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Geologic and Wireline Summaries from Fiscal Year 2002 ILAW Boreholes

S. P. Reidel
A. M. Ho

September 2002

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Richland, Washington 99352

Summary

Four boreholes were drilled at the Immobilized Low-Activity Waste Disposal Site in April 2002. Three were completed as groundwater monitoring wells. This report documents the drilling and data collected from the drilling.

Contents

Figures

Tables

1.0 Introduction

The U.S. Department of Energy Office of River Protection is responsible for safe underground storage of liquid waste from previous Hanford Site operations, the storage and disposal of immobilized tank waste, and closure of underground tanks. The current plan is to dispose of immobilized low-activity tank waste (ILAW) in the south-central part of the 200 East Area (Figure 1).

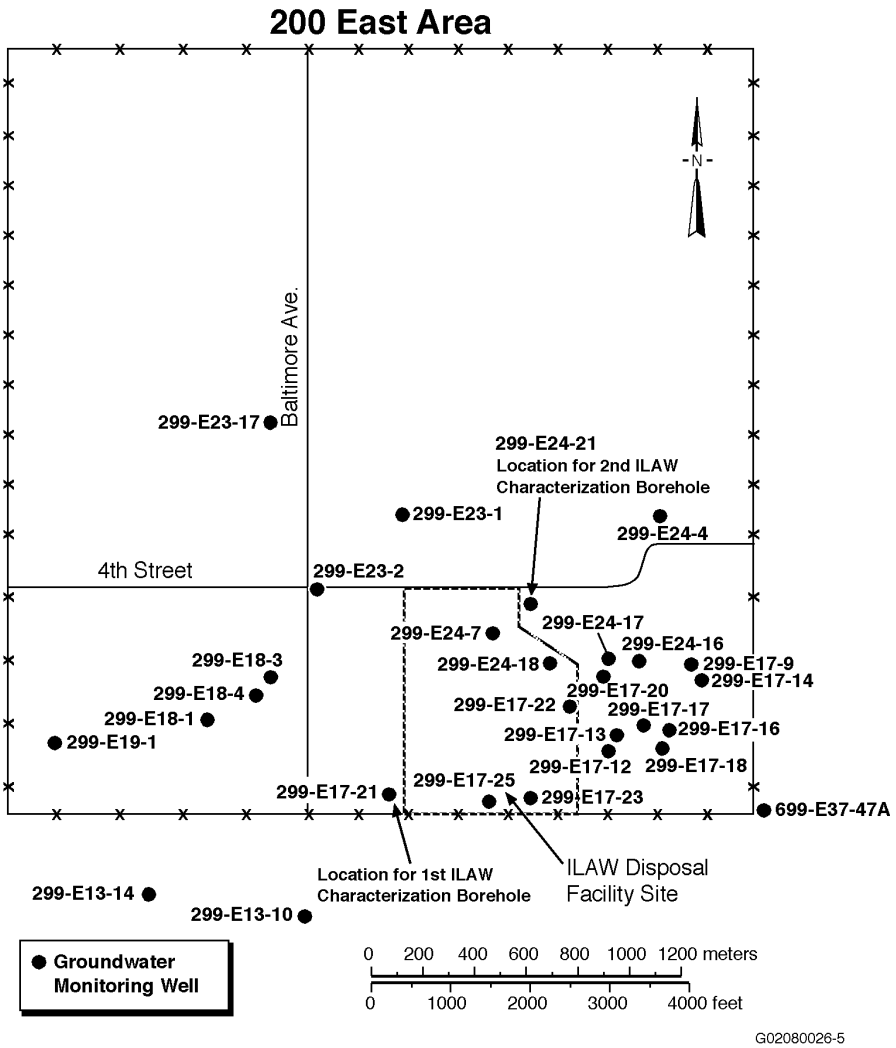


Figure 1. Location Map Showing the ILAW Site and Boreholes

This report summarizes the results of FY 2002 drilling, geologic logging of cores, geophysical logging of the boreholes and preliminary groundwater chemistry from the wells. The drilling and testing activities associated with the boreholes were done in accordance with the Characterization Plan (Reidel 2002).

This report uses the English system of units where discussing drill depth, as it is customary to report borehole depth data in feet rather than meters. Multiply feet by 0.3048 to convert to meters. All other measurements are in metric units.

1.1 Boreholes

Four boreholes (Table 1) were drilled along the south and east sides and at the southeast corner of the ILAW site (Figure 1) in April 2002 in support of the Performance Assessment (PA) activities, to establish a groundwater-monitoring network, and to help establish a pre-operational environmental baseline (Mann et al. 2001; Horton et al. 2000). Three of these boreholes were then completed as groundwater monitoring wells. Walker (2002) provides a summary report of all field activities including drilling and well construction (see Appendix A).

Table 1. Boreholes Drilled at ILAW Site During FY 2002

Borehole Number	Well Name
C3826	299-E17-22
C3827	299-E17-23
C3828	Decommissioned
C3926	299-E17-25

Three of the four boreholes were completed as groundwater monitoring wells (Table 1). Borehole C3828 was drilled and then decommissioned when a measurement critical to insure proper placement of the silica sand pack around the well screen could not be made (Walker 2002). Borehole C3926 was drilled approximately 3 m west of borehole C3828 and completed as a groundwater monitoring well.

1.2 Technical Objectives

The technical objectives of the boreholes were:

- To provide geologic samples to characterize the sediments in the vadose zone in support of the ILAW Performance Assessment and the pre-operational monitoring plan (Horton et al. 2000). This includes physical, hydrologic, and geochemical characterization.

- To install groundwater monitoring wells to establish a pre-operational groundwater baseline.

The primary factor dictating the location of the boreholes was their characterization function with respect to developing the geohydrologic model for the site in support of the PA (Mann et al. 2001), satisfying associated Data Quality Objectives (Reidel et al. 1995; Reidel 2002 [Appendix C, Section 3.2]) and providing information for pre-operational environmental baseline characterization (Horton et al. 2000).

1.3 Report Organization

This report consists of six chapters and five appendices. The first chapter is the introduction and background for the project. Chapter 2 provides a summary on the drilling and sampling methods that were used. Chapter 3 summarizes the borehole stratigraphy. Chapter 4 contains a brief discussion on the groundwater chemistry, Chapter 5 a summary and conclusions, and Chapter 6 lists cited references. The well summary report of Walker (2002) is reproduced in Appendix A, and Appendices B, C, and D contain core descriptions. A summary of the geophysical logging is found in Appendix E.

2.0 ILAW Drilling and Sampling Activities

Drilling, sampling, and well construction objectives for the project are presented in Reidel (2002). That report called for drilling and sampling of three boreholes to be constructed as groundwater monitoring wells. Continuous sample retrieval from selected intervals was needed to achieve the goals of the sampling plan (Table 2).

Table 2. Intervals Selected for Continuous Coring (Reidel 2002)

Depth (ft bgs)	Borehole			Physical Properties	Recharge Tracers	Aquifer Study
	C3826	C3827B	C3828			
8-48	X			X	X	
54-58		X	X	X	X	
58-62	X	X	X	X	X	
62-66		X	X	X	X	
64-68	X			X	X	
68-72	X			X	X	
72-76	X			X	X	
76-80	X	X		X	X	
96-100	X	X		X	X	
120-124	X	X		X	X	
150-154	X	X		X	X	
154-158		X	X	X	X	
158-162		X	X	X	X	
162-166		X	X	X	X	
164-168	X			X	X	
168-172	X					
172-176	X			X	X	
180-184	X	X				
220-224	X	X				

2.1 Drilling and Well Construction

The details of drilling, well construction, and well development are documented in Walker (2002); surveyed borehole locations and depths are given in Table 3 and Figure 2. In summary, the boreholes were drilled in April 2002 using the Becker Hammer drilling method from the surface into the saturated zone.

Table 3. Borehole Locations and Depths (from Walker 2002 and Appendix A)

Borehole Number	Well Name	East[(a,b)] (m)	North[(a,b)] (m)	Elevation[(a,b)] (m)	Water Table[(b)] (ft bgs)
C3826	299-E17-22	574841.067	135195.921	220.589	321.82
C3827	299-E17-23	574694.485	134842.766	223.843	332.5
C3828	Not Applicable	574518.125	134845.545	224.801	341.3
C3926	299-E17-25	574515.171	134845.913	225.028	337.67

(a) Brass cap.
(b) From Walker (2002).

The boreholes were completed as Resource Conservation and Restoration Act groundwater-monitoring wells. Each well has a 4-in diameter stainless steel casing and a 35-ft long stainless steel, continuous wire wrap, 20-slot (0.020-in.) screen. A protective casing with locking cap, a cement pad, and protective posts were installed to complete the surface installations.

The wells were developed in May 2002 with a 3-hp submersible pump used at two depths. Water was pumped at a rate of 13 (299-E17-22), 11 (299-E17-23), and 12 (299-E17-25) gallons per minute; there was no measurable drawdown (Walker 2002; Appendix A). Groundwater samples were taken at the end of well development for analysis of selected parameters (see Chapter 4).

2.2 Sampling

Walker (2002; Appendix A) described the field sampling activities associated with drilling the boreholes. Briefly, split-tube samples were collected in 4-in diameter, 1 ft- (C3826 and C3827) or 2 ft- (C3828) long lexan liners. Table 2 summarizes the intervals collected. No split-spoon samples were collected from C3926 because it was only about 3 m west of C3828. Grab samples were collected every 5 ft from all four boreholes for archive purposes.

End caps were taped to each lexan liner, and then the liners were double-bagged in plastic and placed in ice chests with an additional layer of plastic between the samples and the ice for transportation to the laboratory. Samples were transported under chain-of-custody and stored in refrigerators in the 3720 Building until they were opened for examination.

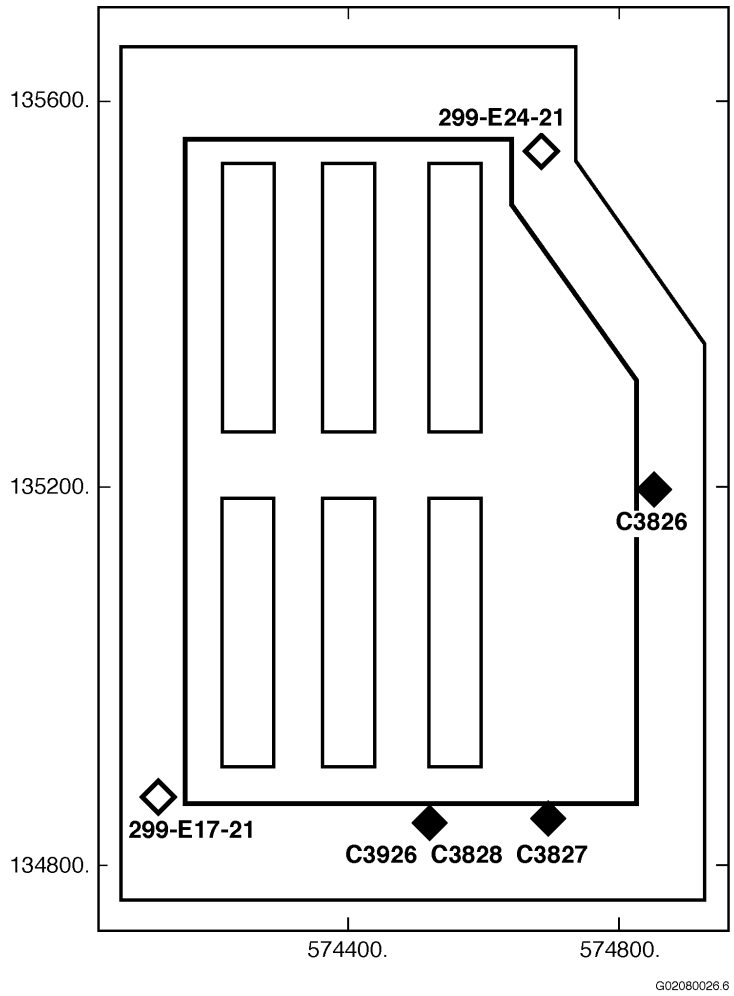


Figure 2. Location of Boreholes Drilled at the ILAW Site

The lexan liners containing the cores from the boreholes were split open in the laboratory and logged following the approved test plan (Reidel 2002). Each sample was photographed, and detailed geologic descriptions made in the laboratory included geologic structure, grain-size, grain shape, sorting, color, moisture, cementation, hardness, and reaction to HCl (see Appendices B, C, and D). Sample liners were resealed with tape after examination and will be archived in the Hanford Geotechnical Sample Library.

2.3 Aquifer Testing

The Sampling and Analysis Plan (Reidel 2002) outlined a testing program for the hydrologic properties of the well. This testing was designed to provide information on recovery rates, effective permeability and other hydrologic properties for the zone in which the aquifer was screened. Testing was done in August 2002 and consisted of slug withdrawal tests. Results of the analyses will be reported separately.

2.4 Geophysical Logging

The boreholes were geophysically logged in August 2002. High-purity germanium logging was conducted to determine the presence of man-made gamma emitting radioisotopes, and to provide analysis of naturally-occurring potassium, thorium, and uranium for stratigraphic studies. Appendix E contains copies of the log suite and the logging analysis report. No man-made radioactive materials were detected

3.0 Borehole Stratigraphy

The boreholes penetrated sediments comprising the Hanford formation and possibly the Ringold Formation in C3828 and C3926. The main elements of the stratigraphy around the ILAW site are shown in Figures 3 through 7. Appendices B, C, and D present a description of the individual cores as they were opened. The well-site geologist's descriptions (Walker 2002; Appendix A) are in good agreement with the lithology and stratigraphy observed in the core. Small-scale features that generally are destroyed during drilling are well preserved in the core, thus allowing a better understanding of the site.

The stratigraphic nomenclature used in this report is consistent with the standardized nomenclature used for the Hanford Site (i.e., Delaney et al. 1991; Reidel et al. 1992; Lindsey et al. 1994; DOE 2002) and with that used in the description of the sediments encountered in the first two ILAW boreholes (299-E17-21 and 299-E24-21; Reidel et al. 1998, 2001).

3.1 Ringold Formation

The Ringold Formation may have been encountered in boreholes C 3828 and C3926 (Figures 3 and 7) based on the well-site geologists logging of the cuttings. Identification of the Ringold Formation is difficult using drill cutting at the ILAW site because of the similarity of the lithologies of the Hanford formation and the Ringold Formation in that area. The amount of water produced by the formations and the presence of cementation are two criteria that can help distinguish the two.

