0700	Shift Change

CR 10/2/06

Reported By: Colleen Rust

Title: Geologist | Date: 10/2/06

Signature: C. F. Rust

Reviewed By: SP Reidel

Title: Staff Geologist | Date: 10/2/06

Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/3/06

Well ID: C4993 | Well Name: NA

Location: Seismic Borehole #4 | Report No.: 49

Start	Finish	Total
Time 07:00	Time 19:00	Time 12 hrs.
Hole Depth/Csg 1222' / NA	Hole Depth/Csg 1222' / NA	Hole Depth/Csg 0 / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:10	P.O.D. – Watch fatigue – Discussed failed cementing job @ C4997.
07:10		Continued Drilling cement @ ≤ 10 ft/hr. in Mahtan Interbed @ 1111'
	09:00	Drilling 7.1 ft/hr in cement
14:00	14:10	Oversaw Waste Mgmt. truck deliver new container @ T-5A
	14:50	Cement drilling @ Prior 10/3/06 1162'
14:50	15:00	Drillers empty cuttings bin and replace w/ empty (into trailer)
14:00	15:00	Drilling Rate = 10.8 ft/hr.
	17:00	Depth = 1187.1 ft bgs, drilling rate ~ 11 ft/hr.
	18:00	Depth = 1195.6' = 8.5 ft/hr since 17:00
	18:45	Depth = 1202' = 8.5 ft/hr

DBB 10/3/06

Reported By: D. B. Barnett | Title: Geologist | Date: 10/3/06 | Signature: D B Barnett

Reviewed By: S P Reidel | Title: Staff Geologist | Date: 10/3/06 | Signature: S P Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/3/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 50

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 1222' /	Hole Depth/Csg 1237.6' /	Hole Depth/Csg 15.6' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	PoD Meeting: Deer, slipping and falling on wet surfaces,
		Weather: rain expected for tonight
	2015	started to charge over mud contaminated with cement grout
	2438	Started drilling again (remaining grout)
	0100	at 1221.1'
	0149	Geograph was recalibrated, and 1225' sample collected
	0200	at 1226.5'
	0300	at 1228.4' DRILL RATE ~ 1.9ft/hr
	0349	1230' sample collected
	0325	RCT came to site and found radon contaminated work gloves,
		gloves were labeled and removed
	0400	at 1231.0'
	0557	1235' sample collected
	0600	at 1235.4' DRILL RATE ~ 2.2ft/hr
	0700	shift change

CR 10/4/06

Reported By: Colleen Rust		Reviewed By: SP Reidel	
Title: Geologist	Date: 10/4/06	Title: Staff Geologist	Date: 10/20/06
Signature: C. F. Rust		Signature: SP Reidel	

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date:

Well ID: C4993 | Well Name: NA

Location: Seismic Borehole #4 | Report No.: 51

Start	Finish	Total
Time 07:00	Time DBB 10/4/06 19:00	Time 12 hrs.
Hole Depth/Csg 1237.6 / NA	Hole Depth/Csg 1265.1 / NA	Hole Depth/Csg 27.5 / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 _____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
00:700	07:10	P.O.D. – Rain today – could be slippery.
/	07:40	Grab sample @ 1240' drilling rate ~ 2.7 ft/hr.
/	09:20	Grab Sample @ 1245' (also sample for inspect @ 1248)
/	11:15	Grab sample @ 1250' drilling rate ~ 1.7 ft/hr.
/	13:55	Grab sample @ 1255' drilling rate @ ~ 2 ft/hr.
13:00	16:05	drilling rate ~ 1.9 ft/hr.
/	16:30	Grab sample @ 1260' Geograph appears to be occasionally slipping – need to watch footage.
/	18:50	Grab sample @ 1265'
/	19:00	Slight change – Rain starts getting heavier.

DBB 10/4/06

Reported By: D.B. Barnett | Title: Geologist | Date: 10/4/06 | Signature: DBBarnett

Reviewed By: SP Reidel | Title: Staff Geologist | Date: 10/20/06 | Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/14/06 PM

Well ID: C4993 | Well Name: NA

Location: WTP SEISMIC BOREHOLE #4 | Report No.: 52

Start	Finish	Total
Time 1900	Time 0700	Time 12 hrs
Hole Depth/Csg 1265.1' /	Hole Depth/Csg 1281.4' /	Hole Depth/Csg 16.3' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	PoD meeting: rain tonight, watch out for slipping hazards
	2016	@ 1267.2'
	2100	@ 1268'
	2212	@ 1269.6'
	2233	1270' sample taken ~ Drill rate 1.3 ft/hr
	2300	@ 1270.9'
	2400	@ 1272.3'
	0100	@ 1274
	0200	1275' sample taken, Drill rate ~1 ft/hr
	0400	@ 1277.4
	0500	@ 1279.1
	0540	1280' sample taken, drill rate ~1.7 ft/hr
	0640	@ 1281.4'
	0700	Shift Change

CR 10/5/06

Reported By: Colleen Rust

Title: Geologist | Date: 10/14/06

Signature: C. F. Rust

Reviewed By: SP Reidel

Title: Staff Geologist | Date: 10/20/06

Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/5/06

Well ID: ~~C4993~~ C4993 CR 10/5/06

Well Name: WTP Seismic Borehole #4

Location: Near Grout Treatment Facility

Report No.: 53

Start	Finish	Total
Time 07:00	Time 19:00 DBB	Time 12 hrs
Hole Depth/Csg 1281.4 / NK	Hole Depth/Csg 1303' / ~~21.6~~ 10/5/06	Hole Depth/Csg 21.6' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
07:00	07:10	P.O.D. – Fog season upon us.
	09:25	Grab sample @ 1285' – drilling rate ~ 1.4 ft/hr.
	12:20	Grab sample @ 1290' 2.1 ft/hr.
	1500	Grab sample @ 1295' 2.2 ft/hr. – S.P. Reidel on site
	17:15	Grab sample @ 1300' ~2 ft/hr.
	19:00	Shift end – depth = 1303

