PNNL-13022, Rev. 1

Pacific Northwest National Laboratory
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U.S. Department of Energy

RCRA Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site

S M. Narbutovskih

September 2006

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

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Richland, Washington 99352

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Geologic and stratigraphic data included in Appendix C were compiled and interpreted into log plots and cross sections by Robert Mackley at the Pacific Northwest National Laboratory, using the Hanford Borehole Geologic Information System (HBGIS). HBGIS, developed and maintained by the Characterization of Systems Project, is a web-based relational data-base management repository that allows access to information stored in other large data bases such as the Hanford Environmental Information System, the Hanford Well Information System and the Virtual Library. The Characterization of Systems Project is managed for the U.S. Department of Energy, Richland Operations Office, by the Pacific Northwest National Laboratory.

Summary

This document was prepared as a groundwater quality assessment plan revision for the single-shell tank systems in Waste Management Area B-BX-BY at the Hanford Site. Groundwater monitoring is conducted at this facility in accordance with Title 40, Code of Federal Regulation (CFR) Part 265, Subpart F and by reference of Washington Administrative Code [WAC] 173-303-400(3). In FY 1996, the groundwater monitoring program was changed from detection-level indicator evaluation to a groundwater quality assessment program when elevated specific conductance in downgradient monitoring well 299-E33-32 was confirmed by verification sampling. Since the inception of the assessment program, elevated technetium-99 and nitrate concentrations have also been observed above the drinking water standard at well 299-E33-41, which is located between 241-B and 241-BX Tank Farms. In PNNL-11826, observations of the groundwater contamination and tank farm leak occurrences combined with a qualitative analysis of possible solutions, led to the conclusion that waste from the waste management area had entered the groundwater and were observed in this well. Based on 40 CFR 265.93 [d] paragraph (7), the owner-operator must continue to make the minimum required determinations of contaminant level and rate/extent of migrations on a quarterly basis until final facility closure. These continued determinations are required because the groundwater quality assessment was implemented prior to final closure of the facility.

Groundwater monitoring objectives of the *Resource Conservation and Recovery Act* (RCRA), *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), and *Atomic Energy Act* (AEA) often differ slightly, and the contaminants monitored are not always the same. For RCRA-regulated units, monitoring focuses on non-radioactive dangerous waste constituents. Radionuclides (source, special nuclear, and by-product materials) may be monitored to support objectives under the AEA and/or CERLCA. Please note that pursuant to RCRA, the source, special nuclear, and by-product material component of radioactive mixed waste, are not regulated under RCRA. These materials are regulated by DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and, may not be used to create conditions or other restrictions set forth in any RCRA permit.

A further determination, as allowed under 40 CFR 265.93(d)(7), requires the owner/operator continue quarterly measurements for contaminant concentrations, rate and extent of migration. This plan, developed using the data quality objectives process, complies with this requirement. Accordingly, the primary purpose of the present plan is to guide further assessment groundwater monitoring, tracking the levels of contaminants and the rate/extent of migration. Planned quarterly monitoring activities are addressed in the descriptive narrative of this plan, which includes a description of the monitoring network and a detailed schedule for this further assessment effort.

Contents

Figures

1.0 Introduction

Since 1944, the single-shell tanks at Hanford have contained hazardous chemical waste generated from plutonium production and separation activities. The 149 single-shell tanks are hazardous waste management units regulated under the *Resource Conservation and Recovery Act* (RCRA) and *Washington's Hazardous Waste Management Act* (HWMA, RCW 70.105) and it's implementing requirements (Washington's Dangerous Waste Regulations, WAC 173-303).

Three single-shell tank farms, 241-B, 241-BX, and 241-BY, constitute the Waste Management Area (WMA) B-BX-BY. This WMA is defined for use in developing and operating the groundwater monitoring network. Located in the 200 East Area of the DOE Hanford Site (Figure 1.1), the facilities are included in the RCRA Dangerous Waste Permit Application, PART A (interim status) submitted in accordance with Title 40, Code of Federal Regulations (CFR) 265.93. A map of the WMA is shown in Figure 1.2.

Groundwater monitoring is conducted at this facility in accordance with 40 CFR Part 265, Subpart F and by reference of Washington Administrative Code [WAC] 173-303-400(3). In FY 1996, the groundwater monitoring program was changed from detection-level indicator evaluation to a groundwater assessment program when elevated specific conductance in a downgradient monitoring well was confirmed by verification sampling. Results from the ensuing investigation led to the conclusion that waste from the WMA had entered and compromised groundwater quality (PNNL-11826). Based on 40 CFR 265.93 [d] paragraph (7), the owner-operator must continue to make the minimum required determinations of contaminant level and rate/extent of migrations on a quarterly basis until final facility closure. These continued determinations are required because the groundwater assessment was implemented prior to final closure of the facility. Accordingly, the primary purpose of the present plan, developed using the data quality objectives process, is to guide further assessment groundwater monitoring, tracking the levels of contaminants and the rate/extent of migration.

Groundwater monitoring objectives of RCRA, *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), and the *Atomic Energy Act* (AEA) often differ slightly, and the contaminants monitored are not always the same. For RCRA regulated units, monitoring focuses on non-radioactive dangerous waste constituents. Radionuclides (source, special nuclear, and by-product materials) may be monitored to support objectives under the AEA and/or CERLCA. Please note that pursuant to RCRA, the source, special nuclear and by-product material component of radioactive mixed waste, are not regulated under RCRA. These materials are regulated by DOE acting pursuant to its AEA authority. Therefore, while this report may be used to satisfy RCRA reporting requirements, the inclusion of information on radionuclides in such a context is for information only and, may not be used to create conditions or other restrictions set forth in any RCRA permit.

1.1 Statement of the Assessment Condition

Based on chemical associations, spatial and temporal relationships, historic plume movement, knowledge of process chemistry, pattern matching, and characteristic chemical ratios of constituent concentrations, two suites of contaminants have been identified associated with past tank farm operations

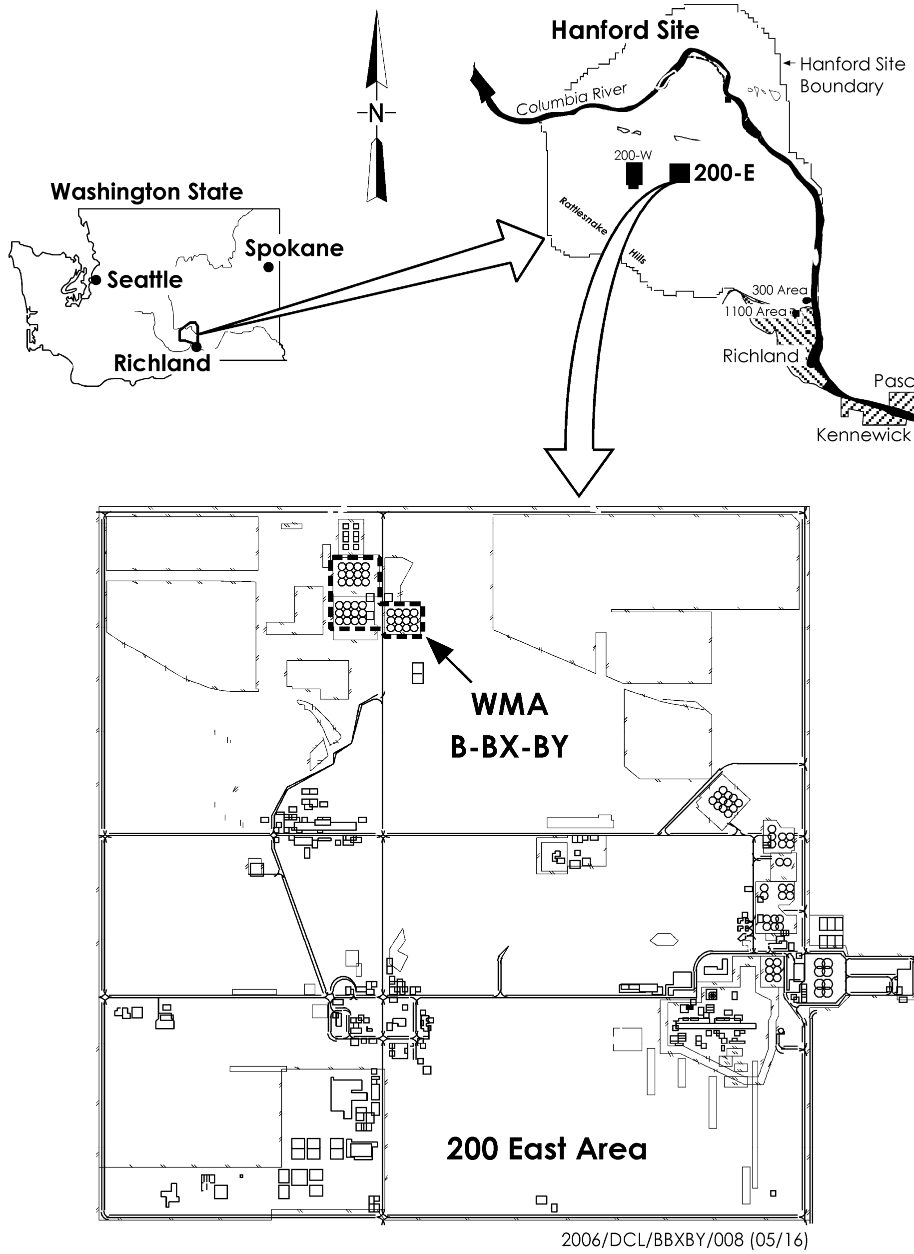


Figure 1.1. Location of WMA B-BX-BY Within the DOE Hanford Site in Washington State

(Narbutovskih and Schalla 2003; PNNL-14187; PNNL-13116; PNNL-14548). The first group, consisting of elevated technetium-99, nitrate, uranium, sulfate, and nitrite, is located under and east of the BY Tank Farm. The second group consists of tritium with low levels of nitrate. It is found along the southern border of the BX Tank Farm. Movement through the vadose zone from a tritium-rich perching zone (PNNL-14083) located about 4.57 meters (15 feet) above the water table under the BX Tank Farm is, most likely, the local source of these contaminants. The tritium in this perching zone may be related to the high volumes of condensate collected directly from the tanks as part of the in-tank solidification program conducted during the 1960s and 1970s.

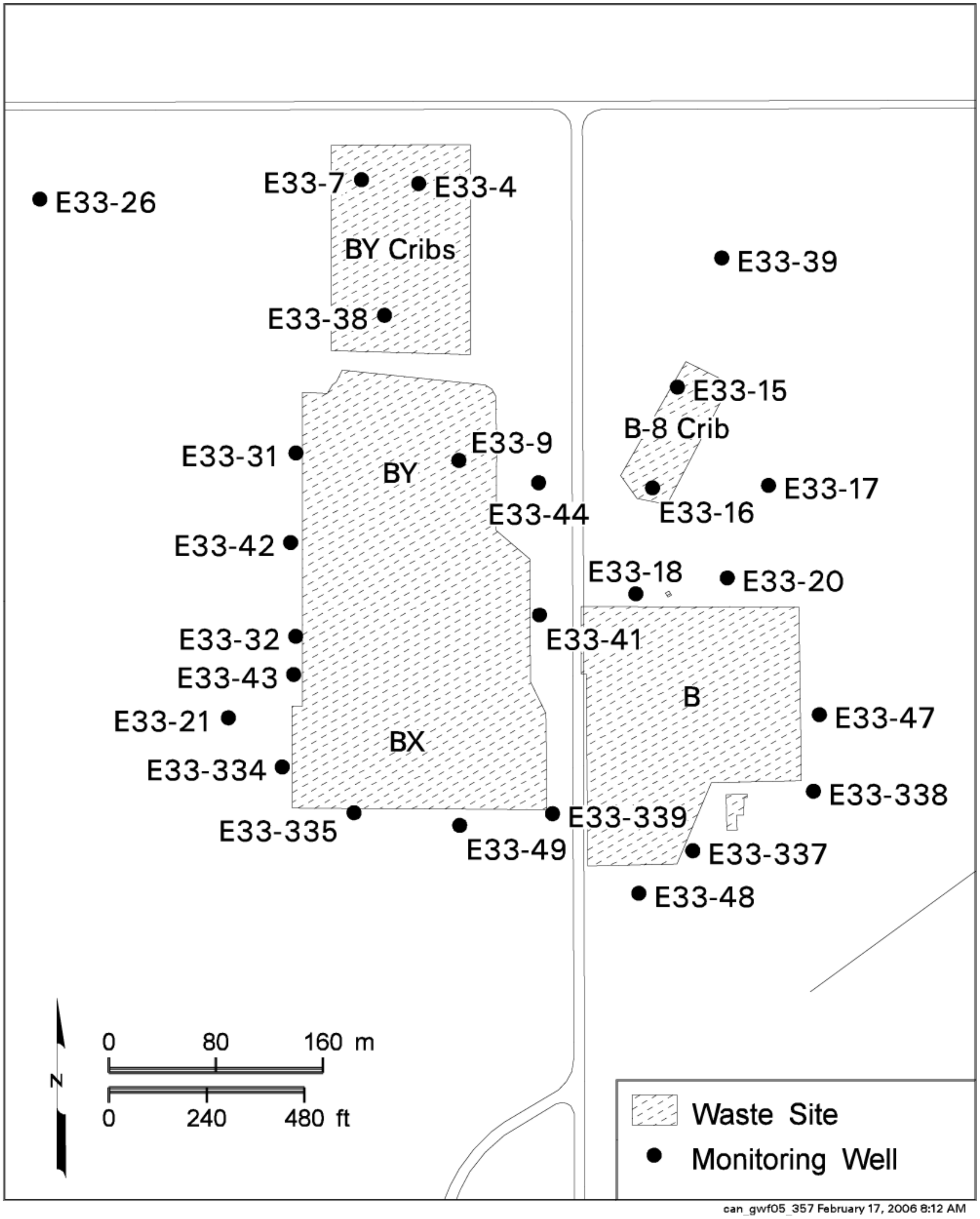


Figure 1.2. Location Map of Groundwater Monitoring Wells Around Waste Management Area B-BX-BY (after PNNL-15670)

Past leaks of processing waste from tank farm operations have left contaminated soils under the farms, which are the most likely present-day source of these contaminants found in the groundwater. Other discrete groups of contamination found under and near the BY cribs and the B-8 crib appear to be related primarily with those facilities and not the tank farms (PNNL-14187).

1.2 Objectives and Scope

In accordance with the primary purpose of this further determination assessment, the monitoring network and supporting information describing conditions in the groundwater are described in the following paragraphs. The sampling and analysis schedule used to track groundwater contamination movement is provided. The monitoring network and list of constituents is reviewed and revised annually as contamination migrates across the WMA.

The specific objectives of this revised groundwater assessment plan are:

- Fulfill requirements specified in 40 CFR 265.93 [d] paragraph (7). Specifically, to provide a plan to continue monitoring contaminant levels, the spatial extent of tank-related contamination and the rate of contaminant migration based on quarterly collection of groundwater samples until final facility closure.
- Identify the appropriate tank waste constituents and required wells to monitor the groundwater, including constituents needed to further identify source.
- Identify an expanded network to investigate groundwater near surrounding disposal facilities to allow differentiation of tank-related contamination from that associated with these other facilities.

This plan defines the monitoring network, constituents and schedule based on the DQO process (EPA 2000). In addition to documenting the DQO, it includes the previously listed information, a local conceptual model of the subsurface, the sample and analysis plan, information on monitoring well construction and a description of the local geologic stratigraphy. This plan incorporates three Internal Change Notices (ICN), released in the last four years, covering improvements and new developments affecting our understanding of how best to monitoring the waste management area. This plan does not cover a detailed *facility* description and related information. This information can be found in the interim status groundwater monitoring plan, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford* Site (PNNL-13022, Rev. 0) and the *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* (DOE/ORP-2005-01). These documents include extensive descriptions of facility history, facility infrastructure, waste characteristics and leak history for WMA B-BX-BY and the surrounding facilities.

1.3 General Approach and Plan Organization

Based on a modification of the seven data quality objectives steps, as described in *Guidance for the Data Quality Objectives Process* (EPA/600/R-96/055 (QA/G-4), EPA 2000, as revised), the DQO process resulted in a sampling and analysis plan that guides the fieldwork for various tasks. The process was originally designed by the U.S. Environmental Protection Agency (EPA) to expedite cleanup activities at superfund sites. Thus not all of the steps apply to a groundwater assessment program. However, the DQO process was followed to the extent possible.

The important or essential aspects of the DQO process are that key decisions are identified in the form of questions or statements and that the acquired data are appropriate to answer these questions or to make the necessary decisions. Thus the DQO steps form the basis and organization of this plan. A brief description of the subsurface site conditions, current groundwater chemistry and a conceptual model based on vadose zone and groundwater results are provided in Section 2.0 as background for the subsequent steps in the DQO process. The key issues, specific to WMA B-BX-BY, are presented in Section 3.0 while DQO decision rules for a further determination investigation are formulated in Section 4.0. Information needs and decision rules are presented in Section 5.0, along with an assessment schedule. The final product of the DQO process is a sampling and analysis plan describing data collection that meets the quantitative and qualitative requirements of the assessment. The sampling and analysis plan is presented in Appendix A. Well information is included in Appendix B while local geologic sections are provided in Appendix C.

2.0 Background

Since 1944, dangerous waste has been generated at the DOE Hanford Site during plutonium production for national defense activities. Mixed waste left from the processing of irradiated fuel rods was stored in 149 underground single-shell tanks since that time. The WMA B-BX-BY consists of the three separate tank farms, 241- B, 241-BX, and 241-BY (Figures 1.1 and 1.2). Each farm contains 12 single-shell tanks with 2 million liter (530,000 gallon) capacity in the 241-B and 241-BX Tank Farms and with 2.9 million liter (758,000 gallon) capacity in the 241-BY Tank Farm. In addition, the 241-B Tank Farm has four smaller single-shell tanks, each with a capacity of 208,000 liters (55,000 gallons), along the north farm boundary. Also included are ancillary equipment consisting of seven diversion boxes, associated piping valve pits, pumps, and the 244-BXR waste transfer vault.

In November 1980, the single-shell tanks were removed from active service and replaced by double-shell tanks, which received new waste and transferred waste from the single-shell tanks. Liquid has been pumped from various single-shell tanks to the newer double-shell tanks for long-term storage (HNF-EP-0182-131). In May 1987, DOE issued a final rule (10 CFR 962) stating that the hazardous waste components of the mixed waste are subject to RCRA regulations. In November 1987, the EPA authorized the Washington State Department of Ecology (Ecology) to regulate these hazardous waste components within the state of Washington (51 FR 24504).

2.1 Hydrogeology

This section provides information on the unconfined aquifer in the immediate region of WMA B-BX-BY. Aquifer properties were determined from the stratigraphic interpretations, current water level, contaminant migration in addition to local hydrographs with respect to well locations, in situ measurements and aquifer tests (WMP-26333; PNNL-13116; PNNL-13404; ASTM STP1415; WMP-18472; PNL-14538; PNNL-13023).

The water table of the uppermost aquifer lies in the lower Hanford formation gravels (H3) under the WMA and is nearly flat across the region (WMP-26333; BHI-00184; WMP-18472; WHC-SD-EN-DP-042; WHC-SD-EN-AP-012, Rev 1). During Hanford operations from the mid-1940s to about 1988, water levels rose as liquid waste was discharged directly to the subsurface causing the water table to rise. The current saturated aquifer thickness around the WMA ranges from 0 to 8.2 meters (0 to 26.7 feet). This variation in aquifer thickness reflects the top of the basalt, which defines the base of the unconfined aquifer. The thickness of the aquifer increases to the south, but local pockets, like under the BY Tank Farm, are erosional features in the basalt surface caused by scouring during the initial Hanford floods, resulting in a scabland-like structure. Since major discharges to the ground ceased in 1988, the water table has been receding to pre-Hanford conditions. In areas where the aquifer thickness is similar to relief on the basalt, local flow may be deviated from the general flow direction.

Because the hydraulic gradient is nearly flat across the 200 East Area, small inaccuracies in water elevations are important when estimating flow direction. These inaccuracies are caused by measurement errors, small differences between elevation references from different surveys, deviations from vertical of the borehole, and pressure effects associated with changing weather conditions (PNNL-12086; PNNL-13116; PNNL-13022; PNNL-13023; PNNL-13078). Consequently, the flow direction has not been reliably established. The hydrogeologic properties used to estimate the rate of groundwater flow have been reported in PNNL-15670, PNNL-15070, PNNL-13023, and PNNL-14538. The region of the aquifer near the basalt subcrop is slowly receding back to pre-Hanford water levels, which will eventually leave most of the area under the WMA devoid of an unconfined aquifer. Structural highs on the basalt may deviate local flow as the aquifer thins.

Estimated flow rates, based on hydraulic conductivities from aquifer testing and calculated using the Darcy equation, range from 0.005 to 0.17 meters (0.02 to 0.56 feet) per day. The local hydraulic gradient, as reported in PNNL-15670, is about 0.00002. The average water table decline beneath the WMA was 10 centimeters (4 inches) in FY 2005. Eventually as the aquifer recedes back to pre-Hanford conditions, wells in the northern part of the WMA may no longer contain water.

2.2 Groundwater Chemistry

The following summary of groundwater contamination is based on recent results from the groundwater monitoring at B-BX-BY WMA. The historical discharge of effluent to the ground in and around WMA B-BX-BY has resulted in complex patterns of groundwater contamination. The highest levels of nitrate, cyanide, tritium, technetium-99, cobalt-60 with some uranium are located beneath the BY cribs to the north and are attributed to discharges to the cribs in the mid-1950s. These contaminants form a plume affecting the groundwater under the north part of WMA B-BX-BY and farther west.

Elevated uranium and sulfate with moderate levels of nitrate and technetium-99 are found beneath the BY Tank Farm while a small area of elevated tritium has been found along the south margin of the waste management area. Residual waste from the waste management area may be contributing to these contaminants in the vicinity of the tank farms.

Assessment studies have identified several distinct groups of contaminants with different vadose zone sources based on chemical associations, spatial and temporal relationships, historic plume movement, knowledge of process chemistry, pattern matching, plume tracking and characteristic chemical ratios of constituent concentrations (PNNL-13116; PNNL-14187; PNNL-14548; Narbutovskih and Schalla 2003). The first two contaminant suites are, most likely, associated with the WMA resulting in degradation of groundwater quality. A summary of these contaminants groups is provided in the following paragraphs. More complete descriptions of these contaminant plumes can be found in PNNL-15070, PNNL-13116, PNNL-14187, PNNL-14548, Narbutovskih and Schalla 2003, and PNNL-13788.

The four main groups of contaminants are:

- Nitrate, nitrite, sulfate, uranium, and technetium-99. These contaminants are located primarily under the BY Tank Farm. Nitrate, technetium-99, and uranium are found above the drinking water standard of 45 mg/L, 900 pCi/L, and 30 µg/L, respectively. Although this area has the highest level of uranium (804 µg/L, June 2006) in the 200 East Area, both spatially and temporally, the co-varying contaminants are not the highest levels seen around the WMA. Past leaks of processing waste from the tank farms have left contaminated soil under the farms, which are, most likely, the source of local groundwater contamination. Further assessment of these contaminants is ongoing.
- Tritium with low levels of nitrate. This contamination is found along the south border of the waste management area. Although the tritium concentration rose sharply from the local background value of ~1,800 pCi/L to over 16,000 pCi/L in seven wells at nearly the same time beginning in early 1999,

the trend has declined in recent years to values that ranged from 14,600 to 8,710 in May 2006. The sharply rising trend indicates the wells may be close to the area where the tritium is entering the groundwater (see Figure 2.10.12 in PNNL-15070). Movement through the vadose zone from a perched water table with elevated tritium located ~4.5 meters above the water table under the BX Tank Farm is, most likely, the source of this contamination. The primary source of tritium in the perched zone may be from leaks in the farm infrastructure during the in-tank solidification process where tritium-rich condensate was removed directly from the tanks.

- Nitrate, technetium-99, cyanide, sulfate, tritium, and cobalt-60. These contaminants, found under and around the BY cribs, comprise the bulk of the contamination in the groundwater near WMA B-BX-BY. Recent sampling of wells within the BY cribs revealed high levels of technetium-99 (23,100 pCi/L), nitrate (1,590 mg/L), tritium (118,000 pCi/L), cyanide (859 µg/L), sulfate (520 mg/L), and cobalt-60 (200 pCi/L) in the groundwater under the BY cribs. These contaminants are attributed to residual waste in the vadose zone associated with the original discharges of tank supernatant to the BY cribs in the mid-1950s. Large volumes of tritium were later discharged during the 1960s and 1970s. At present, it is not clear whether the elevated uranium found in one well (299-E33-38) located between the BY cribs and BY Tank Farm is associated with discharges to the BY cribs or the elevated uranium found under the BY Tank Farm.
- Nitrate and technetium-99. Located under the 241-B-8 crib is another unique suite of contaminants. Until recently, this was the location of the maximum nitrate concentration (695 mg/L in November 2000) found in the area. This area lacks the cyanide and cobalt-60 found under the BY cribs and the high levels of uranium and nitrite associated with the contamination under the BY Tank Farm. In addition, the contaminant signature has a distinctly different nitrate-to-technetium-99 ratio than the other groups. Residual waste left in the vadose zone under and around the 241-B-8 crib is, most likely, the source for groundwater contamination in this location and is not associated with the WMA.

Recently, contaminant levels have been increasing sharply around the WMA, with the greatest increases in the north. Values for nitrate and technetium-99 are generally highest in the north decreasing to the south. The maximum nitrate value observed in July 2006 under the BY cribs was 3,150 mg/L. In the center of the WMA, nitrate increased from 292 mg/L to over 400 mg/L east of the BY Tank Farm during 2006, while farther south values range from 236 to 348 mg/L.

Similar sharp increases were also observed for technetium-99 levels. The highest level observed to date was 23,100 pCi/L in the BY Cribs in November 2004. Other wells have also shown steadily increasing values. For example, the current maximum levels are under the BY Cribs, ranging from 16,400 to 15,200 pCi/L. Contaminant levels decrease to the south. In the central part of the WMA, levels have risen to the highest seen to date at over 11,000 pCi/L. Farther south, technetium-99 concentrations have increased from 5,490 to 6,640 pCi/L during 2006. Along the southern boundary, technetium-99 concentrations have begun to increase in several wells with a current maximum value of 297 pCi/L.

In 2001, the center of the uranium plume was under and east of the BY Tank Farm in wells 299-E33-9 and 299-E33-44. However, over the past few years, uranium has decreased in well 299-E33-44 from 567 µg/L in 2001 to 184 µg/L in 2006. Conversely, under the BY Tank Farm, uranium levels in well 299-E33-9 have reached a new maximum increasing from 590 µg/L in 2004 to over 800 µg/L in 2006. This is the highest value observed in or around the WMA and may indicate a point of entry from the vadose zone to the groundwater close to well 299-E33-9. Farther south, uranium values in well

299-E33-18 increased in 2005 to 711 μg/L but then fell to 387 μg/L. Although at low levels, uranium concentrations continue to show steadily increasing trends along the southern boundary of the WMA.

The historical discharge of effluent to the ground in and around WMA B-BX-BY resulted in complex patterns of groundwater contamination. High levels of nitrate, technetium-99, cyanide, cobalt-60, sulfate and uranium, located beneath the BY cribs to the north, are attributed to discharges to the B-50 crib in the mid-1950s. This contamination forms a vadose zone plume that possibly affects the groundwater under an area greater than the cribs and may be the main source for groundwater contamination that extends south and west from the cribs. Elevated uranium with moderate levels of technetium-99, nitrate, sulfate and nitrite is found beneath the BY Tank Farm. In addition, a small tritium plume exists along the southern margin of the waste management area that is, most likely, entering the groundwater from a tritium-rich perched zone just above the water table. Evidence was discussed in PNNL-14187, PNNL-15070, and PNNL-14548 that indicate the contamination seen in and around WMA B-BX-BY may be entering the groundwater in multiple areas from the vadose zone and is sourced in the contaminated soils under both the tank farms and the surrounding cribs. Residual wastes left in the vadose zone from unplanned releases associated with the farms are, most likely, contributing to the nitrate, technetium-99, sulfate, uranium, tritium and other contamination in the vicinity of the BY and BX Tank Farms (PNNL-14187).

2.3 Conceptual Model of the Subsurface

The purpose of the conceptual model is to explore the complexity and spatial/temporal relationships of three important parameters: contamination source, driving force, and migration pathway. Determinations of contaminant sources are facilitated by use of a conceptual model that integrates these three parameters. The model presented here includes the general waste chemistry and the tank farm settings, which incorporates the driving forces and migration pathways. Residual contaminated soils along with the vadose zone migration pathway are qualitatively depicted.

2.3.1 Contaminant Sources

A graphical summary of the physical characteristics and mechanisms that could potentially affect the generation and transport of contamination at WMA B-BX-BY to the groundwater is presented in Figure 2.1. Various possible contamination sources are shown. The red represents liquid waste at the time an initial leak occurs from a tank, waste transfer line, or surface spill, which would contain both mobile and immobile contaminants like cesium-137. The color shading, from red to orange to yellow, depicts contaminant migration to the present plume location in the vadose zone. The color change may represent either a chemical reaction of the waste with mineral phases in the soil or adsorption of relatively immobile waste constituents on to the soil grains leaving the mobile constituents dissolved in the pore water. Also shown is the interaction of fresh water migrating from the surface, moving the residual waste in the vadose zone to the groundwater. This is shown as blue water interacting with residual red waste in the pore water to form migrating yellow to green waste. In this case, the residual contaminated soils act as a distinct and different source of contamination than the waste material in the tanks since contaminant migration to the groundwater does not require a tank or infrastructure display an active leak today.

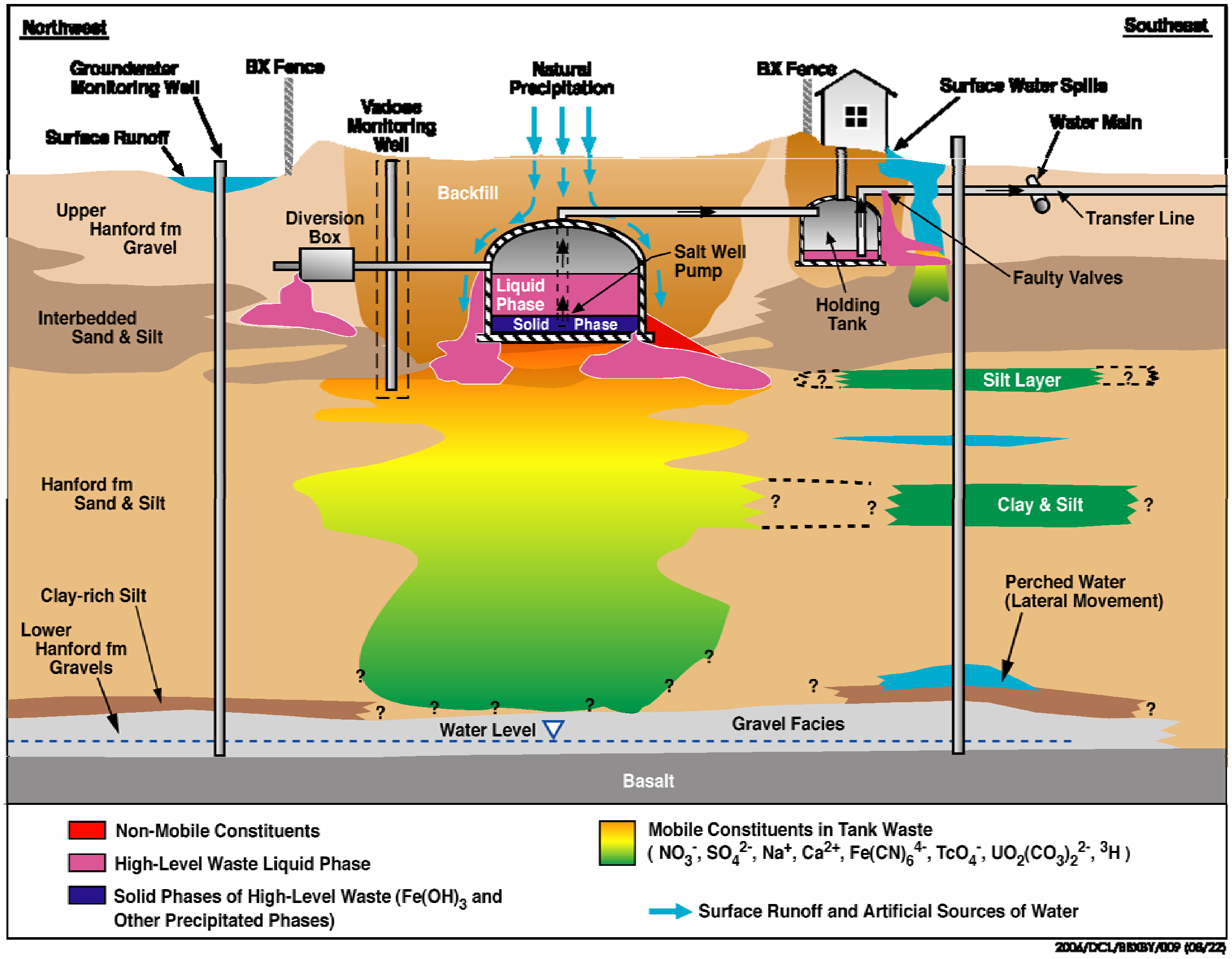


Figure 2.1. Conceptual Model for WMA B-BX-BY. This schematic depicts possible contamination sources. Viable migration pathways are shown from a source to a monitoring well. Driving forces are also illustrated as the most likely mechanism for carrying tank-associated waste constituents through the vadose zone to the groundwater (modified from PNNL-13022).

In the following text, the sources of contamination in and around WMA B-BX-BY and the surrounding facilities are discussed as they relate to this general conceptual model. The schematic depicts possible tank-associated contamination sources in the vicinity of the WMA. Viable migration pathways are shown that hazardous waste could take from a source to a monitoring well. Driving forces are also illustrated as the most likely mechanism for carrying tank-associated waste constituents through the vadose zone to the groundwater.

2.3.1.1 Tank Leaks

Numerous sources of hazardous and radioactive contamination are found in the vicinity of the B-BX-BY WMA. The most concentrated form is the waste currently stored in the single-shell tanks. These tanks were used from the late 1940s through 1980 to store high-level waste streams from the chemical separation processing of spent fuel rods. The dominant processing sources are metals waste from the bismuth-phosphate process at B Plant and tributyl phosphate waste with ferrocyanide from the uranium recovery process at U Plant (WHC-MR-0132). Heel remnants of metals waste solids were left in some tanks following sluicing to remove the waste for the uranium recovery campaign in 1954. Many of these tanks were decommissioned earlier than 1980 because of known or suspected leakage. Further information and references on tank construction, inventories, and operational history can be found in WMC-MR-0132, WHC-SD-WM-ER-311, and HNF-SD-WM-TI-740. Most of the following information on current tank status can be found in HNF-EP-0182.