3.2 Hanford Formation

The thickness and depths of the Hanford formation encountered in the boreholes is given in Table 4. The entire thickness of the Hanford formation at boreholes C3826 and C3827 is not known because these boreholes did not penetrate the underlying Ringold Formation. The Hanford formation consists of pebble to cobble conglomerate and fine- to coarse-grained sand with a few interbedded, thin silt and/or clay beds. It is divided at the ILAW site into a lower gravel and an overlying sand unit with sparse gravel layers.

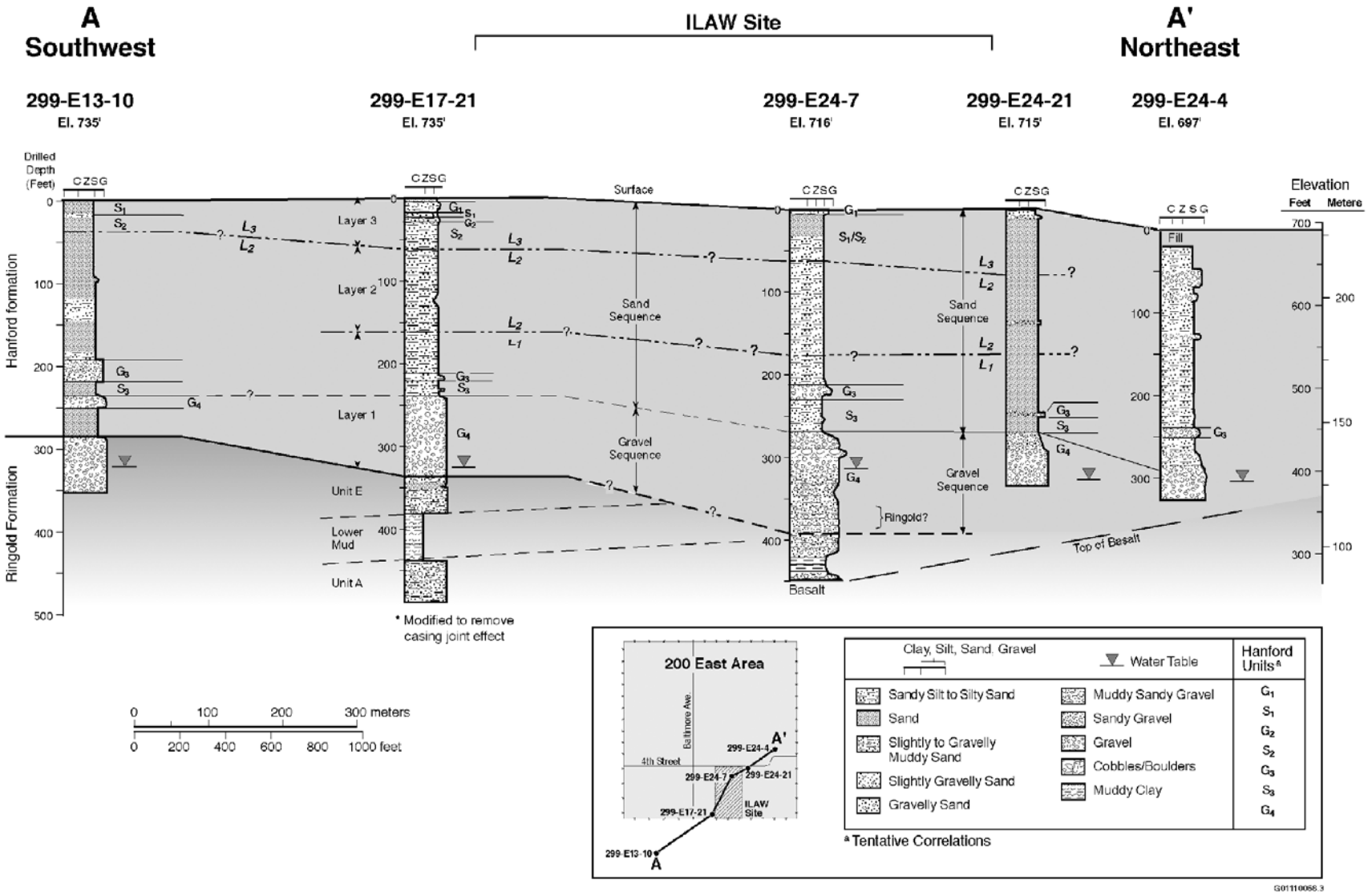


Figure 3. Stratigraphy Across the ILAW Site Based on Pre-FY 2002 Data

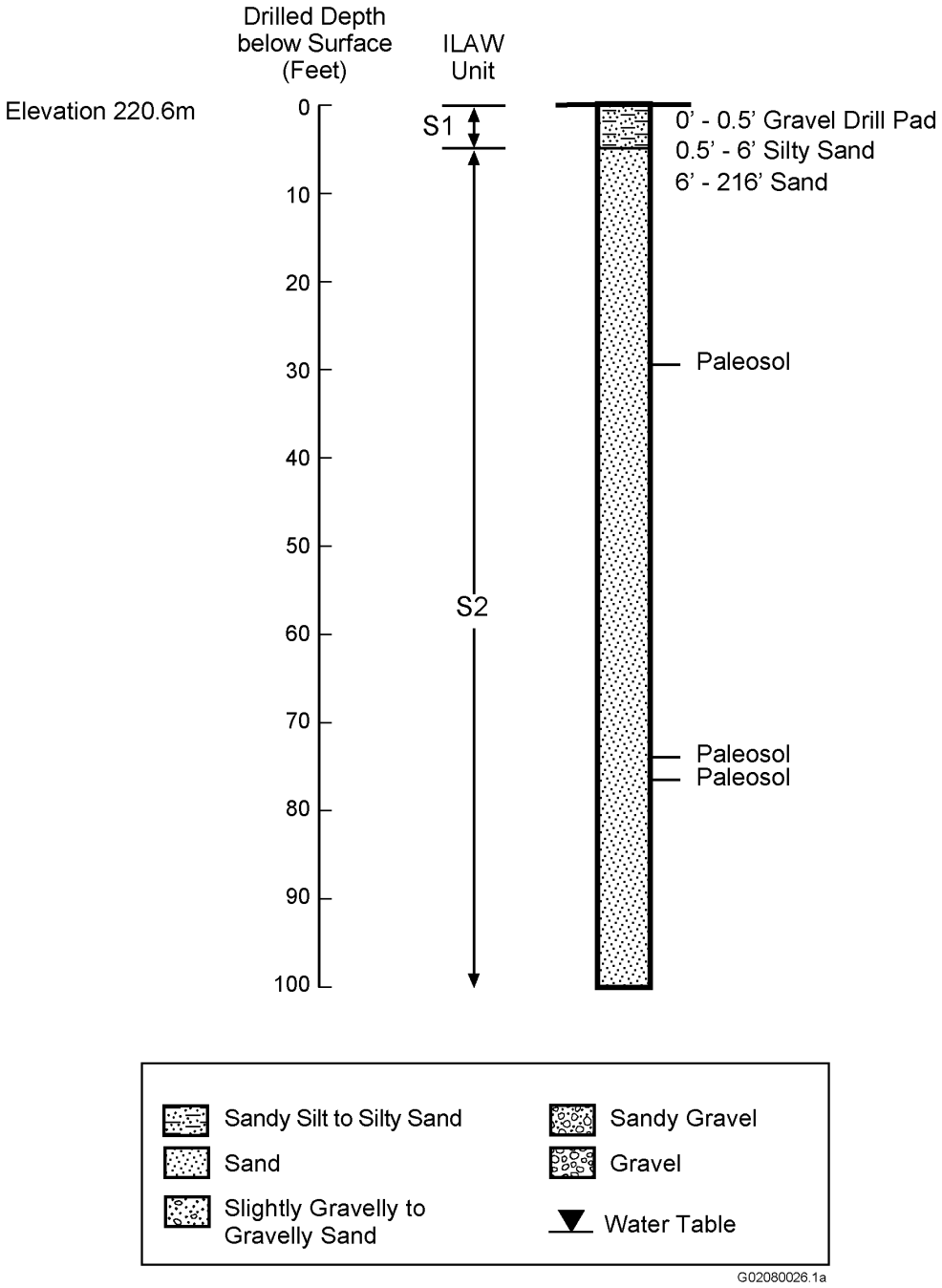
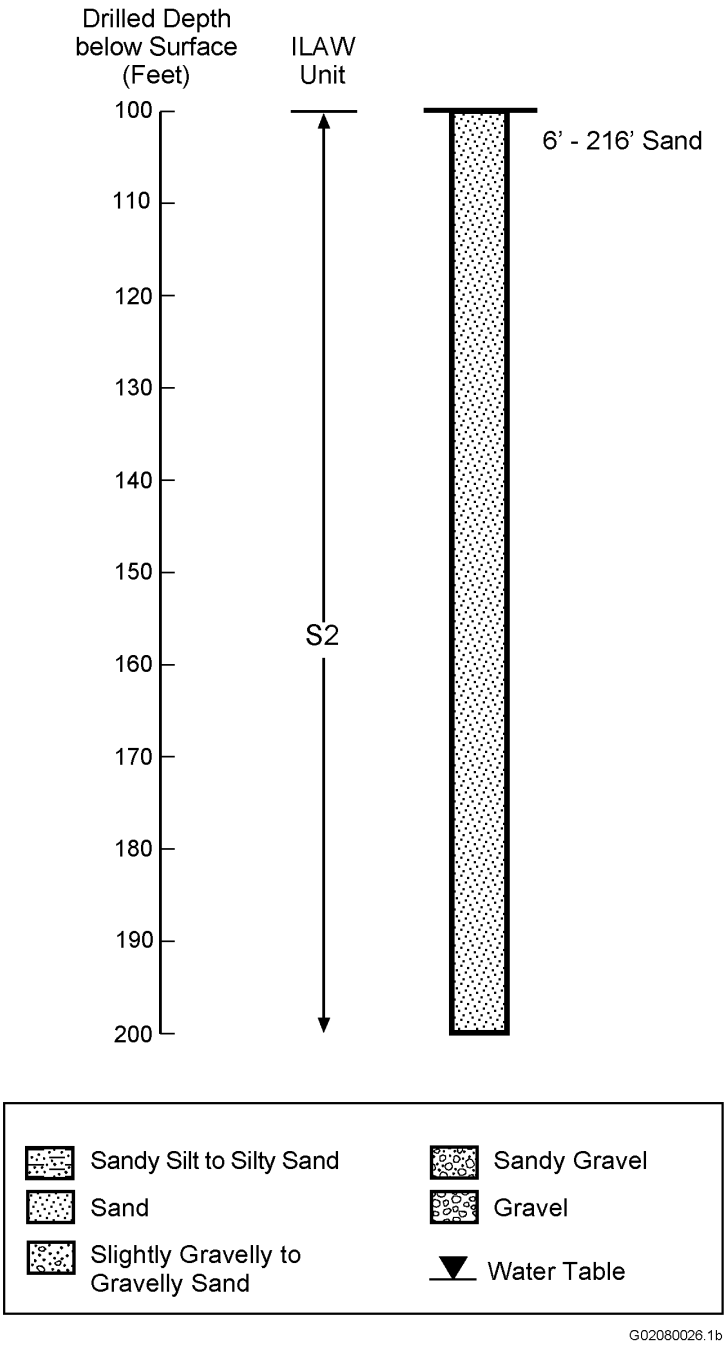


Figure 4. Summary of the Stratigraphy and Lithology of Borehole C3826. ILAW unit refers to sand layers (S) and gravel layers (G) previously observed at the ILAW site. Also see Figure 3.



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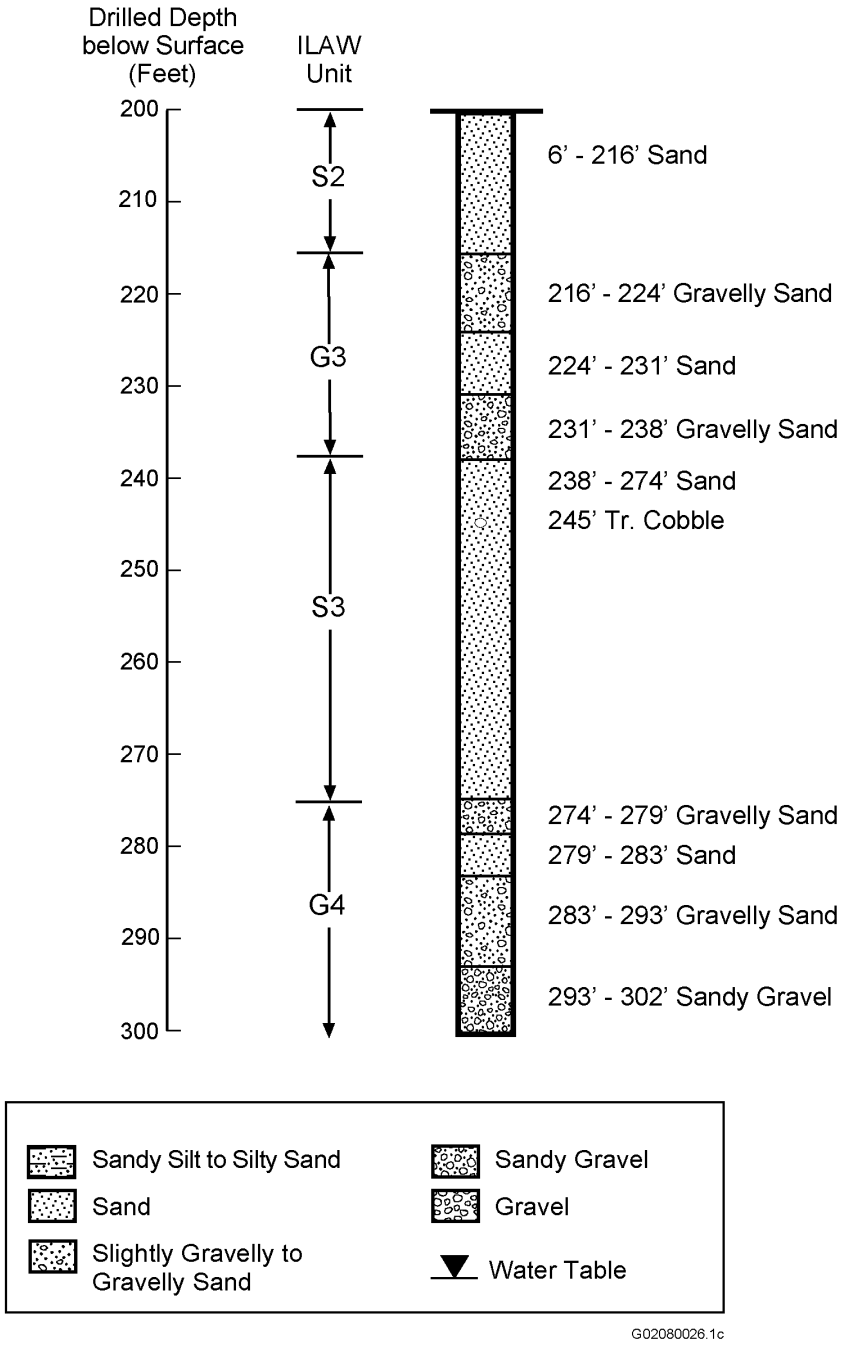