DBB 10/5/06

Reported By: D. B. Barnett

Title: Geologist Date: 10/5/06

Signature: DBB

Reviewed By: SP Reidel

Title: Staff Geologist Date: 10/10/06

Signature: SP Reidel

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/5/06 PM

Well ID: C4993 | Well Name: WTP SEISMIC BOREHOLE #4

Location: WTP BOREHOLE #4 | Report No.: 54

Start	Finish	Total
Time 1900	Time 0700	Time 12hrs
Hole Depth/Csg 1303' /	Hole Depth/Csg 1321.6' /	Hole Depth/Csg 18.6' /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	PoD meeting: Driving in fog
	1957	1305' sample collected
	2100	@ 1307.1'
	2200	@ 1309.6'
	2219	1310' sample collected, drill rate ~1.5ft/hr
	2300	@ 1311.1'
	2400	@ 1313.0'
	0100	@ 1314.7'
	0125	1315' sample collected, drill rate ~1.3 ft/hr
	0200	@ 1316'
	0300	@ 1317', drill rate ~1.0 ft/hr
	0400	@ 1318.5'
	0500	@ 1319.6'
	0529	1320' sample collected, drill rate ~ 1ft/hr
	0600	@ 1321'
	0630	@ 1321.6'
	0700	shift Change

CR 10/6/06

Reported By: Colleen Rust
Title: Geologist | Date: 10/6/06
Signature: C. F. Rust

Reviewed By: D.B. Barnett
Title: Geologist | Date: 10/20/06
Signature: D.B. Barnett

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/6/06

Well ID: C4993

Well Name: WTP Seismic Borehole #4

Location: WTP Seismic Borehole #4

Report No.: 55

Start (MS) 10/6/06	Finish	Total
Time 0700	Time 1900	Time 12.0
Hole Depth/Csg 1321.6' / -N/A-	Hole Depth/Csg 1330' / -N/A-	Hole Depth/Csg 16.4' / -N/A-

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0700	0730	POD & Geo changeover.
0730	0830	Drilling. → To 1325' bgs. G.S. @ 1325' bgs, ~1.7'/hr.
0830	1035	Cont. drilling. → 1329.2' bgs.
1035		Stop drilling for gyro event. ⇒ Circulating, prepare
	1125	for gyro survey.
1125	1305	Tool (Gyro) in hole. Begin Gyro logging.
1305		Done logging (out of hole). Prepare to drill. Add on
	1315	20' drill rod ⇒ 1351' total tally.
1315	1400	Begin drilling. → To 1330' bgs. G.S. @ 1330' bgs.
1400	1700	Drilling cont. → To 1335' bgs. G.S. @ 1335' bgs.
1700		Drilling. → 1338. Done w/ 1st Shift.

Wet hard (NB)

Reported By: N. Bowles

Title: Geologist Date: 10/6/06

Signature:

Reviewed By: D. B. Barnett

Title: Geologist Date: 10/20/06

Signature:

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/6/06 -> 10/7/06

Well ID: C4993	Well Name: WTP Seismic Borehole #4
Location: WTP Seismic Borehole #4	Report No.: 56

Start	Finish	Total
Time 1900 (10/6/06)	Time 0700 (10/7/06)	Time 12 hrs
Hole Depth/Csg 1338 / -N/A-	Hole Depth/Csg 1353 / -N/A-	Hole Depth/Csg 15' / -N/A-

Reference Measuring Point: **GROUND SURFACE**	Casing String No. 1 2 3 4 ____ Rod Size: -N/A- See Report No. 1

Time/Depth From	To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1900	1910	POD
1910	1930	Geologist transition
	1930	1338.7' bgs
	2030	1340.0' bgs collected G.S. ~1.3'/hr
	2130	1341.4' bgs ~1.4'/hr
	2230	1343.9' bgs ~1.5'/hr
	2330	1344.2' bgs ~0.3'/hr
10/7/06	~~000~~ 0030	1345.5' bgs ~1.3'/hr collected G.S. @ 1345' bgs
	0130	1346.9' bgs ~1.4'/hr
	0230	1348.2' bgs ~1.3'/hr
	0300	1349.0' bgs ~1.6'/hr (~1.4'/hr)
	0330	1349.6' bgs ~1.2'/hr
	0400	1350.2' bgs ~1.2'/hr G.S. @ 1350' bgs
0530	0530	Adding 20' joint Tally =
	0530	1351.5' bgs ~0.9'/hr
	0650	1352.5' bgs ~1.0'/hr
0700	~~[illegible]~~	1353' bgs end of shift
		not used GP 10/7/06

Reported By: N. Bowles / J. Horner		Reviewed By: D.B. Barnett	
Title: Geologists	Date: 10/7/06	Title: Geologist	Date 10/20/06
Signature: [signature]		Signature: [signature]	

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING	Page 1 of 2 Date: 10/7/06

Well ID: C4993	Well Name: WTP Seismic Borehole #4
Location: WTP Seismic Borehole #4	Report No.: 57

Start	Finish	Total
Time 0700	Time ~~1393~~ 1930	Time 12.5
Hole Depth/Csg 1353 / -N/A-	Hole Depth/Csg 1393 / -N/A-	Hole Depth/Csg 40' / -N/A-