Twenty of the 40 single-shell tanks in WMA B-BX-BY are confirmed or assumed leakers. A total leak volume of 452,357 liters (119,500 gallons) is reported for all the tanks with 265,000 liters (70,000 gallons) reported from 241-BX-102 and 57,160 liters (15,100 gallons) from 241-BY-107. Nine of the tanks, declared as leakers, have leaked an unknown amount of waste to the subsurface. In addition, reported leak volumes address only tank leaks and not unintentional releases from transfer lines or other ancillary equipment. Surface spills and overflow amounts are also excluded. Consequently, the total leak volume of 452,357 liters (119,500 gallons) is a minimum estimate of the total tank-associated contaminants released to the ground.

Although failure of the tanks may have occurred at welding joints at the heel of the tank, this is less likely at WMA B-BX-BY than at WMA A-AX because the heels on these tanks are rounded reinforced steel that do not allow the concentration of stresses when loaded. However, if the waste level was left stagnant over time, corrosion may have occurred at the level of liquid inside the tank. Also, the tank systems were constructed to allow waste to cascade from one tank to the next as the first tank in the system became full. Thus, the joints, where the cascade lines were attached to the tanks, were also believed to have leaked. These types of leaks are illustrated in Figure 2.1.

To reduce risk of further leaks from the tanks, an interim stabilization program was conducted at the three WMA area farms. The objective was to reduce the risk by removing free liquid from the tanks, both as supernatant and from interstitial pores in the solid salt cake. At the beginning of this groundwater quality assessment, all but four of the 40 tanks in WMA B-BX-BY had been placed on the interim stabilized lists. At that time, only tanks 241-BY-103, 241-BY-105, 241-BY-106, and 241-BY-109 were not stabilized (HNF-EP-0182, Rev. 101). All four are assumed leakers. By 2003, these tanks had been pumped and placed on the interim stabilized lists. In particular, the 241-BY-103 and 241-BY-109 tanks were pumped in 1997 while both the 241-BY-105 and 241-BY-106 tanks were pumped from 2001 to 2003 (HNF-EP-0182, Rev. 130; HNF-EP-0182, Rev. 198). These waste transfers are shortly before and during the time when high levels of uranium, with associated nitrate and technetium-99 were discovered in the groundwater under these tanks.

After pumping and being evaluated as interim stabilized, tanks 241-BX-103 and 241-BX-101 were placed on the candidate intrusion list because liquid levels increased inside the tanks (HNF-EP-0182, Rev. 142). These increases are attributed to water infiltrating through the vadose zone from above the tanks, possibly related to natural precipitation or leaking water lines. Several water line and valve ruptures caused surface flooding near these tanks during this time period and may be the cause of these level increases (PNNL-11826). Also, it was reported that tank 241-B-202 no longer meets the criteria for stabilization as liquid levels increased in that tank, indicating an ongoing intrusion from infiltrating water. This intrusion was confirmed with an in-tank video survey conducted in March 1996. The 241-B-202 tank is next to a well that has shown rapid increases in contamination since the time of the intrusive event. Currently, the status of the tank is listed as in retrieval (HNF-EP-0182, Rev. 214).

Although, most tanks currently contain small amounts of drainable liquids, past unintentional discharges to the soils have left residual contaminants in the unsaturated zone. These pockets of contaminated soil are potential sources of tank-associated waste that could be remobilized by infiltrating water and, under the right conditions, impact groundwater quality. The increasing tank liquid levels along with documentation of water line ruptures and sharp increases in contaminant levels in the groundwater over short time periods indicate this mechanism has been active in the recent past (PNNL-11826).

An example of known tank-associated contaminated soil is located near tank 241-BX-102, the site of the largest known volume leak of about 265,000 liters (70,000 gallons). Verification of the contaminated soil associated with the 241-BX 102 leak event was found when the characterization borehole, 299-E33-45, was drilled inside the 241-BX Tank Farm (PNNL-14083). Further evidence of gamma-emitting contamination in soils have been identified around all the known leaking tanks in the 241-BY Tank Farm (DOE/GJO-HAN-6).

Migration of contamination by infiltrating surface water could transport some of the mobile fraction of tank waste to groundwater as illustrated by the transition from red/yellow to green under the catch tank in the conceptual model (Figure 2.1). Surface water leaks, spills or ponded precipitation that encounter residual vadose zone waste in the pore liquids may cause this waste to move down in near-vertical, high permeability channels, spreading the contamination to new regions. Waste liquid with mobile constituents from this scenario may tend to have some lateral movement by either capillary forces or as perched water if fine-grained sedimentary layers such as silt-rich zones are encountered. With the discovery of perched water at depth in borehole 299-E33-45, well 299-E33-41 and in a characterization borehole north of the B Tank Farm, lateral spreading may be a possible means of migration at this site.

2.3.1.2 Non-Tank Sources

Past-practice liquid effluent disposal facilities exist on the east, west, and north sides of WMA B-BX-BY. The cribs, trenches, tile fields and reverse wells were built to dispose of liquid waste directly to the soil column. The source of this liquid waste varies from high level metals waste to large quantities of ferrocyanide scavenged uranium recovery waste taken directly from tanks in the 241-BY Tank Farm. Some facilities received large volumes tritium-rich tank condensate generated during the in-tank solidification program.

The volumes of this liquid effluent discharges are large, ranging from 27 to 139 million liters (7.2 to 36.8 million gallons). This practice of disposing processing waste that is chemically similar to waste stored in the tanks directly to the ground has resulted in extensive vadose zone and groundwater contamination surrounding WMA B-BX-BY. These highly contaminated vadose zone sources complicate the task of distinguishing tank farm sources from adjacent past-practice disposal facility sources.

2.3.2 Driving Forces

In general, there are two ways that tank-associated waste can migrate to groundwater. Either the volume of the initial leak must be large enough to reach groundwater through gravity drive and/or capillary action, or an external source of water or other liquid must be available. Since most tanks in WMA B-BX-BY no longer contain large volumes of liquids, it is unlikely that a tank could currently leak enough liquid to reach groundwater unassisted. However, a leaking waste transfer line during long-term waste removal operations could result in a substantial leak. Another way might be high pressure sluicing of a tank that already has a leak point developed.

Of these two scenarios, the easiest and most likely mechanisms for driving residual vadose zone contamination to the groundwater are external water sources. For example, a 5-centimeter (2-inch) raw water line broke in February 1978 on the east side of 241-A Tank Farm (WHC-SD-EN-AP-012, Rev. 1 1991). Before the line could be turned off, 227,125 liters (60,000 gallons) of water were released to the soil column. This large volume of water caused soil collapse in the center of the farm between tanks 241 A-102 and A-105, even though the ruptured line was on the east side of the farm.

Sources of water in the vicinity of the tanks can be either artificial (manmade) or natural. Examples of manmade water sources include nearby leaking or ruptured water lines, leaking fire hydrants or broken valves. A complex system of water and waste transfer lines exist within the farms to support farm operations. Failure of these pressurized lines, such as the February 1978 event, could result in driving tank waste to the groundwater.

Mobility of escaped waste can be increased as a result of natural recharge such as heavy rainfalls and sudden snowmelts. Johnson and Chou discuss in PNNL-11810 the extent that rapid snowmelt from recent years has contributed to natural driving forces. The results of a rapid snow melt event in February 1979 are documented in PNNL-11809 with photographs showing extensive flooding in the 241-T Tank Farm. The effects of these events are enhanced by gravel surfaces, lack of plant uptake and transpiration, and surface depressions that tend to collect and pond run-off and snow melt.

Results of assessment studies indicate that the observed groundwater contamination may be associated with the remobilization of residual waste left in the soil caused by infiltration of fresh-water, both long-term natural recharge and/or man-made unintentional releases (PNNL-11826; Narbutovskih and Schalla 2003; PNNL-14187). Data from steady-state water balance studies, performed at the Hanford Site on bare surfaces with no vegetation over a series of years, show that recharge values vary with annual precipitation from 111 millimeters (4.37 inches) per year for high precipitation years to 40 millimeters (1.6 inches) per year for low precipitation years (Gee et al. 1992). Using a one-dimensional flow calculation, described in Gee et al. (1992), contaminant travel through the vadose zone can be estimated to determine feasibility of this mechanism. The steady-state discharge rate is directly related to the total travel time for the contamination to drain through the vadose zone.

Excluding the short-term appearance of contaminants in the groundwater seen in the 1950s from the initial large-volume discharges to the BY Cribs in 1955, and assuming the mid-1990s groundwater contamination increase reflects the steady-state drainage of the residual vadose zone contamination, a 40-year travel time can be calculated. The vadose zone around the WMA is about 72 meters (236 feet) thick. A typical water content for the local soil was found to be 0.063 cm^3/cm^3 in the southeast corner of the B Tank Farm (RPP-10098). Using these values, it would require a recharge rate of 114 millimeters (4.5 inches) per year for stable drainage to cause the residual waste associated with the contaminated soil to affect the groundwater by 1995.

This rate of 114 millimeters (4.5 inches) per year is, however, above the range of directly measured infiltration recharge rates for this area. This suggests that, although the process of steady-state recharge is a viable water driver mechanism to explain the observed groundwater contamination at WMA B-BX-BY and the surrounding facilities, a water source, such as high precipitation events, rapid snow melt or a pipeline leak, may also contribute to the net influence of water drivers on vadose zone migration.

2.3.3 Migration Pathways

Because the vadose zone is about 72 meters (236 feet) thick, much of the migration pathway from the surface source to the groundwater monitoring well will be in the unsaturated zone. The nature of liquid migration through this zone is not well understood because it is highly dependent on heterogeneities and anisotropy in the soil permeability. The bulk of the sediments are high-energy flood deposits with extreme variability in grain size over vertical and horizontal intervals on the order of tens of feet. Hydraulic conductivity values would be expected to change on at least the same scale if not less. Consequently, delineating specific migration pathways through a thick sequence of unconsolidated sediments is a challenging task.

In the 200 East Area, unsaturated sediments are primarily gravelly coarse-grained sands and sandy gravels with intermittent thin to thick silt-rich units. Recently it has been shown that some of these low-permeability horizons can cause significant perching of water thereby causing lateral spreading of infiltrating liquid (DOE/GJO-2002-343-TAR). For example, in borehole 299-E33-45, perched water was found at a depth of about 67 meters (220 feet) near the contaminant soil associated with the leak from tank 241-BX-102. Eight years earlier, a similar perched water zone was found on the same horizon in nearby well 299-E33-41, located outside the BX Tank Farm. Several years after the drilling of well 299-E33-45, another characterization borehole encountered a perched zone at similar depths on the same silt horizon near 216-7A crib. Thus migration pathways from the surface to the groundwater appear not only to be vertical but may involve some significant lateral movement.

As work progresses on the assessment investigations for the single-shell tank WMAs, more information has become available to further our understanding of migration pathways through both the vadose zone and the sediments in the unconfined aquifer. Impacts from various driving forces have also become better understood. Once further drilling in support of the remedial investigation/feasibility study at the 200-BP-5 Operable Unit is completed, this conceptual model may be revised to reflect new findings and the results of drilling the new monitoring wells.

3.0 Statement of Key Issues

In FY 1996, the groundwater monitoring program was changed from detection-level indicator evaluation to a groundwater-quality assessment program when the indicator parameter, specific conductance, was confirmed by verification sampling to above the critical mean in a down gradient well. During the course of the ensuing investigation, results led to the conclusion that waste from the WMA had compromised groundwater quality. Based on 40 CFR 265.93 [d] paragraph (7), the owner-operator must continue to determine the concentrations of contaminants, the extent of contaminant migration and the rate of contaminant migration on a quarterly basis until final facility closure. These continued determinations are required because the groundwater quality assessment was implemented prior to final closure of the facility.

Therefore, this further assessment (phase II) of groundwater quality conditions at WMA B-BX-BY must focus on the basic quarterly determinations of contaminant levels, extent of contaminant migration and rate of migration. The DQO process, as described by EPA (2000) is used to design a cost efficient long-term sampling program, which includes review of existing data.

The fundamental issues for the ongoing groundwater investigation are:

- What are the quarterly levels of contamination and how do these concentrations vary from quarter to quarter? Is there a temporal contaminant pattern that can be used to differentiate tank-associated waste from non-tank groundwater contamination?
- What is the extent of the contamination and how does it change between sampling events?
- What is the rate and direction of contaminant migration? Does it change between sampling events?

For RCRA regulated units, monitoring focuses on non-radioactive dangerous waste constituents. Radionuclides (source, special nuclear, and by-product materials) are not regulated under RCRA. These materials are regulated by DOE acting pursuant to its AEA authority. Therefore, the inclusion of radionuclides in the monitoring strategy is for information only. In Appendix A, the integration of radionuclide monitoring under AEA with the RCRA monitoring of dangerous waste constituents and supporting non-radioactive constituents is documented. The decisions and associated information needs are discussed in Sections 4.0 and 5.0, respectively.

4.0 Decisions

The decisions identified below are regulatory driven as stated in 40 CFR 265.93(d)(5), (6), and (7) [and by reference of WAC 173-303-400(3)] and as indicated in the Technical Enforcement Guidance Document (EPA 1986).

Key site-specific decisions, expressed as questions are listed below:

1. Are site-specific constituents and levels of concentration consistent with the waste composition in WMA B-BX-BY tank waste?
2. Are the levels of contamination observed in the groundwater sufficiently delineated to evaluate environmental risk?
3. Are the number, location, and spacing of monitoring wells strategically located to map the location of contaminant plumes from the regulated unit?
4. Are the number, location, and spacing of monitoring wells strategically located to track the migration rate of contaminant plumes from the regulated unit?

Detailed summary of information needs, decision rules, and data collection design is presented in Section 5.0. The resulting sampling and analysis plan that bridges the gap between groundwater data obtained from earlier investigations under interim status indicator evaluation program and the information required to support decisions for this further determination assessment (phase II) is presented in Appendix A. Information on the network monitoring wells can be found in Appendix B.

5.0 Information Needs and Decision Rules

This section describes the information needs for addressing the general decisions and site-specific questions identified earlier. For discussion purposes, the information needs for WMA B-BX-BY are organized by category as a statement highlighted in bold. Where appropriate, decision rules are provided.

5.1 Characterization and Distribution of Contaminants

The specific contaminants observed in the groundwater should reflect the source from which these constituents originally entered the subsurface. Although not always the case, mobile constituents can be expected to travel at the same rate through the vadose zone and subsequently the groundwater. Consequently, there should be similar relative concentrations in the groundwater with respect to the source unless there have been contributions from multiple sources. Analytes that co-varying in the groundwater should be indicative of waste from a common source.

In the case of WMA B-BX-BY, the surrounding liquid waste facilities let similar waste streams to the ground. Some of these wastes are known to have impacted the groundwater in the past. Thus, another characteristic that must be identified is the grouping or suite of contaminants that co-vary and how these contaminant suites differ spatially and temporally. This information needs support both the first and second site-specific decisions required from the DQO process as delineated in Section 4.0 and required for a groundwater quality assessment program.

5.1.1 Tank-Related Dangerous Waste Constituents

The relationships between suites of mobile dangerous waste constituents and contaminants observed in the groundwater along with the levels of contamination need to be assessed with respect to both tank and non-tank sources to assure tank-related groundwater contamination is identified.

Distinguishing between contaminant suites related to tank waste and co-varying contaminants in the groundwater is fundamental to the identification of tank-sourced groundwater contamination and to differentiate from other sources. As found at other single-shell tank sites, contaminated soil left from previous unplanned events related to past tank farm activities or from events outside the farms are potential sources of groundwater contamination. For example, water from either water line ruptures/leaks or from natural recharge/precipitation can carry vadose zone contaminants to groundwater. The chemistry of these events and those of surrounding waste discharge facilities is studied, spatially and temporally, and correlated to constituents observed in the groundwater. The results may provide additional information discerning the source or sources degrading the groundwater quality in the vicinity of WMA B-BX-BY.

The considerations discussed above lead to the following decision criteria:

- If suites of constituents or mobile contaminants associated with waste sources found in the WMA storage facilities, or from contaminated soils within the farm boundaries are distinguished, both spatially and temporally, tank-related sources may be identified. For mobile constituents with co-varying elements that are not consistent with tank-related sources, either currently stored in tank facilities or from past leak events, non-tank sources are implied.

5.1.1.1 Data Needs

The data needed to resolve this issue include quarterly groundwater sampling results, historic waste process chemistry records, and results from recent characterization boreholes. Data gathering planned in support of the remedial investigation/feasibility study at the 200-BP-5 Operable Unit will assist in supplementing our knowledge of waste constituents residing in the vadose zone and increasing delineation of contaminant suites in the groundwater. Results will be compared with tank waste constituents to answer the above decision.

5.1.1.2 Data Uses

Results of this effort will be used to help answer the DQO question about how contaminants and co-varying constituents currently compromising groundwater quality relate to tank-associated waste.

5.1.2 Levels of Groundwater Contamination

Determine the level and extent of tank-related contamination and the rate of migration.

The spatial distribution of these specific constituents can provide evidence of migration through the groundwater with respect to potential source locations inside the WMA. Conversely, spatial contaminant distributions may provide insight into movement of contaminants with regional extent that may be adversely affecting the groundwater quality under the site. Temporal mapping, as required for a further groundwater quality assessment, of key constituents can provide insight assist delineating plumes from multiple sources. For example, if these constituents are observed downgradient from a facility at values significantly above upgradient values, a source or sources within the facility is implied. Conversely, if similar or higher values of contaminants are found upgradient with respect to levels observed in downgradient wells, an additional contaminant source may be active.

5.1.2.1 Data Needs

While historical trends can be determined from past sampling data, sufficient coverage both spatially and temporally is not always available. Consequently our knowledge of past migration patterns may not be complete enough to answer all questions about early contaminant events. The information required to prepare reliable concentration contour maps is collected quarterly as required. New borings purposed in support of the 200-BP-5 remedial investigation/feasibility study will supplement our current database. At times if a new and/or sudden water driver becomes active such as a water line rupture, quarterly sampling may not delineate the peak or maximum contaminant value associated with that event. If such an event occurs, more frequent local sampling may be recommended. As groundwater contamination under and surrounding WMA B-BX-BY continues the current long-term increasing trend, sampling on at least a quarterly basis is required to assess the environment impact and support risk-based decisions.

5.1.2.2 Data Uses

The data from this type of sampling program will be used to prepare constituent maps to determine contaminant extent and rate of migration. This required information will support evaluation of ongoing groundwater degradation, risk-based decisions and, eventually, remediation strategies.

5.2 Monitoring Well Network

These information needs support both the third and fourth site-specific decisions required from the DQO process as delineated in Section 4.0 and required for a groundwater quality assessment program.

***The number, location, and spacing of monitoring wells must be strategically located to delineate contaminant plumes coming from the regulated unit and determine rate of plume migration*.**

The adequacy of the monitoring well network to perform the above tasks was investigated in FY 2000 to determine if waste from the 241-BX and 241-B Tank Farms could be detected. Based on the results of this investigation, it was recommended that eight wells be installed to increase monitoring efficiency. To optimize the use of existing wells, several non-RCRA compliant wells located north and east of the 241-BY Tank Farm were included in the network to increase the coverage to nearby liquid waste facilities. One additional well, located south of the WMA was included as a far-field well. The detection monitoring network outside the WMA is complete and should be adequate to discern tank-related groundwater contamination from non-tank sources.

In the event that the first two decisions under Section 4.0 lead the investigation to consider the adequacy of the network for assessment purposes, the monitoring network will be reevaluated. However, the purposed drilling program in support of the remedial investigation/feasibility study at the 200-BP-5 Groundwater Operable Unit will provide additional groundwater coverage. If results from these wells prompt re-evaluation of the network, decisions regarding the need for new wells will be coordinated with personnel at the 200-BP-5 Groundwater Operable Unit.

5.3 Assessment Schedule

Because WMA B-BX-BY is a RCRA facility placed in a further assessment (Phase II) groundwater quality assessment program, there are no regulatory decisions that require a specified time frame other than the quarterly sampling of network wells for tank-related constituents and the determination of plume extent and rate of migration, as required by 40 CFR 265.93(d)(7)(i).

6.0 References

Code of Federal Regulations

10 CFR 962. "Byproduct Material." U.S. Department of Energy, *Code of Federal Regulations*. Accessed August 18, 2006, at http://www.access.gpo.gov/nara/cfr/waisidx_02/10cfr962_02.html

40 CFR 265.93(d). "Interim Status Standards for Owners of Hazardous Waste Treatment, Storage, and Disposal Facilities; Preparation, Evaluation, and Response." U.S. Environmental Protection Agency, *Code of Federal Regulations*.

40 CFR 265, Subpart F. "Ground-Water Monitoring." U.S. Environmental Protection Agency, *Code of Federal Regulations*.

Federal Register

51 FR 24504. 1986. "EPA Clarification of Regulatory Authority Over Radioactive Mixed Waste." *Federal Register*.

Public Laws

Atomic Energy Act. 1954. Chapter 1073, 68 Stat. 919, 42 USC 2011 et seq.

Comprehensive Environmental Response, Compensation, and Liability Act. 1980. Public Law 96-150, as amended, 94 Stat. 2767, 42 USC 9601, et seq. Accessed on August 18, 2006, at http://www.epa.gov/region5/defs/html/cercla.htm

Resource Conservation and Recovery Act. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq. Accessed on August 18, 2006, at http://www.epa.gov/region5/defs/html/rcra.htm

Revised Code of Washington

RCW 70.105. *Hazardous Waste Management Act*. Revised Code of Washington, Olympia, Washington.

Washington Administrative Code

WAC 173-303. "Dangerous Waste Regulations." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-400(3). "Dangerous Waste Regulations; Interim Status Facility Standards." *Washington Administrative Code*, Olympia, Washington.

Others

ASTM STP1415. 2002. "Application of the Colloidal Borescope to Determine a Complex Groundwater Flow Pattern." *Evaluation and Remediation of Low Permeability and Dual Porosity Environments*. SM Narbutovskih, RM Schalla, JP McDonald, and MD Sweeney. MN Sara and LG Everett (eds.), ASTM International, West Conshohocken, Pennsylvania.

BHI-00184. 1995. *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*. KA Lindsey, Bechtel Hanford Inc., Richland, Washington.

Dewan JT. 1983. *Essentials of Modern Open-Hole Log Interpretation*. PennWell Publishing Company, Tulsa, Oklahoma.

DOE/ORP-2005-01, Rev. 0. 2006. *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. MP Connelly, U.S. Department of Energy, Richland, Washington.

DOE/GJO-2002-343-TAR. 2002. *Hanford 200 Areas Spectral Gamma Baseline Characterization Project, 216-B-8 Crib and Adjacent Sites Waste Site Summary Report*. Prepared by S.M. Stoller Corp., U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado.

EPA. 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*. U.S. Environmental Protection Agency, Washington, D.C.

EPA. 2000. *Guidance for the Data Quality Objectives Process.* EPA/600/R-96/055 (QA/G-4), as revised, U.S. Environmental Protection Agency, Washington, D.C.

Gee GW, MJ Fayer, RL Rockhold, and MD Campbell. 1992. "Variations in Recharge at the Hanford Site." *Northwest Sci.* 66:237-250.

GJO-HAN-6, MACTEC-ERS. 1996. *Vadose Zone Characterization Project at the Hanford Tank Farms*. U.S. Department of Energy, Richland, Washington.

HNF-EP-0182, Rev. 101. 1996. *Waste Tank Summary Report for Month Ending August 31, 1996*. BM Hanlon, CH2M HILL Hanford Group, Inc. Richland, Washington.

HNF-EP-0182, Rev. 130. 1999. *Waste Tank Summary Report for Month Ending January 31, 1999*. BM Hanlon, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-EP-0182, Rev. 142. 2000. *Waste Tank Summary Report for Month Ending January 31, 2000*. BM Hanlon, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-EP-0182, Rev. 198. 2004. *Waste Tank Summary Report for Month Ending September 30, 2004*. BM Hanlon, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-EP-0182, Rev. 214. 2006. *Waste Tank Summary Report for Month Ending January 31, 2006*. AN Naiknimbalkar, CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-EP-0182-131. 1999. *Waste Tank Summary Report for Month Ending February 28, 1999*. BM Hanlon, Fluor Daniel Hanford, Inc., Richland, Washington.

HNF-SD-WM-TI-740. 1997. *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*. MJ Kupfer, AL Boldt, BA Higley, KM Hodgson, LW Shelton, BC Simpson, RA Watrous, MD LeClair, GL Borsheim, RT Winward, RM Orme, NG Colton, SL Lambert, DE Place, and WW Schulz, Fluor Daniel Hanford, Inc., Richland, Washington.

Narbutovskih, S. M., R.. Schalla 2003. "A Groundwater Quality Assessment at Single-Shell Tank Farms at the DOE Hanford Site." Geological Society of America Abstracts with Programs, Vol. 35, No. 6, September 2003, p. 451.

PNL-8337. 1992. *Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site Unconfined Aquifer System.* PD Thorne and DR Newcomer, Pacific Northwest National Laboratory, Richland, Washington.

PNNL. 2004. Q*uarterly Resource Conservation and Recovery Act Groundwater Monitoring Data for the Period July through September, 2004.* MJ Hartman (ed.), letter to U.S. Department of Energy, Richland Operations Office, Richland, Washington.

PNNL-11809. 1998. *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas T and T-TX at the Hanford Site.* FN Hodges, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-11810. 1998. *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas S-SX at the Hanford Site*. VG Johnson and CJ Chou, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-11826. 1998. *Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas B-BX-BY at the Hanford Site*. SM Narbutovskih, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-12086. 1999. *Hanford Site Groundwater Monitoring for Fiscal Year 1998*. MJ Hartman (ed.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13022. 2000. *Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site*. SM Narbutovskih, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13023. 2001. *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site*. SM Narbutovskih and DG Horton, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13023-ICN-1. 2002. *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site, Interim Change Notice 1.* SM Narbutovskih, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13078. 1999. *Effects of Barometric Fluctuations on Well Water-Level Measurements and Aquifer Test Data*. FA Spane, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13116. 2000. *Hanford Site Groundwater Monitoring for Fiscal Year 1999*. MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13404. 2001. *Hanford Site Groundwater Monitoring for Fiscal Year 2000.* MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13788. 2002. *Hanford Site Groundwater Monitoring for Fiscal Year 2001*. MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14083. 2002. *Characterization of Vadose Zone Sediment: Borehole 299-E33-45 Near BX-102 in the B-BX-BY Waste Management Area*. RJ Serne, GV Last, GW Gee, HT Schaef, DC Lanigan, CW Lindenmeier, MJ Lindberg, RE Clayton, VL Legore, RD Orr, IV Kutnyakov, SR Baum, KN Geiszler, CF Brown, MM Valenta, and TS Vickerman, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14187. 2003. *Hanford Site Groundwater Monitoring for Fiscal Year 2002.* MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14538. 2003. *Borehole Data Package for RCRA Wells 299-E25-93 and 299-E24-22 at Single-Shell Tank Waste Management Area A-AX, Hanford Site, Washington*. BA Williams and SM Narbutovskih, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14548. 2004. *Hanford Site Groundwater Monitoring for Fiscal Year 2003.* MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-15070. 2005. *Hanford Site Groundwater Monitoring for Fiscal Year 2004*. MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-15670. 2006. *Hanford Site Groundwater Monitoring for Fiscal Year 2005*. MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

RPP-10098. 2002. *Field Investigation Report for Waste Management Area B-BX-BY.* AJ Knepp, CH2M HILL Hanford Group, Inc., Richland, Washington.

Sobczyk SM. 2004. *Interpreted Extent of Subsurface Contamination Resulting from the 241-BX-102 Tank Leak*. Prepared for the Department of Science and Engineering, Confederated Tribes of the Umatilla Indian Reservation, Mission, Oregon.

WHC-MR-0132. 1990. *A History of the 200 Area Tank Farms*. JD Anderson, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-AP-012, Rev. 1. 1991. *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks.* JA Caggiano and SM Goodwin, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-DP-042. 1993. *Borehole Completion Data Package for CY 1991 and CY 1992 RCRA Wells at Single-Shell Tanks*. JA Caggiano, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-TI-019. 1992. *Hydrogeologic Model for the 200 East Groundwater Aggregate Area.* MP Connelly, JV Borghese, CD Delaney, BH Ford, JW Lindberg, and SJ Trent, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-ER-311. 1997. *Supporting Document for the Historical Tank Content Estimate for BX-Tank Farm*. CH Brevick, JW Funk and JL Stroup, Westinghouse Hanford Company, Richland, Washington.

WMP-18472, Rev. 0. 2003. *Calendar Year 2003 RCRA Groundwater Monitoring Well Summary Report*. CR Martinez, Fluor Hanford, Richland, Washington.

WMP-26333, Rev. 0. 2005. *Borehole Summary Report for Six CERCLA Wells Drilled in the 200-UP-1 and 200-ZP-1 Operable Units, and Six RCRA Wells Drilled in the A-AX, B-BX, and U WMA; CY 2004-2005*. Prepared by J Weiss, Freestone Environmental Services, Inc., and LD Walker, Fluor Hanford, Inc., for the U.S. Department of Energy, Richland, Washington.

WMP-28945. 2006. *Data Quality Objectives Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process*. GS Thomas, Fluor Hanford, Inc., Richland, Washington.

Appendix A

Sampling and Analysis Plan

Contents

Tables

Appendix A

Sampling and Analysis Plan

This appendix describes groundwater sampling and analysis requirements for the further determination, as allowed under 40 CFR 265.93(d)(5), to continue monitoring contaminant levels, to determine the spatial extent of tank-related contamination and measure the rate of contaminant migration based on quarterly collection of groundwater samples.

This sampling and analysis plan describes the monitoring network, constituents, and sampling schedule based on the outcome of the data quality objectives (DQO) process (EPA 2000) and on previous plans (PNNL-13022). Twenty-two wells are sampled quarterly to continue monitoring the level and extent of contamination in the groundwater. Four additional wells are sampled either semi-annually or annually depending on the far-field contaminant levels and migration. This extensive network is necessary to differentiate tank-related groundwater contamination from the numerous surrounding past-practice discharge facilities surrounding the farms and to assist in measuring contaminant migration rates pursuant to 40 CFR 265.93(d)(7). Site specific waste constituents are nitrate, nitrite, sodium, sulfate and cyanide. Uranium, tritium and technetium-99 are monitored as *Atomic Energy Act* (AEA) co-contaminants for tracking purposes only. Samples are analyzed for additional constituents, including anions, metals and field parameters. Site specific waste constituents and co-varying elements are evaluated quarterly for twenty-two of the twenty-six wells sampled.

A.1 Introduction

The objective of this sampling and analysis plan is to provide the information required to support decisions for the further determination and continue building the groundwater database obtained under interim status indicator evaluation program. This plan describes the monitoring network, constituents, and schedule based on the outcome of the DQO process as described in the main text of this document.

A.2 Field Sampling Plan

This section lists the wells to be monitored, sampling frequency, and constituents. Protocol for sampling, analysis, and related activities are summarized.

A.2.1 Sampling Objectives

The primary objective of assessment groundwater monitoring at the Waste Management Area (WMA) B-BX-BY is to provide data to assist the further determination investigations. For example, data will be collected to help determine whether the contaminant trends observed in key well 299-E33-18 located at the7A Crib are consistent with a single-shell tank source or a crib source. Secondary objectives are to: (a) track concentration trends near the waste site, and (b) provide information on groundwater quality in the 200-BP-5 Groundwater Operable Unit.

A.2.2 Site-Specific Waste Constituents

The constituents that will be monitored at WMA B-BX-BY for the assessment were determined based on the:

- Description of dangerous wastes in the Dangerous Waste Permit Application 88-21 Part A.
- Types and concentrations of constituents in the stored waste.
- Detectability of waste constituents in the groundwater.
- Concentrations or values of the monitoring parameters or constituents in the groundwater background chemistry.

Based on tank waste inventory as discussed in LA-UR-96-3860 and PNNL-13022, the major constituent groups along with sample frequency are presented in Table A.1. Site-specific waste constituents will be evaluated quarterly for specific wells as shown. Additional constituents are monitored as supporting parameters. Section A.2.3 presents further information on constituents at each monitoring location.

Table A.1. Site-Specific Waste Constituent Group

Site-Specific Constituent Group
Alkalinity
Anions
Cyanide
Gamma
Metals
Technetium-99
Tritium
Uranium
Field Parameters/Supporting Constituents
pH
Specific Conductance
Temperature
Turbidity

The analysis for anions captures the values for nitrate, nitrite, sulfate and chloride, which are the main mobile anionic species tracked around these tanks. The analysis for metals provides concentrations for sodium, calcium, and chromium, the main mobile cations tracked with tank waste constituents while cyanide requires a separate analytical technique. Specific conductance and pH are collected to ensure data comparability with prior data.

A.2.3 Sampling Locations and Frequency

At WMA B-BX-BY, the monitoring network includes both near-field and far-field wells to differentiate groundwater contamination associated with the surrounding disposals facilities from tank-related contamination. Additional wells are planned in support of the 200-BP-5 Groundwater Operable Unit remedial investigation/feasibility study (RI/FS). These wells will be added to the network as they are installed.

Table A.2. Groundwater Sampling Matrix for the WMA B-BX-BY

		RCRA Parameters				AEA Parameters			
Well Number	WAC Compliant	Alkalinity	Anions	Cyanide	Metals (filtered)	Technetium-99	Tritium	Gamma	Uranium
299-E33-17		A	A	A	A	A	A		A
299-E33-20	P	A	A	A	A	A	A		A
299-E33-21	P	A	A	A	A	A	A		A
299-E33-15	C	S	S	S	S	S	S	S	S
299-E33-9	P	Q	Q	Q	Q	Q	Q	S	Q
299-E28-8	P	Q	Q	Q	Q	Q	Q	S	Q
299-E33-16	P	Q	Q	Q	Q	Q	Q	S	Q
299-E33-18	P	Q	Q	Q	Q	Q	Q	S	Q
299-E33-26	P	Q	Q	Q	Q	Q	Q	S	Q
299-E33-31	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-32	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-38	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-39	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-41	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-42	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-43	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-44	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-7	C	Q	Q	Q	Q	Q	Q	S	Q
299-E33-47	P	Q	Q	Q	Q	Q	Q		Q
299-E33-48	C	Q	Q	Q	Q	Q	Q		Q
299-E33-49	C	Q	Q	Q	Q	Q	Q		Q
299-E33-334	C	Q	Q	Q	Q	Q	Q		Q
299-E33-335	C	Q	Q	Q	Q	Q	Q		Q
299-E33-337	C	Q	Q	Q	Q	Q	Q		Q
299-E33-338	C	Q	Q	Q	Q	Q	Q		Q
299-E33-339	C	Q	Q	Q	Q	Q	Q		Q

The monitoring wells sampled in support of the WMAB-BX-BY assessment are listed in Table A.2.and located in Figure 1.2. The table also includes constituents and frequency of sampling. Samples are collected in accordance with the procedures described in Section A.2.5.