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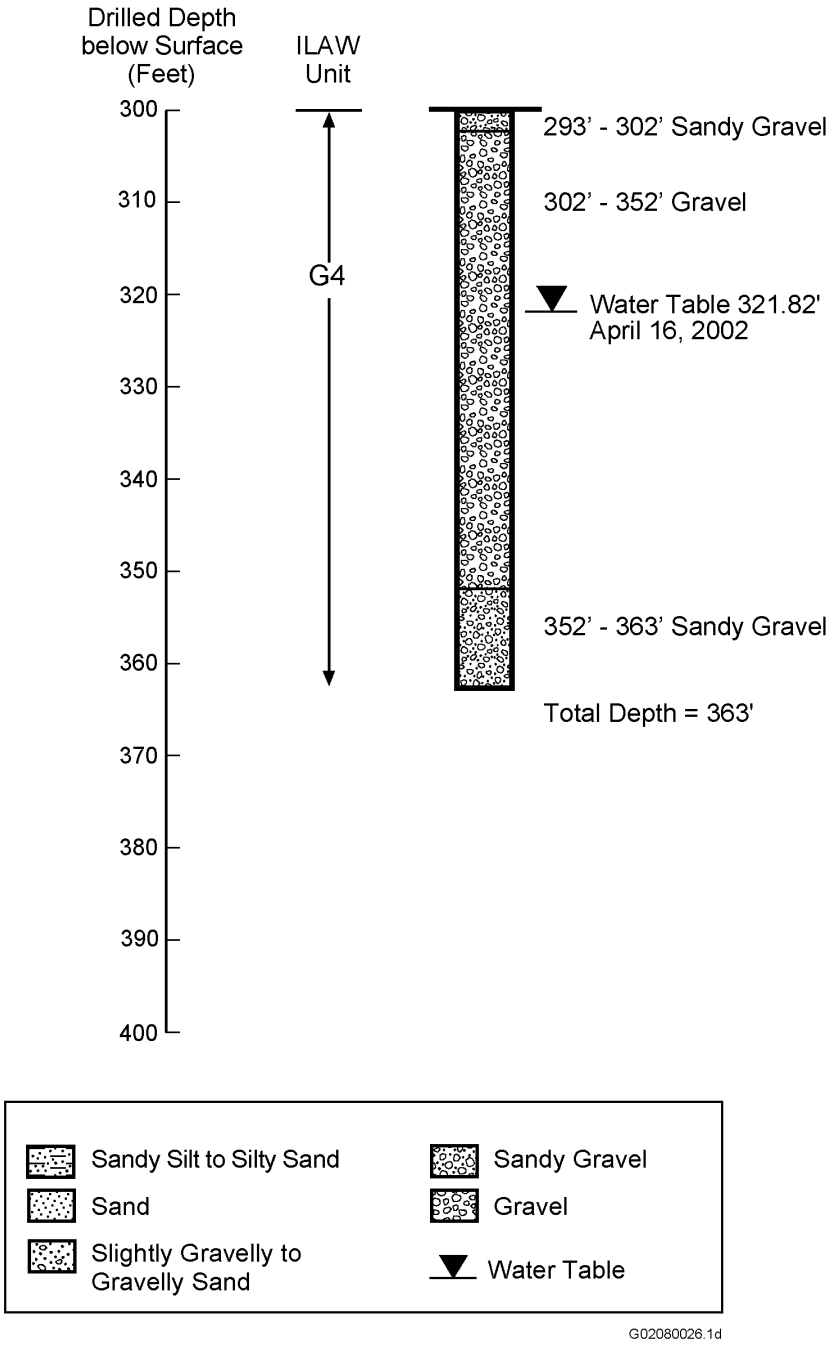

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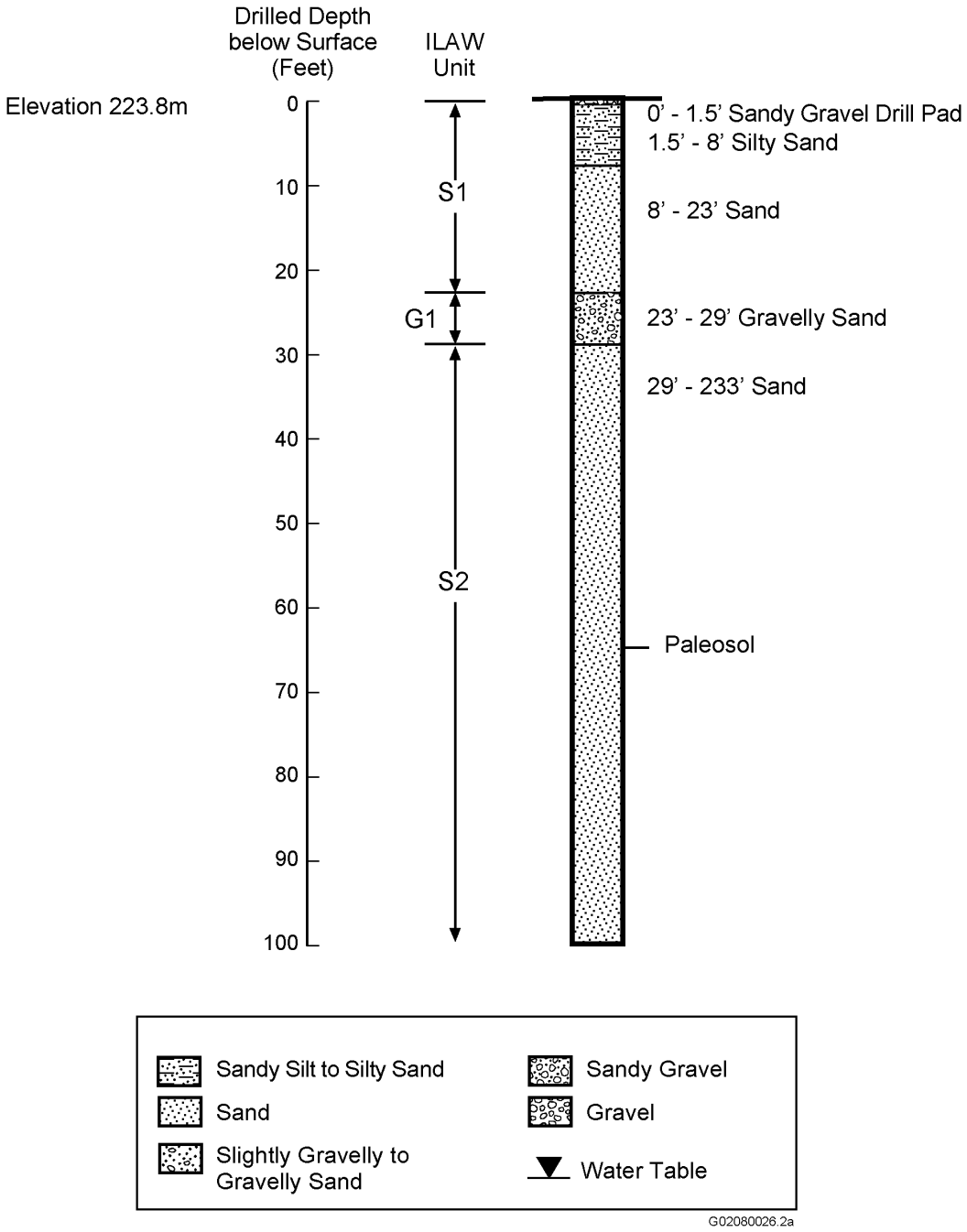
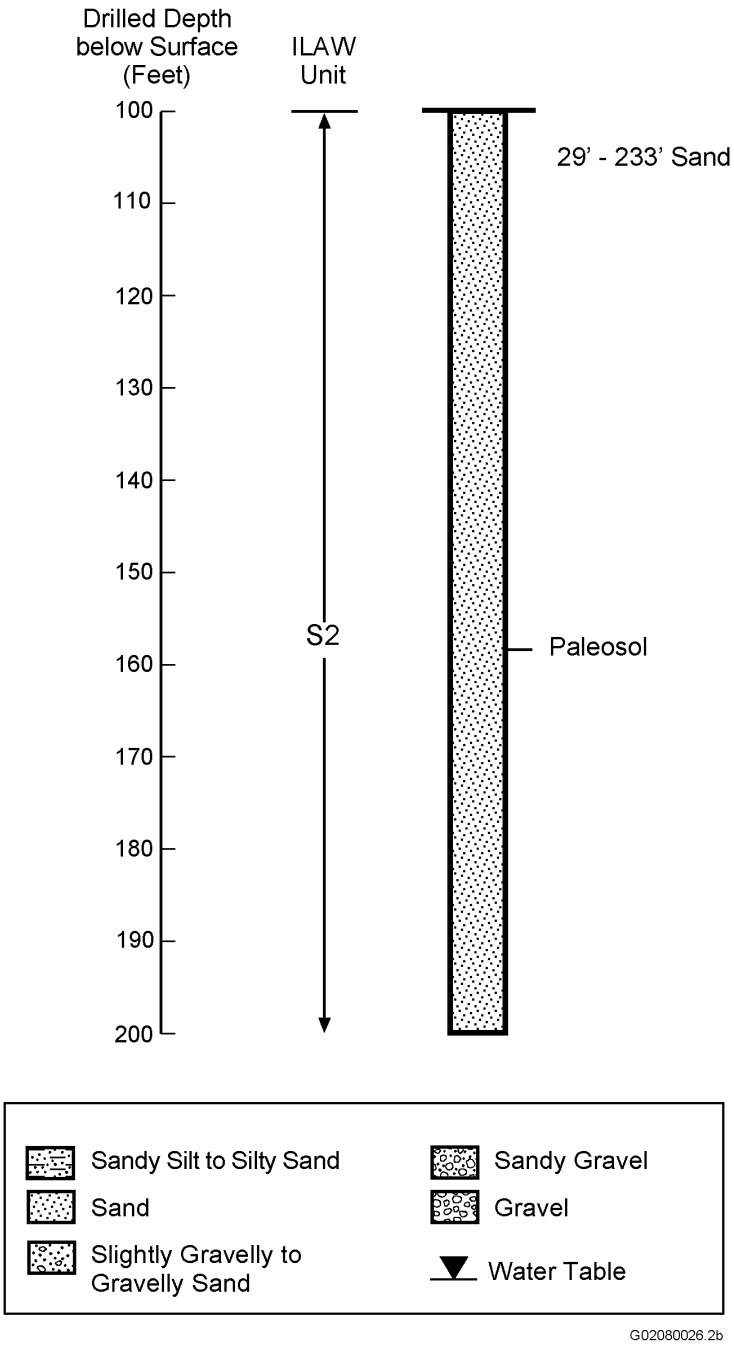


Figure 5. Summary of the Stratigraphy and Lithology of Borehole C3827. ILAW unit refers to sand layers (S) and gravel layers (G) previously observed at the ILAW site. Also see Figure 3.



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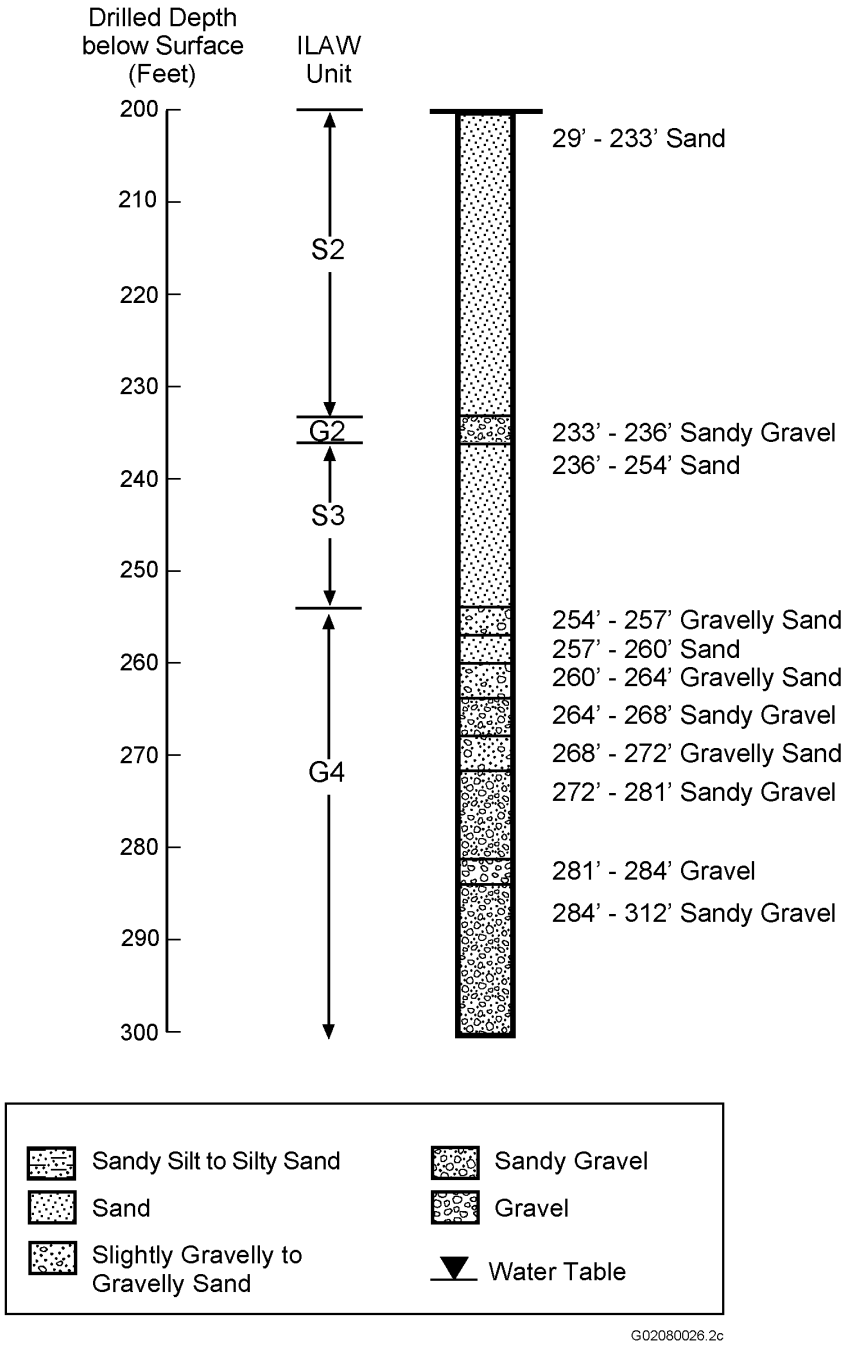