Reference Measuring Point: **GROUND SURFACE**	Casing String No. 1 2 3 4 ____ Rod Size: See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
0700	0715	POD & Geo transition NB 10/7/06
0715	0745	Drilling. → To ~~1354.1~~ 1354. Hitting fractures, drilling ~~speed~~ speed increase. NB 10/7/06
0745		Drilling from ~~1354.1~~ 1354.' NB 10/7/06 to 1356.7' bgs (where drilling
		began to slow down). Drill speed from 1354 → 1356.7'
		= 5.4'/hr. Also, G.S. @ 1355' bgs. Increase in clay
	0815	content w/ ~~sparse~~ NB 10/7/06 blk. clay ?? (or claylike material).
0815		Drilling. → To 1367. G.S. @ 1360 & 1365 w/ additional
		chip tray samples. Drilling speeds were between 5.3 to
		~~1.6~~ 6.7'/hr. Likely in Rosalia flowtop basalt, starting @ ~
	1000	NB 10/7/06 1357. ~~St~~ NB 10/7/06 Slowing down ~~drastically~~ NB 10/7/06 @ 1367.
1000	1100	Cont. drilling. → 1371'. G.S. @ 1370'; ~4'/hr.
1100	1115	Circulate & Add on 20' of drill rod.
1115	~~1300~~ NB 10/7/06	Cont. drilling → 1376.3' bgs G.S. @ 1375' bgs. (1240)
		~3.3'/hr @ 1373.5 (from 1371')
		~2.6'/hr @ 1374.8 (from 1373.5')
		~3.0'/hr @ 1376.3' (from 1374.8')
	1300	~~~3~~ NB 10/7/06
1300		Drilling → 1382.7' bgs., G.S. @ 1380' bgs (1430).
		~3.0'/hr @ 1377.8' bgs
	~~1500~~ ~~1500~~ NB 10/7/06	~2.5'/hr @ 1380' bgs.
~~1500~~ NB 10/7/06 1500		Drilling → 1386.8' bgs., G.S. @ 1385' bgs. (1545).
	1600	Ave 4.1'/hr.
1600		Drilling. → To 1390.3' bgs., G.S. @ 1390 (1655)
	1700	~3.5'/hr.

Reported By: N. Bowles		Reviewed By: D.B. Barnett
Title: Geologist	Date: 10/7/06	Title: Geologist / Date: 10/20/06
Signature: [signature]		Signature: [signature]

A-6003-651 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Continuation Page

Page 2 of 2

Date: 10/7/06

Well Name: WTP Seismic Borehole #4

Well ID: C4993 DBB 10/20/06

Location: WTP Seismic Borehole #4

Continuation of Report No.: 57

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth
1700	1730	Drilling. → 1391 'bgs. Stop to add up.
1730		Circulating mud to remove residual cuttings. →
	1805	Add up 20' of drill rod. → 1411 totaltally.
1805	1845	Resumed drilling. → 1393 'bgs.
1845	1900	Head to POD / Changeover.
1900	1930	POD / Changeover.
1930		Done for day, leave site.

Not used (SB)

Reported By: N. Bowles

Title: Geologist Date: 10/7/06

Signature:

Reviewed By: D.B. Barnett

Title: Geologist Date: 10/20/06

Signature:

A-6003-652 (04/03)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 1 of 1

Date: 10/7/06 →

Well ID: C4993 | Well Name: N/A

Location: ATP Seismic Borehole #4 | Report No.: 58

Start	Finish	Total
Time 1900 (10/7/06)	Time 0715 (10/8/06)	Time 12 hrs 15 min.
Hole Depth/Csg 1393' / N/A	Hole Depth/Csg 1411 / N/A	Hole Depth/Csg 18' / N/A

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size:
See Report No. 1

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1850	1900	POD meeting
1900	1910	Geo/Driller shift change
	1930	Collect G.S. @ 1395' bgs
	2030	1398.7' bgs ~3.7' bgs
	2100	1400' bgs ; collected G.S. ; ~2.6'/hr (last half hour)
	2200	~~1405' bgs~~ 1403' bgs ; collected G.S. ; ~5.0'/hr
	2330	1407.1' bgs ~~@ 10/7/06~~ @ 10/7/06 ~1.4'/hr
2335	2400	Stop drilling & circulate in preparation for gyro
	~~2400~~	Gyro crew on site
2400	0250	Setting up & logging
0250	→	Resume drilling
	0430	1408.6' bgs ~0.9'/hr
	0500	1409.1' bgs ~1.0'/hr
	0600	1410.1' bgs ~1.0'/hr collected G.S. @ 1410' bgs
	0630	1410.6' bgs ~1.0'/hr
	0700	1411' bgs Total depth
0700	0715	Geologist hauls samples up to connex box.
~~0700~~	→	circulate to clean borehole
		not used @ 10/8/06

Reported By: J. Horner
Title: Geologist | Date: 10/8/06
Signature: John Horner

Reviewed By: D.B. Barnett
Title: Geologist | Date: 10/20/06
Signature: D.B. Barnett

A-6003-651 (04/03)

Appendix C

Borehole C4993 Sample Inventory

Appendix C

Borehole C4993 Sample Inventory

Borehole C4993 was drilled by a mud rotary drill rig using a tricone button bit with a 7-7/8-in. outside diameter. Table C.1 provides a summary of the samples collected during the drilling. The sample inventory for the entry hole (from 0 ft to 383.5 ft bgs) is provided by Horner (2006).

During the first few days of the drilling, the geolograph malfunctioned frequently. This was quickly identified and corrected, but some samples collected during this period may have minor errors (1 to 3 ft) in depth estimates. The notes in Table C.1 were summarized from the borehole logs for C4993. Additional details are included in the logs themselves (Appendix A). The photographs referred to in the Notes column of Table C.1 are listed in Appendix E and contained on compact disk (CD) provided with the hardcopy version of this report (inside back cover).

Reference

Horner JA. 2006. *Entry Boreholes Summary Report for the Waste Treatment Plant Seismic Boreholes Project*. WMP-32119, Fluor Hanford, Inc., Richland, Washington.