A.2.4 Water-Level Monitoring

Groundwater levels are monitored on the Hanford Site primarily to help determine the direction and rate of groundwater flow. Static water levels are measured prior to sampling, and a minimum of two consistent measurements are taken to confirm precision of the measurement. A list of wells used for water-level measurements, criteria for their selection, hydrogeologic units monitored, and descriptions of the techniques used to collect the data are provided in *Water-Level Monitoring Plan for the Hanford*

Groundwater Monitoring Project (PNNL-13021). The wells identified are used for annual measurements for WMA B-BX-BY taken in July each year when it is attempted to obtain all the measurements in a few hours to minimize possible barometric effects. Samplers measure depth to groundwater according to a subcontractor's procedure. The depth to groundwater is subtracted from the elevation of a reference point to obtain the water-level elevation above sea level.

A.2.5 Sampling and Analysis Protocol

Groundwater monitoring for WMA B-BX-BY is part of the Groundwater Performance Assessment Project (groundwater project) and follows the project's quality assurance plan, which is compliant with *EPA Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, March 2001, as revised). Groundwater monitoring will follow the requirements of the most recent revision of the quality assurance project plan. This monitoring plan need not be revised to cite future revisions of the quality assurance plan.

Project staff schedule sampling and initiate paperwork. The project uses subcontractors for sample collection, shipping, and analysis. Quality requirements for the subcontracted work are specified in statements of work or contracts.

The statement of work for sampling activities specifies that activities shall be in accordance with a quality assurance project plan that meets the requirements defined in *EPA Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, 2001, as revised). Additional requirements are specified in the statement of work. Groundwater project staff conduct laboratory audits and field surveillances to assess the quality of subcontracted work and initiate corrective action if needed.

A.2.5.1 Scheduling Groundwater Sampling

The groundwater project has the responsibility for scheduling well sampling. Many wells are sampled for multiple objectives and requirements. Scheduling activities help manage the overlap, eliminating redundant sampling and meeting the needs of each sampling objective.

A.2.5.2 Chain of Custody

Pacific Northwest National Laboratory (PNNL) and the well sampling subcontractor use chain-of-custody procedures and documentation that are consistent with *EPA Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, March 2001, as revised). Use of these protocols documents the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during scheduling (see Section A.2.5.1) and managed by the samplers.

A.2.5.3 Sample Collection

Groundwater samples are collected as described in a subcontractor procedure. Samples may be collected after three casing volumes of water have been purged from the well or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized (i.e., after two consecutive measurements are within 0.2 units pH, 0.2°C for temperature, 10% for specific conductance, and turbidity <5 Nephelometric Turbidity Units [NTU]). For routine groundwater samples, preservatives are added to the collection bottles before their use in the field. Samples to be analyzed for metals are usually filtered in the field so that results represent dissolved metals.

A.2.5.4 Analytical Protocols

Procedures for field measurements are specified in subcontractor's procedures. Each instrument is assigned a unique number that is tracked on field documentation and is calibrated and controlled according to procedure. Additional calibration and use instructions are specified in the instrument user's manuals.

Laboratory analytical methods are specified in contracts with the laboratories, and are standard methods from *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA SW-86, 1986, as revised) or *Methods for Chemical Analysis of Water and Wastes* (EPA 600/4-79-020, 1979, as revised).

A.3 Quality Assurance

The groundwater project's quality assurance plan is compliant with *EPA Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003, EPA QA/R-5, March 2001, as revised). A quality control plan is included in the groundwater project quality assurance plan, and quality control sampling requirements for subcontracted work are discussed in a statement of work.

The groundwater project's quality control program is designed to assess and enhance the reliability and validity of groundwater data. This is accomplished through evaluating the results of quality control samples, conducting audits, and validating groundwater data. This section describes the quality control program for the entire groundwater project, which includes the WMA B-BX-BY. The quality control practices of the groundwater project are compliant with the *Tri-Party Agreement* (Ecology et al. 1989, as amended), Section 7.8. Accuracy, precision, and detection are the primary parameters used to assess data. Data for these parameters are obtained from two categories of quality control samples: those that provide checks on field and laboratory activities (field quality control) and those that monitor laboratory performance (laboratory quality control). Table A.3 summarizes the types of samples in each category and the sample frequencies and characteristics evaluated.

A.3.1 Quality Control Criteria

Quality control data are evaluated based on established acceptance criteria for each quality control sample type. For field and method blanks, the acceptance limit is generally two times the method detection limit, or minimum detectable activity (radiochemistry parameters). However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and phthalate esters, the limit is five times the method detection limit. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are flagged with a Q in the database to indicate a potential contamination problem.

Table A.3. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field Quality Control		
Full Trip Blank	Contamination from containers or transportation	1 per 20 well trips
Field Transfer Blank	Airborne contamination from the sampling site	1 each day volatile organic compound samples are collected
Equipment Blank	Contamination from non-dedicated sampling equipment	1 per 10 well trips or as needed[(a)]
Duplicate Samples	Reproducibility	1 per 20 well trips
Laboratory Quality Control		
Method Blank	Laboratory contamination	1 per batch
Lab Duplicates	Laboratory reproducibility	Method/contract specific[(b)]
Matrix Spike	Matrix effects and laboratory accuracy	Method/contract specific[(b)]
Matrix Spike Duplicate	Laboratory reproducibility and accuracy	Method/contract specific[(b)]
Surrogates	Recovery/yield	Method/contract specific[(b)]
Laboratory Control Sample	Accuracy	1 per batch
Double Blind Standards	Accuracy and precision	Varies by constituent[(c)]

(a) When a new type of non-dedicated sampling equipment is used, an equipment blank should be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the equipment's decontamination procedure.

(b) If called for by the analytical method, duplicates, matrix spikes, and matrix spike duplicates are typically analyzed at a frequency of 1 per 20 samples. Surrogates are routinely included in every sample for most gas chromatographic methods.

(c) Double blind standards containing known concentrations of selected analytes are typically submitted in triplicate or quadruplicate on a quarterly, semi-annual, or annual basis.

Field duplicates must agree within 20%, as measured by the relative percent difference (RPD), to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results are also flagged with a "Q" in the database.

For chemical analyses, the acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are generally derived from historical data at the laboratories in accordance with *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA SW-86, 1986, as revised). Typical acceptance limits are within 25% of the expected values, although the limits may vary considerably with the method and analyte.

Table A.4 lists the acceptable recovery limits for the double-blind standards for selected WMA B-BX-BY monitoring constituents. Double-blind standards of the constituents of concern are submitted to the primary laboratory in triplicate or quadruplicate on a quarterly basis. These samples are prepared by spiking background well water, as appropriate, with known concentrations of constituents of interest.

Spiking concentrations range from the detection limit to the upper limit of concentration determined in groundwater on the Hanford Site. Double blind standard results that are outside the acceptance limits are investigated and appropriate actions are taken if necessary. Because the results of double-blind standards provide information on laboratory precision and accuracy, these standards are useful tools to verify that the project DQOs is being met.

Table A.4. Recovery Limits for Double Blind Standards

Constituent	Frequency	Recovery Limits	Precision Limits (RSD)
Nitrate	Quarterly	75–125%	±25%
Sulfate	Quarterly	75–125%	±25%
Sodium	Quarterly	75–125%	±25%
Cyanide	Quarterly	75–125%	±25%
Specific Conductance	Quarterly	75–125%	±25%
RSD = Relative standard deviation.			

Holding time is the elapsed time period between sample collection and analysis. Exceeding recommended holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA SW-86, 1986, as revised) or *Methods for Chemical Analysis of Water and Wastes* (EPA 600/4-79-020, 1979, as revised). Holding times are specified in laboratory contracts. Data associated with exceeded holding times are flagged with an "H" in the Hanford Environmental Information System (HEIS) database.

Additional quality control measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned water pollution and water supply performance evaluation studies. The groundwater project periodically audits the analytical laboratories to identify and solve quality problems or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report.

A.3.2 Groundwater Data Validation Process

The groundwater project's data validation process provides requirements and guidance for validation of groundwater data that are routinely collected as part of the groundwater project. Validation is a systematic process of reviewing data against a set of criteria to determine whether the data are acceptable for their intended use. This process applies to groundwater data that have been verified (see Section A.4.1) and loaded into HEIS. The outcome of the activities described in the following paragraphs is an electronic data set with suspect or erroneous data corrected or flagged. Groundwater monitoring project staff document the validation process quarterly by signing a checklist, which is stored in the project file.

Responsibilities for data validation are divided among project staff. Each groundwater interest area is assigned to a project scientist who is familiar with the hydrogeologic conditions of that site. The data validation process includes the following elements:

- **Generation of data reports**. Twice each month, data management staff provide tables of newly loaded data to project scientists for evaluation (biweekly reports). Also, after laboratory results from a reporting quarter have been loaded into HEIS, staff produce tables of water-level data and analytical data for wells sampled within that quarter (quarterly reports). The quarterly data reports include any data flags added during the quality control evaluation or as a result of prior data review.

- **Project scientist evaluation**. As soon as practical after receiving biweekly reports, project scientists review the data to identify changes in groundwater quality or potential data errors. Evaluation techniques include comparing key constituents to historical trends or spatial patterns. Other data checks may include comparison of general parameters to their specific counterparts (e.g., conductivity to ions) and calculation of charge balances. Project scientists request data reviews if appropriate (see Section A.4.2). If necessary, the laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. After receiving quarterly reports, project scientists review sampling summary tables to determine whether network wells were sampled and analyzed as scheduled. If not, they work with other project staff to resolve the problem. Project scientists also review quarterly reports of analytical and water-level data using the same techniques as for biweekly reports. Unlike the biweekly reports, the quarterly reports usually include a full data set (i.e., all the data from the wells sampled during the previous quarter have been received and loaded into HEIS).
- Staff report results of quality control evaluations informally to project staff, DOE, and Washington State Department of Ecology each quarter; DOE will provide them to EPA on request. Results for each fiscal year are described in the annual groundwater monitoring report.

A.4 Data Management, Evaluation, and Reporting

This section describes how groundwater data are stored, retrieved, and interpreted.

A.4.1 Loading and Verifying Data

The contract laboratories report analytical results electronically and in hard copy. The electronic results are loaded into HEIS. Hard copy data reports and field records are maintained as part of the Tri-Party Agreement administrative record. Project staff perform an array of computer checks on the electronic file for formatting, allowed values, data flagging (qualifiers), and completeness. Verification of the hard copy results includes checks for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems that arose during the analysis of the samples, and (4) correct reporting of results. If data are incomplete or deficient, staff work with the laboratory to get the problems corrected. Notes on condition of samples or problems during analysis may be used to support data reviews (see Section A.4.2).

Field data such as specific conductance, pH, temperature, turbidity, and depth-to-water are recorded on field records. Data management staff enter these into HEIS manually through data-entry screens, verify each value against the hard copy, and initial each value on the hard copy.

A.4.2 Data Review

The groundwater project conducts special reviews of groundwater analytical data or field measurements when results are in question. Groundwater project staff document the process on review forms, and results are used to flag the data appropriately in HEIS. Various staff may initiate a review form, e.g., project scientists, data management staff, and quality control staff. A project scientist assigned to examine a review form determines and records the appropriate response and action on the review form, including changes to be made to the data flags in HEIS. Actions may include updating HEIS with corrected data or result of re-analysis, flagging existing data (e.g., "R" for reject, "Y" for suspect, "G" for good), and/or adding comments. Data management staff updates the temporary "F" flag to the final flag in HEIS.

A.4.3 Interpretation

After data are validated and verified, the acceptable data are used to interpret groundwater conditions at the site. Interpretive techniques include:

- Hydrographs – graph water levels versus time to determine decreases, increases, seasonal, or man-made fluctuations in groundwater levels.
- Trend plots – graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.
- Plume maps – map distributions of chemical in the aquifer to determine extent of contamination. Changes in plume distribution over time aid in determining movement of plumes and direction of flow.
- Contaminant ratios – can sometimes be used to distinguish between different sources of contamination.

A.4.4 Reporting

Chemistry and water-level data are reviewed after each sampling event and are available in HEIS.

Any unusual results for the WMA B-BX-BY Unit will be summarized in letter reports or informal reports to Ecology (e.g., reports via e-mail or presented at meetings). Formal, interpretive reports for the entire Hanford Site are issued annually in March (e.g., *Hanford Site Groundwater Monitoring for Fiscal Year 2005,* PNNL-15670.

A.4.5 Change Control

The approach to making changes in WMA B-BX-BY monitoring activities, associated documents, and approval requirements are listed in Table A.5.

Table A.5. Change Control for Groundwater Monitoring in the WMA B-BX-BY

Type of Change	Action	Documentation
Temporarily (≤1 year) adding constituents, wells, or increasing sampling frequency	Project management approval; notify regulator if appropriate	Project's schedule tracking system.
Permanently (>1 year) adding constituents, wells, or increasing sampling frequency	Revise assessment plan	Revised plan or interim change notice.
Deleting constituents or wells; decreasing frequency	Project management approval; Revise assessment plan.	Revised plan or interim change notice.
Unavoidable changes (e.g., dry wells; delayed samples, one-time missed samples due to broken pump, lost bottle, etc.)	Notify regulator.	Project's schedule tracking system; notification via letter, report, e-mail or meeting minutes.
Revision to sampling and analysis plan	Revise plan; obtain regulator review; distribute plan.	Revised plan.

A.5 Health and Safety

All field operations will be performed consistent with PNNL health and safety requirements as described in PNNL's online Systems Based Management System. For work performed by other contractors, these standards are implemented via subcontracts and work orders.

Where necessary, work planning packages will include, as appropriate, a job hazard analysis, and/or a site-specific health and safety plan, and applicable radiological permits.

The sampling procedures and associated activities will implement as low as reasonably achievable practices to minimize radiation exposure to the sampling team, consistent with requirements outlined in accepted PNNL procedures.

A.6 References

40 CFR 265, Subpart F. "Interim Status Standards for Owners of Hazardous Waste Treatment, Storage, and Disposal Facilities." *Code of Federal Regulations*. Available online at http://www.access.gpo.gov/nara/cfr/waisidx_04/40cfr265_04.html

Atomic Energy Act. 1954. Chapter 1073, 68 Stat. 919, 42 USC 2011 et seq.

Ecology - Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. 1989. *Hanford Federal Facility Agreement and Consent Order*. Document No. 89-10, as amended, (The Tri-Party Agreement), Olympia, Washington.

LA-UR-96-3860, Rev. 4. 1997. *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*, SF Agnew, Los Alamos National Laboratory, Los Alamos, New Mexico.

EPA. 1979, as revised. *Methods for Chemical Analysis of Water and Wastes.* EPA-600/4-79-020, U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1986, as revised. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition.* Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available online at: http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm

EPA. 2000, as revised. *Guidance for the Data Quality Objectives Process*. EPA/600/R-96/055 (QA/G-4), U.S. Environmental Protection Agency, Washington, D.C. Available online at: http://www.epa.gov/quality1/qa_docs.html

EPA. 2001, as revised. *EPA Requirements for Quality Assurance Project Plans*. EPA/240/B-01/003/ (QA/R-5). U.S. Environmental Protection Agency, Washington, D.C. Available online at: http://www.epa.gov/quality1/qs-docs.html

PNNL-13022. 2000. *Groundwater Quality Monitoring Plan for Single-Shell Tank Waste Management Area B-BX-BY at the Hanford Site*. SM Narbutovskih, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-15670. 2006. *Hanford Site Groundwater Monitoring for Fiscal Year 2005.* MJ Hartman, LF Morasch, and WD Webber (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13021. 1999. *Water-Level Monitoring Plan for the Hanford Groundwater Monitoring Project.* JP McDonald, MA Chamness, and DR Newcomer, Pacific Northwest National Laboratory, Richland, Washington.

WAC 173-160, Part Two. "General Requirements for Resource Protection Well Construction and Geotechnical Soil Borings." *Washington Administrative Code*, Olympia, Washington.

Appendix B

As-Built Diagrams of Groundwater Monitoring Wells at Waste Management Area B-BX-BY

Appendix B

As-Built Diagrams of Groundwater Monitoring Wells at Waste Management Area B-BX-BY

The following as-built diagrams illustrate specifications of well construction and the general lithologic information recorded during the drilling of each well. All depths and casing dimensions are in feet and inches, as they were recorded during the drilling and construction of the wells. Included are the wells in the current B-BX-BY network. As-built diagrams for some newly installed are not available. However, well summary sheets, which have similar information, are substituted for these wells. Additional wells may be added to the network if results from the assessment monitoring find it necessary.

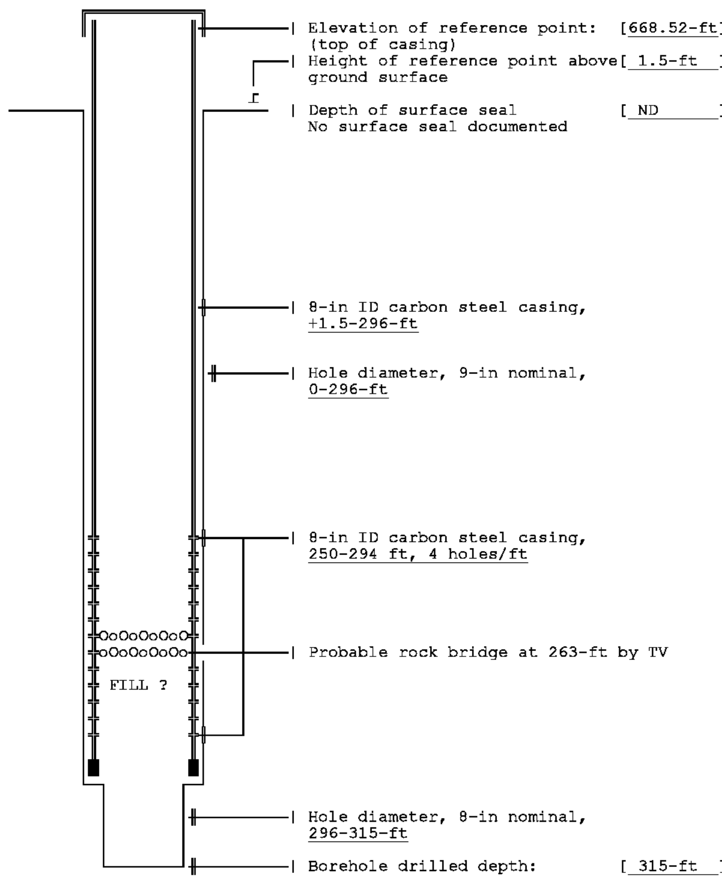
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E28-8 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 44,603 E/W W 53,124
Driller's Name: Row/Roberts	WA State Lic Nr: Not documented	State NAD83 N 137,074.3m E 573,698.1m Coordinates: N 449,768 E 2,242,087
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 19Aug57	Date Complete: 12Sep57	Elevation Ground surface: 667.0-ft Estimated

Depth to water: 268-ft Sep57
(Ground surface) ~262-ft Mar88

GENERALIZED STRATIGRAPHY   Driller's Log

0-3: SAND & SILT
3-15: GRAVEL and BOULDERS
15-25: BOULDERS, SAND and SILT
25-35: SAND and GRAVEL
35-45: SAND
45-55: SAND, GRAVEL and SILT
55-230: SAND and SILT
230-235: GRAVEL and SAND
235-245: GRAVEL, SAND and SILT
245-268: GRAVEL and SAND
268-275: GRAVEL
275-296: SAND and GRAVEL
296-315: BASALT



Drawing By: RRL/2E28-08.ASB
Date : 10Sep93
Reference : HANFORD WELLS

299-E28-8 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

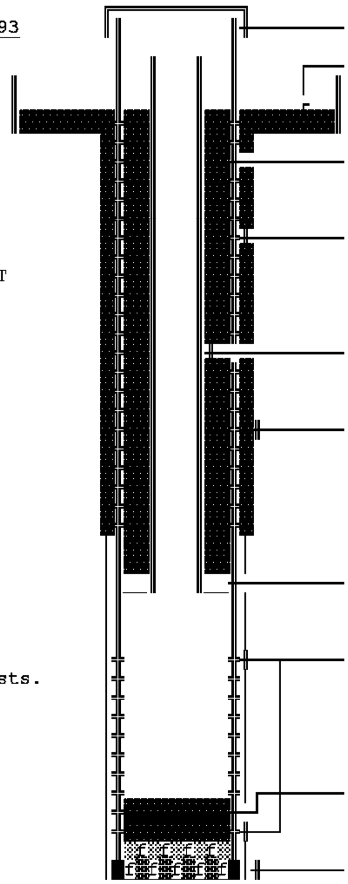
Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-7 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 46,619 E/W W 53,520
Driller's Name: Row, Richards	WA State Lic Nr: Not documented	State (NAD83) N 137,696.2m 573,574.3m
Drilling Company: Not documented	Company Location: Not documented	Coordinates: N 451,783 E 2,241,685
Date Started: 29Feb55	Date Complete: 08Apr55	Start Card #: Not documented T___ R___ S___
		Elevation Ground surface: 622.6-ft Estimated

Depth to water: 225-ft Apr55
(Ground surface) 223.2-ft 28Jun93

GENERALIZED STRATIGRAPHY   Driller's Log

0-20: BACKFILL
20-55: GRAVEL and SAND
55-110: SAND and SILT
110-150: SAND
150-165: SAND and SILT
165-192: SAND
192-230: GRAVEL
230-233: GRAVEL, SAND and BASALT

REMEDIATION:
Feb79 by Bultena.
Installed 4½-in OD casing on packer to 210-ft, (nom).
Perforated 8-in casing 0-~205-ft and grouted with 733-gals. of cement.
A cement plug was also placed 228-231-ft.
Jun92 by WHC-GWWS
Placed fill around well site.
Excavated for and installed surface pad and protective posts.
Extended 8-in casing 0.83-ft



Elevation of reference point: (top of casing) [626.58-ft]

Height of reference point above ground surface [4.0-ft]

Depth of surface seal [0-~205-ft]

Type of surface seal: Cement grout between 4-in liner and 8-in (perforated) casing

8-in ID carbon steel casing, +2.5-233-ft
Perforated during remediation, 0-~205-ft

4-in ID carbon steel casing, +~1.5-~210-ft

Hole diameter, 9-in nominal 0-233-ft

Packer set: @ ~210-ft

8-in casing perforations,
0-85-ft, 2 cuts/rd/ft
85-205-ft, not documented
215-231-ft, 4 holes/ft

Grouted 228-231-ft

Borehole drilled depth: [233-ft]

Drawing By: RKL/2E33-07.ASB
Date : 10Sep93
Reference : HANFORD WELLS

299-E33-7 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

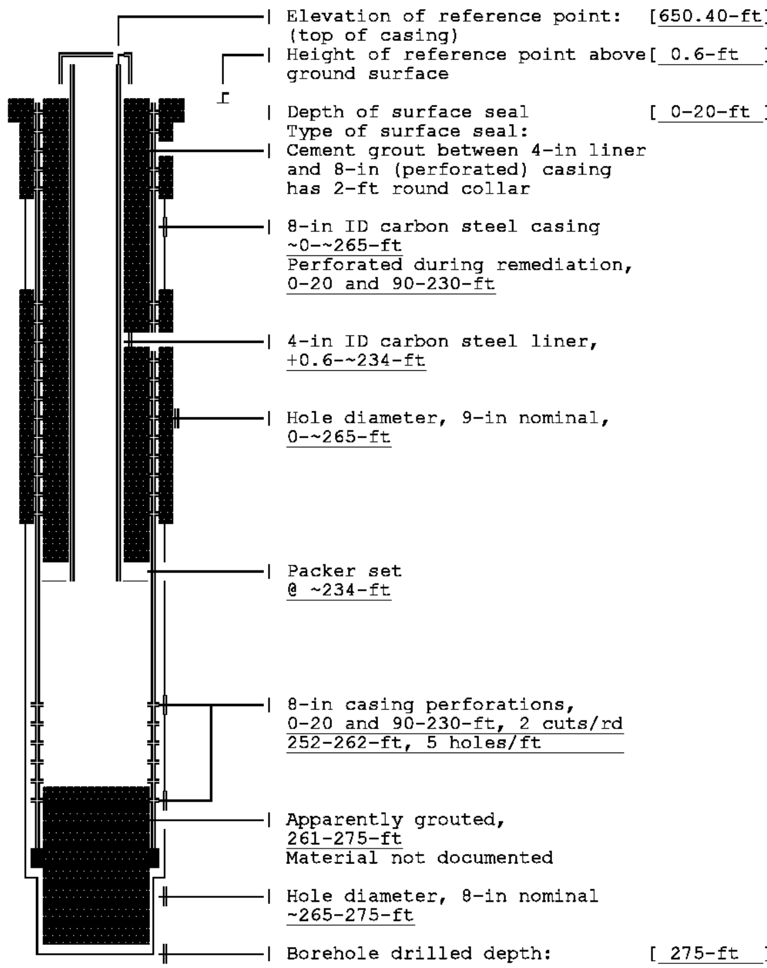
Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-9 — TEMPORARY WELL NO: 241-BY-2
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 45,960 — E/W W 53,285
Driller's Name: Chausse, Row	WA State Lic Nr: Not documented	State Coordinates: N 451,125 — E 2,241,922
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented — T____ R____ S________
Date Started: 27Jun49	Date Complete: 21Jul49	Elevation Ground surface: 649.8-ft Estimated

Depth to water: 255-ft Jul49
(Ground surface) 245.3-ft Mar90 TV

GENERALIZED STRATIGRAPHY — Driller's Log

0-38: GRAVEL and SAND
38-57: GRAVEL, SAND and SILT
57-75: SAND
75-150: SAND and SILT
150-160: SAND
160-185: SAND and SILT
185-205: SAND, some SILT and CLAY
205-225: SAND, BASALT GRAVEL, SILT
225-264: GRAVEL, SAND, little SILT
264-265: "ROCK", SAND
265-275: BASALT

NOTE: Remediation May78. By Evans. Installed 4-1/2-in OD casing on packer to 234-ft, (nom). Perforated 8-in casing 0-20 and 90-230-ft and grouted with 124-cu ft of cement. A cement plug was apparently also placed from 261-275-ft.



Drawing By: RKL/2E33-09.ASB
Date : 10Sep93
Reference : HANFORD WELLS

299-E33-9 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-15 / TEMPORARY WELL NO: 241-B-11
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 46,133.8 E/W W 52,751.0
Driller's Name: Row	WA State Lic Nr: Not documented	State NAD83 N 137,386.32m E 573,779.39m / Coordinates: N 451,300 E 2,242,456
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T____ R____ S____
Date Started: 26Jan48	Date Complete: 10Feb53	Elevation Ground surface: 624.78-ft Brass cap

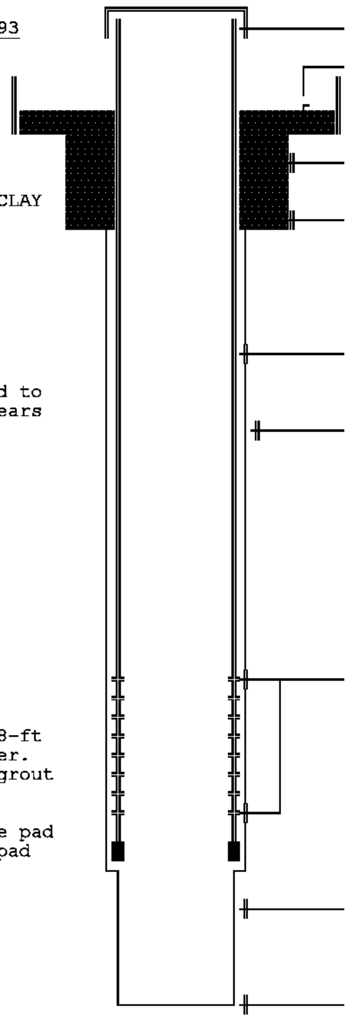
Depth to water: 232-ft Feb53
(Ground surface) 223.0-ft 28Jun93

GENERALIZED STRATIGRAPHY — Driller's Log

0-10: TOPSOIL and BACKFILL
10-20: BACKFILL
20-25: BASALT ROCKS and SAND
25-35: Coarse BASALT, SAND and CLAY
35-150: SAND and CLAY
150-180: SANDY SILT
180-195: SAND, GRAVEL and SILT
195-238.5: GRAVEL and SAND
238.5-251: BASALT

NOTE: Well was completed at 150-ft, then continued to total depth several years later.

REMEDIATION:
Oct92 by WHC GWWS
Overdrilled 8-in casing to 18-ft with 15-in OD hollowstem auger. Grouted annulus with cement grout with Al powder additive. Excavated for and installed 4-ft by 4-ft concrete surface pad with brass survey marker in pad and four protective posts. Primed and painted.



| Elevation of reference point: (top of casing) [627.29-ft]
| Height of reference point above ground surface [2.51-ft]
| Depth of surface seal [0-18-ft]
Type of surface seal:
| Cement grout outside 8-in casing, has 4-ft by 4-ft concrete pad
| 15-in hollowstem auger overdrilled hole to 18-ft
| 8-in ID carbon steel casing, +2.5-~238.5-ft
| Hole diameter, 9-in nominal 18-~238.5-ft
| 8-in casing perforations, 222-237-ft, 5 holes/ft
| Hole diameter, 8-in nominal ~238.5-251-ft
| Borehole drilled depth: [251-ft]

Drawing By: RKL/2E33-15.ASB
Date : 13Sep93
Reference : HANFORD WELLS

299-E33-15 As-Built Diagram

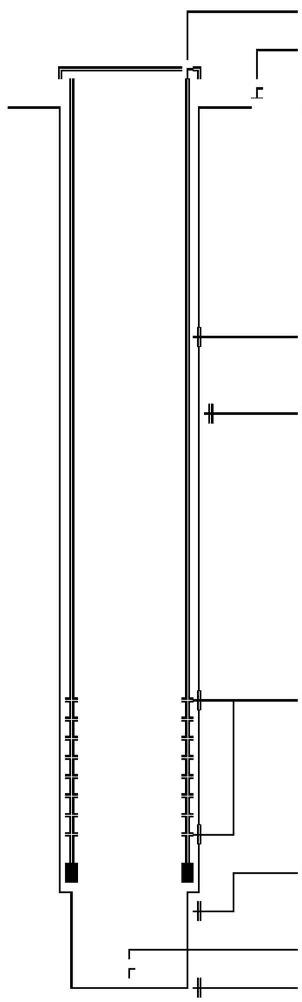
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-16 / TEMPORARY WELL NO: 241-B-5
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 45,887 E/W W 52,815
Driller's Name: Rodda/Row	WA State Lic Nr: Not documented	State Coordinates: N 451,053 E 2,242,392
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T____ R____ S________
Date Started: 28Nov47	Date Complete: 26Jan53	Elevation Ground surface: 632.0-ft Estimated

Depth to water: 240-ft Jan53
(Ground surface) 231.4-ft Apr92

GENERALIZED STRATIGRAPHY — Driller's Log

0-5: BACKFILL
5-14: SAND and GRAVEL
14-24: Coarse SAND and fine GRAVEL
24-40: SAND
40-50: Coarse SAND and fine GRAVEL
50-77: Coarse SAND
77-110: SAND
110-135: SAND with little CLAY
135-140: SAND
140-150: SAND and CLAY
09Dec47
17Dec52
150-161: Sandy SILT
161-164: SAND, GRAVEL and SILT
164-193: SAND and SILT
193-200: SAND
210-203: GRAVEL and SAND
203-227: SILT
227-229: SILT and GRAVEL
229-247.25: GRAVEL and SAND
247.25-258: BASALT



Drawing By: RKL/2E33-16.ASB
Date : 13Sep93
Reference : HANFORD WELLS

299-E33-16 As-Built Diagram

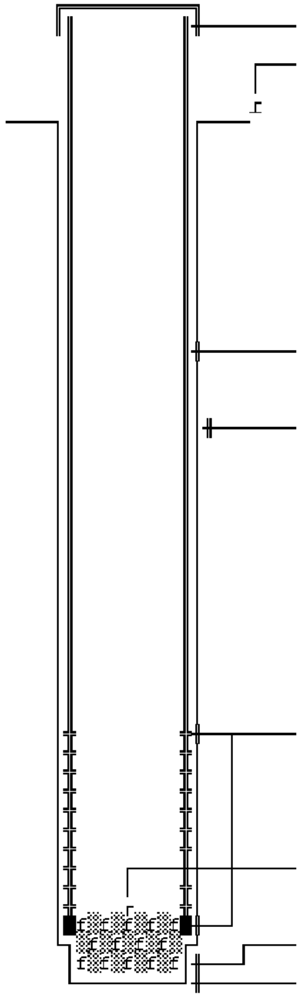
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-17 TEMPORARY WELL NO: 241-B-16
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 45,894 E/W W 52,529
Driller's Name: Gentz	WA State Lic Nr: Not documented	State Coordinates: N 451,061 E 2,242,678
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 22Sep53	Date Complete: 15Oct53	Elevation Ground surface: 629.9-ft Estimated

Depth to water: 240-ft Oct53
(Ground surface) 227.8-ft 09Jun93

GENERALIZED STRATIGRAPHY   Driller's Log

0-25: SAND, SILT and GRAVEL
25-45: Coarse SAND
45-55: SAND, very little SILT
55-65: Coarse SAND
65-110: SAND, little SILT
110-115: SAND, SILT, little CLAY
115-120: SAND and SILT
120-125: Coarse SAND
125-160: SAND
160-175: SAND and SILT
175-185: SAND
185-202: Coarse SAND
202-208: SAND, SILT and CLAY
208-215: GRAVEL
215-244: Coarse GRAVEL
244 : BASALT



| Elevation of reference point: [631.65-ft] (top of casing)
| Height of reference point above [1.75-ft] ground surface
| Depth of surface seal [ND] No surface seal documented
| 8-in ID carbon steel casing, +~1.6-ft-242.5-ft
| Hole diameter, 9-in nominal 0-242.5-ft
| 8-in casing perforations, 220-~242.5-ft, cuts not documented
| Depth to bottom, 241.1-ft, 10Aug93
| Hole diameter, 8-in nominal 242.5-244-ft
| Borehole drilled depth: [244-ft]

Drawing By: RKL/2E33-17.ASB
Date : 13Sep93
Reference : HANFORD WELLS

299-E33-17 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-18 TEMPORARY WELL NO: 224-B-4
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 45,626.5 E/W W 52,854.4
Driller's Name: Hash/Row	WA State Lic Nr: Not documented	State NAD83 N 137,386.32m E 573,779.39m Coordinates: N 450,793 E 2,242,354
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T____ R____ S______
Date Started: 29May47	Date Complete: 23Feb50	Elevation Ground surface: 649.34-ft Brass cap

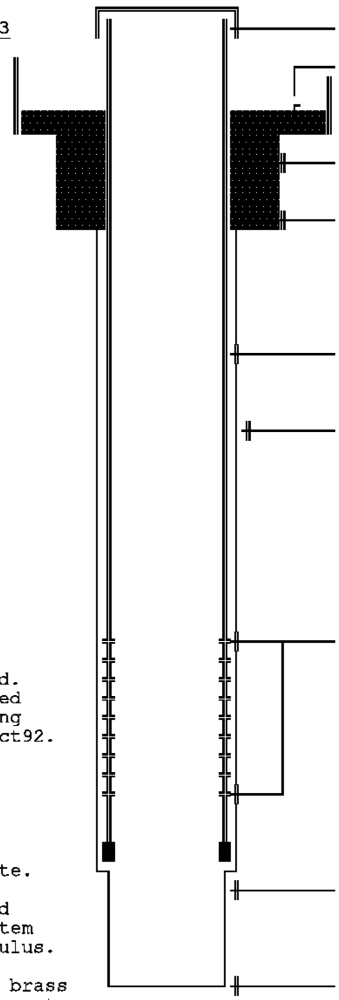
Depth to water: 255-ft Feb50
(Ground surface) 247.1-ft 24Jun93

GENERALIZED STRATIGRAPHY — Driller's Log

0-15: NOT DOCUMENTED
15-22: SAND and GRAVEL
22-25: SAND
25-36: SAND and GRAVEL
36-45: CLAY and GRAVEL
45-52: SAND
52-55: GRAVEL
55-65: GRAVEL and CLAY
65-120: CLAY and SAND
120-139: SILT
139-160: SAND
160-165: SAND and fine GRAVEL
165-180: Coarse SAND
180-195: SAND and fine GRAVEL
195-200: CLAY and fine GRAVEL
200-210: Coarse SAND, light CLAY
210-239: CLAY
239-248: Coarse SAND, some CLAY
248-250: SAND
250-255: Coarse SAND
255-257: LAVA dust
257-264: LAVA rock
264-265: SAND
265-269.5: LAVA rock
269.5-270: Fine SAND
270-272.5: UNDOCUMENTED
272.5-278: BASALT

NOTE: Above depths are as-drilled. About 6-ft of fill was added to ground surface and casing extended 8-ft in Apr and Oct92.