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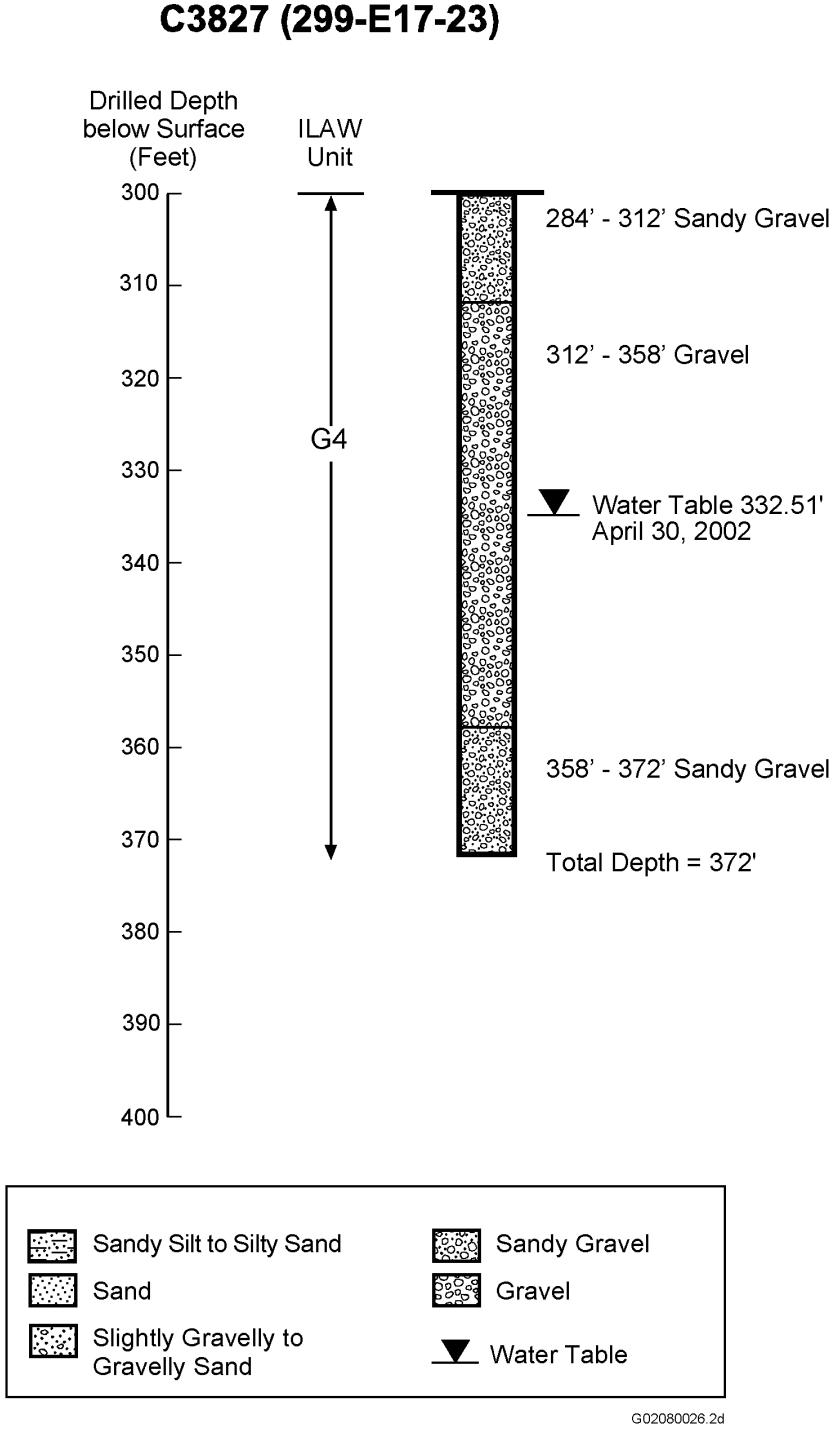

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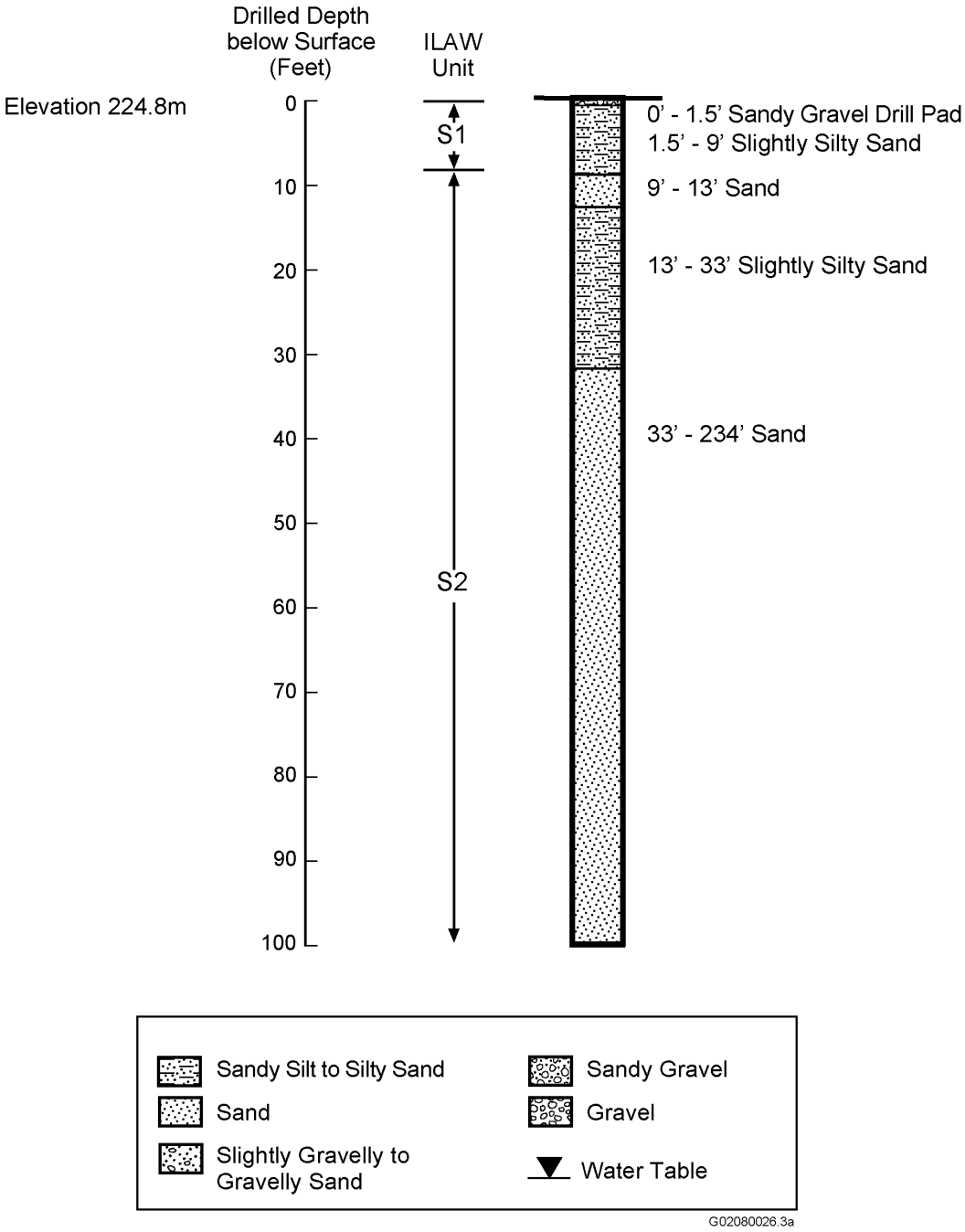
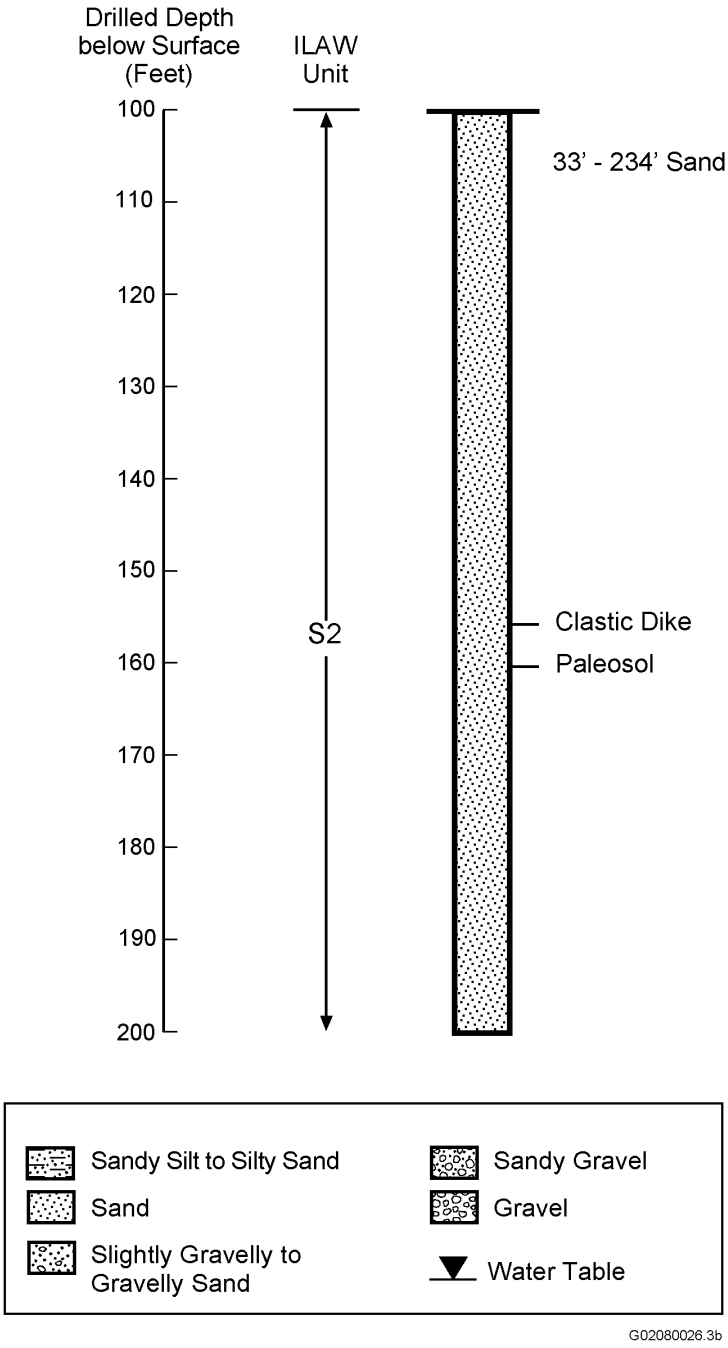


Figure 6. Summary of the Stratigraphy and Lithology of Borehole C3828. ILAW units refers to sand layers (S) and gravel layers (G) previously observed at the ILAW site. Also see Figure 3.

C3828



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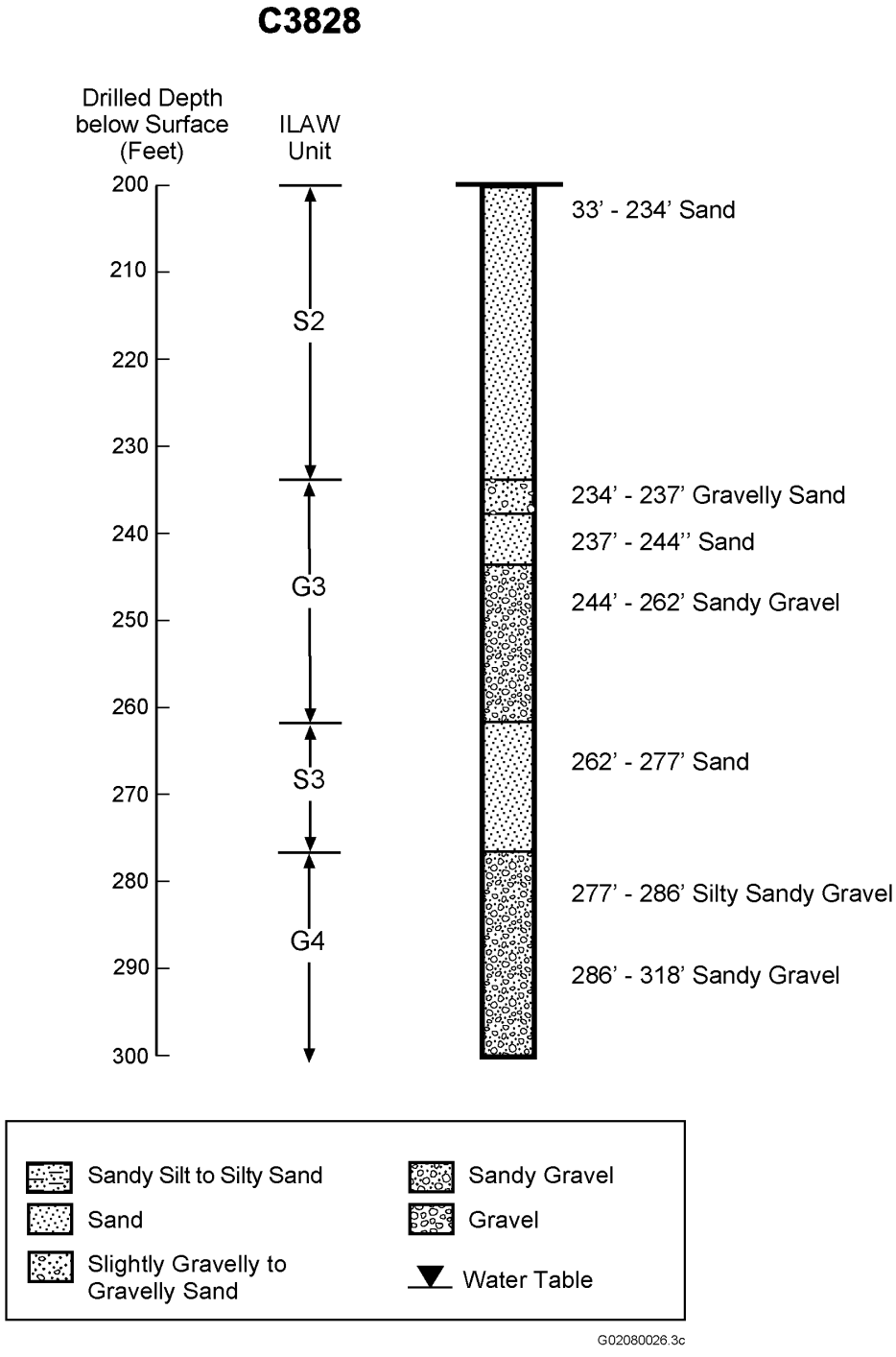