Table C.1. Sample Inventory for Borehole C4993

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
358	✔	✔	✔	X	X	358 ft - contact, top of Elephant Mountain Member basalt with cable entry borehole. Samples collected from entry hole drilling.
364	✔	✔	✔	✔	X	Samples collected from entry hole drilling; upper Elephant Mountain Member XRF Sample C4993-XRF-364′
383.5	✔	✔	✔	X	X	First basalt drilled with mud rotary drill rig. 383.5–473.5 ft - basalt, black to grayish-black, very hard.
390	X	X	✔	X	X	First sample collected from deep mud rotary borehole.
392	✔	✔	X	X	X	
397	✔	✔	X	X	X	
402	✔	✔	✔	X	X	
405	✔	✔	✔	X	X	
410	✔	✔	✔	X	X	
415	✔	✔	✔	X	X	
420	✔	✔	✔	X	X	
425	✔	✔	✔	X	X	
430	✔	✔	✔	✔	X	Middle Elephant Mountain Member XRF Sample C4993-XRF-430′
435	✔	✔	✔	X	X	Lost circulation; possible fractures at 436 ft; unwashed samples.
440	✔	✔	✔	X	X	
445	✔	✔	✔	X	X	
450	✔	✔	✔	X	X	
455	✔	✔	✔	X	X	
460	✔	✔	✔	X	X	
465	✔	✔	✔	X	X	
470	✔	✔	✔	X	X	
475	✔	✔	✔	✔	X	473.5 ft - contact, top of Rattlesnake Ridge Interbed; greenish-gray clay. Lower Elephant Mountain Member XRF Sample C4993-XRF-475′ (sample mostly basalt, although top of interbed was interpreted at this depth, based on drilling parameters).
480	✔	✔	✔	X	X	
485	✔	✔	✔	X	X	483 ft - color change to light gray.
490	✔	✔	✔	X	X	
495	✔	✔	✔	X	X	Color change to dark grayish-brown.
500	✔	✔	✔	X	X	Color change to light gray; rock chips present.

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
505	✔	✔	✔	X	X	
510	✔	✔	✔	X	X	Color change to light reddish-brown
515	✔	✔	✔	X	X	Color change to medium reddish-brown
520	✔	✔	✔	X	X	Color change to dark reddish-brown
525	✔	✔	✔	X	X	Color change to medium brown
530	✔	✔	✔	X	X	Appearance of basalt chips ~10–20%
532	X	✔	X	X	X	532 ft - contact, top of Pomona Basalt
535	✔	✔	✔	X	X	
540	✔	✔	✔	X	X	Bag sample labeled for 540 ft and 545 ft, combined sample.
545	✔	✔		X	X	
550	✔	✔	✔	X	X	
555	✔	✔	✔	X	X	
560	✔	✔	✔	X	X	Less than 5% clays, likely mini fractures
565	✔	✔	✔	✔	X	XRF Sample C4993-565
570	✔	✔	✔	✔	X	XRF Sample C4993-570 568.5 ft - likely fractures; observed drill bit jumping around.
575	✔	✔	✔	X	X	
580	✔	✔	✔	X	X	Likely fractures, possible opal.
585	✔	✔	✔	X	X	
590	✔	✔	✔	X	X	
595	✔	✔	✔	X	X	
600	✔	✔	✔	X	X	
605	✔	✔	✔	X	X	601 ft - likely fractures. 605 ft - very fine returned cuttings; very slow drilling, ~1.0 ft/hr
610	✔	✔	✔	X	X	607.2 ft - likely fractures. 609.5 ft - very rough drilling.
615	✔	✔	✔	X	X	
620	✔	✔	✔	X	X	
625	✔	✔	✔	X	X	623–627 ft - multiple fractures present based on rough drilling.
630	✔	✔	✔	X	X	
635	✔	✔	✔	X	X	633.9 ft - significant fracture zone.

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
640	✔	✔	✔	✔	X	637.6 ft and 640–642.5 ft – fractures. XRF Sample C4993-XRF - Middle Pomona, 9-15-06 - from the middle of the Pomona Basalt. Photos: 5900-5902
645	✔	✔	✔	X	X	647.5 ft - fractures. Photos: 5903-5907
650	✔	✔	✔	X	X	Photos: 5908-5911
655	✔	✔	✔	X	X	
660	✔	✔	✔	X	X	Photos: 5912-5813
665	✔	✔	✔	X	X	
670	✔	✔	✔	X	X	Sample 670 ft taken over estimated interval 668.5–670 ft. 670.5 ft - possible fractures.
675	✔	✔	✔	X	X	674 ft, 677.5 ft - fractures. Photos: 5914-5915, 5916-5918, 5920-5923
680	✔	✔	✔	X	X	679.5–681.5 ft - fractures.
685	✔	✔	✔	X	X	683.5–684.5 ft - fractures.
690	✔	✔	✔	X	X	
695	✔	✔	✔	X	X	
700	✔	✔	✔	X	X	
705	✔	✔	✔	X	X	703.5–704 ft - fractures.
710	✔	✔	✔	X	X	709.8–710.1 ft - fractures.
715	✔	✔	✔	X	X	713–716.5 ft - fractures. Numerous fragments with small vesicles. XRF Sample C4993-9-18-06, 715′ Photos: 5924-5926
720	✔	✔	✔	X	X	719 ft - clay content increases. Photo: 5927
723.5	✔	✔	X	X	X	723.5 ft - contact, top of Selah Interbed. Unwashed samples, low sample return.
725	✔	✔	✔	X	X	Unwashed samples.
730	✔	✔	✔	X	X	Color change to tan-brown clay with mafic sand; sample from top of pipe plus washed shaker sample in tray (50/50); unwashed samples.
735	✔	✔	✔	X	X	Color change to light tan to off-white; unwashed samples.
740	✔	✔	✔	X	X	Unwashed samples.
742.3	✔	✔	✔	X	X	742.3 ft - contact, top of Esquatzel Basalt; unwashed sample.