REMEDIATION:
21Apr92 by WHC GWWS
Extended 8-in casing. Amount not documented.
Not documented
About 6-ft of fill added to site.
Oct92 by WHC GWWS.
Removed old pad and overdrilled 8-in casing w/15-in OD hollowstem auger to 18.5-ft. Grouted annulus. Excavated for and installed 4-ft by 4-ft concrete pad with brass survey marker and 4 protective posts. Extended casing 17-in (total of ~8-ft). Primed and painted casing and protective posts.



Elevation of reference point: [651.86-ft] (top of casing)
Height of reference point above ground surface [2.52-ft]
Depth of surface seal [0-18.5-ft]
Type of surface seal: Cement grout outside 8-in casing, has 4-ft by 4-ft concrete pad
15-in hollowstem auger overdrilled hole to 18.5-ft
8-in ID carbon steel casing, +2.5-271-ft (after extension)
Hole diameter, 9-in nominal 0-~271-ft (after extension)
8-in casing perfortions, 240-260-ft, 2 holes/ft/rd 246-266 ft after extension
Hole diameter, 8-in nominal ~265-278-ft as-drilled 271-284-ft after extension
Borehole drilled depth: [278-ft] *284-ft
*=Present estimated depth from ground surface

Drawing By: RKL/2E33-18.ASB
Date : 13Sep93
Reference : HANFORD WELLS

299-E33-18 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

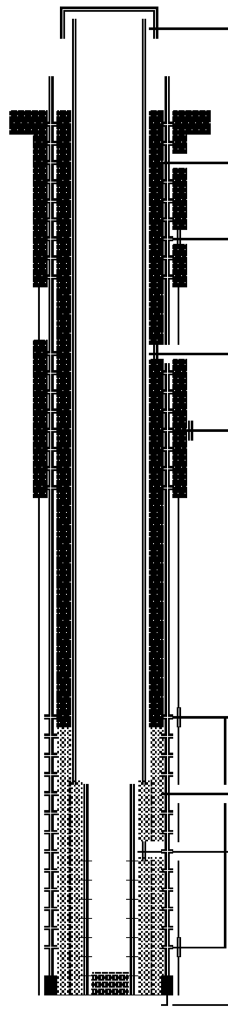
Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-20 TEMPORARY WELL NO: 603-B-2
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 45,664.5 E/W W 52,629.7
Driller's Name: Rydman	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 137,398.11m / 450,832 E 573,847.82m / 2,242,578
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 26Jun56	Date Complete: 05Jul56	Elevation Ground surface: 638.8-ft Estimated

Depth to water: 243-ft Jul56
(Ground surface) ~234-ft Nov89 TV

GENERALIZED STRATIGRAPHY   Driller's Log

0-8: SAND and GRAVEL
8-36: GRAVEL, some SAND
36-82: Coarse SAND, some GRAVEL and SILT
82-162: Medium to coarse SAND, some SILT
162-198: Coarse SAND, some GRAVEL and SILT
198-203: Medium to coarse SAND
203-226: SILT and fine SAND
226-254: GRAVEL, SAND and BOULDERS
254 : BASALT

NOTE: Remediation Jun83. By David (Garcia?)



Elevation of reference point: (top of casing) [640.08-ft]

Height of reference point above ground surface [1.25-ft]

Depth of surface seal [0-60-ft]

Type of surface seal: Cement grout between 6-in liner and 8-in (perforated) casing
Has 2-ft round collar

8-in ID carbon steel casing, +~0.5-254-ft
Perforated during remediation 0-60 and 75-120-ft

6-in ID carbon steel liner, +1.25-~234-ft

Hole diameter, 9-in nominal 0-254-ft

8-in casing perforations, 0-60 and 75-120-ft, >2 cuts/ft
225-251-ft, >5 holes/ft

Pea-gravel and fine sand filter pack, 225-254-ft

6-in stainless steel telescoping screen, 239-254-ft, #10-slot
5-ft blank section, assumed 234-239-ft

Borehole drilled depth: [254-ft]

Drawing By: RKL/2E33-20.ASB
Date : 13Sep93
Reference : HANFORD WELLS

299-E33-20 As-Built Diagram

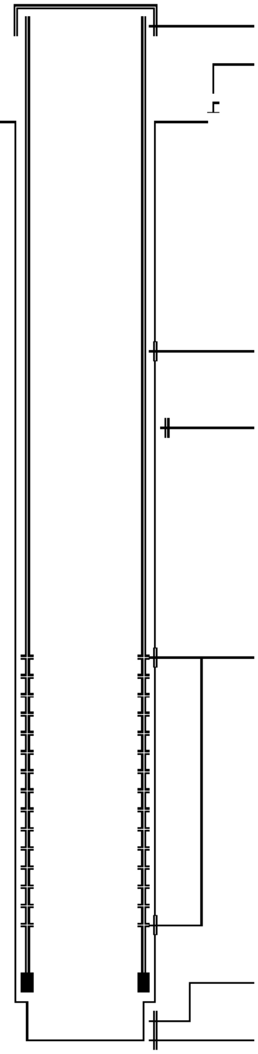
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-21 — TEMPORARY WELL NO:
Drilling Fluid Used: Not documented	Additives Used: Not documented	Hanford Coordinates: N/S N 45,324.4 E/W W 53,855.1
Driller's Name: Gentz	WA State Lic Nr: Not documented	State NAD83 N 137,293.40m E 573,474.67m; Coordinates: N 450,488 E 2,241,354
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T____ R____ S________
Date Started: 19Feb57	Date Complete: 05Apr57	Elevation Ground surface: 663.5-ft Estimated

Depth to water: 261-ft Apr57
(Ground surface) 261.7-ft 23Jun93

GENERALIZED STRATIGRAPHY — Driller's Log

0-15: COBBLES, GRAVEL, SAND and SILT
15-20: BOULDERS, COBBLES, GRAVEL and SAND
20-26: COBBLES, GRAVELS and SAND
26-46: COBBLES and GRAVEL
46-72: Coarse SAND
72-90: SAND - little SILT
90-95: SAND and SILT
95-140: Coarse SAND
140-155: Fine and coarse SAND
155-165: SAND
165-185: SAND - little SILT
185-190: Fine and coarse SAND
190-200: SAND and GRAVEL
200-210: Coarse SAND and GRAVEL
210-215: Coarse SAND
215-225: SAND - little SILT
225-245: SAND, SILT and GRAVEL
245-250: Coarse GRAVEL - COBBLES
250-255: Small GRAVEL
255-260: SAND and GRAVEL
260-275: Coarse GRAVEL and SAND
275-279: COBBLES, GRAVEL and SAND
279-282: BASALT



| Elevation of reference point: [668.13-ft] (top of casing)
| Height of reference point above ground surface [4.6-ft]
| Depth of surface seal [ND]
No surface seal documented
| 8-in ID carbon steel casing, +4.6-~279-ft
| Hole diameter, 9-in nominal 0-~279-ft
| 8-in casing perforations, 235-270-ft, 6 cuts/ft 270-275-ft, 2 cuts/ft
| Hole diameter, 8-in nominal ~279-282-ft
| Borehole drilled depth: [282-ft]

Drawing By: RKL/2E33-21.ASB
Date : 13Sep93
Reference : HANFORD WELLS

299-E33-21 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

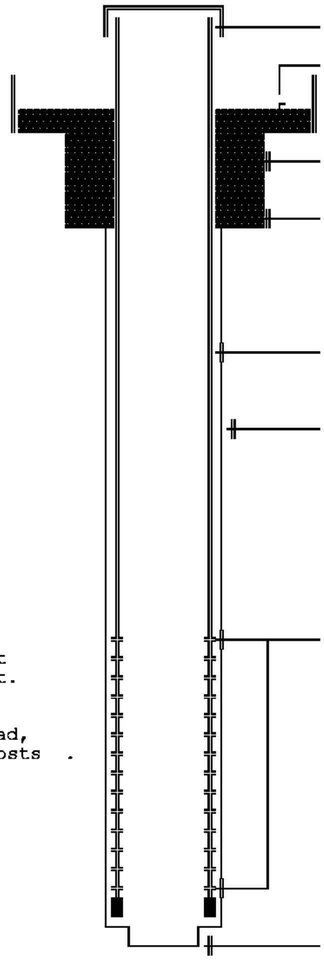
Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E33-26 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 46,600 E/W W 54,315
Driller's Name: Bigham	WA State Lic Nr: 0036	State Coordinates: N 451,762 E 2,240,891
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T ___ R ___ S ___
Date Started: 18Feb69	Date Complete: 05Mar69	Elevation Ground surface: 630.34-ft Brass cap

Depth to water: 214-ft Mar69
(Ground surface) 229.4-ft 28Jun93

GENERALIZED STRATIGRAPHY   Driller's Log

0-10: GRAVEL and COBBLES
10-15: GRAVEL, COBBLES&BOULDERS
15-25: GRAVEL and BOULDERS
25-30: GRAVEL and COBBLES
30-31: SAND and COBBLES
31-35: SILT, SAND and GRAVEL
35-70: SAND and GRAVEL
70-95: SAND and SILT
95-115: SAND
115-140: SAND and SILT
140-190: SILT and GRAVEL
190-205: SAND, GRAVEL and COBBLES
205-235: SAND and GRAVEL
235-239: SAND, GRAVEL and COBBLES
239-240: BASALT

REMEDIATION:
22Nov-13Dec91 by WHC GWWS
Overdrilled 6-in casing to 19-ft with 15-in hollow-stem auger bit. Grouted annulus w/cement grout. Excavated for and installed 4-ft by 4-ft concrete surface pad, brass marker and 4 protective posts .



| Elevation of reference point: (top of casing) [632.77-ft]
| Height of reference point above ground surface [2.43-ft]
| Depth of surface seal [0-19-ft]
Type of surface seal:
| Cement grout outside 6-in casing, has 4-ft by 4-ft concrete surface pad
| 15-in hollow-stem auger overdrilled hole to 19-ft
| 6-in ID carbon steel casing, +2.4-~239-ft
| Hole diameter, 7-in nominal 19-~239-ft
| 6-in casing perforations, 199->220-ft, 6 cuts/ft by TV
Perforations extend below water
| Borehole drilled depth: [240-ft]

Drawing By: RKL/2E33-26.ASB
Date : 13Sep93
Reference : HANFORD WELLS

299-E33-26 As-Built Diagram

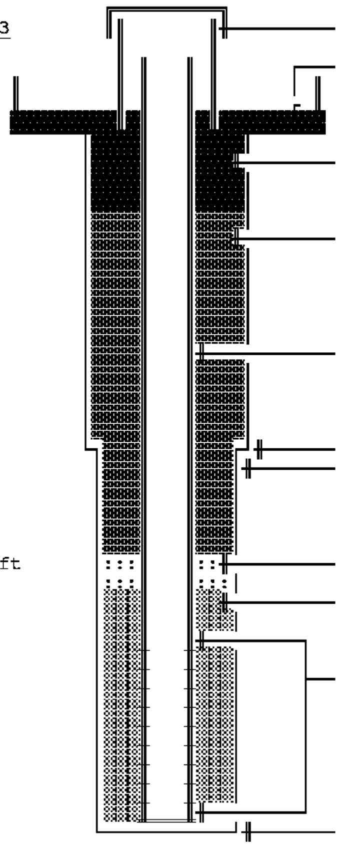
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-E33-31 / TEMPORARY WELL NO:
Drilling Fluid Used: 200 E Water Supply	Additives Used: Not documented	Hanford Coordinates: N/S N 45,974.7 E/W W 53,687.4
Driller's Name: Thoresen	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 137,491.7m E 573,525.2m; N 451,139 E 2,241,520
Drilling Company: Kaiser Engineers	Company Location: Hanford	Start Card #: Not documented T____ R____ S________
Date Started: 11Jul89	Date Complete: 11Sep89	Elevation Ground surface: 644.44-ft Brass cap

Depth to water: 239.2-ft Sep89
(Ground surface) 242.5-ft 23Jun93

GENERALIZED STRATIGRAPHY Geologist's Log

0-5: Muddy sandy GRAVEL
5-10: Sandy GRAVEL
10-20: Muddy sandy GRAVEL
20-25: Sandy GRAVEL
25-40: Gravelly SAND
40-50: Sandy GRAVEL
50-55: SAND
55-60: Sl. gravelly SAND
60-65: Gravelly SAND
65-70: Sl. gravelly SAND
70-80: SAND (FS-VFS)
80-85: Muddy SAND
85-90: SAND
90-100: Sl. gravelly SAND
100-120: SAND
120-130: Sl. gravelly SAND
130-140: SAND
140-150: Sl. gravelly SAND
150-155: Gravelly SAND
155-165: SAND
165-170: Gravelly SAND
170-175: Sandy GRAVEL
175-205: SAND, CLAY lens at 202-ft
205-210: Sandy GRAVEL
210-215: Muddy sandy GRAVEL
215-255.6: Sandy GRAVEL
255.6 : BASALT



Elevation of reference point: [647.50-ft] (top of 6-in casing)
Height of reference point above ground surface [3.06-ft]
Depth of surface seal [2-19.7-ft]
Type of surface seal: Cement grout to 19.7-ft, has 4-ft x 4-ft x 6-in concrete pad extending 2-ft into annulus
Bentonite crumbles, 19.7-226.0-ft, 8-20-mesh
4-in ID stainless steel casing, +0.7-234.9-ft
Hole diameter, 2-154.0-ft, 11-in nominal
154.0-255.9-ft, 9-in nominal
¼-in Volclay pellets, 226.0-231.2-ft
Silica sand pack, 231.2-255.9-ft, 20-40-mesh
4-in stainless steel screen, 234.9-255.9-ft, #10-slot
Has channel pack and bottom cap
Borehole drilled depth: [255.9-ft]

Drawing By: RKL/2E33-31.ASB
Date : 13Sep93
Reference : WHC-MR-0209

299-E33-31 As-Built Diagram

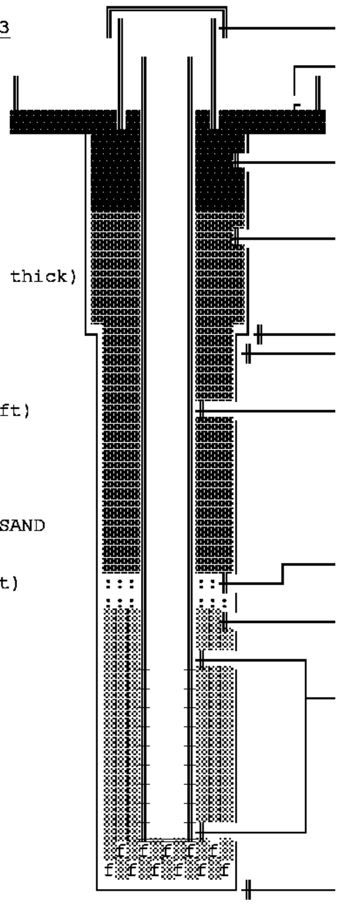
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-E33-32 TEMPORARY WELL NO:
Drilling Fluid Used: 200 E Water Supply	Additives Used: Not documented	Hanford Coordinates: N/S N 45,523.7 E/W W 53,689.2
Driller's Name: Watkins	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 137,354.3m 450,688 E 573,525.0m 2,241,519
Drilling Company: Kaiser Engineers	Company Location: Hanford	Start Card #: Not documented T ___ R ___ S ___
Date Started: 11Jul89	Date Complete: 05Sep89	Elevation Ground surface: 656.96-ft Brass cap

Depth to water: 251.6-ft Aug89
(Ground surface) 255.0-ft 23Jun93

GENERALIZED Geologist's
STRATIGRAPHY Log

0-10: Muddy sandy GRAVEL
10-15: Sandy GRAVEL
15-20: Gravelly SAND
20-25: Sandy GRAVEL
25-30: GRAVEL
30-60: Gravelly SAND
60-65: Sl. gravelly SAND
65-70: SAND (MUD at 68-ft, ~9-in thick)
70-75: Sandy gravelly MUD
75-85: Sl. gravelly SAND
85-90: SAND
90-95: Sl. gravelly SAND
95-100: SAND
100-105: Sl. gravelly SAND
105-120: SAND (Sandy MUD at 118-ft)
120-125: Sl. muddy SAND
125-140: SAND
140-155: Sl. muddy SAND
155-170: SAND
170-175: Gravelly muddy SAND
175-180: Sl. gravelly sl. muddy SAND
180-190: Gravelly SAND
190-210: Sl. gravelly SAND
210-225: SAND (MUDSTONE at 223-ft)
225-240: Gravelly SAND
240-250: Sandy GRAVEL
250-255: Gravelly SAND
255-260: SAND
260-265: Sl. gravelly SAND
265-271: Gravelly SAND
271 : BASALT



Elevation of reference point: (top of 6-in casing) [660.05-ft]
Height of reference point above ground surface [3.09-ft]
Depth of surface seal [2-20.5-ft]
Type of surface seal: Cement grout to 20.5-ft, has 4-ft x 4-ft x 6-in concrete pad extending 2-ft into annulus
Bentonite crumbles, 20.5-239.6-ft, 8-20-mesh
Hole diameter, 0-75.0-ft, 11-in nominal
75.0-270.3-ft, 9-in nominal
4-in ID stainless steel casing, +0.6-246.4-ft
╝- -in Volclay pellets, 239.6-243.2-ft
Silica sand pack, 243.2-~267.4-ft, 20-40-mesh
4-in stainless steel screen, 246.4-267.4-ft, #10-slot W/channel pack and bottom cap
Borehole drilled depth: [270.3-ft]

Drawing By: RKL/2E33-32.ASB
Date : 13Sep93
Reference : WHC-MR-0209

299-E33-32 As-Built Diagram

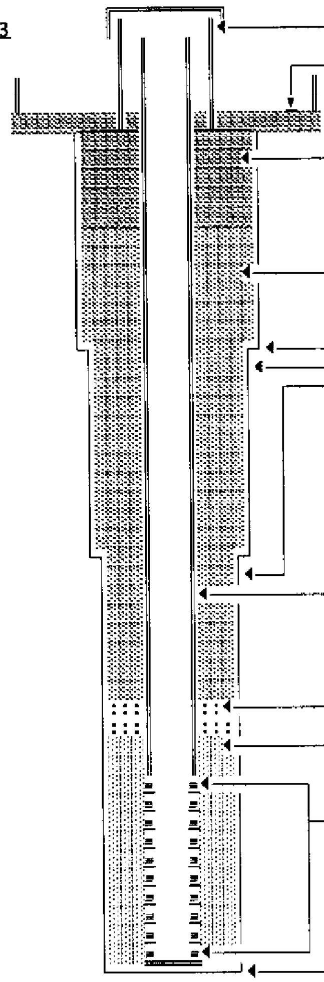
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard toool	WELL NUMBER: 299-E33-38
Drilling Fluid Used: 200E Area Water	Additives Used: None	TEMPORARY WELL NO:
Driller's Name: D. Garcia	WA State Lic Nr:	Hanford Coordinates: N/S N 46.312 E/W W 53.469
Drilling Company: Kaiser Engineers	Company Location: Hanford	State NAD83 Coordinates: N 137,594.78m 451,477 E 573,591.39m 2,241,737
Date Started: 16Nov90	Date Complete: 01Apr91	Start Card #: Not documented T____ R____ S____
		Elevation Ground surface: 629.97-ft (Brass cap)

Depth to water: 226.6-ft Jan91
(Ground surface) 228.1-ft 28Jun93

GENERALIZED STRATIGRAPHY Geologist's Log
Sl = slightly

0↔3.8: Silty GRAVEL
3.8↔6.2: Gravelly silty SAND
6.2↔13.1: Silty sandy GRAVEL
13.1↔13.9: SILT lens
13.9↔50: Sl silty gravelly SAND
50↔55: Gravelly SAND
55↔78: Sl gravelly SAND
78↔79: SILT lens
79↔89: Sl gravelly SAND
89↔165: SAND
165↔183: Gravelly SAND
183↔189.4: SAND
189.4↔190: SILT
190↔210: Sandy GRAVEL
210↔228.6: Silty sandy GRAVEL
228.6↔236: GRAVEL
236↔238: SAND
238↔239.6: BASALT



Elevation of reference point: [631.95-ft]
(top of casing)

Height of reference point above [2.0-ft]
ground surface

Depth of surface seal [2.7↔18.4-ft]
Type of surface seal:
Cement grout to 18.4-ft, has 4x4-ft x 6-in concrete pad extending 2.7-ft into annulus

Bentonite crumbles,
18.4↔208.1-ft, 8↔20-mesh

Hole diameter,
0↔76.5-ft, 14-in nominal
76.5↔227.0-ft, 11¾-in
227.0↔239.6-ft, 9.3-in

4-in ID T304 stainless steel casing,
+ND↔218.6-ft

⅜-in bentonite pellets,
208.1↔212.5-ft

Silica sand pack,
212.5↔239.6-ft, 8↔12-mesh

4-in T304 stainless steel screen,
218.6↔239.6-ft, #20-slot w/cap

Borehole drilled depth: [239.6-ft]

Drawing By: RKL/2E33-38.ASB
Date : 13Sep93
Reference :

299-E33-38 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Water
Driller's Name: T. Gifford
Drilling Company: Kaiser Engineers
Date Started: 03Dec90

Sample Method: Drive barrel Hard toool
Additives Used: None
WA State Lic Nr: Not documented
Company Location: Hanford
Date Complete: 08Feb91

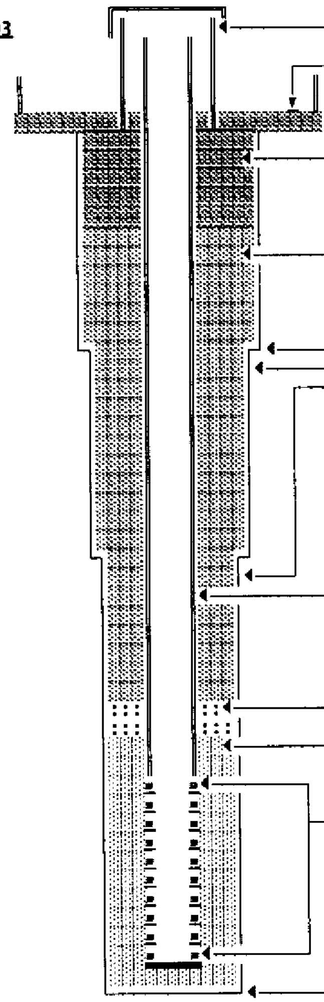
200E Area

WELL NUMBER: 299-E33-39
TEMPORARY WELL NO: ______
Hanford Coordinates: N/S N 46.451 E/W W 52.641
State NAD83 N 137,637.65m 573,843.75m
Coordinates: N 451,618 E 2,242,565
Start Card #: Not documented T____ R____ S______
Elevation Ground surface: 620.42-ft (Brass cap)

Depth to water: 218.6-ft Jan91
(Ground surface) 218.7-ft 28Jun93

GENERALIZED Geologist's STRATIGRAPHY Log
Sl = slightly

0↔11: Silty sandy GRAVEL
11↔15: Sl gravelly SAND
15↔29: Gravelly SAND
29↔34: SAND
34↔44: Sl gravelly SAND
44↔50: Gravelly SAND
50↔59: Sl gravelly SAND
59↔64: Gravelly SAND
64↔69: SAND
69↔89: Gravelly SAND
89↔114: Sl gravelly SAND
114↔125: Gravelly SAND
125↔139: SAND
139↔159: Gravelly SAND
159↔175: Silty SAND
175↔178: Gravelly SAND
178↔185: Sandy GRAVEL
185↔190: Gravelly SAND
190↔229: Silty sandy GRAVEL
229↔229.5: SAND
229.5↔230.1: BASALT



Elevation of reference point: [623.32-ft]
(top of casing)
Height of reference point above [2.9-ft]
ground surface
Depth of surface seal [2.0↔20.0-ft]
Type of surface seal:
Cement grout to 20.0-ft, has 4x4-ft x 6-in concrete pad extending 2.0-ft into annulus
Bentonite crumbles, 20.0↔199.6-ft
Hole diameter,
0↔101-ft, 14-in nominal
101↔ND-ft, 12-in nominal
ND↔230.1-ft, 9.3-in
4-in ID T304 stainless steel casing, +ND↔208.2-ft
Bentonite pellets, 199.6↔203.1-ft
Silica sand pack, 203.1↔230.1-ft, 8↔12-mesh
4-in T304 stainless steel screen, 208.2↔229.2-ft, #20-slot w/cap
Borehole drilled depth: [230.1-ft]

Drawing By: RKL/2E33-39.ASB
Date : 13Sep93
Reference : ______

299-E33-39 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

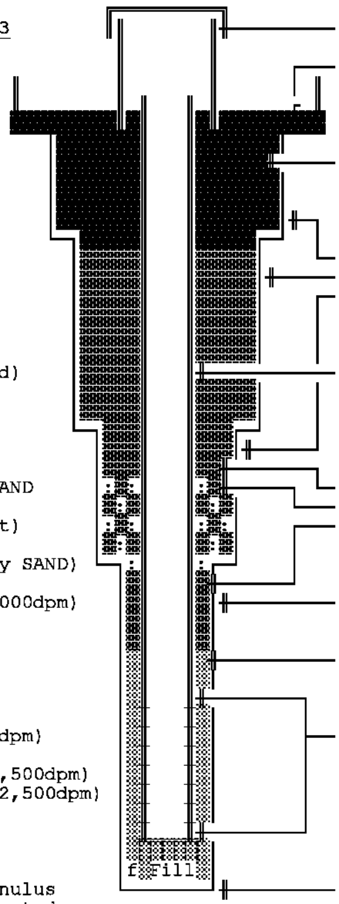
Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-E33-41
Drilling Fluid Used: Raw water	Additives Used: None	TEMPORARY WELL NO: None
Driller's Name: M Thorosen L Watkins/B Strode	WA State Lic Nr: Not documented	Hanford Coordinates: N/S N 45,573.4 E/W W 53,091.4
Drilling Company: Kaiser Engineers	Company Location: Hanford	State NAD83 Coordinates: N 137,369.94m 450,739 E 573,707.19m 2,242,117
Date Started: 31Jan91	Date Complete: 28Mar91	Start Card #: Not documented T____ R____ S______
		Elevation Ground surface: 651.53-ft Brass cap

Depth to water: 252.4-ft Apr91
(Ground surface) 249.6-ft 23Jun93

GENERALIZED STRATIGRAPHY Geologist's Log
Sl=slightly

0-5: GRAVEL and SAND
5-10: Sl silty gravelly SAND
10-15: Gravelly SAND
15-20: Sl silty sandy GRAVEL
20-25: Gravelly SAND
25-35: Sandy GRAVEL
35-45: SAND
45-50: Sl gravelly SAND
50-60: SAND
60-65: Sl gravelly SAND
65-70: Gravelly SAND
70-73: Sl gravelly SAND
(Contamination encountered)
73-74: Interbedded SAND and SILT
74-80: Gravelly SAND
(4,000dpm @ 78-ft)
80-95: Sl gravelly SAND
95-102.5: SAND
102.5-104.5: Interbedded silty SAND and cse SAND (Wet)
104.5-110: SAND (PEBBLES @ 106-ft)
110-115: Sl gravelly SAND
115-125: SAND (Stringers of silty SAND)
125-140: Sl gravelly SAND
(SILT lens @ 137-ft; 4,000dpm)
140-164: SAND
(2,000dpm @ 160-ft)
164-164.5: Sandy SILT
164.5-170: SL gravelly SAND
170-217: Gravelly SAND
217-218: Sandy GRAVEL
218-220: Sl clayey SILT (25,000dpm)
220-230: Sl clayey sandy SILT
(Contamination 30,000>2,500dpm)
230-242: Sl clayey silt SAND (~2,500dpm)
242-262.7: Sandy GRAVEL
262.7-263: BASALT

DRILLIING NOTE:
Well was completed with 1-in annulus 240.7-263.0-ft with variance granted by Ecology



Elevation of reference point: [654.95-ft]
(top of casing)
Height of reference point above ground surface [3.42-ft]
Depth of surface seal [2.5-20.4-ft]
Type of surface seal:
Cement grout to 20.4-ft, has 4x4-ft x 6-in concrete pad extending 2.5-ft into annulus

Hole diameter,
0-20-ft, 13-in nominal
20-158.7-ft, 11-in nominal
158.7-263.0-ft, 9-in nominal

4-in ID stainless steel casing,
+0.5-244.9-ft

Bentonite,
20.4-172.6-ft, 8-20-mesh crumbles
172.6-239.9-ft, slurry
239.9-243.1-ft, 8-20-mesh crumbles

Hole diameter, 7-in nominal
240.7-263.0-ft

Silica sand pack,
243.1-262.0-ft, 10-20-mesh

4-in stainless steel screen,
244.9-261.0-ft, #10-slot
W/channel pack

Borehole drilled depth: [263.0-ft]

Drawing By: RKL/2E33-41.ASB
Date : 13Sep93
Reference : WHC-SD-EN-DP-041

299-E33-41 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-E33-42 A4868
Drilling Fluid Used:	NA	Additives Used:	None	TEMPORARY WELL NO:	None
Driller's Name:	J. McKnight	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	KEH Constr. Forces	Company Location:	Hanford	Coordinates: E	Not documented
Date Started:	29Aug91	Date Completed:	09Oct91	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: **247 ft** **04Nov91**
(Ground surface)

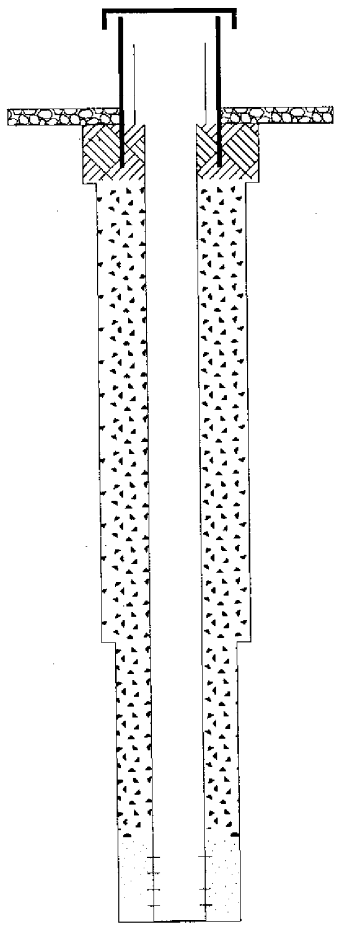
GENERALIZED STRATIGRAPHY **Geologist's Log**

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **18 ft.**

Type of Surface Seal: **4x4 Concrete Pad**



Generalized Stratigraphy

- 0 - 15 ft : Sand
- 15 - 30 ft : Pebbles
- 30 - 50 ft : Sand - Gravel
- 50 - 80 ft : Light Moisture in Section
- 80 - 170 ft : Sand
- 170 - 200 ft : Sand trace of Gravel
- 200 - 250 ft : Sand - Silty, dry, and hard
- 250 - 259.9 ft : Gravel/Sand - large Pebbles

Fill	*Casing*	*Screen*
0 - 18 ft : 13-inch hole Cement	0 - 19.2 ft : 13 inch 12-3/4" CS Temp. Casing	
18 - 19.2 ft : 13-inch hole Bentonite Crumbles	0 - 238.5 ft : 4 inch 4" Perm. Casing	
19.2 - 168.6 ft : 11-inch hole Bentonite Crumbles	19.2 - 168.6 ft : 11 inch 10-3/4" CS Temp. Casing	
168.6 - 229.5 ft : 9-inch hole Bentonite Crumbles	168.6 - 259.9 ft : 9 inch 8-5/8" CS Temp. Casing	
229.5 - 233 ft : 9-inch hole Bentonite Pellets		238.5 - 259.2 ft : 4 inch 4" .020 SS Wire Wrap Pipe Size
233 - 259.5 ft : 9-inch hole 10-20 Silica Sand	259.2 - 259.5 ft : 4 inch End Cap	
259.5 - 259.9 ft : 9-inch hole 10-20 Silica Sand		

259.9 ft : Borehole drilled depth

0 - 19.2 ft : 13-in. 12-3/4" CS Temp. Casing
19.2 - 168.6 ft : 11-in. 10-3/4" CS Temp. Casing
168.6 - 259.9 ft : 9-in. 8-5/8" CS Temp. Casing

Drawing By:	DLF
Reference:	Hanford Wells
Revision:	0
Revision Date:	07Jan98
Print Date:	07Jan98