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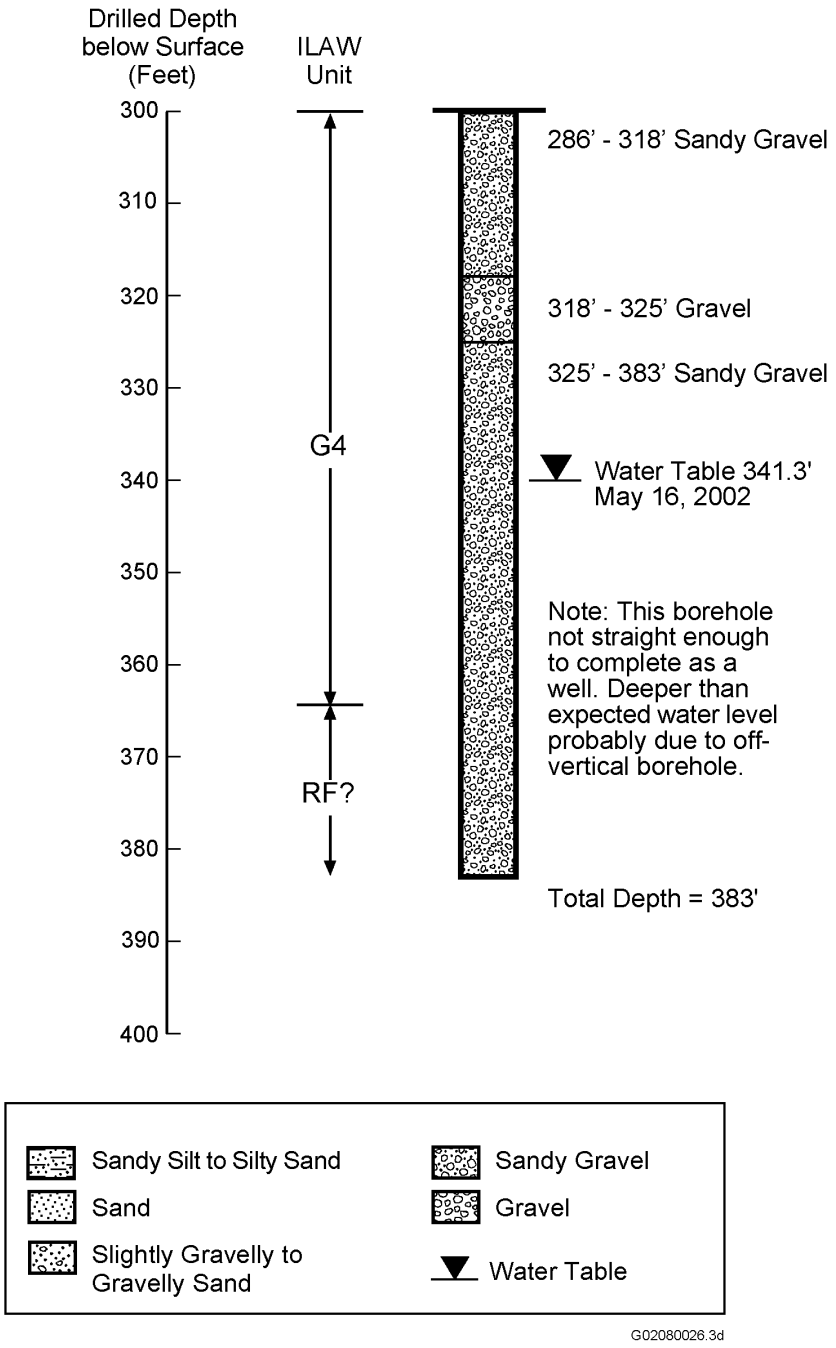

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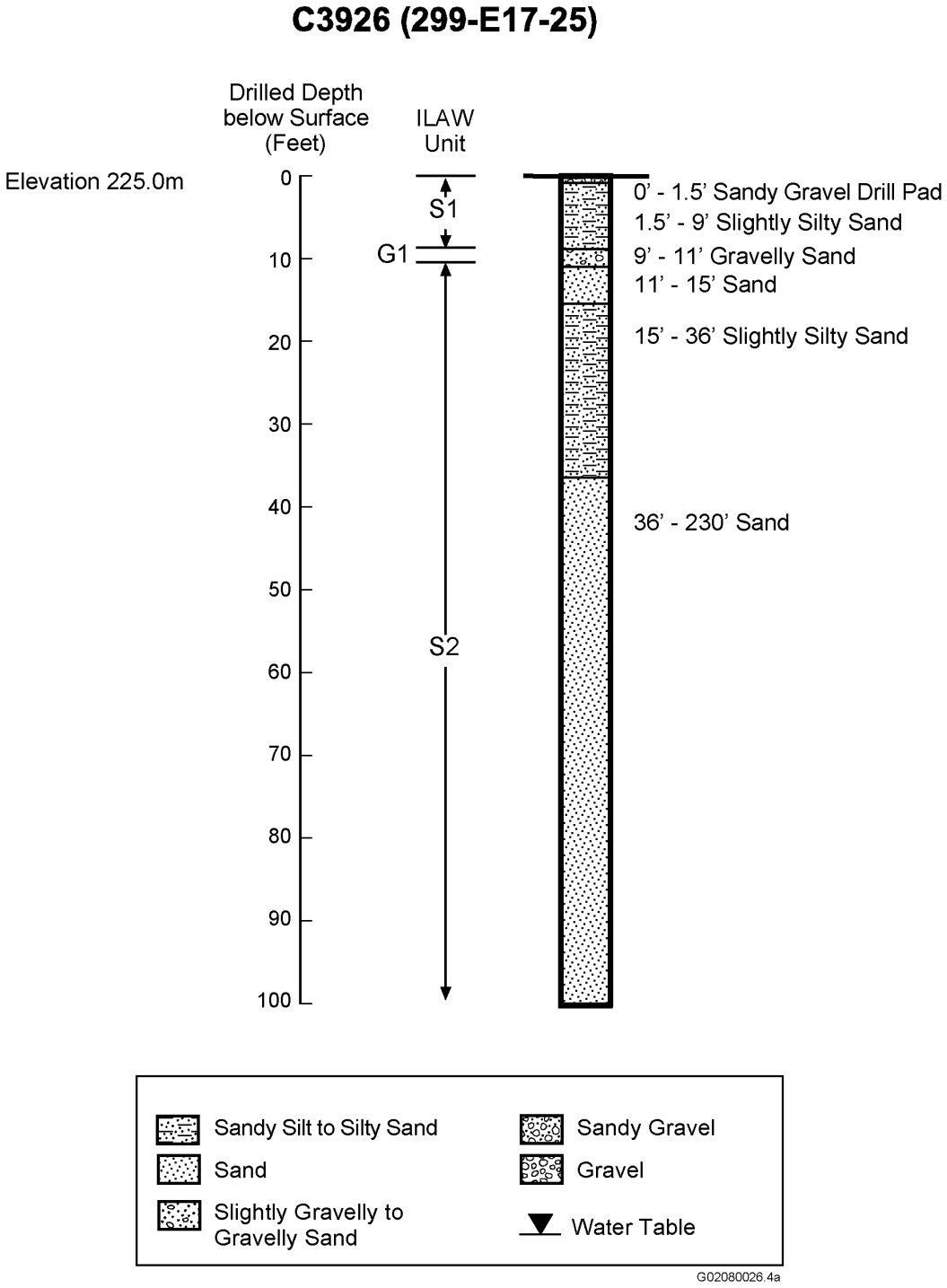
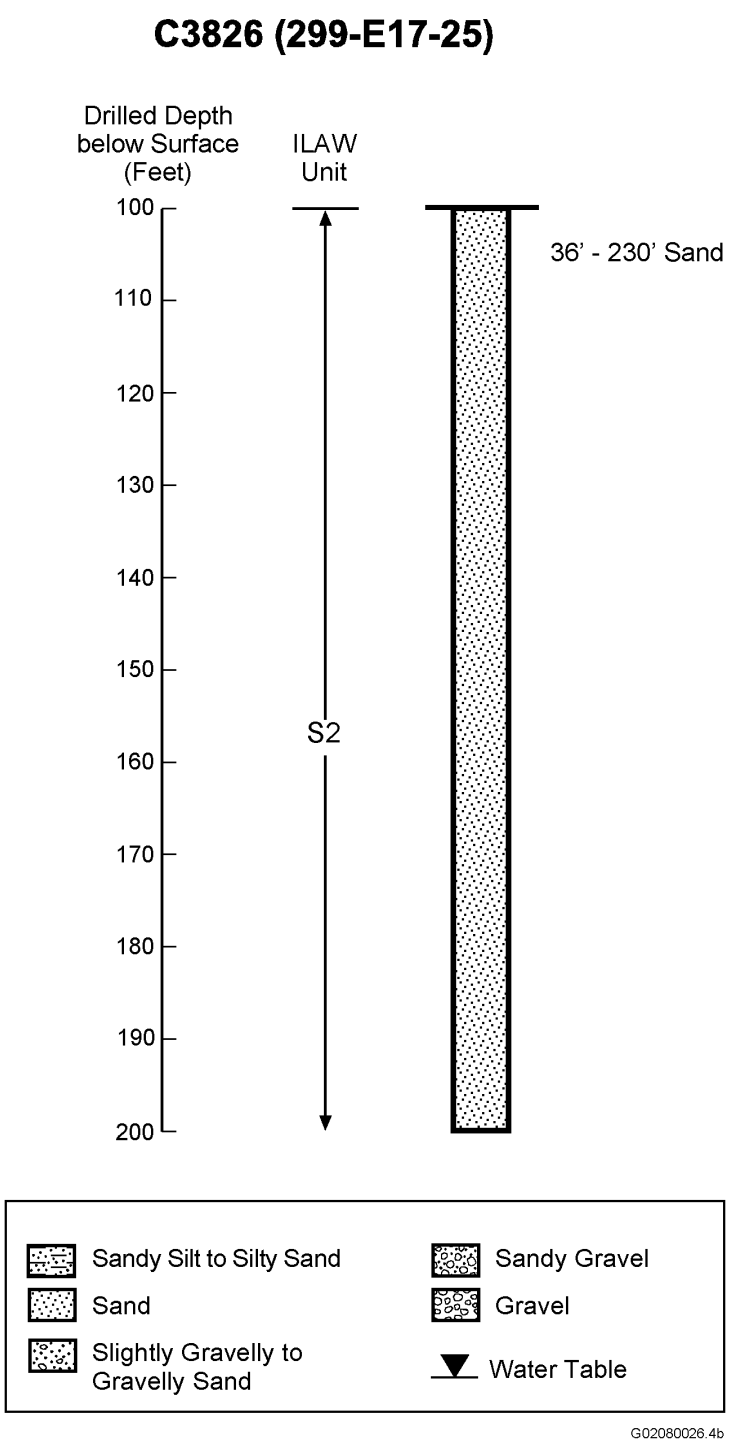


Figure 7. Summary of the Stratigraphy and Lithology of Borehole C3926. ILAW units refers to sand layers (S) and gravel layers (G) previously observed at the ILAW site. Also see Figure 3.



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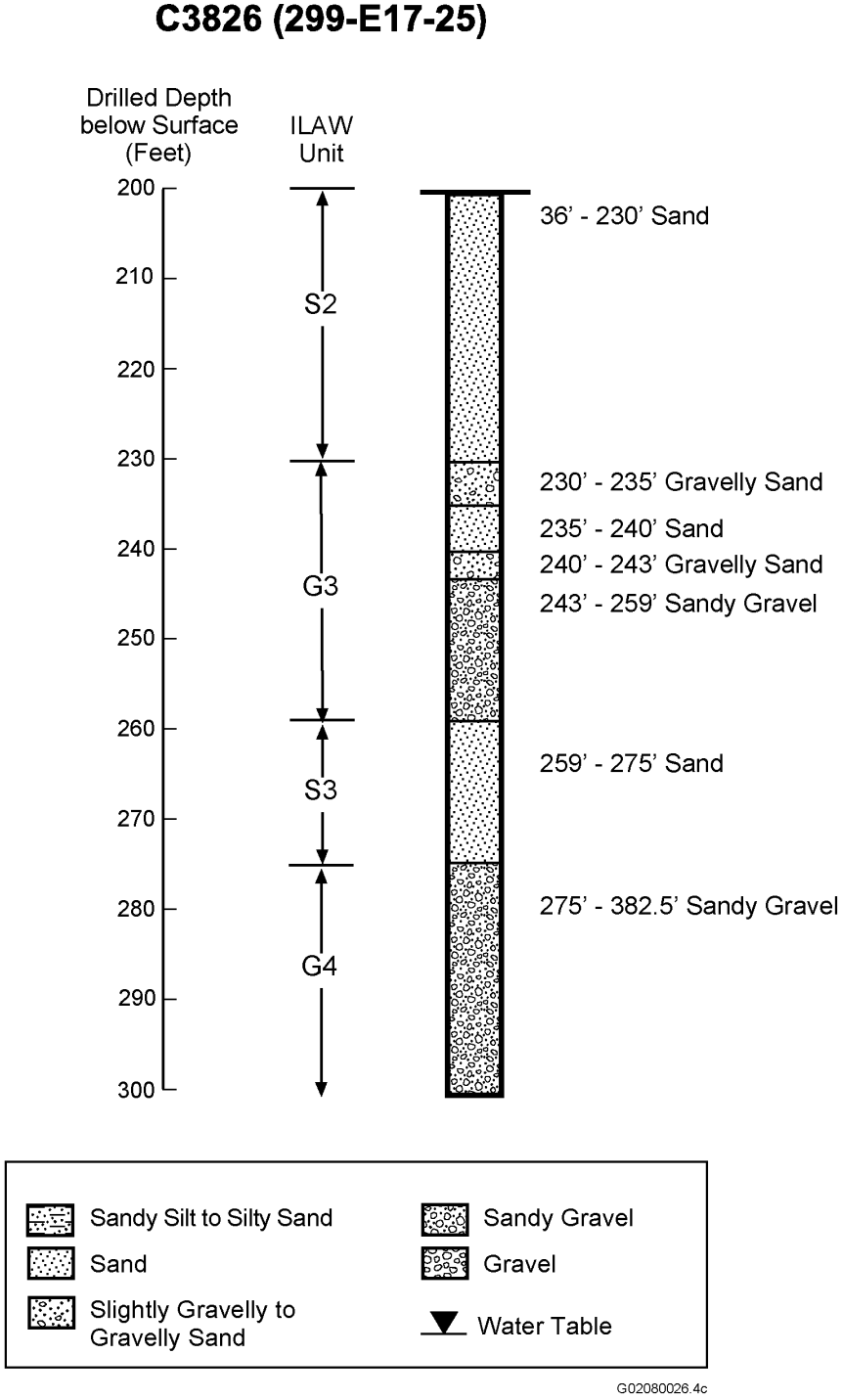