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
745	✔	✔	✔	X	X	
750	✔	✔	✔	✔	X	XRF Sample C4993-9-18-06 750′ collected from top of Esquatzel Basalt. Photo: 5928
755	✔	✔	✔	X	X	Photos: 5929-5930
760	✔	✔	✔	X	X	
765	✔	✔	✔	X	X	
770	✔	✔	✔	X	X	
775	✔	✔	✔	X	X	773.5–774 ft - fractures. Photos: 5931-5938
780	✔	✔	✔	X	X	Photos: 5941-5952
785	✔	✔	✔	X	X	Photos: 5953-5954
790	✔	✔	✔	X	X	
795	✔	✔	✔	✔	X	795 ft - middle of Esquatzel Member; XRF Sample C4993-9-21-06 middle Esquatzel-795′ Photos: 5957-5959
800	✔	✔	✔	X	X	Photos: 5960-5962
805	✔	✔	✔	X	X	Low sample return.
810	✔	✔	✔	X	X	
815	✔	✔	✔	X	X	
820	✔	✔	✔	X	X	Photos: 5964-5966
825	✔	✔	✔	X	X	824–827 ft - fractures, rough drilling.
830	✔	✔	✔	X	X	829–830 ft - fractures, very rough drilling.
835	✔	✔	✔	X	X	
840	✔	✔	✔	✔	X	Lower Esquatzel Member XRF Sample C4993-XRF-840′
843	✔	X	✔	X	X	
845	✔	✔	✔	X	X	845 ft - contact, top of Cold Creek Interbed. Clays sticking to drill bit; gray-green clay with a few fine pieces of sand.
850	✔	✔	✔	X	X	Color change to green-gray clay; less sand; unwashed sample; low sample return.
855	✔	✔	✔	X	X	Color change to light green clay with ~50% very fine sand. Very low sample return; unwashed.
860	✔	✔	✔	X	X	Sandy clay, green clay with very fine quartz sand; unwashed sample.

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
865	✔	✔	✔	X	X	Sandy clay, green clay with coarse quartz sand; unwashed sample.
870	✔	✔	✔	X	X	Same as above; unwashed sample; low sample return.
875	✔	✔	✔	X	X	Increase in coarse sand grains (~75%); low sample return.
880	✔	✔	✔	X	X	Coarse-grained sand with less clay.
885	✔	✔	✔	X	X	Poorly sorted sand; predominantly quartz sand.
890	✔	✔	✔	X	X	Medium-size sand with green grains. All sands look green due to possible green clay coating present in all interbed samples.
895	✔	✔	✔	X	X	Color change in clay; green and white plastic clay, ~50% fine sand.
900	✔	✔	✔	X	X	Very coarse poorly sorted sand, ~5% clay
905	✔	✔	✔	X	X	Slightly silty green clay.
910	✔	✔	✔	X	X	Slightly silty green clay.
915	✔	✔	✔	X	X	Same, plus a few coarse sand grains; low sample return.
920	✔	✔	✔	X	X	Silty green clay.
925	✔	✔	✔	X	X	Silty gray-green clay.
930	✔	✔	✔	X	X	Silty gray clay with some basalt; drilling rate slowed down.
935	✔	✔	✔	X	X	932–933 ft - flow top, drill vibration. 933–935 ft - hard clay, drilled similar to basalt. 935 ft - contact, top of Umatilla Basalt. Low sample return.
940	✔	✔	✔	X	X	
945	✔	✔	✔	X	X	
950	✔	✔	✔	X	X	
955	✔	✔	✔	X	X	953 ft – fractures.
960	✔	✔	✔	X	X	
965	✔	✔	✔	X	X	
970	✔	✔	✔	✔	X	XRF Sample C4993-970 collected from upper Umatilla Member. 970–985 ft - multiple fractures.
975	✔	✔	✔	X	X	
980	✔	✔	✔	X	X	Photos: 5969-5970
985	✔	✔	✔	X	X	Jar sample from 985.8 ft.
990	✔	✔	✔	X	X	
995	✔	✔	✔	X	X	

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
1000	✔	✔	✔	X	X	
1005	✔	✔	✔	X	X	
1010	✔	✔	✔	X	X	
1015	✔	✔	✔	✔	X	XRF Sample C4993-1015 collected from middle of Umatilla Member.
1020	✔	✔	✔	X	X	
1025	✔	✔	✔	X	X	
1030	✔	✔	✔	X	X	
1035	✔	✔	✔	X	X	
1040	✔	✔	✔	X	X	
1045	✔	✔	✔	X	X	
1050	✔	✔	✔	X	X	
1055	✔	✔	✔	X	X	
1060	✔	✔	✔	✔	X	XRF Sample C4993-1060 collected from lower Umatilla Member.
1065	✔	✔	✔	X	X	
1070	✔	✔	✔	X	X	
1075	✔	✔	✔	X	X	
1080	✔	✔	✔	X	X	
1085	✔	✔	✔	X	X	
1090	✔	✔	✔	X	X	1088 ft - apparent fractures. Clay content increases; slow drilling.
1095	✔	✔	✔	X	X	1094.6 ft - contact, top of Mabton Interbed. Dark bluish-gray clay, fine sand.
1100	✔	✔	✔	X	X	Color change to dark greenish-gray clay.
1105	✔	✔	✔	X	X	
1110	✔	✔	✔	X	X	
1115	✔	✔	✔	X	X	Dark greenish-gray clay, increasing very fine angular sand.
1120	✔	✔	✔	X	X	1119 ft - drilling with less flow constriction, driller notes likely sand. 1120 ft - clay/sand difficult to determine; unwashed sample.
1125	✔	✔	✔	X	X	
1130	✔	✔	✔	X	X	
1135	✔	✔	X	X	X	Greenish-gray clay with ~40% very fine to coarse sand.