Report Form: WELLS Project File: WELLS.GPJ

299-E33-42 As-Built Diagram

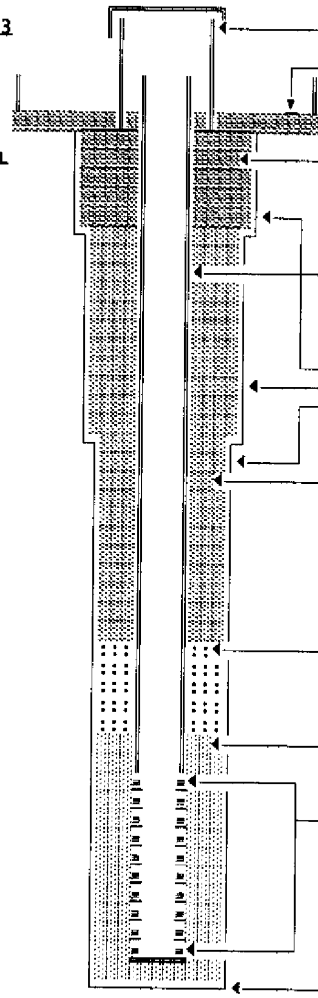
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-E33-43
Drilling Fluid Used: Raw water	Additives Used: None	TEMPORARY WELL NO:
Driller's Name: B Smith/G Howel	WA State Lic Nr: Not documented	Hanford Coordinates: N/S N 45,429.1 E/W W 53,695.6
Drilling Company: Kaiser Engineers	Company Location: Hanford	State NAD83 Coordinates: N 137,325.43m E 573,523.19m; N 450,593 E 2,241,513
Date Started: 30Aug91	Date Complete: 05Nov91	Start Card #: Not documented T___ R___ S___
		Elevation Ground surface: 659.18-ft (Brass cap)

Depth to water: 255.5-ft Oct91
(Ground surface) 257.3-ft 23Jun93

GENERALIZED STRATIGRAPHY
Geologist's Log
Sl=slightly

0↔45: GRAVEL w/SAND
45↔240: SAND w/SILT, CLAY, GRAVEL
240↔273.7: SAND/GRAVEL



Elevation of reference point: [662.68-ft]
(top of casing)

Height of reference point above ground surface [3.50-ft]

Depth of surface seal [2.2↔19.3-ft]
Type of surface seal:
Cement grout to 19.3-ft, has 4x4-ft x 6-in concrete pad extending 2.2-ft into annulus

4-in ID stainless steel casing, ~+1.0↔250.2-ft

Hole diameter,
0↔19.7-ft, 13-in nominal
19.7↔166.1-ft, 11-in nominal
166.1↔273.7-ft, 9-in nominal

Bentonite crumbles, 19.3↔236.9-ft, 8↔20 mesh

3/8-in bentonite pellets, 236.9↔246.9-ft

Silica sand pack, 246.9↔273.7-ft, 10↔20-mesh

4-in T304 stainless steel screen, 250.2↔271.3-ft, #20-slot

Borehole drilled depth: [273.7-ft]

Drawing By: RKL/2E33-43.ASB
Date : 13Sep93
Reference :

299-E33-43 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	**Cable Tool**	Sample Method:	**Grab/Split Spoon**	WELL NUMBER:	**299-E33-44 B8554** TEMPORARY WELL NO: **Not Allowed**
Drilling Fluid Used:	**Water**	Additives Used:	**None**	Coordinates: N	**Not documented**
Driller's Name:	**M. Wraspir**	WA State Lic Nr:	**Not Available**	Coordinates: E	**Not documented**
Drilling Company:	**Layne Christensen**	Company Location:	**Salt Lake City, Ut**	Start Card #:	**Not Available**
Date Started:	**12Sep98**	Date Completed:	**26Sep98**	Elevation Ground Surface:	**Brass Marker**

Depth to Water: **239.6 ft 26Sep98**
(Ground surface)

Elevation of Reference Point: m

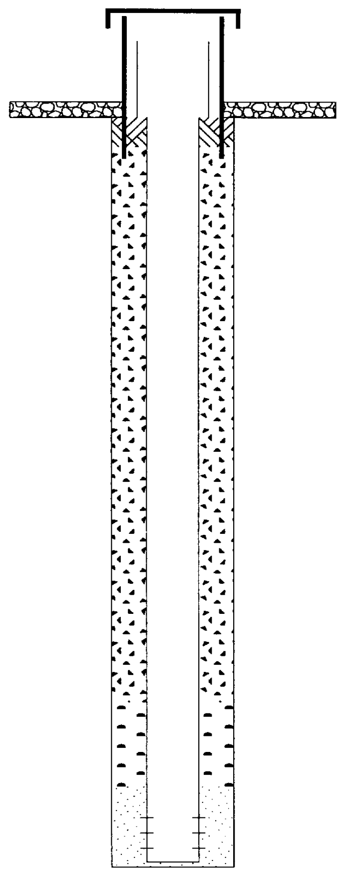
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **9.8 ft**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY — **Geologist's Log & Geophysical Logs**

0 - 9 ft : Silty Sandy Gravel
9 - 23 ft : Sandy Gravel
23 - 39 ft : Slightly Silty Gravel Sand
39 - 44 ft : Gravelly Sand
44 - 70 ft : Sand
70 - 74.5 ft : Silty Sand
74.5 - 124 ft : Sand
124 - 128 ft : Silty Sandy Gravel
128 - 134 ft : Slightly Silty Sand
134 - 154 ft : Sand
154 - 163.5 ft : Slightly silty Sand
163.5 - 165 ft : Silty Sand
165 - 167.5 ft : Sandy Silt
167.5 - 174.5 ft : Sand
174.5 - 207 ft : Gravelly Sand
207 - 208 ft : Silt
208 - 209.5 ft : Sand
209.5 - 212.5 ft : Silty Sandy Gravel
212.5 - 229 ft : Silty Sandy Gravel
229 - 231 ft : Gravelly Silty Sand
231 - 247.4 ft : Silty Sandy Gravel
247.4 - 255 ft : Basalt



Fill	*Casing*	*Screen*
0 - 9.8 ft : 9-inch hole Cement Seal	0 - 238 ft : 4 inch 4" Sch 5 SS Cag.	
9.8 - 199 ft : 9-inch hole Med. Bentonite Chunks		
199 - 227.3 ft : 9-inch hole 1/4" Bentonite Pellets		
227.2 - 253.3 ft : 9-inch hole 20/40 Silica Sand		238 - 253 ft : 4 inch 4" Wire Wrap SS Screen .010 Slot
253.3 - 255 ft : 9-inch hole 20/40 Silica Sand	253 - 253.3 ft : 4 inch 4" SS End Cap	

255 ft : Borehole drilled depth

0 - 255 ft : 9-in. 8-5/8" Temp. CS Csg.

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **29Sep98**
Print Date: **28Dec98**

BECHTEL

299-E33-44 As-Built Diagram

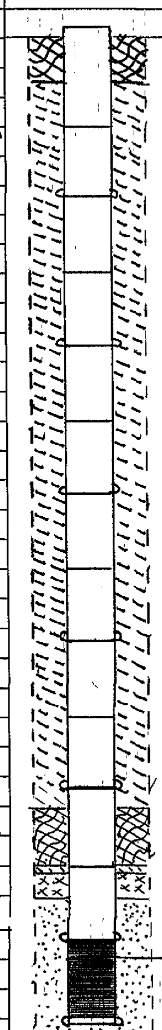
WELL SUMMARY SHEET

Start Date 06/03/04	Page 1 of 1
Finish Date: 8/5/04	
Well ID: C4259	Well Name: 299-E33-47
Location: East side of WMA-B/200 East Area	Project: RCRA/CERCLA drilling/FY2004
Prepared By: Jeffrey Weiss — Date: 8/5/04	Reviewed By: L.D. Walker — Date: 8/25/04
Signature: [signature]	Signature: [signature]

CONSTRUCTION DATA

Description
10 3/4" OD carbon steel temp. casing used.
6" ID SS304 protective casing +1.01 → Above permanent (cm)
4" ID SS304, sch.5 riser: +2.0' → 244.11'
Portland cement Grout: 0' → 11'
Granular Bentonite: 11' → 209.4
Portland Cement Grout: 209.4' → 224.1'
Granular Bentonite: 224.1' → 226.8'
All depths in feet below ground surface.
All temporary casing removed from ground.
3/8" Bentonite Pellets: 226.8' → 233.6'
10-20 mesh Colorado Silica Sand: 233.6' → 268.9'
4" ID SS304, sch.5, 0.020" slot well screen: 244.11' → 264.10'
4" ID SS304, sch 5 sump: 264.10' → 267.1'

Diagram:



Depth in Feet: 0, 40, 80, 120, 160, 200, 240, 280, 320

GEOLOGIC/HYDROLOGIC DATA

Graphic Log:

Lithologic Description
0'-3' SAND(S)
3'-13' Silty Sandy GRAVEL(msG)
13'-16' Sandy GRAVEL(sG)
16'-18' gravelly SAND(gS)
18'-20' SAND(S)
20'-30' silty sandy GRAVEL(msG)
30'-48' sandy GRAVEL(sG)
48'-211' SAND(S)
211'-213' silty SAND(mS)
213'-223' SILT(m)
223'-251' silty Sandy GRAVEL (msG)
251'-264' Sandy GRAVEL(sG)
264'-268.9' BASALT
TD=268.9' bgs
Static water = 248.01' bgs (08/05/04)

299-E33-47 As-Built Diagram

WELL SUMMARY SHEET

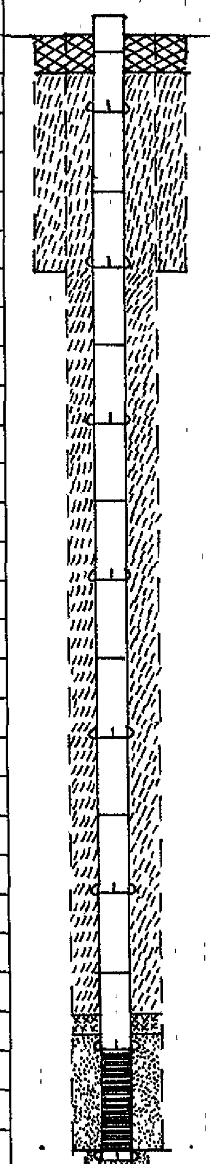
Start Date 08/5/04	Page 1 of 1
Finish Date 9/3/04	

Well ID. C4260	Well Name 299-E33-48
Location S. of WMA-B / 200 EAST	Project: RCRA / CERCLA DRILLING FY 2004
Prepared By Jess Hocking — Date. 8/30/04	Reviewed By: L.D. Walker — Date. 9/21/04
Signature. [signature]	Signature. [signature]

CONSTRUCTION DATA

Description
4" TP-304/304L sch 05s Riser +2.00' → 260.2'
4" TP-304/304L sch 05s 0.020" CONT. WIRE WRAP SCREEN 260.2' → 285.2'
4" TP-304/304L sch 05s Sump 285.2' → 288.2'
Type-I,II,V Portland Cement 0 → 10.3'
CETCO Granular Bentonite 10.3' → 250.2'
5/8" CETCO Bentonite Pellets 250.2' → 255.9'
Colorado 10-20 mesh Silica Sand 255.9' → 290.9'
Temporary Casing, 13 5/8" 0 → 60'
Temporary Casing, 10 3/4" 60 → 285'
NOTE: All Temporary casing has been removed from the ground. All depths reported in ft. below ground surface.

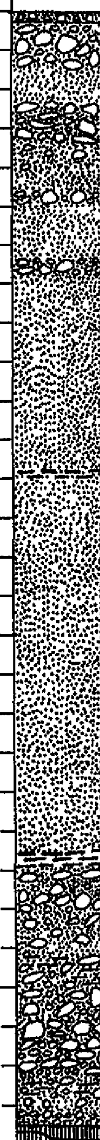
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 50, 100, 150, 200, 250

Graphic Log



Lithologic Description
0-1' Fill Material
1-14' sandy Gravel (sG)
14-16' Sand (S)
16-22' Sand (S)
22-34' Sandy Gravel (sG)
34-40' gravelly Sand (gS)
40-44' Sand (S)
44-49' sandy Gravel (sG)
49-63' Sand (S)
63-67' sandy Gravel (sG)
67-128' Sand (S)
128-129' sandy Silt (sM)
129-216.5' Sand (S)
216.5-217.5' Silt (M)
217.5-243' sandy Gravel (sG) to gravelly Sand (gS)
243-250' sl. silty gravelly Sand ((m)gS)
250-266' sandy Gravel (sG)
266-273' Gravel (G)
273-281' sl. silty gravelly Sand ((m)gS)
281-284' gravelly Sand (gS)
284-285.5' silty sandy gravel (msG)
285.5'-290' BASALT
TD=290.9' bgs
static water 265.23' bgs (08/31/04)

299-E33-48 As-Built Diagram

WELL SUMMARY SHEET

Start Date	4/30/04
Finish Date	08/09/04
Page	1 of 1
Well ID	C4261
Well Name	299-E33-49
Location	South of BX Tank Farm, 200 East
Project	2004 RCRA Drilling
Prepared By	Charlene Martinez
Date	08/11/04
Reviewed By	L.D. Walker
Date	8/25/04
Signature	Charlene Martinez
Signature	LD Walker

CONSTRUCTION DATA

Description

10-20 MESH SILICA SAND
288.4' → 258.6'

3/8" Sodium Bentonite Pellets
258.6' → 253.7'

Sodium Bentonite Crumbles
253.7' → 9.5'

Type I/II Portland Cement
9.5' → 0'

4" TP-304/304L sch. 05s Riser
+1.99' → 263.5'

4" TP-304/304L sch. 05s 0.020" CONT WIRE WRAP SCREEN
263.5' → 283.5'

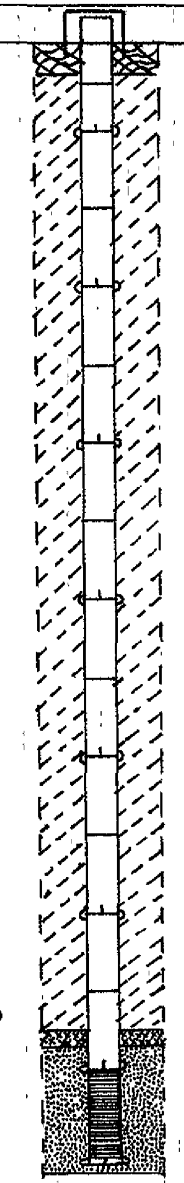
4" TP-304/304L sch 05s Sump
283.5' → 286.5'

6" ID protective casing (SS 304, Sch 5) set; +1.02' above permanent.

All depths in feet below ground surface.

All temporary casing (12") removed from ground

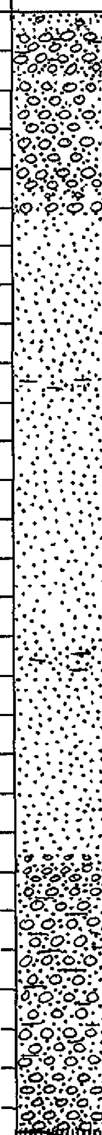
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 50, 100, 150, 200, 250

Graphic Log



Lithologic Description

0-5.5' Slightly Silty Gravelly SAND (m)gS
5.5'-13' Silty Sandy GRAVEL (msG)
13'-16' Gravelly SAND + Sandy GRAVEL
16'-17' SAND (S) 17'-45.5' Sandy GRAVEL
45.5'-48' Gravelly SAND (gS)
48'-51' Sandy GRAVEL (sG)
51'-93' SAND (S)
93'-98' Slightly Silty SAND (m)S
98'-163' SAND (S)
163'-171' Slightly Silty SAND (m)S
171'-217' SAND (S)
217'-217.3' Silty Sandy GRAVEL (msG)
217.3'-217.8' SAND (S)
217.8'-223' Sandy GRAVEL (sG)
223'-270' Silty Sandy GRAVEL (msG)
270'-273' Sandy Gravel (sG)
273'-283.5' Sandy Gravel (sG)
283.5'-288.8' Basalt
TD = 288.8' bgs
Static water 265.44' bgs (08/10/04)

299-E33-49 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	**Cable Tool**	Sample Method:	**Grab/Split Spoon**	WELL NUMBER:	**299-E33-334** TEMPORARY **B8810** WELL NO: **Not Allowed**
Drilling Fluid Used:	**water as needed**	Additives Used:	**None**	Coordinates: N	**Not documented**
Driller's Name:	**M. Wraspir**	WA State Lic Nr:	**1909**	Coordinates: E	**Not documented**
Drilling Company:	**Resonant Sonic Intl.**	Company Location:	**Woodland, Ca.**	Start Card #:	**Not Available**
Date Started:	**09Dec99**	Date Completed:	**05Jan00**	Elevation Ground Surface:	**Brass Marker**

Depth to Water: **263.85 ft** **30Dec99**
(Ground surface)

Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.5 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 34 ft : Sandy GRAVEL

34 - 44 ft : Gravelly SAND

44 - 47.5 ft : Sandy GRAVEL

47.5 - 123.5 ft : SAND

123.5 - 125 ft : Silty SAND

125 - 151.5 ft : SAND

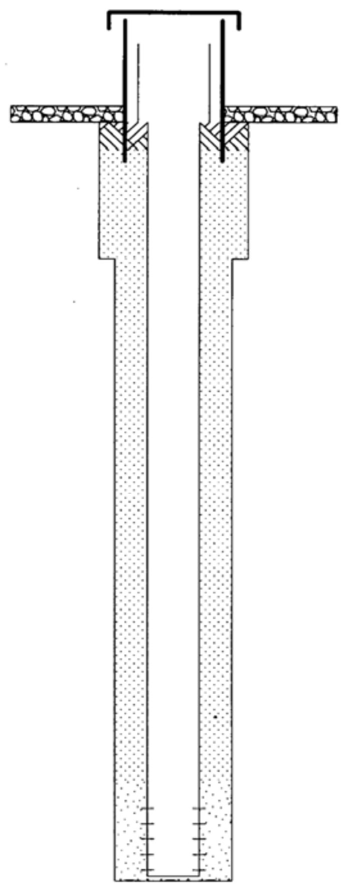
151.5 - 154 ft : Silty SAND

154 - 222.5 ft : SAND

222.5 - 233 ft : Sandy GRAVEL

233 - 269 ft : Silty Sandy GRAVEL

269 - 280 ft : Sandy GRAVEL



Fill	***Casing***	***Screen***
0 - 10.5 ft : 11-inch hole Cement Surface Seal	0 - 257.7 ft : 4 inch 4" SS Sch. 5 csg.	
10.5 - 51.5 ft : 11-inch hole Granular Bentonite		
51.5 - 247.4 ft : 8.62-inch hole Granular Bentonite		
247.4 - 284.1 ft : 8.62-inch hole 10/20 Silica Sand		257.7 - 282.72 ft : 4 inch 4" SS Wire Wrap Scrn. .020 Slot
284.1 - 285 ft : 8.62-inch hole Sluff	282.72 - 283.14 ft : 4 inch 4" SS Sch. 5 End Cap	

285 ft : Borehole drilled depth

0 - 51.5 ft : 11-in. Cable Tool 11" Temp. Csg.
51.5 - 280 ft : 8.62-in. Cable Tool 8-5/8" Temp. Csg.

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **07Mar00**
Print Date: **06Mar00**

299-E33-334 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-E33-335 B8811 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	N/A	Additives Used:	None	Coordinates: N	Not documented
Driller's Name:	M. Wrasplr	WA State Lic Nr:	1909	Coordinates: E	Not documented
Drilling Company:	Resonant Sonic Intl.	Company Location:	Woodland, Ca.	Start Card #:	R43391
Date Started:	02Dec99	Date Completed:	10Feb00	Elevation Ground Surface:	Brass Marker

Depth to Water: **264.4 ft 09Feb00**
(Ground surface)

Elevation of Reference Point: m

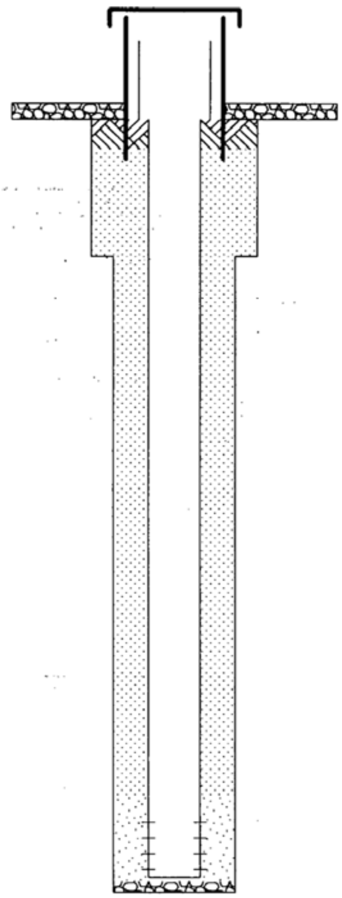
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.9 ft.**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 12 ft : Sandy GRAVEL
12 - 14 ft : SAND
14 - 14.5 ft : Sandy SILT
14.5 - 20 ft : Sandy GRAVEL
20 - 22 ft : Silty SAND
22 - 58 ft : Silty Sandy GRAVEL
58 - 219 ft : SAND
219 - 226 ft : Slightly Silty SAND
226 - 250 ft : Silty Sandy GRAVEL
250 - 280.5 ft : Sandy GRAVEL
280.5 - 286 ft : Basalt



Fill	*Casing*	*Screen*
0 - 10.9 ft : 12.25-inch hole Cement Surface Seal 10.9 - 50.4 ft : 12.25-inch hole Granular Bentonite	0 - 260.01 ft : 4 inch 4" SS Sch. 5 well csg.	
50.4 - 250.5 ft : 9-inch hole Granular Bentonite		
250.5 - 281.9 ft : 9-inch hole 10/20 Silica Sand 281.9 - 286 ft : 9-inch hole Slough	280.03 - 280.43 ft : 4 inch 4" SS End Cap	260.01 - 280.03 ft : 4 inch 4" SS Wire Wrap .020 Slot Scrn.

286 ft : Borehole drilled depth

0 - 50.4 ft : 12.25-in. 11-3/4" CS Temp. Csg. Air Rotary/Sonic Assist to 50 ft.
50.4 - 286 ft : 9-in. 8-5/8" Csg Temp. csg. Air Rotary fr. 50.4 to 286 ft.

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	07Mar00
Print Date:	06Mar00

299-E33-335 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary Drl & Drive	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-E33-337
Drilling Fluid Used:	Air	Additives Used:	None	TEMPORARY C3390 WELL NO:	Not Allowed
Driller's Name:	Mike Gomez	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	RSI	Company Location:	Woodland, Ca.	Coordinates: E	Not documented
Date Started:	10Jul01	Date Completed:	03Aug01	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: **259.92 ft 03Aug01**
(Ground surface)

GENERALIZED STRATIGRAPHY **Geologist's Log**

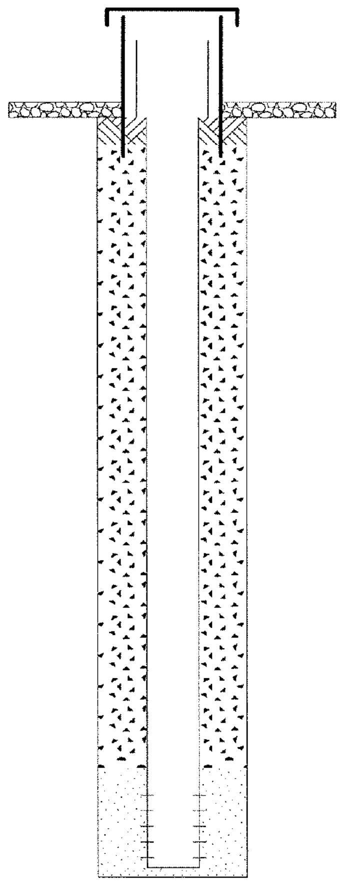
Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.1 ft**

Type of Surface Seal: **4x4 Concrete Pad**

0 - 18 ft : sandy gravel (sg)
18 - 35 ft : Sand (S)
35 - 37 ft : gravelly sand (gs)
37 - 45 ft : Sand (S)
45 - 60 ft : sandy gravel (sg)
60 - 125 ft : Sand (S)
125 - 138 ft : silty sand (ms)
138 - 178 ft : Sand (S)
178 - 185 ft : Slightly Silty Sand
185 - 189 ft : silty sand (ms)
189 - 195 ft : Gravelly sand (Gs)
195 - 205 ft : Sand (S)
205 - 212 ft : silty sand (ms)
212 - 215 ft : Sand (S)
215 - 226 ft : Gravelly Sand (gs)
226 - 228 ft : Sandy gravel (Sg)
228 - 230 ft : Gravel (G)
230 - 259.5 ft : Sandy gravel (Sg)
259.5 - 265 ft : Gravel (G) trace of sand
265 - 281 ft : Sandy Gravel (Sg)
281 - 286 ft : Basalt



286 ft : Borehole drilled depth

0 - 286 ft : 11-in. Air Rotary Drl & Drive
10-3/4" CS Temp csg

Fill	*Casing*	*Screen*
0 - 10.1 ft : 11-inch hole Cement Surface Seal	0 - 255.36 ft : 4 inch 304L SS sch 5 csg	
10.1 - 239.6 ft : 11-inch hole Bentonite crumbles		
239.6 - 245.1 ft : 11-inch hole 1/4" & 3/8" Bentonite Pellets		255.36 - 280.39 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
245.1 - 282.4 ft : 11-inch hole 10/20 Silica Sand	280.39 - 282.4 ft : 4 inch 304L SS Sump	
282.4 - 283.6 ft : 11-inch hole 10/20 Silica Sand		
283.6 - 286 ft : 11-inch hole 1/4" COATED Bentonite Pellets		

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **17Oct01**
Print Date: **17Oct01**

BECHTEL

299-E33-337 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	**Cable Tool**	Sample Method:	**Grab/Split Spoon**	WELL NUMBER:	**299-E33-338** **C3391** TEMPORARY WELL NO: **Not Allowed**
Drilling Fluid Used:	**none**	Additives Used:	**None Documented**	Coordinates: N	**Not documented**
Driller's Name:	**Gary Howell**	WA State Lic Nr:	**1930**	Coordinates: E	**Not documented**
Drilling Company:	**RSI**	Company Location:	**Woodland, Ca.**	Start Card #:	**R037814**
Date Started:	**23Jul01**	Date Completed:	**31Aug01**	Elevation Ground Surface:	

Depth to Water: **254.24 ft** **04Sep01**
(Ground surface)

GENERALIZED STRATIGRAPHY **Geologist's Log**

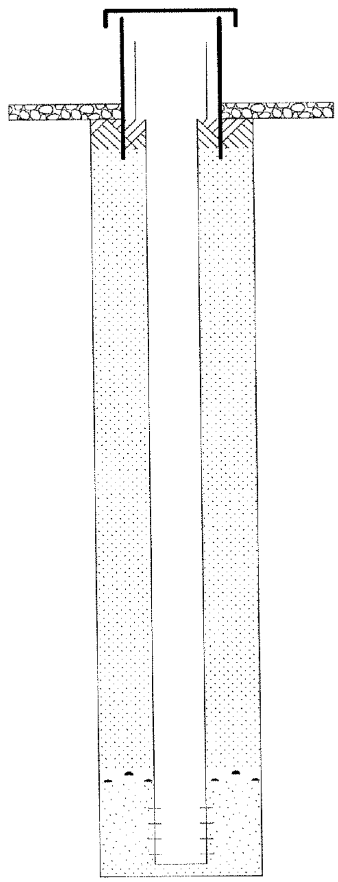
Elevation of Reference Point: **m**

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.6 ft**

Type of Surface Seal: **4x4 Concrete Pad**

0 - 12.5 ft : Silty Sandy Gravel (msG)
12.5 - 14.5 ft : Silty Gravelly Sand (mgS)
14.5 - 15 ft : Silt lens
15 - 16.5 ft : Silty Gravelly Sand (mgS)
16.5 - 20 ft : Silty Sand (mS)
20 - 31 ft : Silty Sandy Gravel (msG)
31 - 35.5 ft : Silty Sand (mS)
35.5 - 51.5 ft : Silty Sandy Gravel (msG)
51.5 - 52 ft : Silt lens
52 - 57.7 ft : Silty Sand (mS)
57.7 - 66.3 ft : Sand (S)
66.3 - 71.3 ft : Silty Sand (mS)
71.3 - 72.3 ft : Sand (S) lens
72.3 - 94 ft : Silty Sand (mS)
94 - 104.5 ft : Slightly Silty Gravelly Sand (mgS)
104.5 - 114 ft : Silty Sand (mS)
114 - 127.6 ft : Sand (S)
127.6 - 136 ft : Silty Sand (mS)
136 - 143.2 ft : Sand (S)
143.2 - 167 ft : Silty Sand (mS)
167 - 169.5 ft : Sand (S)
169.5 - 175 ft : Silty Sand (mS)
175 - 203.5 ft : Sand (S) w/ silt lenses
203.5 - 212.5 ft : Slightly Gravelly Sand (gS)
212.5 - 216 ft : Sand (S)
216 - 218 ft : Silty Sand (mS)
218 - 222.4 ft : Silt to Sandy Silt (m)
222.4 - 258 ft : Silty Sandy Gravel (msG)
258 - 271 ft : Sandy Gravel (sG)
271 - 275.75 ft : Basalt



Fill	*Casing*	*Screen*
0 - 10.6 ft : 12-inch hole Cement Surface Seal	0 - 250.9 ft : 4 inch 304L SS sch 5 csg	
10.6 - 236 ft : 12-inch hole Granular Bentonite		
236 - 241 ft : 12-inch hole Bentonite Pellets		250.9 - 270.9 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
241 - 271.32 ft : 12-inch hole 10/20 Silica Sand	270.9 - 271.32 ft : 4 inch 304L SS Sump	
271.32 - 271.5 ft : 12-inch hole 10/20 Silica Sand		
271.5 - 275.6 ft : 12-inch hole 1/4" Bentonite Hole Plug		
275.6 - 275.75 ft : 12-inch hole Slough		

275.75 ft : Borehole drilled depth

0 - 275.75 ft : 12-in. Cable Tool 11-3/4" CS Temp csg

Report Form: WELLS Project File: WELLS.GPJ

Drawing By: **JEA**
Reference: **Hanford Wells**
Revision: **0**
Revision Date: **19Oct01**
Print Date: **19Oct01**

299-E33-338 As-Built Diagram

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	**Air Rotary Drl & Drive**	Sample Method:	**Grab/Split Spoon**	WELL NUMBER:	**299-E33-339** C3392 TEMPORARY WELL NO: **Not Allowed**
Drilling Fluid Used:	**Air**	Additives Used:	**None**	Coordinates: N	**Not documented**
Driller's Name:	**Mike Gomez**	WA State Lic Nr:	**Data not available**	Coordinates: E	**Not documented**
Drilling Company:	**RSI**	Company Location:	**Woodland, Ca.**	Start Card #:	**R037814**
Date Started:	**17Jul01**	Date Completed:	**17Aug01**	Elevation Ground Surface:	

Depth to Water: **261.27 ft** **21Aug01**
(Ground surface)

Elevation of Reference Point: **m**

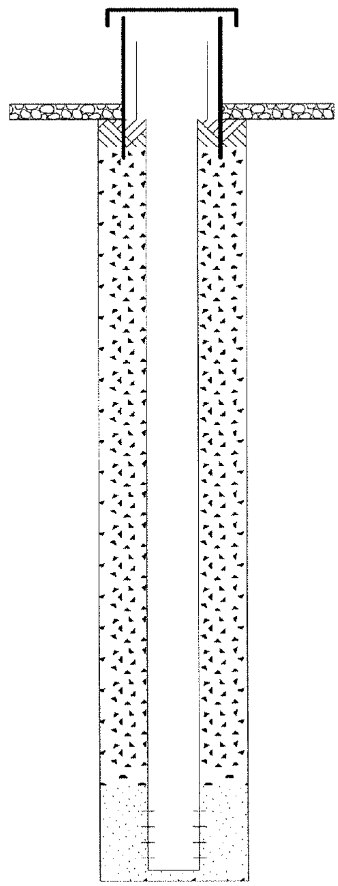
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **10.4 ft**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 6 ft : Backfill material
6 - 15 ft : Silty Sandy Gravel (msG)
15 - 18.5 ft : Slightly Silty Sandy Gravel
18.5 - 20 ft : Silt Lens
20 - 23 ft : Sand (S)
23 - 25 ft : Silty Sand (mS)
25 - 30 ft : Slightly Silty Gravelly Sand with silt lens at 28 ft
30 - 34 ft : Silty Sandy Gravel (msG)
34 - 37 ft : Silty Sand (mS)
37 - 37.5 ft : Silt Lens
37.5 - 55 ft : Silty Sandy Gravel (msG)
55 - 56 ft : Sandy Gravel (sG)
56 - 223 ft : Sand (S)
223 - 225 ft : gravelly Sand (gS)
225 - 235 ft : Sandy Gravel (sG)
235 - 250 ft : Silty Sandy Gravel (msG)
250 - 252 ft : Gravel (G)
252 - 253.5 ft : Silt (m)
253.5 - 254 ft : slightly silty sandy Gravel (msG)
254 - 260 ft : Gravel (G)
260 - 275 ft : sandy Gravel (sG)
275 - 279 ft : silty Grael (mG)
279 - 285.44 ft : Basalt



Fill	*Casing*	*Screen*
0 - 10.4 ft : 11-inch hole Cement Surface Seal	0 - 259.4 ft : 4 inch 304L SS sch 5 csg	
10.4 - 244.35 ft : 11-inch hole Bentonite Crumbles		
244.35 - 249.7 ft : 11-inch hole 1/4" & 3/8" Bentonite Pellets		259.4 - 279.3 ft : 4 inch 304L SS Wire Wrap .020 slot scrn
249.7 - 281.4 ft : 11-inch hole 10/20 Silica Sand	279.3 - 281.4 ft : 4 inch 304L SS Sump	
281.4 - 283.1 ft : 11-inch hole 10/20 Silica Sand		
283.1 - 285.44 ft : 11-inch hole 3/8" COATED Bentonite Pellets		

285.44 ft : Borehole drilled depth

0 - 285.44 ft : 11-in. Air Rotary drl & Drive 10-3/4" CS Temp csg

Drawing By:	**JEA**
Reference:	**Hanford Wells**
Revision:	**0**
Revision Date:	**17Oct01**
Print Date:	**19Oct01**

299-E33-339 As-Built Diagram

Appendix C

Stratigraphic Information of Groundwater Monitoring Wells at Waste Management Area B-BX-BY

Appendix C

Stratigraphic Information of Groundwater Monitoring Wells at Waste Management Area B-BX-BY

The geologic cross sections and subsurface information, pertaining to individual wells, illustrate the available specific and detailed lithologic, geophysical and soils information that are considered most useful in understanding subsurface factors that control contaminant migration at WMA B-BX-BY. Although there is some question on the age of the basal gravels at the base of the soil column, (WMP-26333, 2005; BHI-01607, 2002; WMP-18472, 2003; PNNL-13199, 2000; PNNL-13827, 2002; HNF-5507, 2000; BHI-00184; RPP-23748, 2006; WHC-SD-EN-TI-012, 1992), the unit is largely an unconsolidated and highly permeable boulder gravel. From the view of groundwater monitoring, this equates to an open, clean, highly permeable aquifer with little need for well maintenance, provided well construction parameters match the aquifer properties. Because there is lack of agreement on whether this lower unit is basal Hanford fm, commonly known as the H3 or a Plio-Pleistocene unit, no formation names are provided on the sections. The detail and scope of the geologic sections are presented to provide a basis for better understanding the role sediments may play in contaminant migration. These detailed plots assist the development of future conceptual models and the plans pertaining to sample acquisition needs of future drilling.