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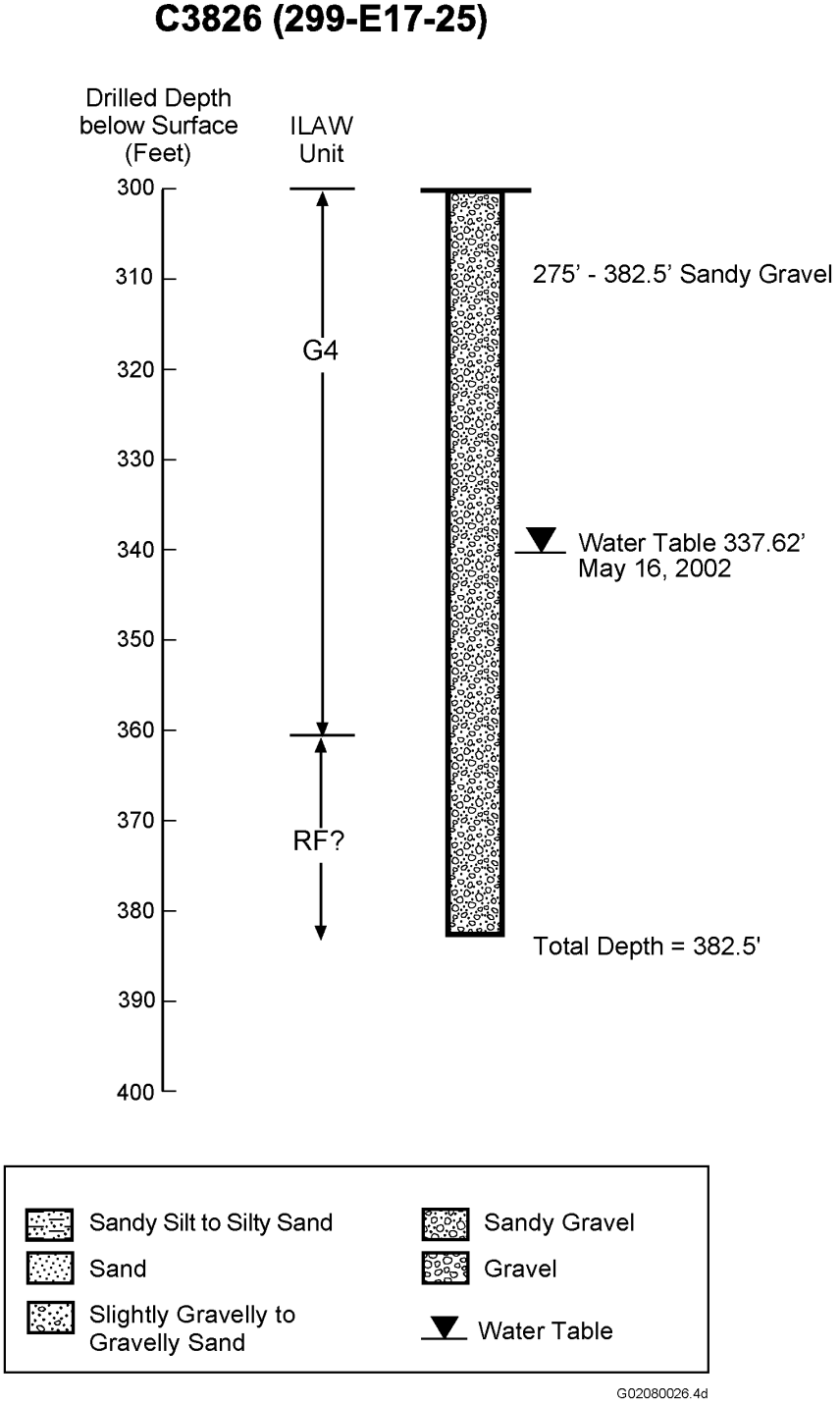

Figure 7. (contd)

Table 4. Thickness and Depth of the Hanford Formation Encountered in Boreholes

Borehole	Top of Hanford Formation (ft bgs)	Base of Hanford Formation (ft bgs)	Thickness of Hanford Formation (ft)	Thickness of Ringold Formation (ft)
C3826	0	>363 (TD)	>363	Not Known.
C3827	0	>372 (TD)	>372	Not Known.
C3828	0	~365	~365	>18
C3926	0	~360	~360	>22.5

3.2.1 Lower Gravel Sequence

A basal conglomerate (Figure 8) is present in all four boreholes (G4 in Table 5; Reidel and Horton 2000). This is consistent with the first and second ILAW boreholes (299-E17-21 and 299-E24-21, respectively). The upper part of the conglomerate consists of sandy gravel with very minor silt. The gravel content increases with depth, reaching 80 to 100% near the bottom of the boreholes. In boreholes C3826 and C3827, the lowermost gravel encountered was an open-framework, medium to coarse pebble (with some cobble) gravel. The open-framework texture was recognized by the field geologist and reflected during drilling, when air used to expel the drill cuttings from the borehole quickly dissipated into the formation.

This lower gravel sequence is equivalent to unit H3 of Lindsey et al. (1994), mapping unit Qfg_1, Missoula Outburst flood gravel deposits, of Reidel and Fecht (1994a, b), and the gravel-dominated facies association (GD) of the Hanford formation of DOE (2002).

3.2.2 Sand Sequence

Most of the Hanford formation encountered in the boreholes consists dominantly of fine- to coarse-grained sand with traces of silt and fine gravel (S2 and S3 in Table 5) (Figure 9). Within this sequence is a zone (G3) of gravelly sand and sandy gravel between depths of approximately 230 and 260 ft bgs in boreholes C3828 and C3926; this zone is thinner in boreholes C3826 and C3827. In boreholes C3827 and C3926, the sand sequence in these boreholes is topped by gravelly sand (G1) up to 2 ft thick.

This sand sequence is equivalent to unit H2 of Lindsey et al. (1994) and the following mapping units of Reidel and Fecht (1994a, b): Qfs_1, Qfs_2, and Qfs_3, Missoula Outburst Flood Deposits consisting of sand, silt, and clay. This sequence is also equivalent to the sand-dominated facies association (SD), and the uppermost part of the sequence is equivalent to the interbedded sand- to silt-dominated facies association (ISSD), of the Hanford formation of DOE (2002).

The sands range in composition from about 30% basaltic and 70% felsic to 70% basaltic and 30% felsic. Generally, the more basaltic-rich sands are deeper than the felsic-rich sands. The sands are generally subrounded to subangular and moderately to well sorted. The degree of compaction varies within the sand-dominated sequence with some samples being loose, uncompacted sediment and others

Figure 8. Basal Gravel from Borehole C3826 at the ILAW Site

Table 5. Summary of the Geology and Lithology of Boreholes C3826, C3827, C3828, and C3926

Hanford Units		Borehole C3826	Borehole C3827	Borehole C3828	Borehole C3926
DOE 2002	ILAW Units				
ISSD	S1	0’ to 6’	0’ to 23’	0’ to 9’	0’ to 9’
GD	G1	Not present	23’ to 29’	Not present	9’ to 11’
SD	S2	6’ to 216’	29’ to 233’	9’ to 234’	11’ to 230’
GD	G3	216’ to 238’	23’ to 236’	234’ to 262’	230’ to 259’
SD	S3	238’ to 274’	236’ to 254’	262’ to 277’	259’ to 275’
GD	G4	274’ to 363’ (TD)	254’ to 372’ (TD)	277’ to 383’ (TD)	275’ to 382.5’ (TD)
Not Applicable	Paleosol horizons recognized	30’6” to 30’10” 73’to 73’4”, 76’8” to 77’3”	62’6” to 62’8” and 158’1.6” to 158’5.2”	161’5.7” to 161’9.7"	

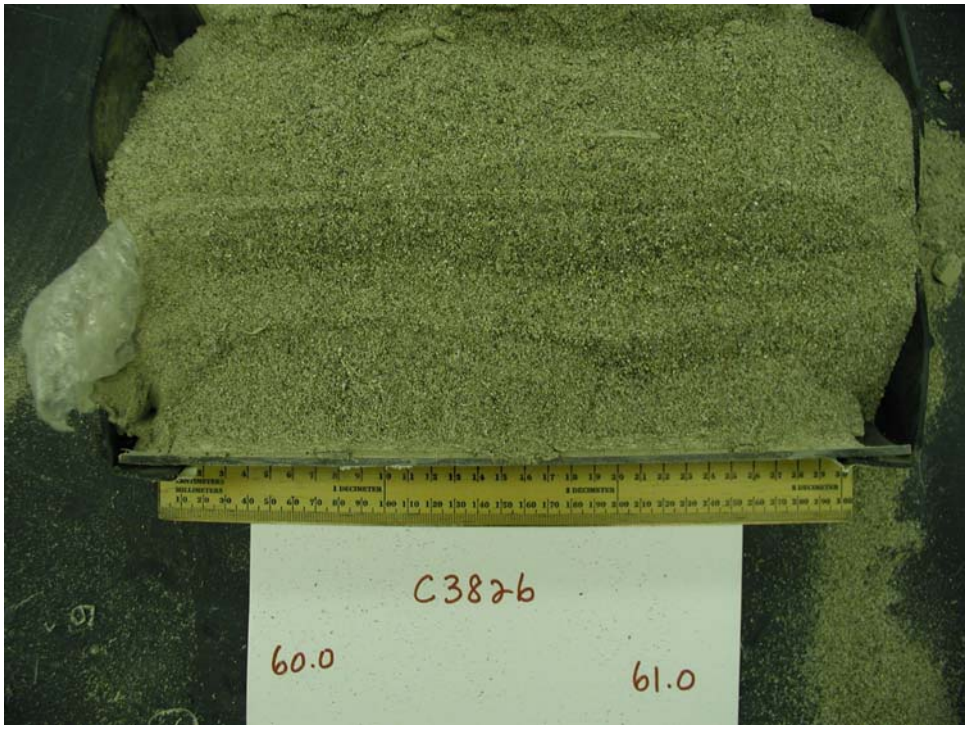

Figure 9. Sand-Dominated Unit from Borehole C3826, 60.0-61.0 Feet, at the ILAW Site

being compacted, competent sediment. The part of the sand-dominated sequence below the sandy gravel (S3) is generally more compact than the sands above the sandy gravel zone. Cementation is rare throughout the sand-dominated sequence, except at paleosols.

The dominant sedimentary feature of the sand-dominated sequence is bedding. Generally, bedding is fairly subtle and is defined by slight color changes (due to slight changes in composition) or changes in grain size. The S3 sands are generally coarser. Bedding defined by grain size changes reflects upward-fining sequences generally 2 to 4 in. (5 to 10 cm) thick.

3.2.3 Paleosols

Paleosols, or ancient soil zones, are generally calcite-cemented (caliche), bioturbated and apparently leached soil horizons where encountered. At least three paleosol horizons are identified in the drill core from these boreholes (Table 5). The first is encountered at about 30’6” bgs (Figure 10) in boreholes C3826 and C3926. A second, deeper paleosol was encountered in C3827 at a depth of about 62’6” bgs. Apparent paleosols, one of which may correlate to the deeper paleosol in C3827, were encountered at 73’ bgs and 76’8” bgs in borehole C3826. A third paleosol was encountered at a depth of about 160’ bgs in boreholes C3827 and 155’ in C3828 (Table 5). In general, these paleosols are between 2 and 4 in. (5 to 10 cm) thick and may correlate with paleosols identified in the first and second ILAW boreholes (299-E17-21 and 299-E24-21).

Figure 10. Paleosol from Borehole C3826, Depth 30.5-31.5 Feet.
Paleosol is the light colored zone beginning at 30.5 feet.

3.2.4 Clastic Dikes

The core interval 155'6" to 157'6" from borehole C3828 contains a clastic dike (Figure 11). A cross-section cut through the core sample reveals a 3 cm-wide dike of very fine to fine sand crosscutting medium-grained sand. The dike is not observed in core samples above 155' and below 158', and its orientation and continuity is unknown.

3.3 Passive Gamma Spectral Results

Boreholes 299-E17-22, 299-E17-23, and 299-E17-25 were logged during August 2002 using a spectral gamma ray tool to verify the absence of man-made radionuclides. Previous experience from geophysical logging at 299-E17-21 and 299-E24-21 showed that the vadose zone at the ILAW site does not exhibit significant stratigraphic changes that can be detected during geophysical logging. The results of these surveys are presented in Appendix F. There are four logs: total gamma, potassium-40, uranium-238 and thorium-232. No man-made gamma-emitting contamination was detected.

Figure 11. Clastic Dike Penetrated in Borehole C3828

4.0 Groundwater Chemistry

A summary of the chemistry of groundwater samples from wells 299-E17-22, 299-E17-23, and 299-E17-25 is given in Table 6. With the exception of sulfate, all values are similar to known Site-wide background levels from DOE (1992). Measured sulfate concentrations are 84.9 and 64.1 mg/L in wells C3827 and C3926, respectively, notably higher than background. Sulfate levels in background areas range between 30.6 mg/L and 41.3 mg/L (DOE 1992). The difference between sulfate levels measured in wells C3827 and C3926 and the background levels appears to be significant.

5.0 Conclusions

Results from the FY 2002 ILAW boreholes are consistent with results from the first and second ILAW boreholes (299-E17-21, 299-E24-21, respectively). These results indicates that the ILAW site is situated above an erosional channel, that is cut into the Ringold Formation and filled with unconsolidated, open-framework gravel of the Hanford formation. Stratigraphy above the channel appears to consist of sediments representing at least three individual Lake Missoula cataclysmic flooding events.