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
1140	✔	✔	✔	X	X	
1145	✔	✔	✔	X	X	
1150	✔	✔	✔	X	X	
1155	✔	✔	✔	X	X	
1160	✔	✔	✔	X	X	
1165	✔	✔	✔	X	X	Noticed increased amount of basalt drill cuttings likely from above basalt member, not fully washed out?
1170	✔	✔	✔	X	X	
1175	✔	✔	✔	X	X	
1180	✔	✔	✔	X	X	
1185	✔	✔	✔	X	X	1183 ft - rough drilling started. Increase in basalt cuttings, clay clogging bit, rough drilling as if fractured basalt, 1185-ft sample contained steel fragments (0.5–1.0 mm) Photo: 5986
1190-1191	✔	✔	✔	X	X	*Jar & bag sample combined for 1190 ft and 1191 ft.* 1190.5 ft - torque vibrations, no sample return at 1190 ft. 1191 ft - contact, top of Lolo Flow of Priest Rapids Basalt.
1192		X	✔	X	X	Jar sample combined for 1190–1192 ft.
1195	✔	✔	✔	X	X	
1200	✔	✔	✔	✔	X	XRF sample collected from top of Lolo Flow of the Priest Rapids Member; sample labeled C4993-9-30-06, Top of Priest Rapids.
1205	✔	✔	✔	X	X	
1210	✔	✔	✔	X	X	Photos: 5991-5992
1215	✔	✔	✔	X	X	Photos: 5993-5994, 5995-5997 Steel filings still present in sample.
1220-1221	✔	✔	✔	X	X	Combined 1220—1221-ft samples.
1225	✔	✔	✔	X	X	Dominated by green clay with some fine to medium sand.
1230	✔	✔	✔	X	X	Increase in basalt with decreasing green clay.
1235	✔	✔	✔	✔	X	XRF Sample C4993-10-5-06; basalt at 1235′. Dominated by basalt with limited green clay
1240	✔	✔	✔	X	X	1241.5–1249 ft - claystone, silty with minor fine sand, lignite fragments, carbonaceous debris, diatoms, some basalt. Photos: 6000-6003, 6004-6007, 6008-6011, 6012-6013, 6014-6015, 6016

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
1245	✔	✔	✔	X	X	
1250	✔	✔	✔	X	X	1249 ft - dominantly basalt (60-70%). 1250–1255 ft - fractures present.
1255	✔	✔	✔	✔	X	XRF Sample C4993-10-4-06, Priest Rapids at 1255′
1260	✔	✔	✔	X	✔	Increase in basalt content (~80%). XRD Sample "Felsite" Segregation high grade @ 1260′
1265	✔	✔	✔	X	X	
1270	✔	✔	✔	X	X	Presence of large muscovite mica (1–2 mm), probably from above sediment interval.
1275	✔	✔	✔	X	X	
1280	✔	✔	✔	X	X	
1285	✔	✔	✔	✔	X	XRF Sample C4993-10-5-06; basalt at 1285′
1290	✔	✔	✔	X	X	1287.5 ft – fractures. 1288.5–1299.5 ft - claystone/clay (50–70%), some basalt and felsite, organic/carbonaceous debris partially coalified. Photos: 6023-6025
1295	✔	✔	✔	X	X	Increase in clay (60–70%) and some basalt (30–40%), trace sand.
1300	✔	✔	✔	X	X	Increase in basalt (60–70%).
1305	✔	✔	✔	✔	X	XRF Sample C4993-10-11-06; 1305′ Lolo Basalt
1310	✔	✔	✔	X	X	
1315	✔	✔	✔	X	X	
1320	✔	✔	✔	X	X	
1325	✔	✔	✔	X	X	
1230	✔	✔	✔	X	X	
1335	✔	✔	✔	X	X	
1340	✔	✔	✔	X	X	
1345	✔	✔	✔	✔	X	XRF Sample C4993-10-11-06; 1345′ basalt
1350	✔	✔	✔	X	X	
1355	✔	✔	✔	X	X	1354 ft – contact, top of Rosalia Basalt. Highly weathered, soft flow-top basalt (>90%); likely new basalt flow section; faster drilling, ~5.3 ft/hr.
1356.3	X	✔	X	X	X	
1357	X	✔	X	X	X	
1359	X	✔	X	X	X	

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Table C.1. (contd)

Bottom Depth (ft bgs)	Jar	Chip Tray	Bag	XRF	XRD	Notes
1360	✔	✔	✔	X	X	
1362	X	✔	X	X	X	
1364	X	✔	X	X	X	
1365	✔	✔	✔	X	X	
1370	✔	✔	✔	X	X	
1373	X	✔	X	X	X	
1375	✔	✔	✔	✔	X	1373 ft - estimated bottom of flow top. XRF Sample C4993-10-11-06-1375′ top of Rosalia basalt
1380	✔	✔	✔	X	X	
1385	✔	✔	✔	X	X	
1390	✔	✔	✔	X	X	
1395	✔	✔	✔	X	X	1395 ft - fractures, rough drilling.
1400	✔	✔	✔	X	X	1400 ft - multiple fractures, increase in drill rate to ~5 ft/hr.
1405	✔	✔	✔	X	X	1405–1407 ft - minimal fractures.
1410	✔	✔	✔	X	X	
1411 TD	**NO Samples Collected**				**Total Depth Reached at 0700, 10/8/2006**	

✔ = Sampled.
X = No sample.
XRF = X-ray fluorescence.
XRD = X-ray diffraction.
Brown = Basalt.
Yellow = Sediment.

Appendix D

Formation Table for Borehole C4993

Appendix D

Formation Table for Borehole C4993

This summary describes the stratigraphic sequence below the initial top of basalt.