The following brief discussion of stratigraphic relationships for the unconsolidated sediments is based on recent drilling results reported in WMP-26222 (2005). This borehole package was prepared in conjunction with well site geologists that logged eight wells recently installed on the south side of the WMA and is the most recent information from direct sediment sampling for the local area. More detailed descriptions can be found in the references listed previously.

In this area, unconsolidated Hanford formation sediments overlie the fine-grained tholeiitic basalt of the Elephant Mountain Member of the Saddle Mountains Basalt Formation. In general, the Hanford formation consists of pebble to boulder gravels, fine- to coarse-grained sands and interbedded silts. These deposits are divided into three facies consisting of a lower gravel sequence termed the H3, a middle sand-dominated sequence or H2 and a Hanford formation upper gravel sequence or H1 sequence (WHC-SD-EN-TI-290, Rev. 0). At WMA B-BX-BY, all three units are present in the undisturbed sediment package, which is approximately 91 meters (300 feet) at the thickest. Under the tank farms, the backfill is about 10 meters (35 feet) thick. Where the ground is undisturbed, the upper gravel sequence is overlain by a thin veneer of eolian sand, up to 1 meter (3 feet) thick.

The following pages contain logplots and well-to-well cross sections within WMA B-BX-BY. Borehole geologic data were assembled and entered into the Hanford Borehole Geologic Information System (HBGIS) as the first step in this process. HBGIS is a web-based relational database system that provides systematic entry, management and dissemination tools for borehole geologic data with configuration control (PNNL-15362). The HBGIS website provides a graphical user interface to browse and download the raw data used to generate the logplots and construct the geologic cross sections. It is located at http://hbgis.emsl.pnl.gov/HBGIS/login.jsp, and can be accessed from within the Hanford Local Area Network (HLAN). First-time users are required to obtain a user name from the website administrator, Robert D. Mackley (rob.mackley@pnl.gov).

The logplots present the major relevant and diagnostic variables for a specific well in a single plot – a holistic view of the data rather than multiple independent plots. These data come from various hard-copy and electronic sources and may include: driller's logs, geologist logs, lab analysis of particle size, particle lithology and/or mineralogy, lab analysis of moisture and calcium carbonate, soil chemistry (e.g., NO_3), and borehole geophysical logs. Further information can be found in the individual logplot footnotes. It is important to note that the lithology data from the driller and geologist logs were systematically translated into electronic form according to standardized and reproducible operating procedures (PNNL-MA-567).

The four cross sections contain profiles of lithology and one or more key variables useful for interpreting the geology for each well. Interpreted contacts for the five major lithofacies (upper gravelly, middle sandy, fine-grained, lower gravelly, and basalt) are called out when identifiable. Major lithofacies contacts that are uncertain and contrasting sub-lithofacies units (e.g., 5-ft sandy subunit within a 20-ft gravelly lithofacies) are symbolized with dashed lines.

The appendix is organized with the logplots in order of well name: 299-E32-9, 299-E32-10, 299-E33-9, 299-E33-18, 299-E33-22, 299-E33-23, 299-E33-24, 299-E33-34, 299-E33-38, 299-E33-40, 299-E33-41, 299-E33-44, 299-E33-45, 299-E33-47, 299-E33-339, C3103, and C3104. Next, are the cross sections in the following order: Plate 1 (A-A') northern west-to-east transect, Plate 2 (B-B') north-to-south transect, Plate 3 (C-C') southern west-to-east transect, and Plate 4 (D-D') northwest-to-southeast transect.

References

BHI-01607. 2002. *Borehole Summary Report for Boreholes C3103 and C3104, and Drive Casings C3340, C3341, C3342, C3343, and C3344, in the 216-B-38 Trench and 216-B-7A Crib, 200-TW-2 Tank Waste Group Operable Unit*. ME Todd, and C Trice, Bechtel Hanford Inc., Richland, Washington.

BHI-00184. 1995. *Miocene-to-Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*. KA Lindsey, Bechtel Hanford, Inc., Richland, Washington.

PNNL-15362. 2005. *Hanford Borehole Geologic Information System (HBGIS) User's Guide for Viewing and Downloading Data*. GV Last, RD Mackley, and VR Saripalli, Pacific Northwest National Laboratory, Richland, Washington.

HNF-5507. 2000. *Subsurface Conditions Description of the B-BX-BY Waste Management Area*. MI Wood, TE Jones, R Schalla, BN Bjornstad, and SM Narbutovskih, CH2M HILL Hanford Group, Inc., Richland, Washington.

WHC-SD-EN-TI-290, Rev. 0. 1994. *Geologic Setting of the Low-Level Burial Grounds*. KA Lindsey, JL Slate, GK Jaeger, KJ Swett, and RB Mercer, Westinghouse Hanford Company, Richland, Washington.

PNNL-13199. 2000. *Borehole Data Package for Wells 299-E33-334 and 299-E33-335 at Single-Shell Tank Waste Management Area B-BX-BY*. DG Horton, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13827. 2002. *Borehole Data Package for Calendar year 2001 RCRA Wells at Single-Shell Tank Waste Management Area B-BX-BY*. DG Horton, Pacific Northwest National Laboratory, Richland, Washington.

PNL-MA-567. 1994, as revised. *Procedures for Ground-Water Investigations.* Pacific Northwest National Laboratory, Richland, Washington.

RPP-23748. 2006. *Geology, Hydrogeology, Geochemistry, and Mineralogy Data Package for the Single-Shell Tank Waste Management Area at the Hanford Site*. SP Reidel, CH2M HILL Hanford, Inc., Richland, Washington.

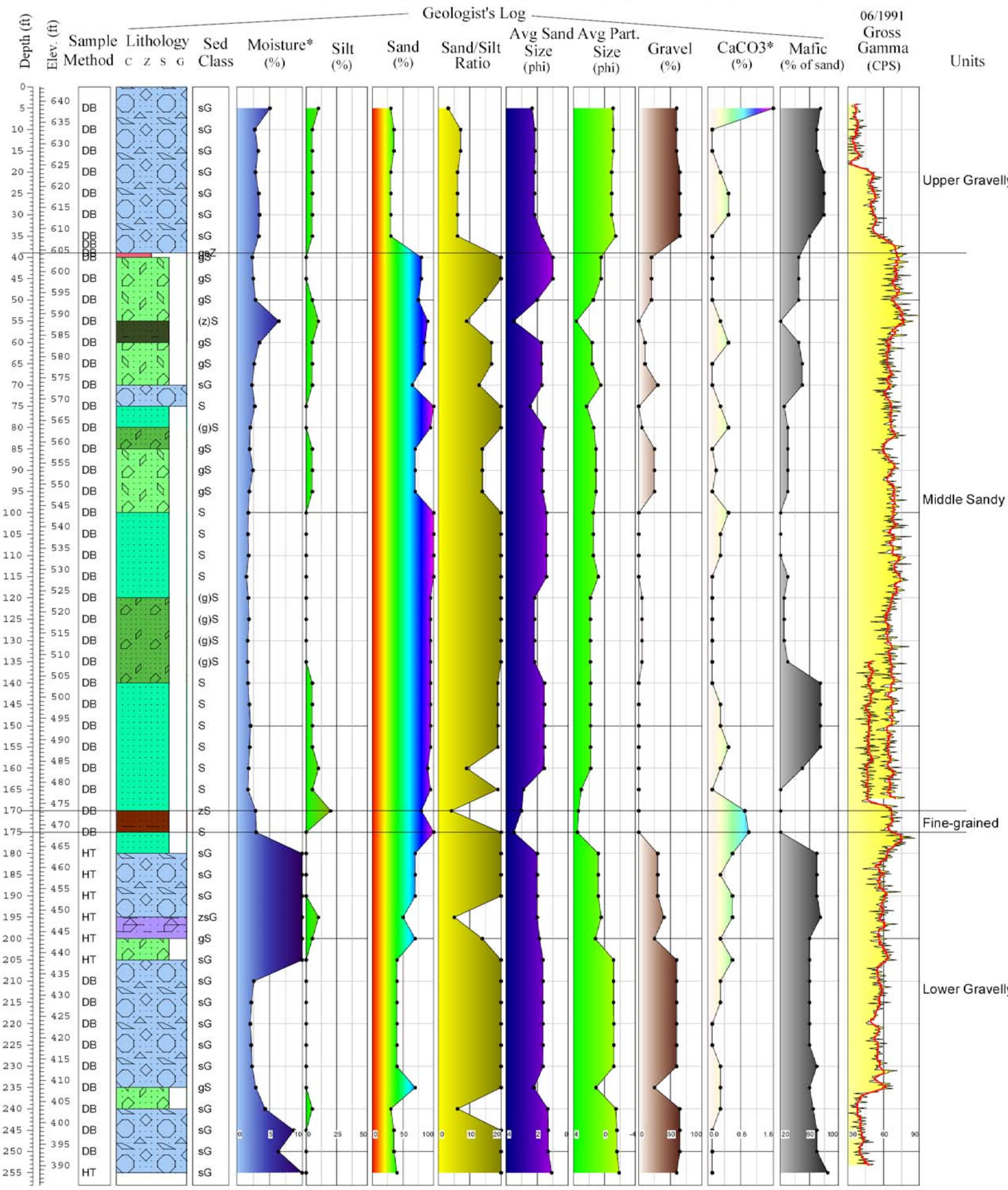
WHC-SD-EN-TI-012, Rev. 1. 1992. *Interim-Status Groundwater Monitoring Plan for the Single-Shell Tanks*. JA Caggiano and SM Goodwin, Westinghouse Hanford Company, Richland, Washington.

WMP-18472, Rev. 0. 2003. *Calendar Year 2003 RCRA Groundwater Monitoring Well Summary Report*. CR Martinez, Fluor Hanford, Richland, Washington.

WMP-26333, Rev. 0. 2005. *Borehole Summary Report for Six CERCLA Wells Drilled in the 200-UP-1 and 200-ZP-1 Operable Units, and Six RCRA Wells Drilled in the A-AX, B-BX, and U WMA; CY 2004-2005*. Prepared by J Weiss, Freestone Environmental Services, Inc., and LD Walker, Fluor Hanford, Inc., for the U.S. Department of Energy, Richland, Washington.

Borehole ID A4837 | **Well Number** 299-E32-9

Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
137741.69	572795.11	643.3	254.6	5/22/1991



C Z S G — CLAY SILT SAND GRAVEL — Increasing Size →

( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

rdm_B_BX_BY_FY06_23

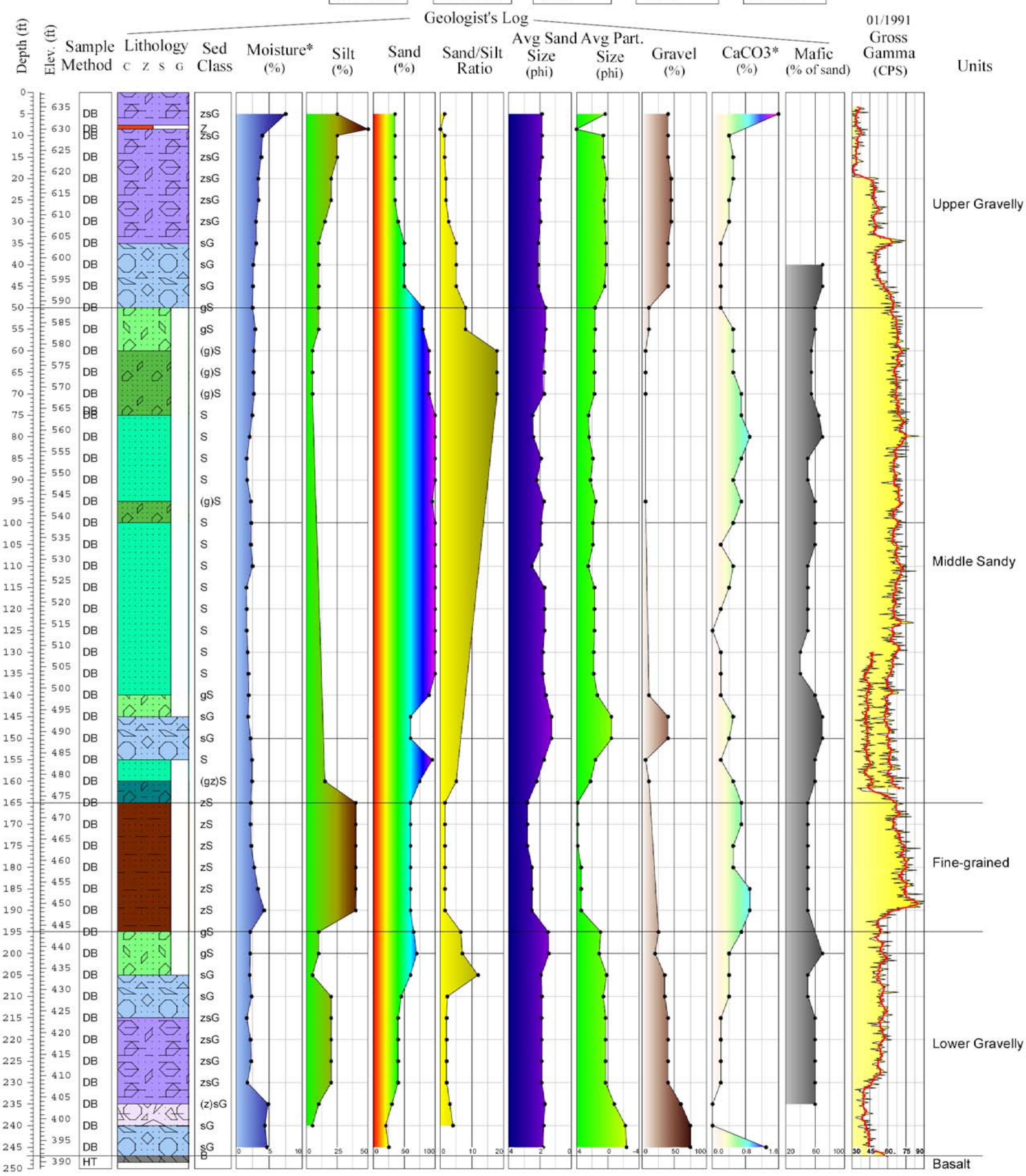
Page 1 of 1

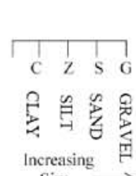
Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html)

Geologist's Log and lab moisture and CaCO3 data are from WHC-SD-EN-DP-044 Rev. 0 and are depth-referenced to the 1991 ground surface elevation, just the same as the depth-elevation scale bar on the left side of the plot.
The 1991 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

Borehole ID A5432 **Well Number** 299-E32-10

Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
137741.69	572951.69	638.4	248.5	1/3/1992





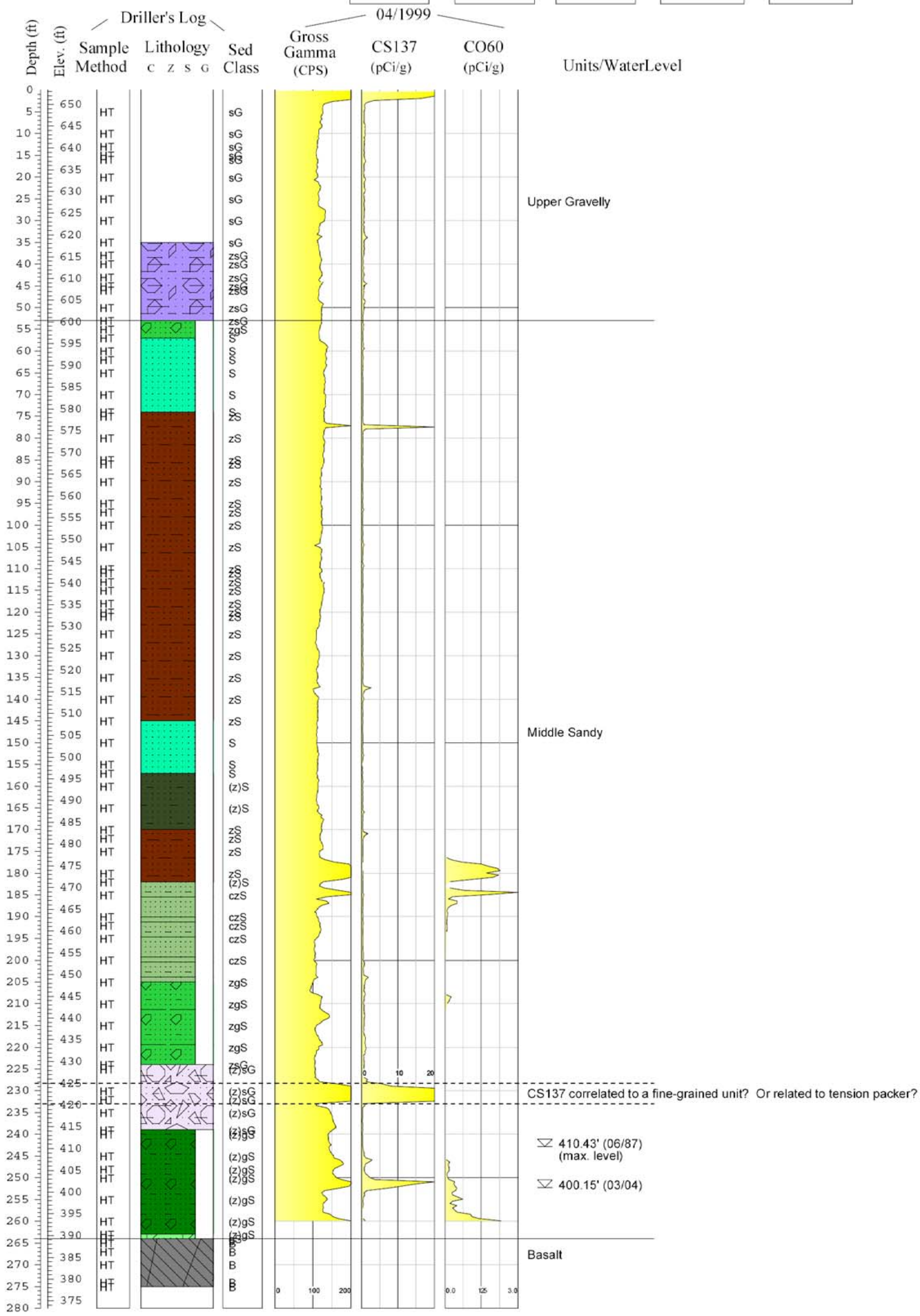
( ) = "slightly" modifier   Ex: (z)sG = slightly silty sandy gravel

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html)

Geologist's Log and lab moisture and CaCO3 data from WHC-SD-EN-DP-049 Rev. 0 and are depth-referenced to the 1991 ground surface elevation.
The 1991 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

rdm_B_BX_BY_FY06_23
Page 1 of 1

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
A4873	299-E33-9	137485.878	573646.833	653.3	275.0	06/28/1949



C Z S G
CLAY SILT SAND GRAVEL
Increasing Size →

( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

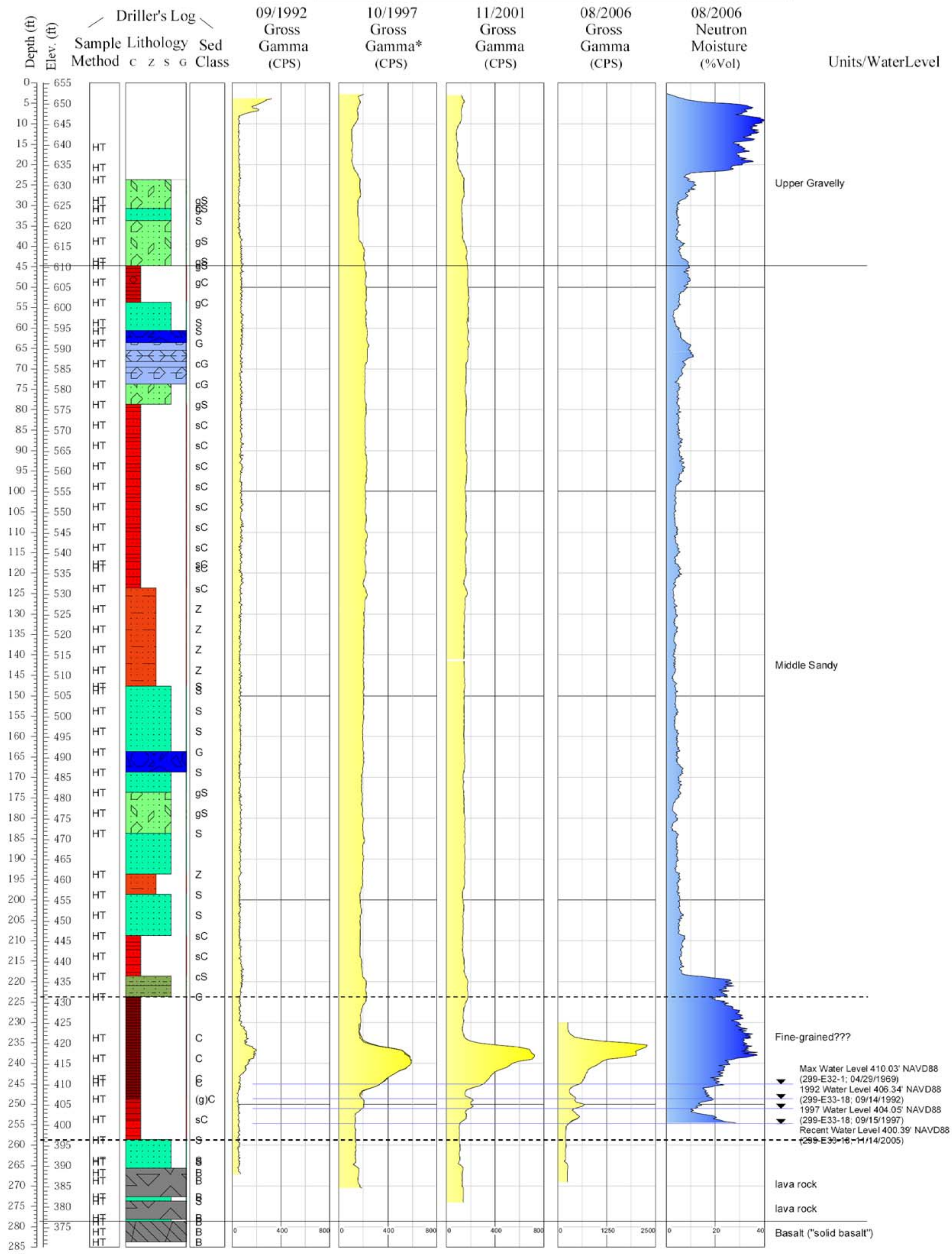
rdm_B_BX_BY_FY06_23
Page 1 of 1

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is estimated ground surface (undated, but pre-1993) from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html). This may or may not be the same ground surface elevation as existed originally at time of drilling in 1949, but is the earliest and most traceable survey available.

Driller's Log data are from PNNL Sigma V Well Log Library and are depth-referenced to the (undated but pre-1993) ground surface elevation reported in Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0).
The 1999 geophysical logs are from a Sigma Plot file emailed to Rob D. Mackley from Rick McCain (Stoller) on 02/09/2006. The depths have been adusted -.88' to adjust for the difference between the top of casing (654.17' NAVD88) surveyed in 1994 (HWIS) and the pre-1993 estimated ground surface (653.29' NAVD88) reported in Ledgerwood (1993).
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

Borehole ID A4844   **Well Number** 299-E33-18

Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
137386.064	575779.166	655.22	275	05/29/1947



C Z S G — CLAY SILT SAND GRAVEL — Increasing Size →

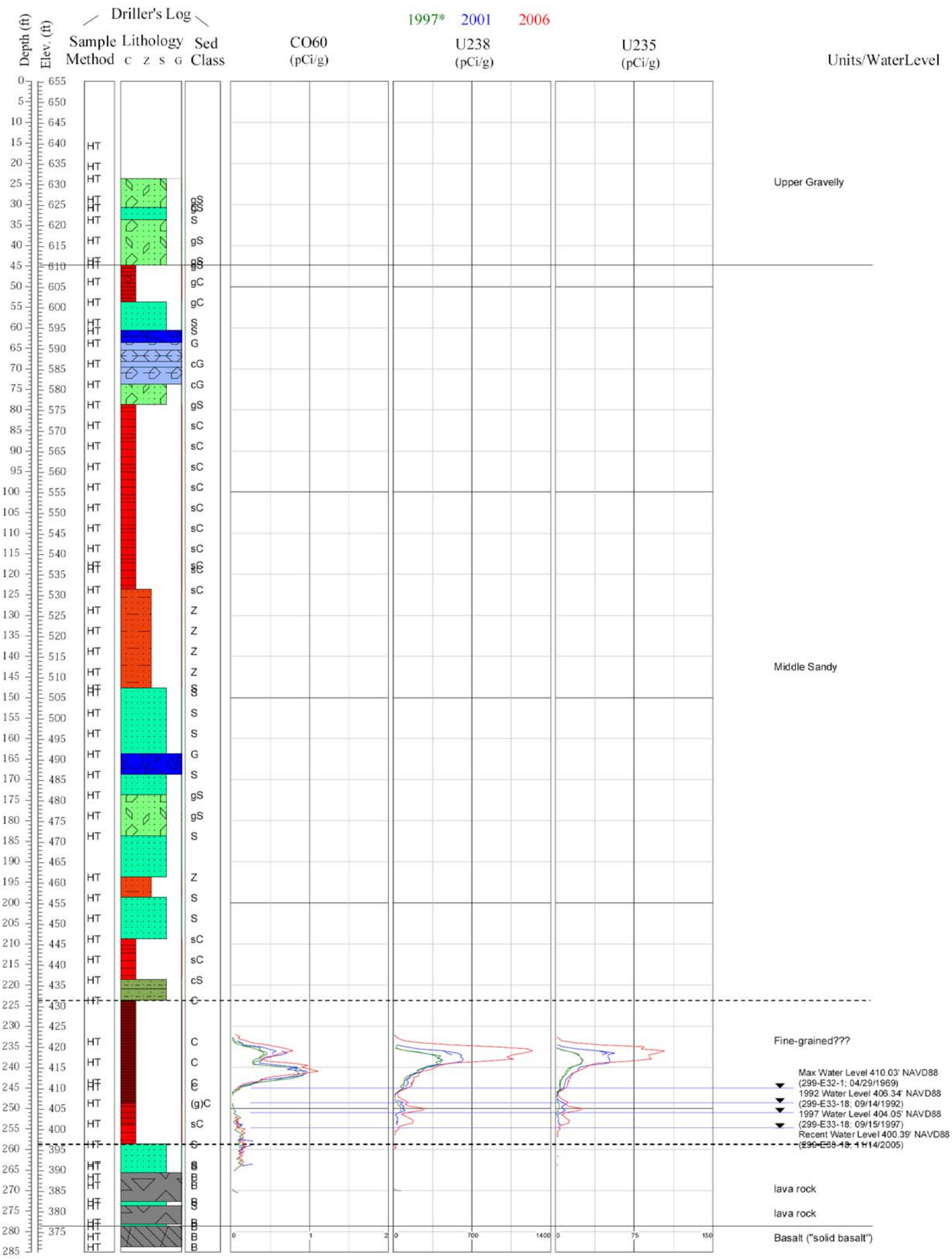
( ) = "slightly" modifier   Ex: (z)sG = slightly silty sandy gravel

rdm_B_BX_BY_FY06_23

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is top of casing surveyed in 1993 (HWIS).
Driller's Log data are from Sigma V Well Log Library, PNNL, and were depth-adjusted +7.27' to adjust for the difference between the 1950 ground surface (brass cap) of 646.55' (NAVD88; unpub. historical survey) and the top of casing measured in 1993 of 655.22' (NAVD88; from HWIS).
The 1992 geophysical log is from the PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and were depth-adjusted +0.13' to adjust for the difference between top of casing (655.351' NAVD88) surveyed in 1992 (Ledgerwood, 1993; WHC-SD-ER-TI-007 Rev. 0) and top of casing (655.22' NAVD88) surveyed in 1993 (HWIS). The 1997, 2001, and 2006 geophysical logs are from the PNNL Borehole Log database (see above), Stoller's website (http://www.gjo.doe.gov/programs/hanf/), and email from Rick McCain (09/18/06), respectively. All are depth-referenced to top of casing elevation (655.22' NAVD88) reported by a civil survey done in 1993 (HWIS), the same as the depth-elevation scale on left of logplot.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

* "Uncorrected" geophysical log, meaning the depth-adjustment factor of 0.98852 performed by R. Randall of Three Rivers Scientific, initially done to adjust for incorrect depths of the logging unit based upon depths calibrated in 299-E33-17 (see RLS Log Header for a more complete discussion of the original depth correction), was removed. The "corrected" depths were divided by 0.98852 in order to bring them back to an "un-corrected" state. This has an effect of bringing depths for the peak in the spectral logs down several feet, more in line with the 1992 and 2001 logs.

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
A4844	299-E33-18	137386.064	575779.166	655.22	275	05/29/1947



C Z S G — CLAY SILT SAND GRAVEL — Increasing Size →

( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

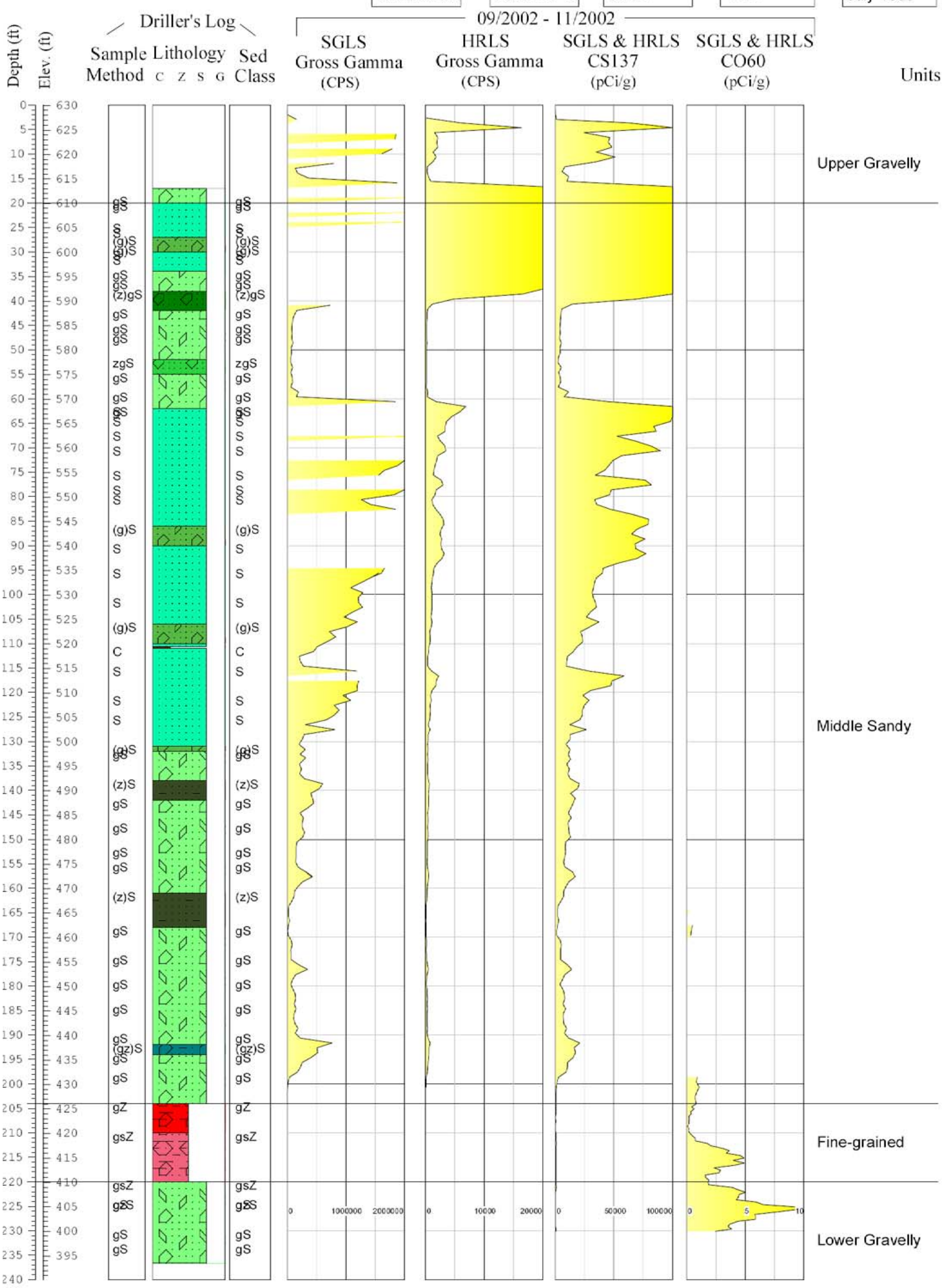
rdm_B_BX_BY_FY06_23

Page 2 of 2

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is top of casing surveyed in 1993 (HWIS).
Driller's Log data are from Sigma V Well Log Library, PNNL, and were depth-adjusted +7.27' to adjust for the difference between the 1950 ground surface (brass cap) of 646.55' (NAVD88; unpub. historical survey) and the top of casing measured in 1993 of 655.22' (NAVD88; from HWIS).
The 1997, 2001, and 2006 geophysical logs are from the PNNL Borehole Log database (see above), Stoller's website (http://www.gjo.doe.gov/programs/hanf/), and email from Rick McCain (09/18/06), respectively. All are depth-referenced to top of casing elevation (655.22' NAVD88) reported by a civil survey done in 1993 (HWIS), the same as the depth-elevation scale on left of logplot.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

* "Uncorrected" geophysical log, meaning the depth-adjustment factor of 0.98852 performed by R. Randall of Three Rivers Scientific, initially done to adjust for incorrect depths of the logging unit based upon depths calibrated in 299-E33-17 (see RLS Log Header for a more complete discussion of the original depth correction), was removed. The "corrected" depths were divided by 0.98852 in order to bring them back to an "un-corrected" state. This has an effect of bringing depths for the peak in the spectral logs down several feet, more in line with the 1992 and 2001 logs.