Table 6. Groundwater Chemistry

	299-E17-22	299-E17-23	299-E17-25[e]	PNL[a]	USGS[b]	WHC[c]
Chloride, mg/L	9.7	11.4	10.8	10.3±6.5	12.2 ± 7.8	8.8 ± 7.7
Fluoride, mg/L	0.43	0.57	0.49	0.37±0.1	0.55 ± 0.33	0.44 ± 0.13
Nitrate, mg/L	4.1	4.5	6.9	NA	3.2 ± 3.4	5.2 ± 3.6
Sulfate, mg/L	37.5	84.9	64.1	34.4±16.9	41.3 ± 27.9	30.6 ± 22.6
Tritium, pCi/L	12,600 ± 840[d]	4,000 ± 430	66,900 ± 3100	NA	NA	NA

(a) From PNL-6886 (Evans et al. 1989) and DOE (1992).
(b) Compiled by the U.S. Geological Survey from Hanford Site area sources in the National Water Information System database; from DOE (1992).
(c) Based on 7 wells located in the background area upgradient of Hanford facilities or in the southern part of the site; from DOE (1992).
(d) Total uncertainty (2σ).
(e) When planning for sampling, borehole C3828 (299-E17-24) was originally planned as the groundwater monitoring well and labels were prepared. When it was determined to abandon C3828 and offset drill C3926 (299-E17-25), the sampling labels were not changed but the correction was noted in the drilling activity logs.

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Appendix A

Well Summary Report for 2002 ILAW Well Installations

Appendix A

BHI-01647
Rev. 0

Well Summary Report: 2002 Immobilized Low-Activity Waste Well Installation

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Environmental Restoration

Submitted by: Bechtel Hanford, Inc.

For ERC Review

BHI-01647
Rev. 0
OU: N/A
TSD: N/A
ERA: N/A

APPROVAL PAGE

Title: Well Summary Report: 2002 Immobilized Low-Activity Waste Well Installation

Approval: L. R. Curry, Acting Project Manager/Project Engineer
Groundwater/Vadose Zone Integration Project

L. R. Curry — Signature — 6/24/02 — Date

L. M. Dittmer, Project Environmental Lead,
Groundwater/Vadose Zone Integration Project

Lorna M. Dittmer — Signature — 24 June 2002 — Date

R. L. Jackson, Groundwater Operations Task Lead,
Groundwater/Vadose Zone Integration Project

Ronald L. Jackson — Signature — 06/24/02 — Date

The approval signatures on this page indicate that this document has been authorized for information release to the public through appropriate channels. No other forms or signatures are required to document this information release.

BHI-DIS JLR 6/24/02

BHI-01647
Rev. 0

Well Summary Report: 2002 Immobilized Low-Activity Waste Well Installation

Authors

L. D. Walker
C. S. Wright
CH2M HILL Hanford, Inc.

Date Published

June 2002

TABLE OF CONTENTS

APPENDICES

FIGURE

TABLES

ACRONYMS

bgs	below ground surface
DQO	data quality objective
FY	fiscal year
ID	inside diameter
ILAW	immobilized low-activity waste
OD	outside diameter
PNNL	Pacific Northwest National Laboratory
TD	total depth
UCL	upper confidence limit
WAC	*Washington Administrative Code*

METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.0836	sq. meters
sq. miles	2.6	sq. kilometers
Acres	0.405	hectares
Mass (weight)		
Ounces	28.35	grams
Pounds	0.454	kilograms
Ton	0.907	metric ton
Volume		
Teaspoons	5	milliliters
Tablespoons	15	milliliters
fluid ounces	30	milliliters
Cups	0.24	liters
Pints	0.47	liters
Quarts	0.95	liters
Gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
Picocuries	37	millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

1.0 INTRODUCTION

This document describes the fiscal year (FY) 2002 field activities associated with drilling three characterization boreholes (299-E17-22, 299-E17-23, and 299-E17-24) at the Immobilized Low-Activity Waste (ILAW) disposal site in the 200 East Area of the Hanford Site. A fourth borehole was drilled (299-E17-25) after technical problems forced borehole 299-E17-24 to be decommissioned. The data obtained from these boreholes will support current and future ILAW disposal site performance assessments. Well locations are shown in Figure 1.

1.1 PURPOSE AND SCOPE

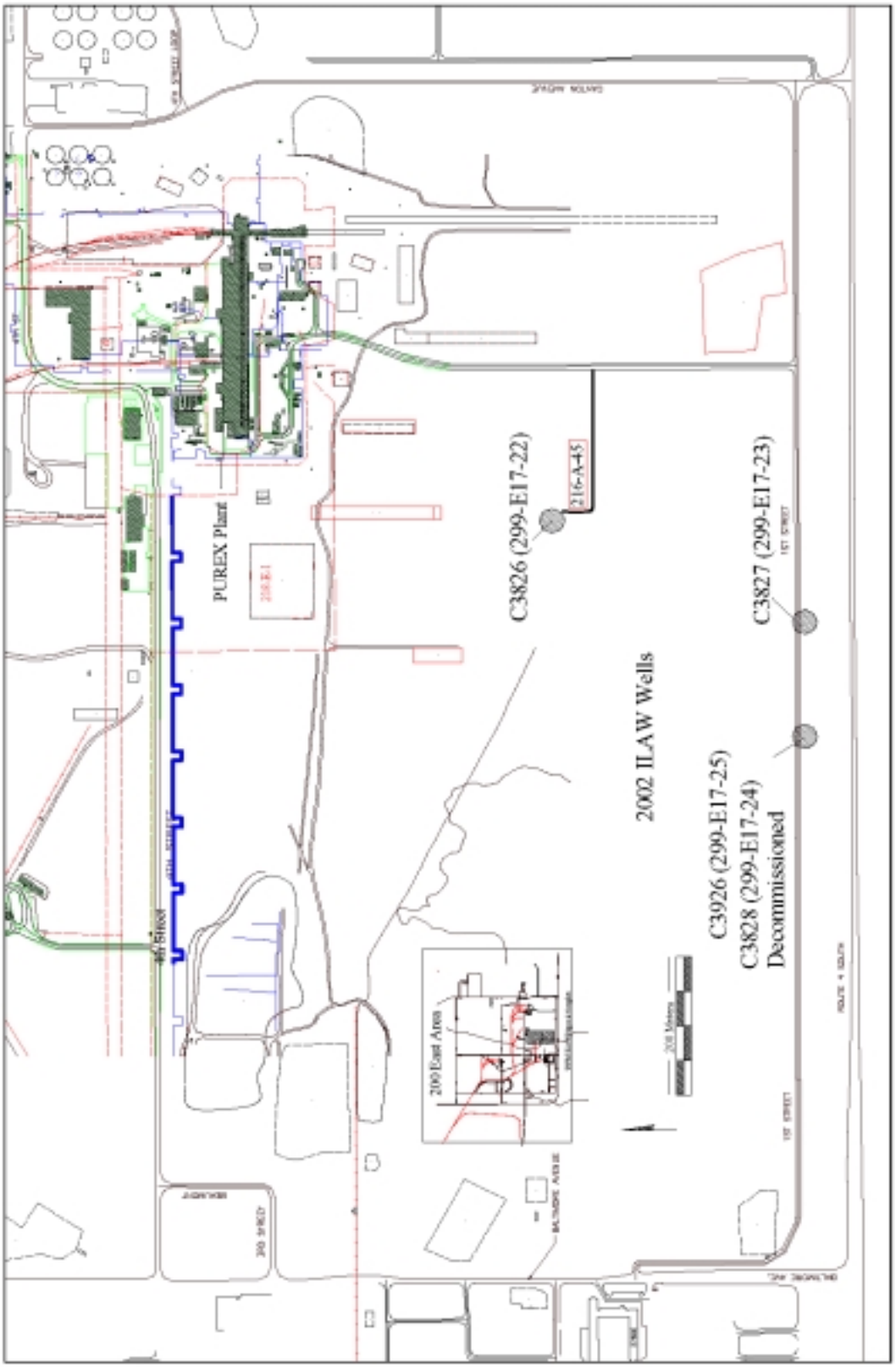
The three wells were drilled to support characterization of the physical properties of the soil at the ILAW disposal site and eventually the disposal of waste from the Hanford Site underground storage tanks. After waste is retrieved from the Hanford Site underground storage tanks, waste will be separated into two streams: (1) a low-volume, high-activity waste stream; and (2) a high-volume, low-activity waste stream. Both streams will be immobilized using the vitrification process. The immobilized high-level waste will be stored at the Hanford Site prior to shipment to a deep geological repository. The ILAW will be disposed at the Hanford Site, southwest of the Plutonium-Uranium Extraction Facility in the 200 East Area. The first ILAW disposal site characterization borehole (299-E17-21) was drilled in April 1998. The second borehole (299-E24-21) was drilled in March and April 2001.

The objective of the vadose and saturated zone characterization is to provide data to develop a geohydrologic conceptual model of the ILAW disposal site for use in the Hanford Site ILAW performance assessment (Reidel 2000). The conceptual model will be used in the performance assessment to model the movement of moisture and contaminants through the vadose zone. The characteristics of the saturated zones, as well as the results of in situ testing, will be used in groundwater modeling. After drilling, the boreholes were completed as a *Resource Conservation and Recovery Act of 1976*-compliant groundwater monitoring wells.

Descriptions of drilling, geologic conditions and materials, well construction, and well development for both wells are presented in Section 2.0. Section 3.0 provides a brief description of subsurface conditions based on geologic and hydrogeologic data collected during the installation of the wells. References are listed in Section 4.0. Well summary sheets and geologic borehole logs are included in Appendices A and B, respectively. Well development data are presented in Appendix C. Survey data report sheets are included in Appendix D.

All drilling activities were documented in accordance with BHI-EE-02, *Environmental Requirements*, Procedure 14.0, "Drilling, Maintaining, Remediating, and Decommissioning Resource Protection Wells, GeoProbe and Geotechnical Soil Borings." A geologic log was prepared for each well in accordance with BHI-EE-01, *Environmental Investigations Procedures*, Procedure 7.0, "Geologic Logging." The drilling data in this report are presented in the English units in which they were measured.

Figure 1. Well Location Map.



2.0 TECHNICAL DATA

2.1 WELL C3826/299-E17-22

This section contains a summary and description of drilling, well completion, and well development activities performed during the installation of well C3826/299-E17-22.

2.1.1 Drilling Summary

Drilling of well C3826/299-E17-22 was performed in accordance with the *Characterization Plan for Fiscal Year 2002 Immobilized Low-Activity Waste Site Characterization Boreholes* (Reidel 2002). Well summary information for this well is presented in Appendix A.

Drilling of well C3826/299-E17-22 using the dual-wall percussion method (Becker hammer drill®) began on March 29, 2002, advancing outer 9-in. outside diameter (OD) and inner 6-in. inside diameter (ID) temporary casing. Groundwater was encountered at approximately 322 ft below ground surface (bgs) on April 9, 2002. Waste designation samples were collected at 70 and 170 ft bgs, as described in Section 2.5. Archive samples (in volumes of 1 pint each) were collected at 5-ft intervals, and 23 split-spoon samples were collected from the intervals shown in Table 1. Split-spoon samplers consisted of two 2-ft (4 ft total) sample bodies coupled together in series with a 0.5-ft drive shoe. The split spoons were 5 in. OD and contained four 1-ft Lexan® liners (4 in. in diameter). Each sampler was driven on a 3.5-in.-diameter drill rod by the surface diesel hammer. The borehole was advanced to a total depth (TD) of 363 ft bgs (temporary casing 362.5 ft bgs) on April 11, 2002.

2.1.2 Well Completion

Well construction materials, filter-pack installation and initial well development, and the annular seal for well C3826 are discussed in the following subsections. A summary of well completion is provided in Table 2 and in the well summary sheets presented in Appendix A.

2.1.2.1 Screen, Riser Casing, and Filter Pack. A 35-ft-long 20-slot (0.020-in.) continuous v-wire wrap stainless-steel screen (with a 2-ft sump) and 10-20 mesh (0.0787- to 0.0331-in.) filter-pack sand were preselected for this well based on data from nearby wells and anticipated formation characteristics. The bottom of the sump was placed at 358.66 ft bgs, and the bottom of the screen was placed at 356.66 ft bgs. The top of the screen was located at 321.63 ft bgs. The borehole was backfilled with 10-20 mesh filter-pack sand from TD to 15 ft above the top of the screen (306.3 ft bgs).

® Becker hammer is a registered trademark of Foremost Industries, Calgary, Canada.
® Lexan is a registered trademark of General Electric Company, USA.

Table 1. Split-Spoon Sample Intervals.

Well C3826	Well C3827	Well C3828
8-51 (10 samples)		
	53.5-57.5	53.5-57.5
58-62	58-62	58-62
63.5-67.5	62.5-66.5	62.5-66.5
68-72		
72.5-76		
76.5-80.5	76-80	
96-100	98-102	
119-123	119-123	
149-153	149-153	
	153.5-157.5	153.5-157.5
	158-162	158-162
163.5-167.5	162.5-166.5	162.5-166.5
168-172		
172.5-176.5		
179-183	179-183	
219-223	219-223	

Note: Depths are in feet below ground surface.

2.1.2.2 Filter-Pack Installation and Initial Well Development. When installing the filter-pack material the objectives are to introduce the silica sand into the annular space around the screen, settle the filter pack to eliminate void spaces, and begin removal of fines and recondition the borehole walls from the effects of drilling. A dual-flange surge block was used to develop and settle the filter-pack material opposite the screen. The surge block was typically operated for 20 minutes per 2- to 3-ft stroke interval. Care was taken to maintain overlap between the filter sand and temporary casing so that formation material would not cave in against the well screen. The level of the filter pack was measured periodically with a weighted steel tape to monitor progress and ensure the integrity of the completion. The bottom of the well was also checked for fill material to determine if any fine material was accumulating in the screen during surging. This material was removed, as needed.

2.1.2.3 Annular Seal. Approximately 9 ft (297.0 to 306.3 ft bgs) of annular seal was constructed above the filter pack using 0.25-in. bentonite pellets, and a granular bentonite seal placed to 9.4 ft bgs. A grout seal was placed from the bentonite seal to ground surface. The grout seal consisted of Portland cement mixed with no more than 5% bentonite by weight, in accordance with *Washington Administrative Code* (WAC) 173-160.

2.1.3 Final Well Development and Pumping Test

Final well development was performed on May 21, 2002, after the surface cement pad and protective casing were installed. A 3-HP electric submersible pump (Grundfos® type 16S30-24) was used to pump at two depth intervals until the turbidity was less than 5 nephelometric turbidity units (NTU) and other water parameters had stabilized (i.e., temperature, conductivity, pH). First, the pump was operated with the intake 5 ft above the bottom of the well screen. At this depth the pump could only produce 11 gal/min. Drawdown of the water level during pumping was monitored by a pressure transducer and recorded in a datalogger. Water samples (C3828_1, C3828_2, and C3828_3) were collected at this depth for analyses by Pacific Northwest National Laboratory (PNNL). The pump intake was then raised to 22 ft above the bottom of the screen, and pumping resumed until the turbidity was again below 5 NTU. Final groundwater parameters are presented in Table 3.