		Member	Observed Lithology	Depth Interval in Feet Below Ground Surface (bgs)	Thickness in Feet
Saddle Mountain Basalt		**Elephant Mountain Member**	Weathering, oxidized reddish-brown, and highly vesicular at top. Amygdaloidal, with green-blue clay filled fractures. Abundant microphenocrysts of plagio-clase, most common secondary mineral green-blue clay. Increase in glassy fragments, and clay at bottom.	358'-473.5'	115.5'
	Ellensburg Formation	**Rattlesnake Ridge Interbed**	Green-gray/dark grayish-brown/light gray/light reddish-brown/dark reddish-brown/medium brown silty-sandy clay, very fine to medium quartz and mafic sand from (<5-48%).	473.5'-532'	58.5'
		Pomona Member	Flow-top breccia present, heavily palagonitized, and highly fractured with various sediments in fractures. Plagio-clase phenocrysts common (up to 2 mm). Up to 40% tan to blue-green clay filling at the top from 532' to 545', dropping to about 1% downward through most of the thickness of the unit. Yellow opal found near top and occasionally throughout the unit. Fracture fill with blue-gray-green clay (Photo: 5912), slickensides (Photo: 5902), and felsic-appearing material present throughout section (Photos: 5905, 5924), clay content increase in last 5 ft of basalt, vesicles present with blue-green mineral lining some of walls, increased tan-brown clay at bottom.	532'-725'	193'
	Ellensburg Formation	**Selah Interbed**	Gray/tan-brown/tan-brown/light tan-off-white/tan-brown/light gray-off-white/light gray silty clay. Very fine to coarse mafic sand (~5-50%).	725'-742.3'	17'

		Member	Observed Lithology	Depth Interval in Feet Below Ground Surface (bgs)	Thickness in Feet
		Esquatzel Member	~1% red-brown iron oxide trace mineral through most of the section, on surfaces of basalt and on the inside of vesicles. Blue-green secondary mineral about 1% throughout most of section; highest percentage in flow-top. Minor plagioclase in limited intervals. Marcasite/pyrite and magnetite crystals. Glassy flow bands observed at flow bottom.	742.3'-843'	101'
	Ellensburg Formation	**Cold Creek Interbed**	Greenish-grey/green clay at top of section, then a large section olive green/dark green, very fine to coarse sand, fining downward to green-white clay then darkening to dark green-gray hard clay near base.	843'-935'	92'
		Umatilla Member	Hard clay present directly above flow-top from 933'-935', followed by basalt with fractures with gray-green clay fill and sparse plagioclase phenocrysts occurring throughout unit. Multiple basalt fragments with pyrite veins (1/2 mm) (Photo: 5970). The flow bottom had an increase in fractures and the increased occurrence of light gray brittle clay/claystone.	935'-1095'	160'
	Ellensburg Formation	**Mabton Interbed**	Dark blue-gray/dark green-gray/dark green/green-gray clays, dark greenish-grey very fine to very coarse angular grained sand, alternating throughout section	1094.6'-1191'	96.4'
Wanapum Basalt		**Priest Rapids Member, Lolo flow**	Flow-top dominated with soft, weathered altered basalt from 1191 ft to 1195 ft bgs, and fracture fill or vesicle fill of soft opal. Fractures with blue-green clay, silica (opal & quartz), and iron oxide mineral fill and ~5-15% felsic-appearing material occur throughout the unit. Some basalt rock chips are glassy and some show botryoidal/mammillary texture on sides probably vesicle or fracture fill (Photo: 5993). Clear plagioclase phenocrysts, some as large as 3 mm long, increase in occurrence down through the basalt flow unit.	1191'-1354' (includes Byron Interbed sequences)	163'
		Byron Interbed Interval 1	Dominated by green clay lithology with some fine to medium grained sand and a few muscovite mica flakes. Gradually transitioned back to a basalt dominant lithology with the presence of minor felsic-appearing material, clay, and iron oxide minerals.	1225'-1234'	9'

		Member	Observed Lithology	Depth Interval in Feet Below Ground Surface (bgs)	Thickness in Feet
		Byron Interbed Interval 2	Silty claystone with very minor sand dominated with fossiliferous carbonaceous debris embedded in clay and siltstone. The carbonaceous debris (Photo: 6005) included lignite pieces with wood texture (Photo: 6012) and diatoms (Photos: 6001, 6009, and 6018).	1241.5'-1249'	7.5'
		Byron Interbed Interval 3	Gray-black silty claystone, firmer than previous sedimentary interval. Abundant carbonaceous debris partially coalified with large (up to 3 mm) lignite fragments (Photo: 6025).	1288.5'-1299.5'	11'
		Priest Rapids Member, Rosalia flow	Highly weathered soft flow top basalt with l green-gray clay (>5-25%), and felsic-appearing material (~5-10%). Sparse visible plagioclase phenocrysts (up to 1 mm), limited gray-brown-green clay fracture fill, and vesicles present until total depth of 1411 ft bgs.	1354'	NA
			1411 ft: Total Depth of C4993		

(1) *Note:* Samples in interbed sands and silts should be considered to be suspect because the sand vortex pump on the mud shaker was not continually in operation throughout the drilling of C4993. Consequently, interbed slurry samples in archive jars may contain particles from outside the sampling interval.

Appendix E

Log of Sample Photographs

Appendix E

Log of Sample Photographs

Waste Treatment Plant C4993 Photograph Log

Photographs for borehole C4993 are contained on a compact disk (CD) provided with the hardcopy version of this report (inside back cover).