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
A6856	299-E33-22	137660.792	573624.745	630.1	234	July 1965



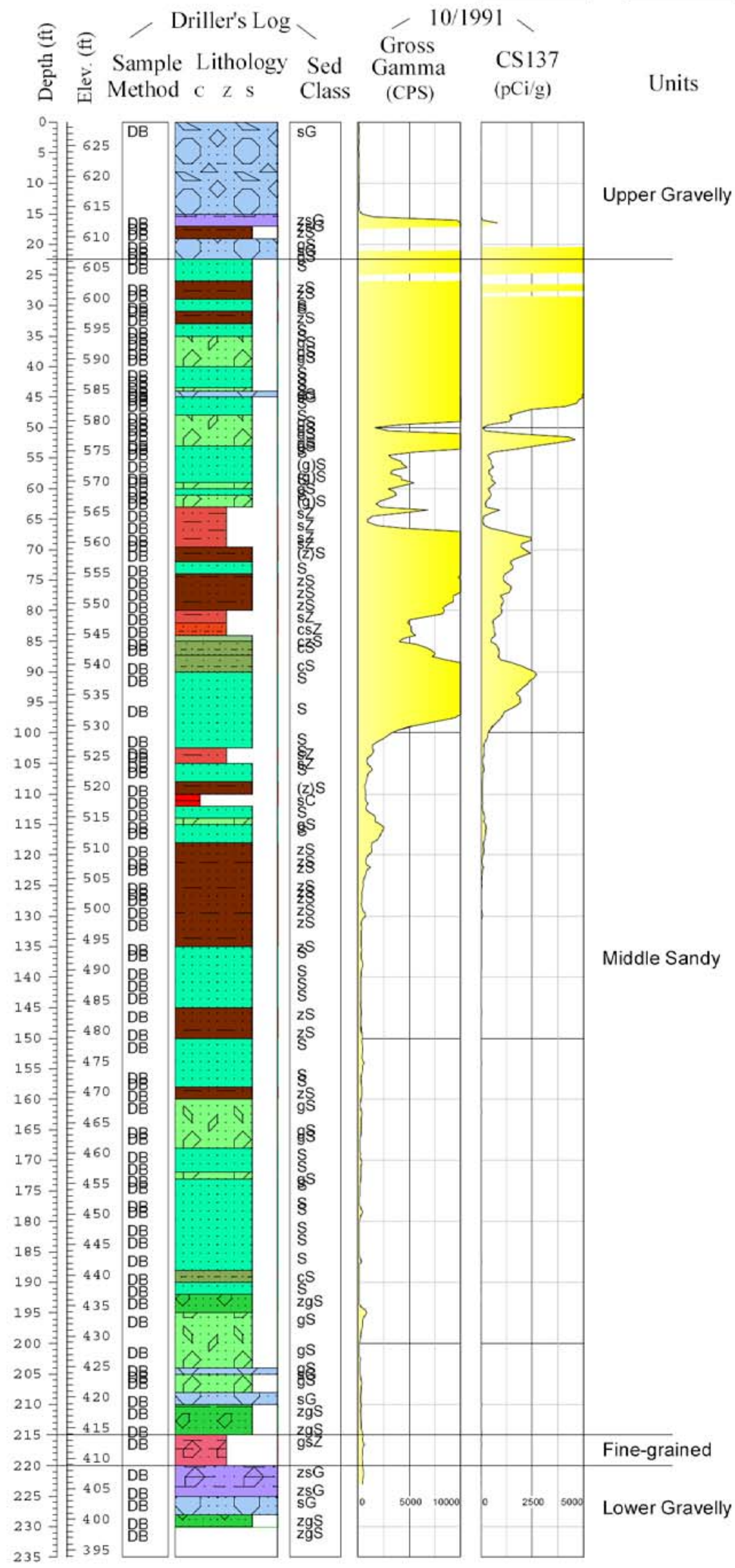
C Z S G
CLAY SILT SAND GRAVEL
Increasing Size →

( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html). This may or may not be the same ground surface elevation as existed originally at time of drilling in 1965, but is the earliest and most traceable survey available.
Driller's Log data are from PNNL Sigma V Well Log Library and are depth-referenced to the (undated but pre-1993) ground surface elevation reported in Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0).
The geophysical logs are from Rick McCain at Stoller. They were depth-adjusted -4.4' to adjust for the difference between top of casing (634.5' NAVD88) surveyed in 1993 (HWIS) and pre-1993 estimated ground surface reported in Ledgerwood (630.1' NAVD88).
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

rdm_B_BX_BY_FY06_23
Page 1 of 1

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
A6857	299-E33-23	137695.139	573617.061	628.8	230	08/19/1965



C Z S G
CLAY SILT SAND GRAVEL
Increasing Size →

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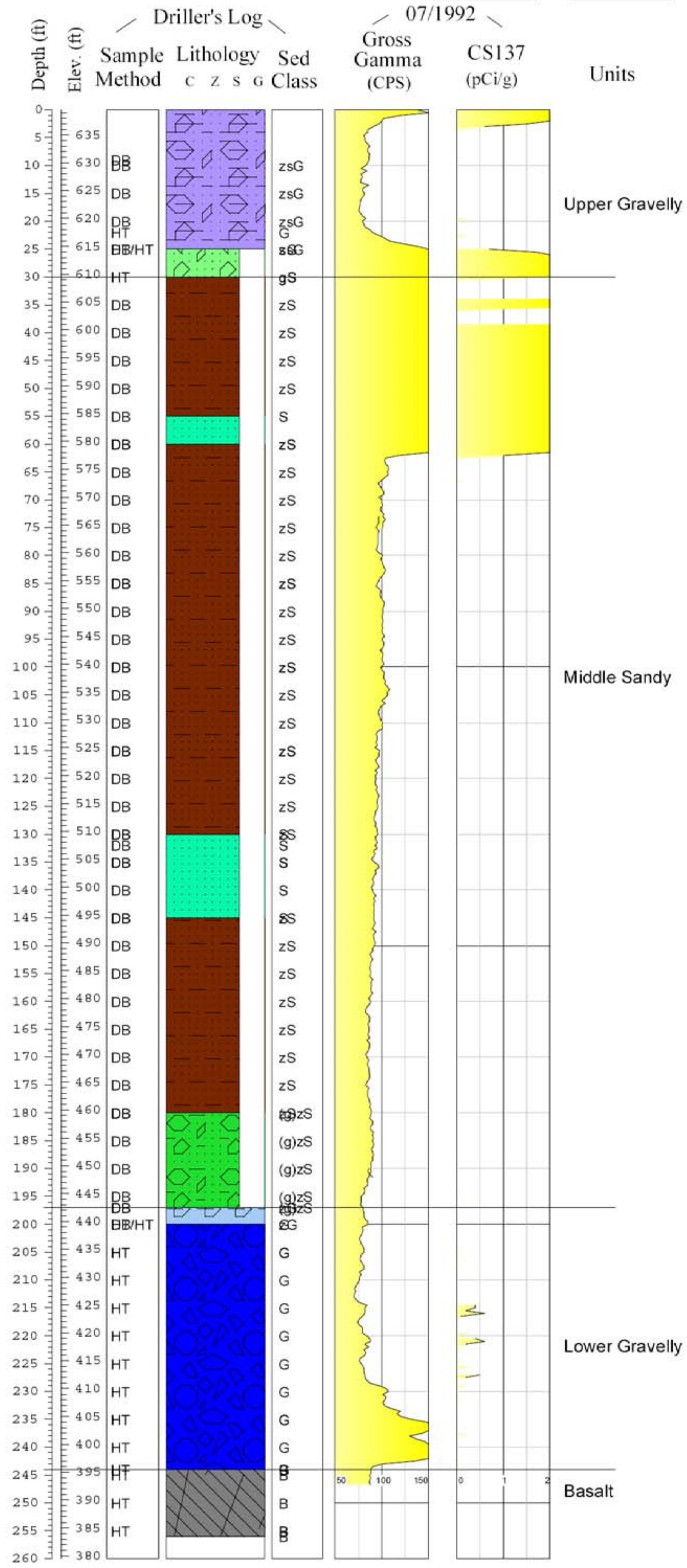
Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html). This may or may not be the same ground surface elevation as existed originally at time of drilling in 1965, but is the closest and most traceable survey available.

Driller's Log data are from PNNL Sigma V Well Log Library and are depth-referenced to the 1991 ground surface elevation (see explanation above)
The 1991 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

rdm_B_BX_BY_FY06_23
Page 1 of 1

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
A4849	299-E33-24	137578.531	573493.539	639.5	256.0	04/17/1967



C Z S G
CLAY SILT SAND GRAVEL
Increasing Size →

( ) = "slightly" modifier   Ex: (z)sG = slightly silty sandy gravel

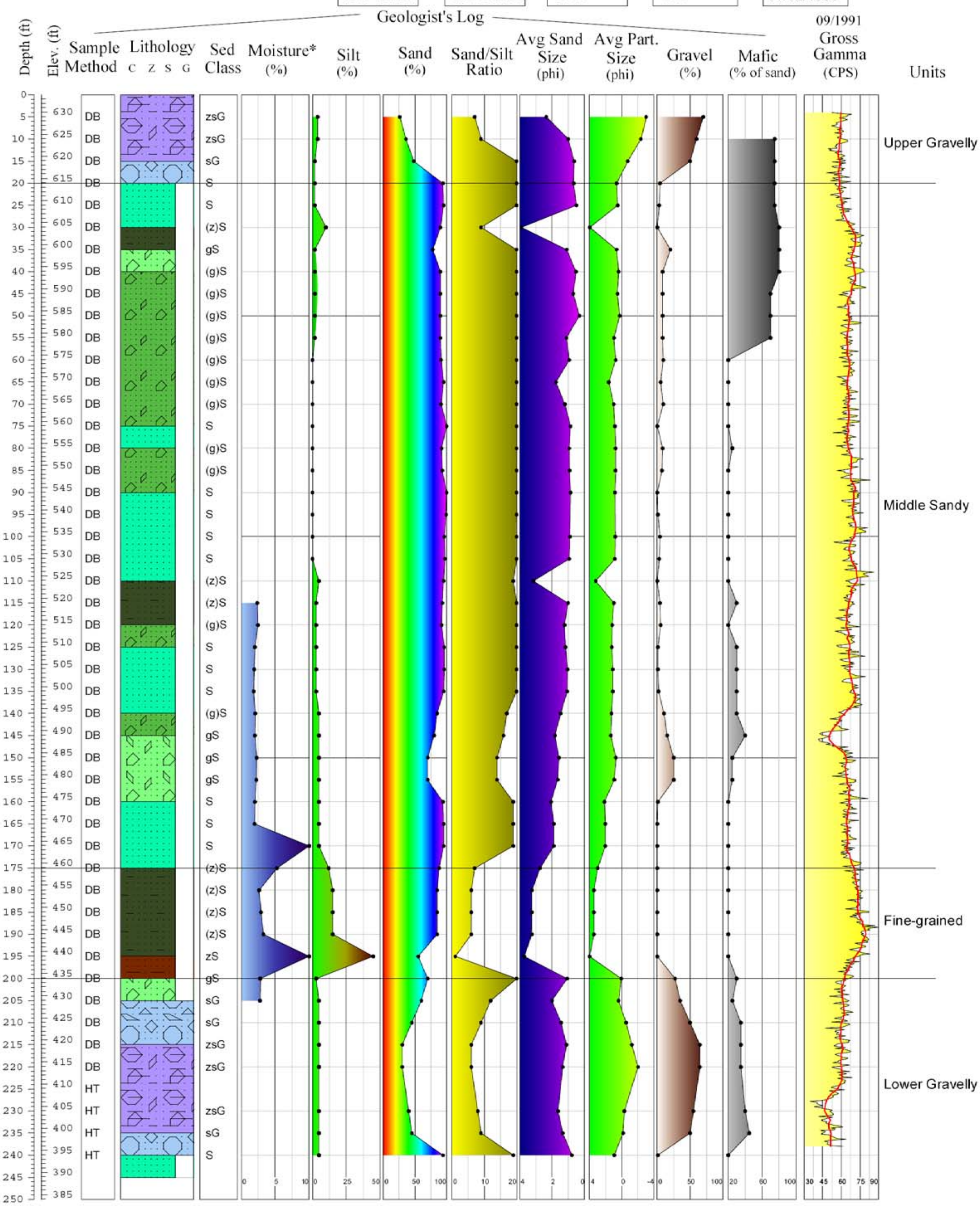
Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap surveyed on 10/27/1992 and reported in Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html). This appears to be the same elevation as the ground surface at the time of drilling in 1967 since it closely matches the current Brass Cap ("disc_z" field) in HWIS.

Driller's Log data are from PNNL Sigma V Well Log Library and are depth-referenced to the 1992 brass cap elevation (see explanation above)
The 1992 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and is also depth-referenced to the 1992 brass cap.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

rdm_B_BX_BY_FY06_23
Page 1 of 1

Borehole ID	Well Number
A4859	299-E33-34

Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
137740.427	573104.458	633.9	245	01/02/1990

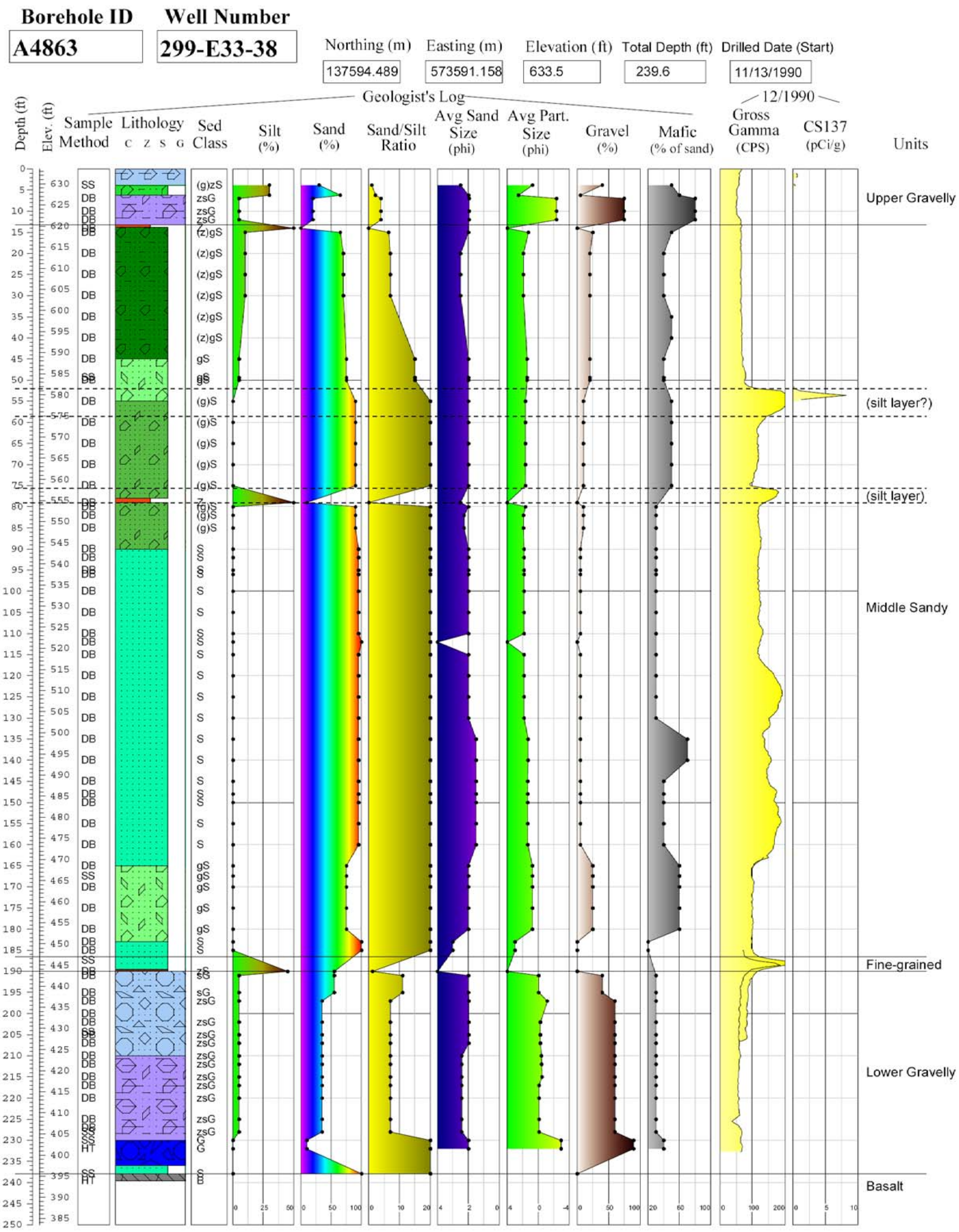


( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

C Z S G — CLAY SILT SAND GRAVEL — Increasing Size →

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html)
Geologist's Log and lab moisture data from WHC-MR-0205 and are depth-referenced to the 1991 ground surface elevation.
The 1991 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

rdm_B_BX_BY_FY06_23
Page 1 of 1



C Z S G
CLAY SILT SAND GRAVEL
Increasing Size →

( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

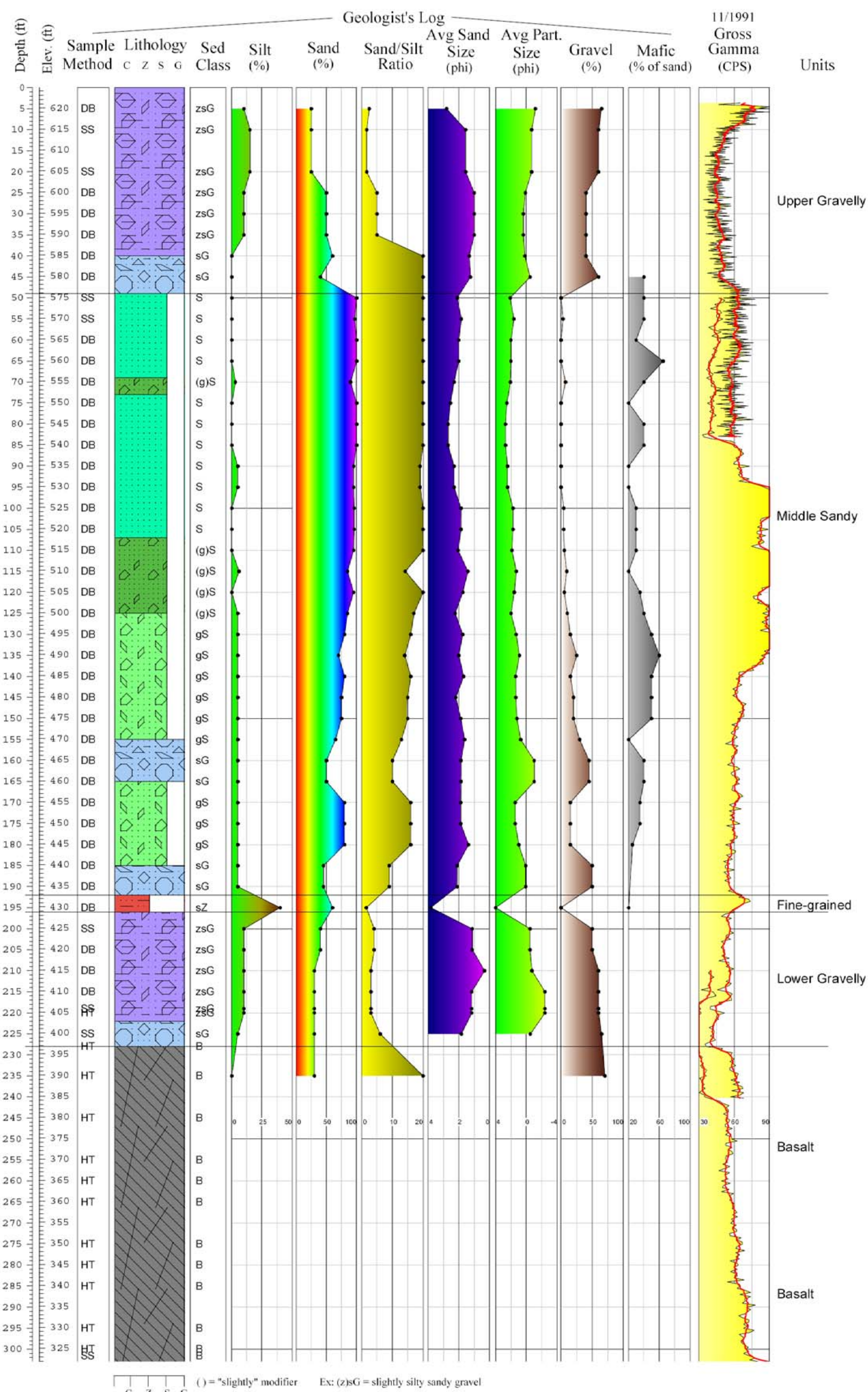
rdm_B_BX_BY_FY06_23

Page 1 of 1

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html)

Geologist's Log is from PNNL Sigma V Well Log Library and are depth-referenced to the 1991 ground surface elevation near the time of drilling, just the same as the depth-elevation scale bar on the left side of the plot.
The 1990 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
A4866	299-E33-40	137723.099	573546.232	624.8	318.0	11/8/1990



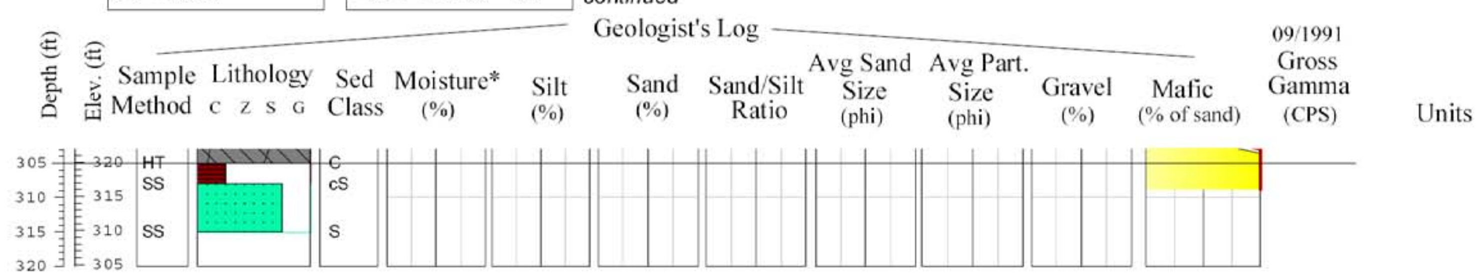
( ) = "slightly" modifier   Ex: (z)sG = slightly silty sandy gravel

rdm_B_BX_BY_FY06_23
Page 1 of 2

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html)
Geologist's Log data are from PNNL Sigma V Well Log Library and are depth-referenced to the 1991 ground surface elevation.
The 1991 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

Borehole ID	Well Number
A4866	299-E33-40

continued



C Z S G
CLAY SILT SAND GRAVEL
Increasing Size →

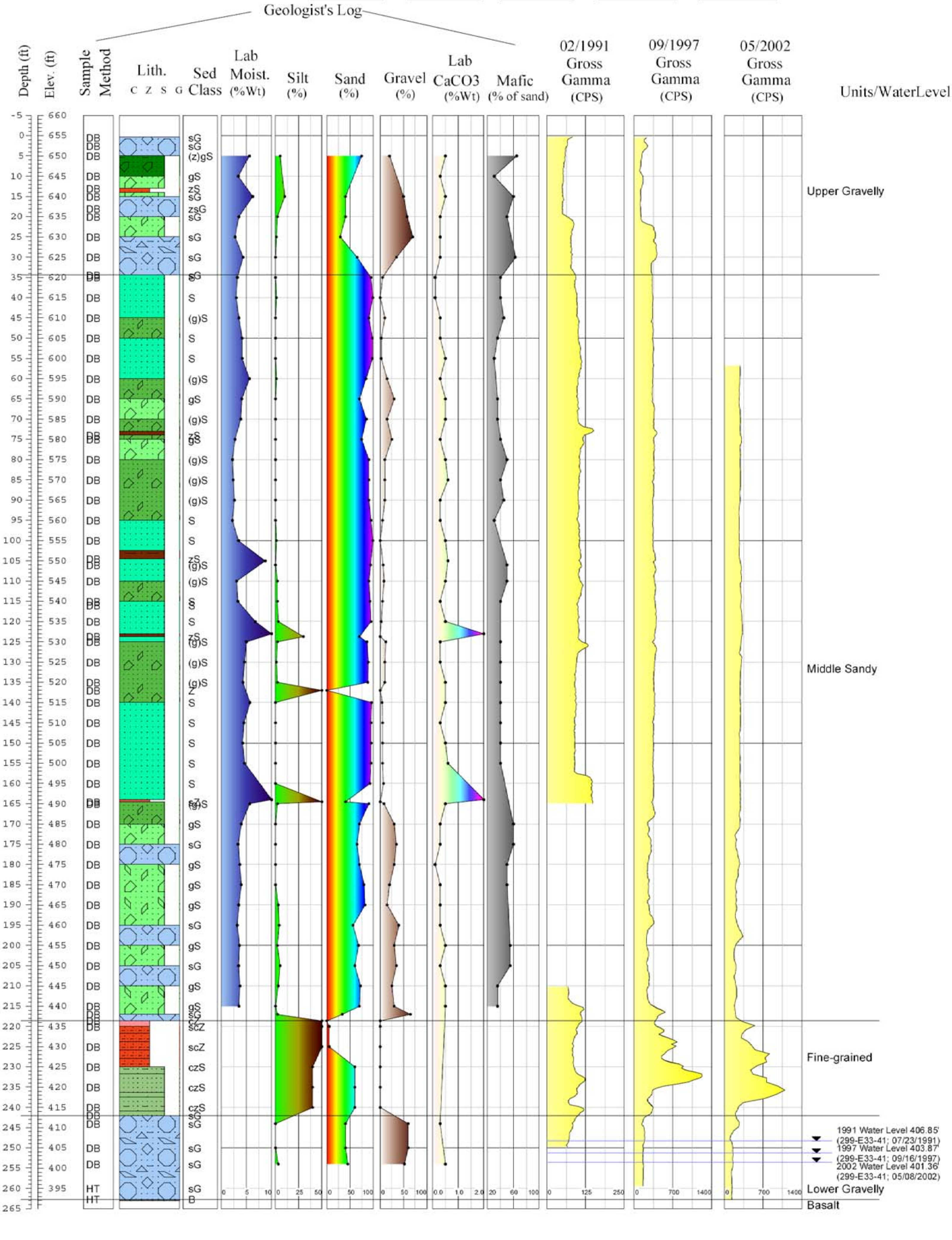
( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html)

Geologist's Log data are from PNNL Sigma V Well Log Library and are depth-referenced to the 1991 ground surface elevation.
The 1991 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

rdm_B_BX_BY_FY06_23
Page 2 of 2

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
A4867	299-E33-41	137369.94	573707.19	655.02	263.0	01/31/1991



CLAY SILT SAND GRAVEL (C Z S G) — Increasing Size →

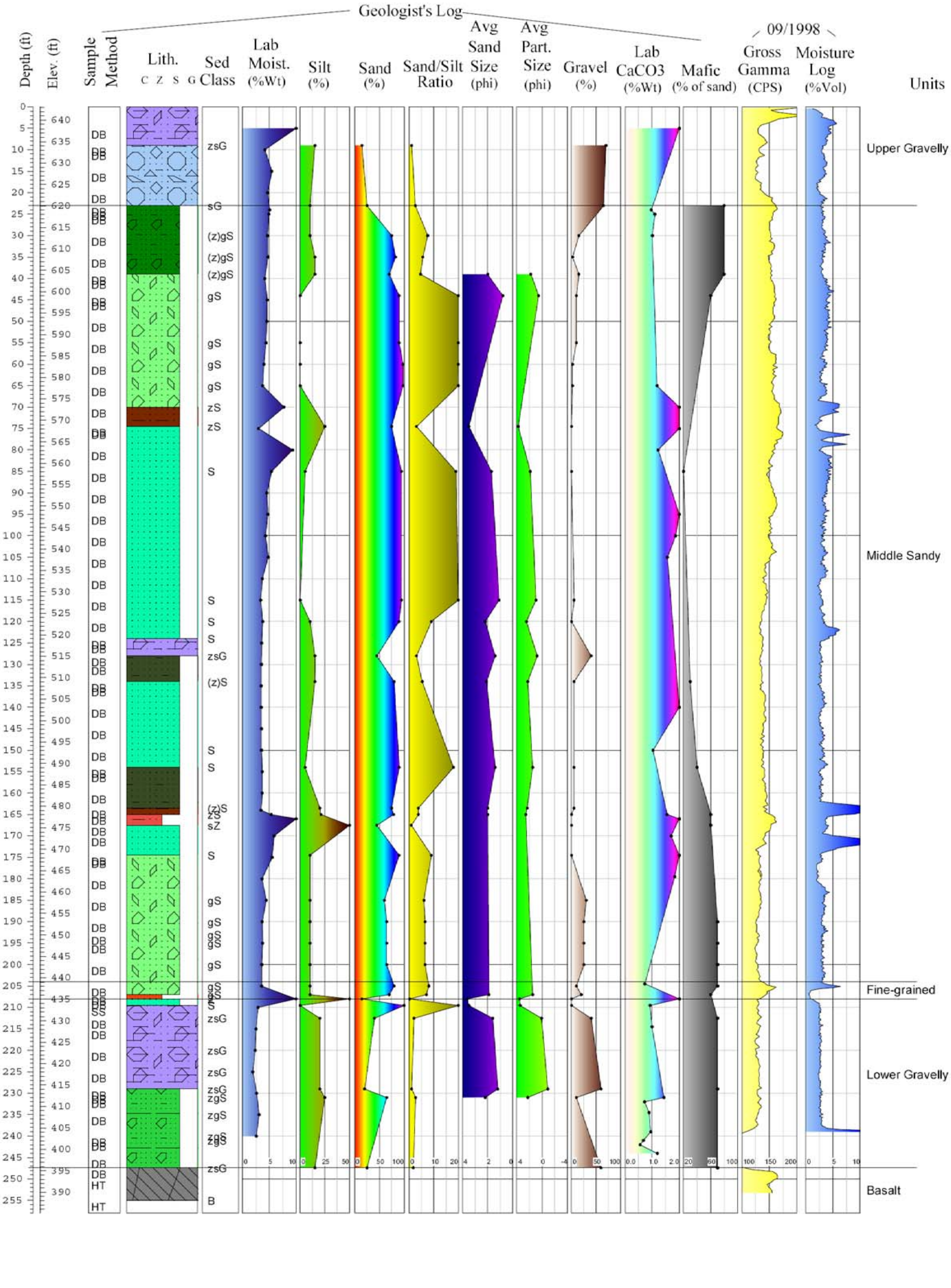
( ) = "slightly" modifier   Ex: (z)sG = slightly silty sandy gravel

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Ledgerwood (1993; WHC-SD-ER-TI-007 Rev. 0), converted from NGVD29 to NAVD88 using CORPSCON 6.x (USACE; http://crunch.tec.army.mil/software/corpscon/corpscon.html)
Geologist's Log, moisture, and CaCO3 data are from Caggiano (1992; WHC-SD-EN-DP-041) and are depth-referenced to the 1991 ground surface elevation, just the same as the depth-elevation scale bar on the left side of the plot.
The 1991 geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling. The 1997 and 2002 geophysical logs are from the PNNL Borehole Log database and Stoller's website (http://www.gjo.doe.gov/programs/hanf/), respectively, and were both originally referenced to top of casing when logged in the field. In order to to adjust for the difference between top of casing (658.26' NAVD88) surveyed in 1996 (HWIS) and the ground surface elevation surveyed in 1991 near time of drilling (655.02' NAVD88), both were depth-adjusted -3.24'.

rdm_B_BX_BY_FY06_23

Page 1 of 1

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
B8554	299-E33-44	137469.164	573706.411	643.1	254.1	09/12/1998



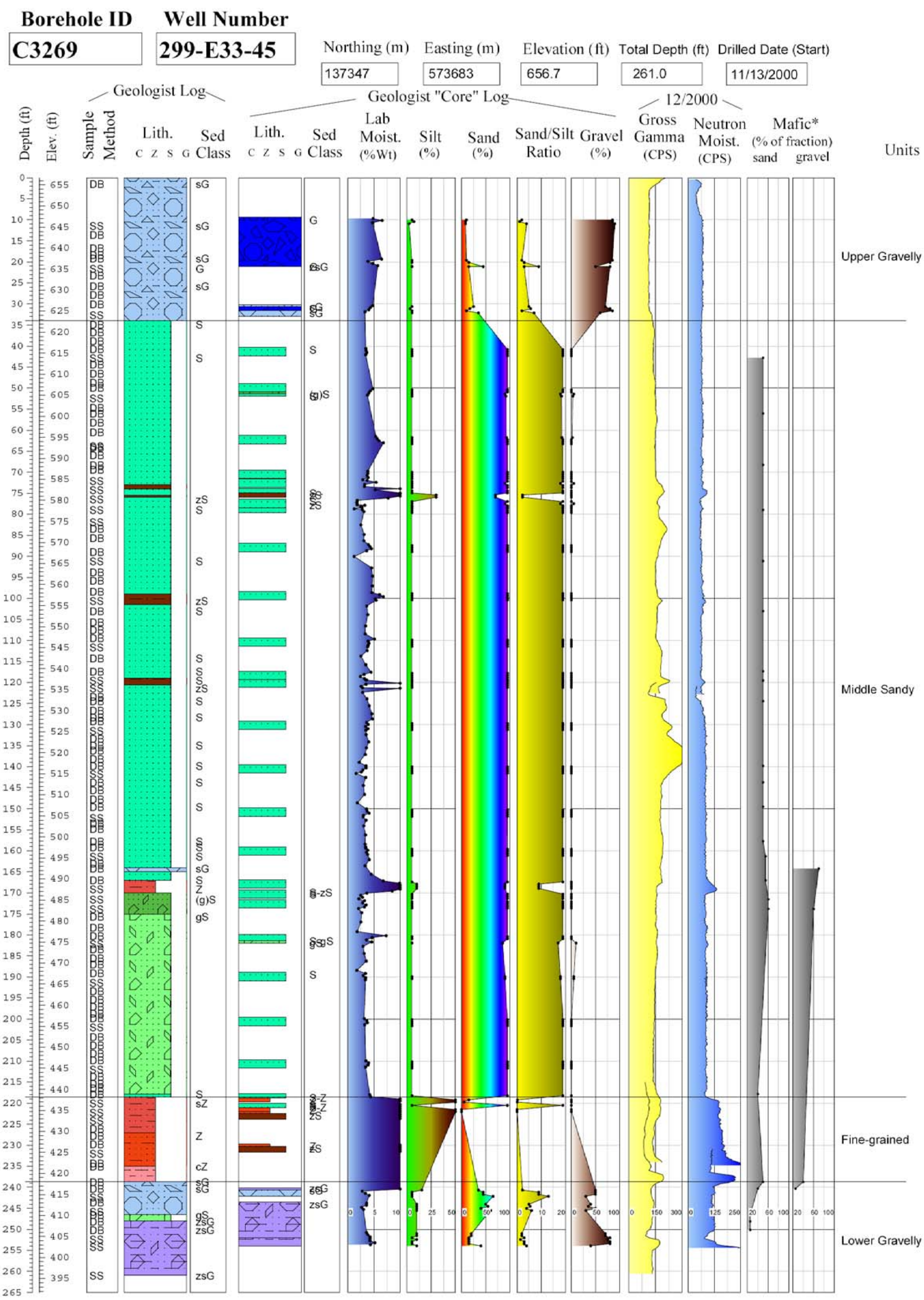
C Z S G
CLAY SILT SAND GRAVEL
Increasing Size →

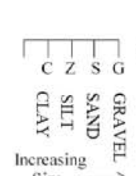
( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

rdm_B_BX_BY_FY06_23

Page 1 of 1

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is brass cap from Horton & Narbutovskih (1999; PNNL-12128).
Geologist's Log, moisture, and CaCO3 data are from Horton & Narbutovskih (1999; PNNL-12128) and are depth-referenced to the 1998 ground surface elevation near the time of drilling, just the same as the depth-elevation scale bar on the left side of the plot.
The 1998 HPGe geophysical log is from PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and also depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels





( ) = "slightly" modifier   Ex: (z)sG = slightly silty sandy gravel

rdm_B_BX_BY_FY06_23

Page 1 of 1

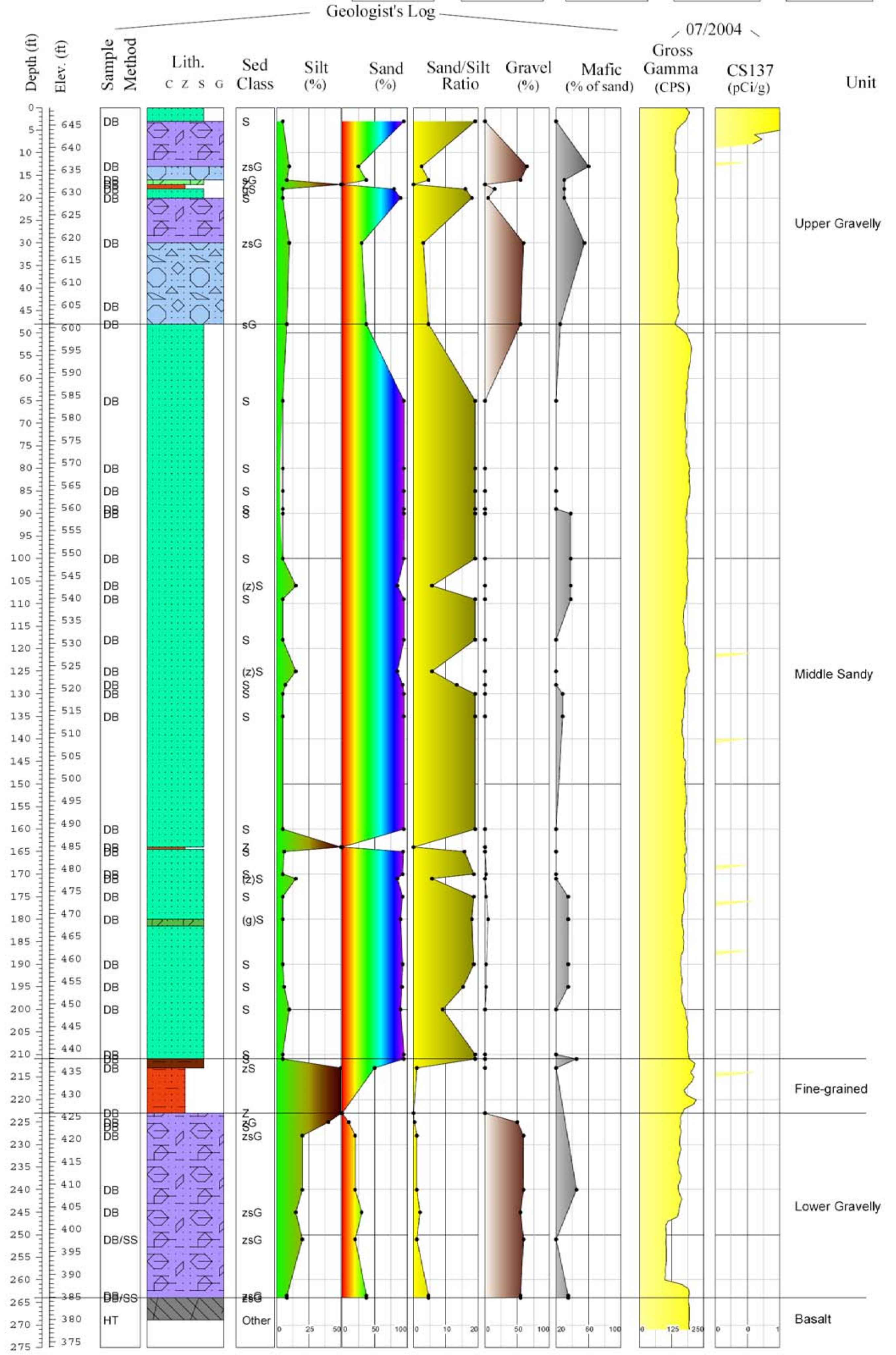
Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/)
Elevation (NAVD88) for depth-elevation scale on left is "land surface" from the Water Well Report for the State of Washington in Appendix C of Serne et al. (2002; PNNL-14083).

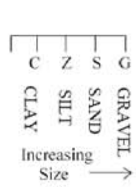
Geologist's Log data come from two sources, the geologist's log based on observations at the drill site, and also a geologist's log of core samples. Both are from Serne et al. (2002; PNNL-14083) and are depth-referenced to the ground surface elevation at time of drilling, just the same as the depth-elevation scale bar on the left side of the plot. Laboratory moisture values also come from Serne et al. (2002) are are depth-referenced the same as the lithology data.
The 2000 geophysical log is from the PNNL Borehole Log database (http://boreholelogs.pnl.gov/) and depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels
*Mafic percentages of the sand and gravel fractions come also from the geologist's log (Serne et al., 2002).

Borehole ID C4259

Well Number 299-E33-47

Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
137295.46	573916.48	648.8	268.9	06/03/2004



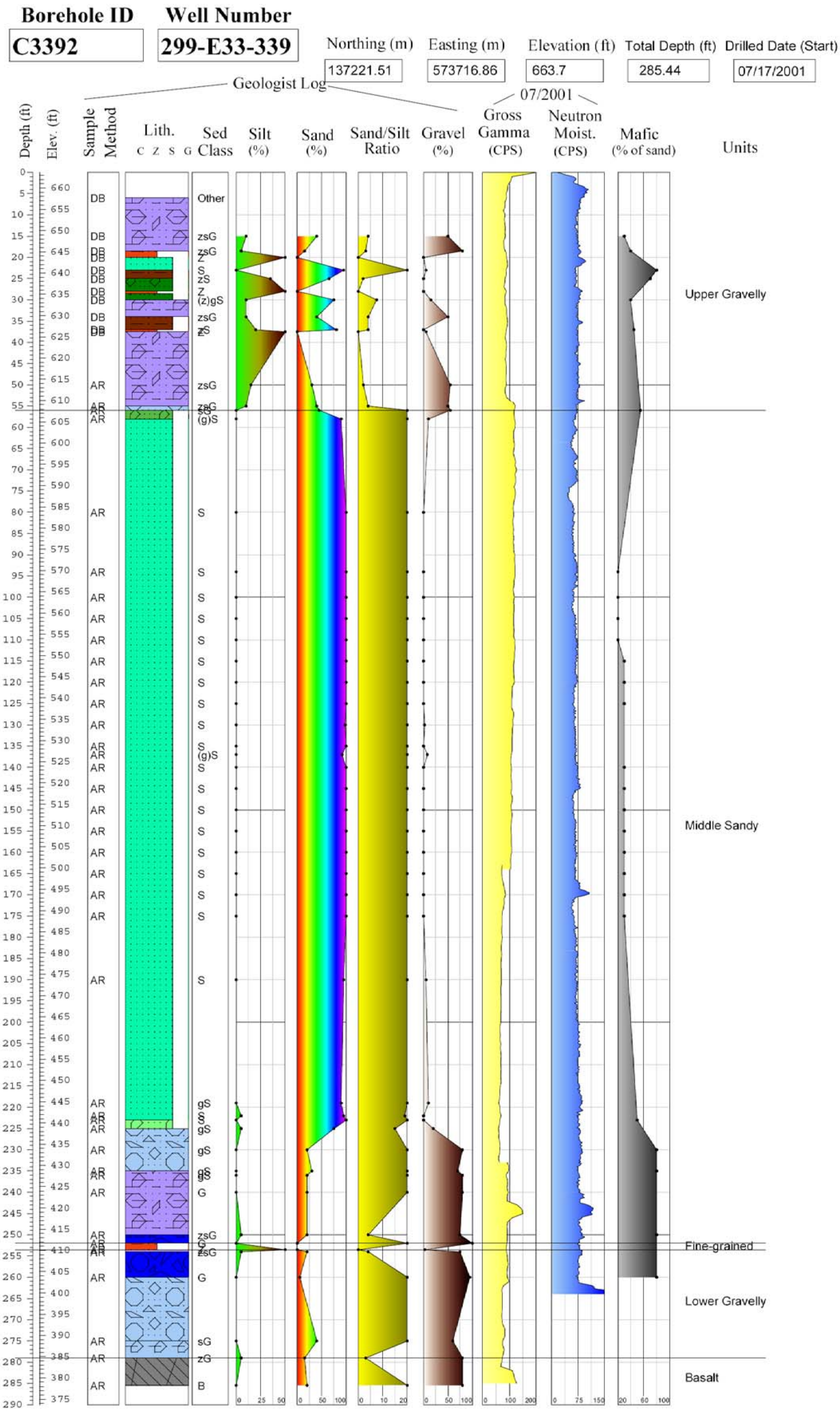


( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/).
Elevation (NAVD88) for depth-elevation scale on left is brass cap from the Well Survey Data Report by GF Brazil of FFS Survey Dept., conducted on 09/29/2004.
Geologist's Log data are from PNNL Sigma V Well Log Library and are depth-referenced to the 2004 ground surface elevation near the time of drilling, just the same as the depth-elevation scale bar on the left side of the plot.
The 2004 geophysical logs are from Stoller's website (http://www.gjo.doe.gov/programs/hanf/) and are also depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

rdm_B_BX_BY_FY06_23

Page 1 of 1



| | | | | | ( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

C Z S G

CLAY SILT SAND GRAVEL

Increasing Size →

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/).
Elevation (NAVD88) for depth-elevation scale on left is brass cap reported in the Well Survey Data Report by GB Wagner of Rogers Surveying, Inc., conducted on 12/05/01 (HWIS).

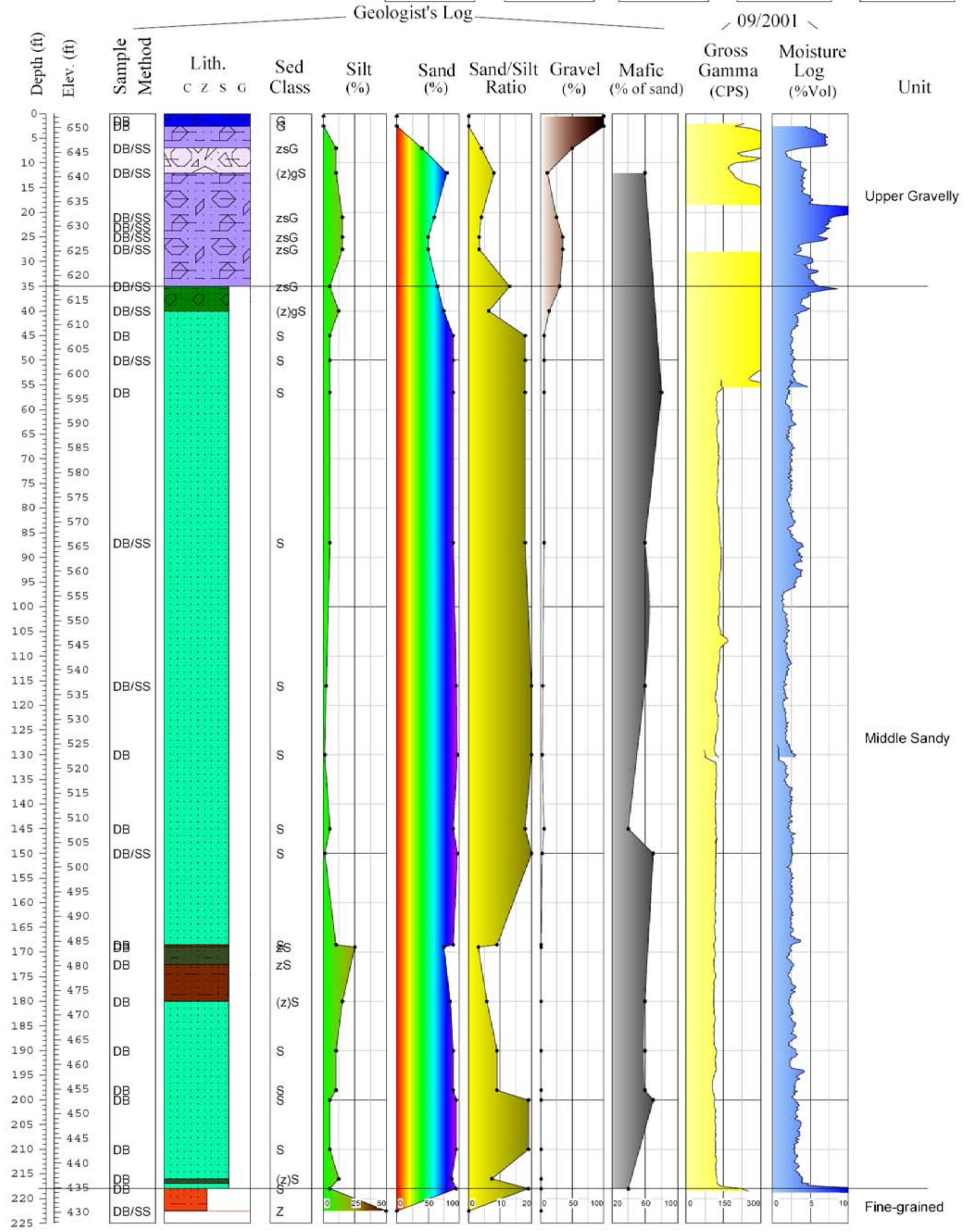
Geologist's Log data are from the PNNL Sigma V Well Log Library and are depth-referenced to the ground surface elevation at time of drilling, just the same as the depth-elevation scale bar on the left side of the plot.
The 2001 geophysical logs are from Stoller's website (http://www.gjo.doe.gov/programs/hanf) and are depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels
*Mafic percentages of the sand fraction comes also from the geologist's log.

rdm_B_BX_BY_FY06_23

Page 1 of 1

Borehole ID C3103 | **Well Number** C3103

Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
137385.58	573802.55	652.8	225.5	08/21/2001



C Z S G — CLAY SILT SAND GRAVEL — Increasing Size →

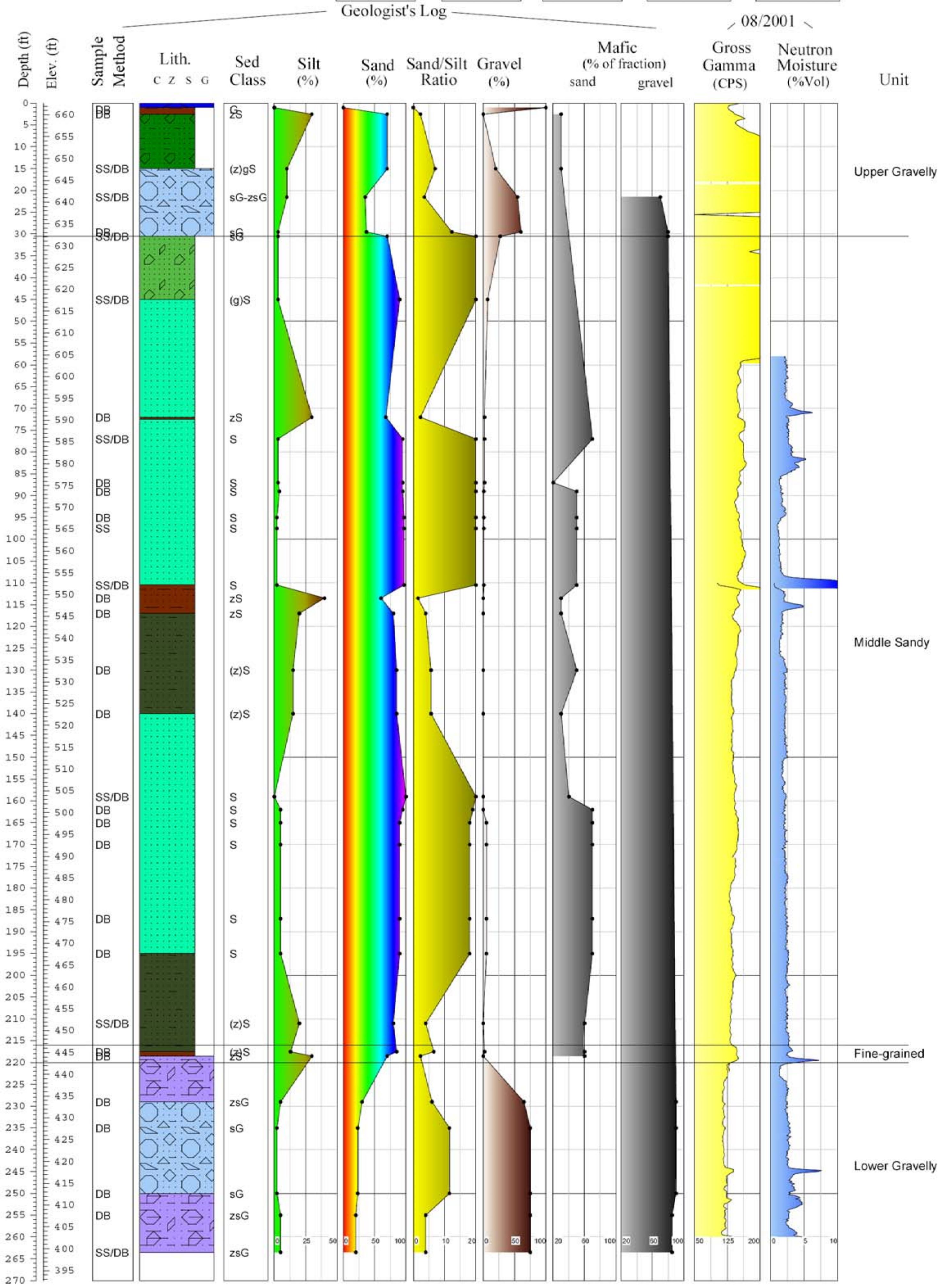
( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

rdm_B_BX_BY_FY06_23

Page 1 of 1

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/).
Elevation (NAVD88) for depth-elevation scale on left is brass cap from the Well Survey Data Report by GB Wagner of Rogers Surveying, Inc., conducted on 01/29/2002.
Geologist's Log data are from Todd and Trice (2002; BHI-01607 Rev. 0) and are depth-referenced to the 2001 ground surface elevation near the time of drilling, just the same as the depth-elevation scale bar on the left side of the plot.
The 2001 geophysical logs are from Stoller's website (http://www.gjo.doe.gov/programs/hanf/) and are also depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

Borehole ID	Well Number	Northing (m)	Easting (m)	Elevation (ft)	Total Depth (ft)	Drilled Date (Start)
C3104	C3104	137347.64	573471.18	662.7	263.5	08/01/2001



( ) = "slightly" modifier Ex: (z)sG = slightly silty sandy gravel

C CLAY, Z SILT, S SAND, G GRAVEL — Increasing Size →

Geospatial Coordinates:
Horizontal (Washington StatePlane; NAD83) from Hanford Well Information System (HWIS; http://apweb02.rl.gov/cfroot/rapidweb/phmc/cp/hwisapp/).
Elevation (NAVD88) for depth-elevation scale on left is brass cap from the Well Survey Data Report by GB Wagner of Rogers Surveying, Inc., conducted on 01/29/2002.
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The 2001 geophysical logs are from Stoller's website (http://www.gjo.doe.gov/programs/hanf/) and are also depth-referenced to ground surface at time of drilling.
Lithology colors: Red - Silts or Clays, Green - Sands, Blue - Gravels

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Page 1 of 1

Plate 1
Cross-Section A-A'

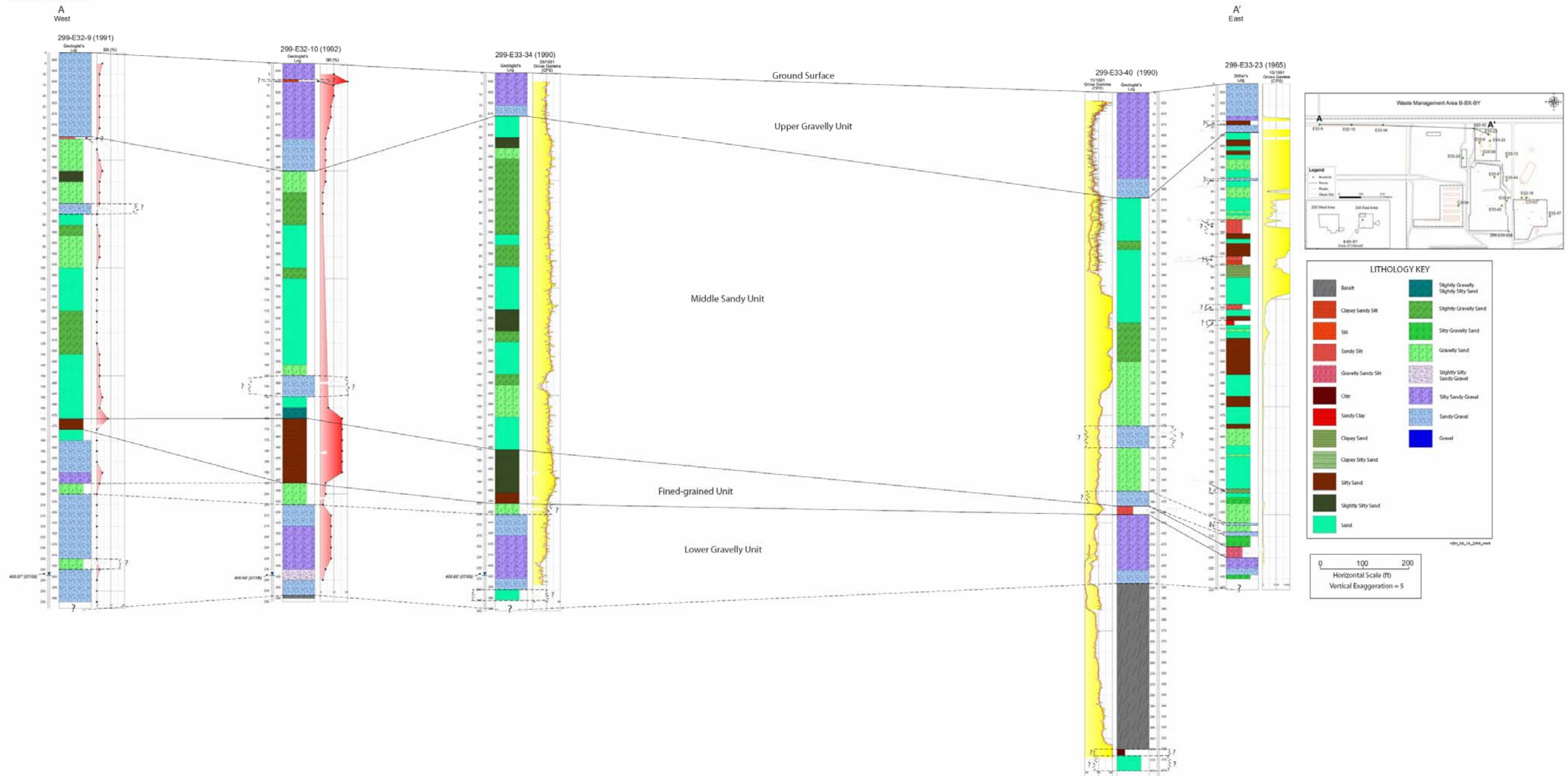


Plate 2
Cross-Section B-B'

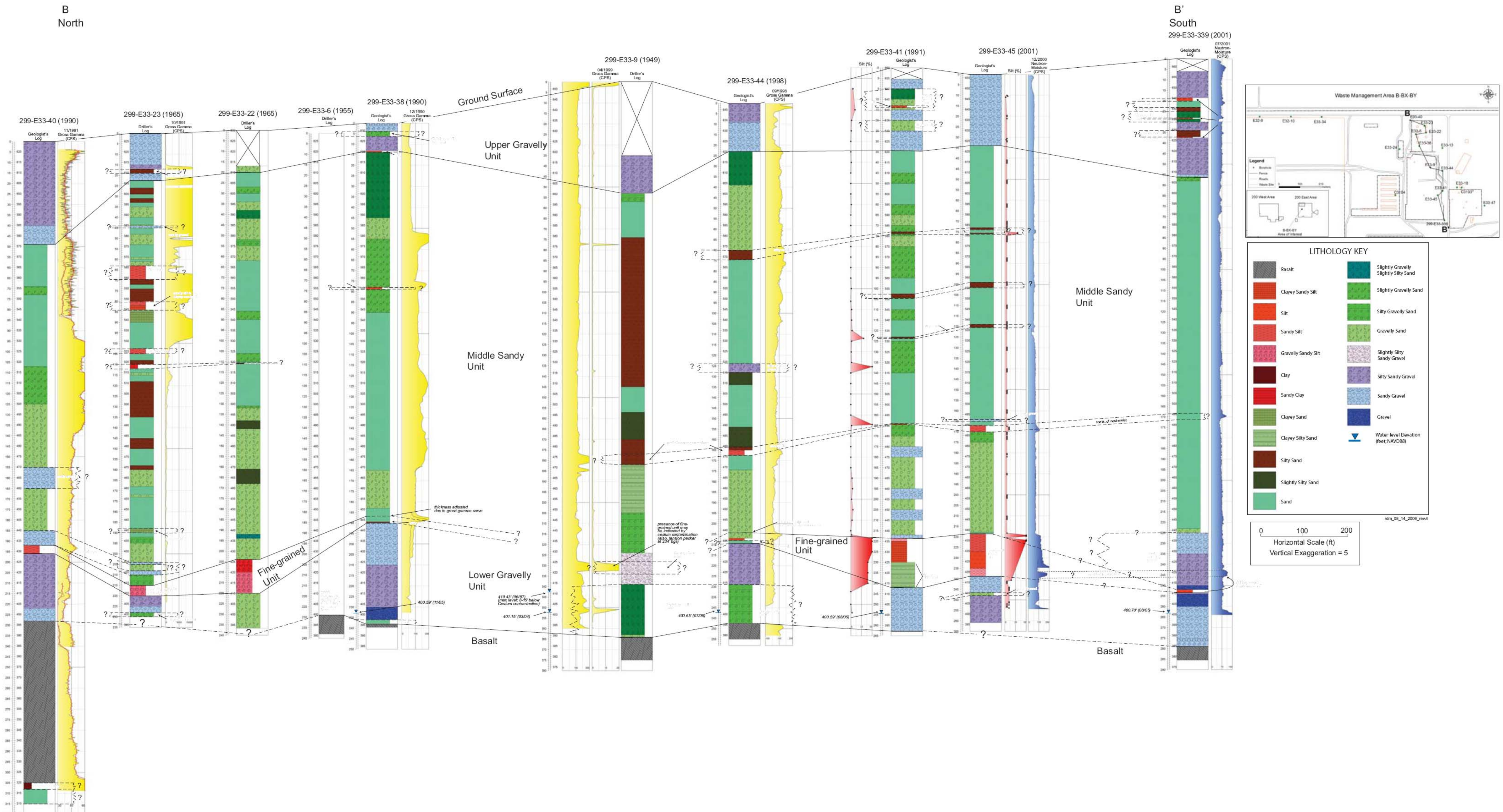


Plate 3
Cross-Section C-C'

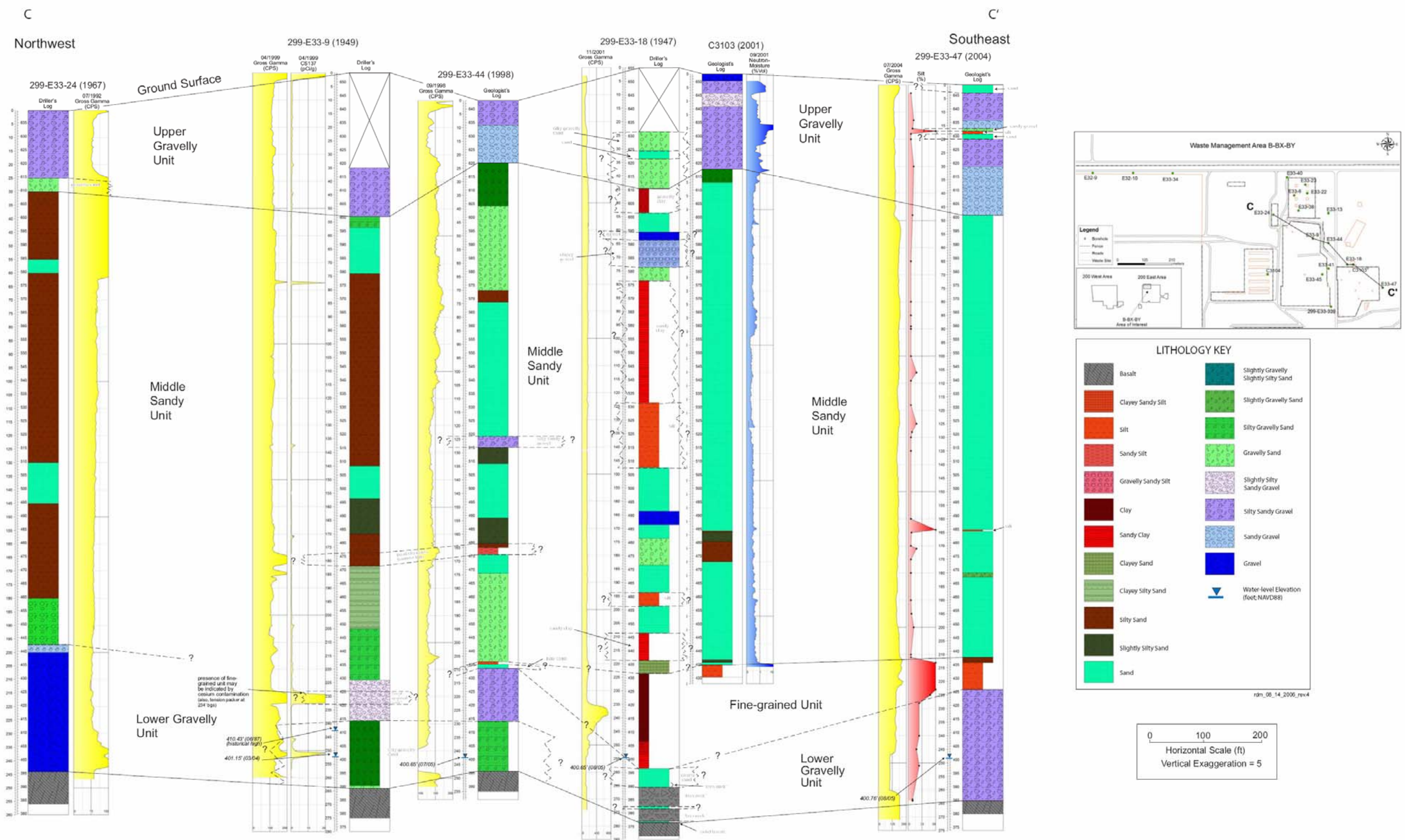
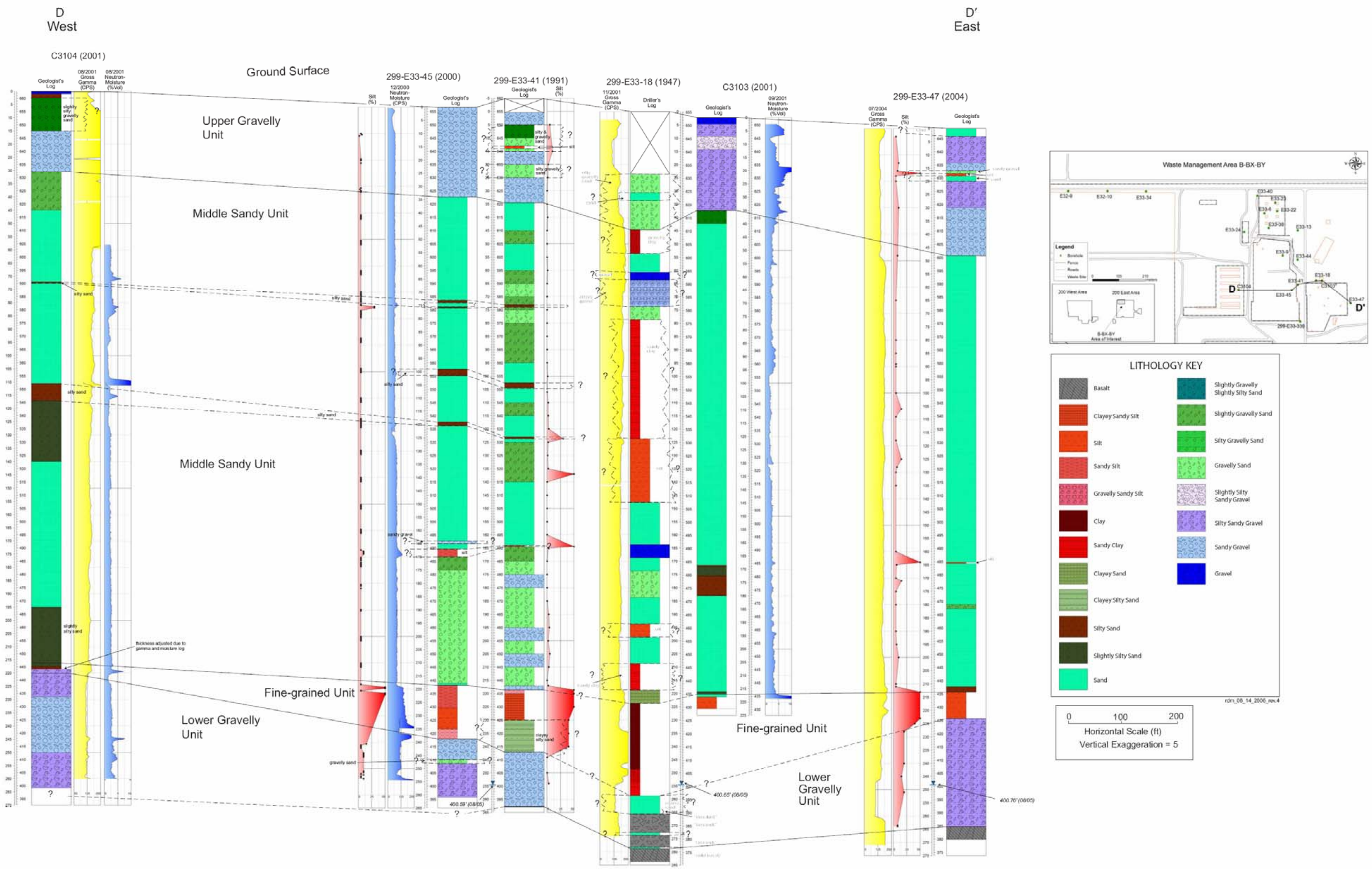


Plate 4
Cross-Section D-D'



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