Date	Depth	Photo Number	Subject
9/15/06	--	5899	View of C4993 drill rig and mud shaker (Figure 2)
9/15/06	640′	5900–5902	Green soft fracture fill or clay on basalt fragments, some observed slickensides
9/15/06	645′	5903–5905	"Speckled" rock fragments resembling sandstone or altered micro pegmatite
9/15/06	645′	5906–5907	Same as #5903 and #5905 except high magnification showing lineations on surface
9/15/06	NR	5908	Deleted
9/15/06	650′	5909–5911	Small piece showing what looks to be slickensides, fracture fill
9/16/06	660′	5912–5913	Green-blue clay mineral on a basalt face—fracture fill
9/16/06	670′	5914–5915	Felsic-appearing fragment
9/16/06	675′	5916–5918	Same as above
9/16/06	NR	5919	Deleted
9/16/06	675′	5920–5923	Felsic-appearing fragments showing foliation and dark mineral alignment (#5919 deleted)
9/17/06	715′	5924	Felsic-appearing fragment that appears to be a blue clay when wet
9/17/06	715′	5925–5926	Same as #5924 but wet
9/17/06	720′	5927	Vesiculated basalt chip in grab sample
9/17/06	750′	5928	Basalt with vesicle with a red-brown iron oxide coating
9/17/06	755′	5929–5930	Tan pink mineral with black spots on one surface (1 mm)
9/18/06	775′	5931	Plagioclase crystal in basalt (Esquatzel Basalt)
9/18/06	775′	5932	Flip side of grain in #5931
9/18/06	775′	5933–5934	Another felsic-appearing grain and close up
9/18/06	775′	5935–5936	Front and back sides of another felsic-appearing fragment, with scale in mm
9/18/06	775′	5937–5938	Vesicular basalt with iron oxide mineral coating
9/19/06	NA	5939	View of C4993 drill rig and mud shaker
9/18/06	NR	5940	Deleted
9/20/06	780′–785′	5941–5942	Felsic-appearing fragment in interval 780′–785′
9/20/06	780′–785′	5943	Felsic-appearing fragment with plagioclase, quartz and mafic phenocrysts
9/20/06	780′–785′	5944	Felsic-appearing fragment
9/20/06	780′–785′	5945–5946	Cuttings in 780′–785′ interval (dry)
9/20/06	--	5947–5949	Cement fragment under microscope from 9/12/06 cement job
9/20/06	780′–785′	5950	Close up of "pseudo vesicle" in cement fragment
9/20/06	785′	5951–5952	Vesicular basalt

Date	Depth	Photo Number	Subject
9/20/06	785′	5953–5954	Basalt grain w/magnetite and marcasite; grain is 2 mm long from left to right
9/20/06	785′	5955–5956	Felsic-appearing fragment
9/20/06	795′	5957–5958	Felsic-appearing fragment with a phenocryst
9/20/06	795′	5959	Pyrite on a surface of a piece of basalt fill within a void
9/20/06	795′	5960–5961	Variation of the colors of clay (green-blue) light tan clay (far right) darker red piece is well cemented, looks like sand pieces w/iron oxide
9/20/06	--	5962–5963	Deleted
9/21/06	820′	5964–5965	Fragment showing contact/selvage between intermediate and basaltic compositions
9/21/06	820′	5966	Plagioclase phenocryst
9/21/06	NA	5967	Deleted
9/21/06	835′	5968	Glass bands ?
9/25/06	980′	5969–5970	Multiple basalt fragments are speckled with pyrite, ½ mm vein of pyrite
9/29/06	--	5971–5992	Deleted
9/30/06	1215′	5993–5994	Botryoidal/mammillary texture on reverse sides, probably vesicle or fracture fill
9/30/06	1215′	5995–5997	At least 3 steel filings attached or embedded within grains
9/30/06	NA	5998–5999	Deleted
10/4/06	1248′	6000–6003	Fossils (probably diatoms) in clay/siltstone
10/4/06	1248′	6004–6007	Carbonaceous debris embedded in clay/siltstone
10/4/06	1248′	6008–6011	Diatoms in clay (0.3 mm long)
10/4/06	1248′	6012	Fragment of lignite
10/4/06	1248′	6013	Close up of lignite in #6012 showing texture
10/4/06	1248′	6014–6015	Felsic-appearing fragment
10/4/06	1248′	6016	Dark veins in felsic-appearing fragment
10/4/06	1248′	6017–6022	Picture of fossil (probably a diatom) in clay/siltstone (similar material as #6000–6003, #6008–6011), #6019 and #6021 deleted
10/5/06	1288.5′–1299.5′	6023–6025	Organic/carbonaceous debris partially coalified, large (up to 3 cm long), lignite fragments
NA = Not Applicable. NR = Not Recorded.			

The above tabulated photographs are found in the attached compact disk under folders for each day represented in the table. In addition, all chip trays (cuttings for display purposes) at 5-foot intervals for the C4993 rotary borehole were photographed in order of shallow to deep. These are found on the compact disk in the file "C4993 392'–1410' Chips.pdf."

Distribution

No. of Copies

OFFSITE

C. J. Costantino
4 Rockingham Road
Spring Valley, NY 10977

B. B. Redpath
Redpath Geophysics
P.O. Box 540
Murphys, CA 95247

K. H. Stokoe II
University of Texas at Austin
Department of Civil Engineering
College of Engineering
1 University Station C1700
Austin, TX 78712

6 U.S. Army Corps of Engineers
Seattle District
P.O. Box 3755
Seattle, WA 98124-3755
ATTN: A. P. Dimbirs (4)
R. O. Garrison
R. E. Smith

J. A. McCloskey
U.S. Department of Energy
Headquarters, EM-23
19901 Germantown Road
Germantown, MD 20874

C. F. Rust
Freestone Environmental Services, Inc.
1100 Jadwin Avenue, Suite 250
Richland, WA 99352

No. of Copies

ONSITE

2 **Bechtel National, Inc.**

M. R. Braccia	MS 5-K
L. T. Lamm	MS 4-A2

4 **DOE Office of River Protection**

W. Abdul	H6-60
J. R. Eschenberg	H6-60
T. R. Hoertkorn	H6-60
L. F. Miller	H6-60

Energy Solutions

M. G. Gardner	G1-62

4 **Fluor Hanford, Inc.**

N. A. Bowles	E6-35
J. A. Horner	E6-35
S. H. Worley	E6-35
C. S. Wright	E6-35

Washington Closure Hanford

K. R. Fecht	H4-21

Washington State Department of Ecology

J. A. Caggiano	H0-57

12 **Pacific Northwest National Laboratory**

D. B. Barnett	K6-75
B. N. Bjornstad	K6-81
T. M. Brouns (5)	K9-69
S. P. Reidel	K6-75
A. C. Rohay	K6-75
Information Release (3)	P8-55