2.2 WELL C3827/299-E17-23

This section contains a summary and description of drilling, well completion, and well development activities performed during the installation of well C3927/199-E17-23.

2.2.1 Drilling Summary

Drilling of well C3827/299-E17-23 was performed in accordance with the characterization plan for FY 2002 (Reidel 2002). Well summary information for this well is presented in Appendix A.

Drilling of well C3827/299-E17-23, using the dual-wall percussion method (Becker hammer drill) began on April 17, 2002, advancing outer 9-in. OD and inner 6-in. ID temporary casing. Groundwater was encountered at approximately 332.5 ft bgs on April 25, 2002. Archive samples were collected at 5-ft intervals, and 12 split-spoon samples were collected from the intervals shown in Table 1. The split-spoon samplers for this borehole retrieved 4 ft of sediment in four 1-ft-length Lexan liners. The borehole was advanced to a TD of 372 ft bgs (temporary casing 372 ft bgs) on April 25, 2002.

2.2.2 Well Completion

Well construction materials, filter-pack installation and initial well development, and the annular seal for well C3827 are discussed in the following subsections. A summary of well completion is provided in Table 2 and in the well summary sheets presented in Appendix A.

® Grundfos is a registered trademark of Grundfos Pumps Corporation, Clovis, California.

Table 2. Well Completion Summary.

Well Name	Well ID	Water Level (ft bgs)	Screen					Sandpack	Bentonite Pellets	Granular Bentonite Seal	Grout
			Screen Top (ft bgs)	Screen Bottom (ft bgs)	Screen Length (ft)	Sump (ft)	Screen Material	Interval (ft bgs)	Interval (ft bgs)	Interval (ft bgs)	Interval (ft bgs)
299-E17-22	C3826	321.82	321.63	356.66	35	2	304L SS	306.3-362.7	297.0-306.3	9.4-297.0	0-9.4
299-E17-23	C3827	332.5	332.98	368.10	35	2	304L SS	323.0-370.5	316.1-323.0	316.1-9.9	0-9.9
299-E17-24	C3828	341.3	NA	NA	NA	NA	NA	330-383	NA	330-9.5	0-9.5
299-E17-25	C3926	337.67	336.56	371.57	35	2	304L SS	326.8-382.5	316-326.8	316-10.8	0-10.8

NA = not applicable
SS = stainless steel

Table 3. Well Development Data.

Well Name	Well ID	Static Water Level (ft bgs)	Development Date	Duration (minutes)	Final Turbidity (NTU)	Final Conductivity (μS/cm)	Final pH (standard units)	Final Temp. (ºC)	Final Flow Rate (gal/min)	Final Drawdown (ft)	Total Gallons Pumped
299-E17-22	C3826	321.82	5/21/02	99	2.66	454	7.96	19.6	13	0	1,150
299-E17-23	C3827	332.51	5/20/02	75	4.34	513	7.79	21.4	11	0	870
299-E17-24	C3828	341.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
299-E17-25	C3926	337.62	5/20/02	88	4.32	428	7.77	20.1	12	0	1,020

NA = not applicable

2.2.2.1 Screen, Riser Casing, and Filter Pack. A 35-ft-long 20-slot (0.020-in.) continuous v-wire wrap stainless-steel screen (with a 2-ft sump) and 10-20 mesh (0.0787- to 0.0331-in.) filter-pack sand were preselected for this well based on data from nearby wells and anticipated formation characteristics. The bottom of the sump was placed at 370.11 ft bgs, and the bottom of the screen placed at 368.10 ft bgs. The top of the screen was located at 332.98 bgs. The borehole was backfilled with 10-20 mesh filter-pack sand from TD to 10 ft above the top of the screen (323 ft bgs). Filter-pack installation at injection well C3827 followed the same procedure as previously described for extraction well C3826 (see Section 2.1.2.2).

2.2.2.2 Annular Seal. Approximately 7 ft (316.1 to 323.0 ft bgs) of annular seal was constructed above the filter pack using 0.25-in. bentonite pellets and a granular bentonite seal placed to 9.9 ft bgs. A grout seal was placed from the bentonite seal to ground surface. The grout seal consisted of Portland cement mixed with no more than 5% bentonite by weight, in accordance with WAC 173-160.

2.2.3 Final Well Development and Pumping Test

Final well development was performed on May 20, 2002, after the surface cement pad and protective casing had been installed. A 3-HP electric submersible pump was used at two depths to develop the well. First, the pump intake was set 2 ft above the bottom of the screen, and pumping continued until the turbidity was less than 5 NTU. A pressure transducer was used to monitor water-level drawdown during pumping, and information was recorded in a datalogger. Other parameters monitored during pumping were temperature, conductivity, and pH. At this depth, water samples (C3827_1, C3827_2, and C3827_3) were collected for PNNL analyses. The pump intake was raised to 16 ft above the bottom of the screen, and pumping resumed until the turbidity was less than 5 NTU. The pumping rate was 12 gal/min. Final groundwater parameters are presented in Table 3. No significant water-level drawdown was noted at either depth.

2.3 WELL C3828/299-E17-24

This section contains a summary and description of drilling and well decommissioning activities performed during the attempted installation of well C3828/299-E17-24.

2.3.1 Drilling Summary

Drilling of well C3828/299-E17-24 was performed in accordance with the characterization plan for FY 2002 (Reidel 2002). Well summary information for this well is presented in Appendix A.

Drilling of well C3828/299-E17-24 using the dual-wall percussion method (Becker hammer drill) began on May 2, 2002, advancing outer 9-in. OD and inner 6-in. ID in temporary casing. Groundwater was encountered at approximately 340 ft bgs on April 9, 2002. Six split-spoon samples were collected from the intervals shown in Table 1. The split-spoon samplers for this borehole retrieved 4 ft of sediment in two 2-ft-length Lexan liners. The borehole was advanced to a TD of 383 ft bgs (temporary casing 383 ft bgs) on May 6, 2002.

2.3.2 Well Completion

Borehole C3828 was drilled to 383 ft bgs and passed the straightness test prior to installation of the well screen. When the well construction was started, the drilling subcontractor was unable to get a measuring tape to the bottom of the well in the annular space between the 4-in. stainless-steel permanent casing and the inner 6-in. temporary casing. This measurement is critical to ensure the proper placement of the silica sand pack around the well screen. The well was observed to veer to the east at approximately 85 ft bgs. During drilling a rock was hit at 280 ft, which may also have deflected the drill bit. After a discussion with CH2M Hill Hanford Group, Inc. and project management, it was agreed to decommission well C3828, move the drilling rig, and drill a new borehole.

A summary of well decommissioning is provided in Table 2 and in the well summary sheets presented in Appendix A. A well decommissioning profile for well C3828 (299-E17-24) was generated by the Groundwater/Vadose Zone Integration Project single point of contact prior to the actual well decommissioning.

2.3.2.1 Well Decommissioning. During backpulling of the temporary casing from well C3828 (299-E17-24), silica sand was emplaced from 383 ft bgs to approximately 330 ft bgs, granular bentonite (crumbles) placed from 330 ft bgs to 9.5 ft bgs, and a concrete seal was placed from the bentonite seal to ground surface. A brass marker was placed in the surface of the concrete seal. Decommissioning was completed on May 10, 2002.

2.4 WELL C3926/299-E17-25

This section contains a summary and description of drilling, well completion, and well development activities performed during the installation of well C3926/299-E17-25.

2.4.1 Drilling Summary

Drilling of extraction well C3926/299-E17-25 was performed as a redrill of well C3828. The borehole location was set approximately 10 ft due west of the C3828 site. The well was drilled in accordance with the characterization plan for FY 2002 (Reidel 2002). Well summary information for this well is presented in Appendix A.

Drilling of well C3926/299-E17-25 using the dual-wall percussion method (Becker hammer drill) began on May 10, 2002, advancing outer 9-in. OD and inner 6-in. ID in temporary casing. Groundwater was encountered at approximately 338 ft bgs on May 13, 2002. Archive grab samples were collected at 10-ft intervals. No split-spoon samples were collected. The borehole was advanced to a TD of 382.5 ft bgs on May 13, 2002.

2.4.2 Well Completion

Well construction materials, filter-pack installation and initial well development, and annular seal for well C3826 are discussed in the following subsections. A summary of well completion is provided in Table 2 and in the well summary sheets presented in Appendix A.

2.4.2.1 Screen, Riser Casing, and Filter Pack. A 35-ft 20-slot (0.020-in.) continuous v-wire wrap stainless-steel screen (with a 2-ft sump) and 10-20 mesh (0.0787- to 0.0331-in.) filter-pack sand were preselected for this well based on data from nearby wells and anticipated formation characteristics. The bottom of the sump was placed at 373.58 ft bgs and the bottom of the screen placed at 371.57 ft bgs. The top of the screen was located at 336.56 ft bgs. The borehole was backfilled with 10-20 mesh filter-pack sand from TD to 10 ft above the top of the screen (326.8 ft bgs). Filter-pack installation at well C3827 followed the same procedure as previously described for well C3826 (see Section 2.1.2.2).

2.4.2.2 Annular Seal. Approximately 10 ft (326.8 to 316 ft bgs) of annular seal was constructed above the filter pack using 0.38-in. bentonite pellets and a granular bentonite seal placed to 9.4 ft bgs. A grout seal was placed from the bentonite seal to ground surface. The grout seal consisted of Portland cement mixed with no more than 5% bentonite by weight, in accordance with WAC 173-160.

2.4.2.3 Final Well Development and Pumping Test. Final well development was performed on May 20, 2002, after the surface pad and protective casing had been set. A 3-HP electric submersible pump was first set near the bottom of the screen interval, with the pump intake at 6 ft above the bottom of the screen. From that depth, the pump could only produce 11 gal/min. A pressure transducer was used to monitor water-level drawdown during pumping, and information was stored in a Hermit™ 3000 datalogger. Pumping continued until the turbidity was measured to be less than 5 NTU. Other water quality parameters measured during pumping were temperature, conductivity, and pH. Water samples (C3826_1, C3826_2 and C3826_3) were collected for PNNL analyses. The pump intake was then raised to 20 ft above the bottom of the screen, and pumping resumed until the turbidity was less than 5 NTU. The pumping rate was about 12 gal/min. Final groundwater-quality parameters are presented in Table 3. No significant drawdown of the water table was noted at either pumping depth.

2.5 WASTE MANAGEMENT

Waste for all boreholes was managed in accordance with the *Data Quality Objective Summary Report for ILAW Well Installation - Waste Disposition* (BHI 2002) and the *Site Specific Waste Management Instruction Well Decommissioning, Maintenance and Sampling* (Stocker 2000).

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2.5.1 Vadose Zone Cuttings

As discussed in the data quality objective (DQO) summary report (BHI 2002), waste designation samples were collected from ILAW borehole C3826 (299-E17-22) at two locations (70 and 170 ft bgs). Soil samples B149P3 (70 ft) and B149P5 (170 ft) were analyzed for selected radionuclides and nitrate per the DQO summary report (BHI 2002).

Initial radiological screening (for sample shipping purposes) showed nondetects for gamma emitters and 18 pCi/g for gross beta. While gross beta was not discussed as a contaminant of concern in the DQO summary report (BHI 2002), after a discussion with the Bechtel Hanford, Inc. waste management task lead, it was determined that it was appropriate to compare the screening data with the 90% upper confidence limit (UCL) background value for gross beta. The published background value is 22.96 pCi/g (DOE-RL 1996). As shown in Table 4, laboratory sample values were compared to the 90% UCL as requested by the DQO, for site background data. All reported values are less than background.

Table 4. Waste Designation Sample Results, Well C3826 (299-E17-22).

Constituent	90% UCL Background	Sample B149P3 (70 ft)	Sample B149P5 (170 ft)
Cesium-137	0.0919 pCi/g	Nondetect	Nondetect
Strontium-90	0.167 pCi/g	-0.014 pCi/g	-0.149 pCi/g
Uranium-234	1.1 pCi/g	0.336 pCi/g	0.611 pCi/g
Uranium-235	0.109 pCi/g	0.057 pCi/g	0.085 pCi/g
Uranium-238	1.06 pCi/g	0.46 pCi/g	0.423 pCi/g
Plutonium-238	0.0047 pCi/g	0.003 pCi/g	-0.008 pCi/g
Plutonium-239/240	0.0192 pCi/g	-0.003 pCi/g	0.008 pCi/g
Nitrate	99.38 mg/kg	2.79 mg/kg	2.29 mg/kg

Waste from boreholes C3827 (299-E17-23), C3828 (299-E17-24), and C3926 (299-E27-25) did not require waste designation sampling. The drilling area and drill cuttings were monitored regularly for radioactive contaminants; no contaminants were detected above background levels. Drilling spoils from above the water table were accumulated in piles near the point of generation until surveyed by a radiological control technician. Spoils piles were approved for return to ground following clearance from the radiological control technician, the project task lead, and the waste management task lead.

2.5.2 Saturated Zone Cuttings

Drill cuttings removed below the water table in all four boreholes were contained in waste storage drums for final disposition.

2.5.3 Purgewater

All groundwater pumped from these wells during development activities was contained and transferred to purgewater trucks for final disposal at the Purgewater Storage and Treatment Facility and/or ModuTanks,™ in accordance with the DQO summary report (BHI 2002).

2.6 WELL ACCEPTANCE

A well acceptance walkdown for the three completed wells was performed on May 21, 2002 (see Table 5 for a summary).

Table 5. Summary of Well Drilling and Survey Data.

Well Name	Well ID	Drilling Start Date	Drilling Finish Date	Northing[a] (Brass Cap) (m)	Easting[a] (Brass Cap) (m)	Ground-Surface Elevation[b] (Brass Cap) (m)	Total Depth (ft bgs)
299-E17-22	C3826	3/27/02	4/11/02	135195.921	574841.067	220.589	363
299-E17-23	C3827	4/16/02	4/26/02	134842.766	574694.485	223.843	372
299-E17-24	C3828	5/1/02	5/06/02	134845.545	574518.125	224.801	383
299-E17-25	C3926	5/10/02	5/13/02	134845.913	574515.171	225.028	382.5

NOTE: Feet are used because field measurements were reported and recorded in English units.
[a] Northing and easting coordinates are based on Washington State Plane Coordinates (North American Datum of 1983[91]).
[b] North American Vertical Datum of 1988 values rounded to 0.001 m.

2.7 CIVIL SURVEY

Well location and elevation surveys were performed on the wells in May 2002 by Rogers Surveying, Inc. The coordinates for the wells were determined using Trimble 4000ssi™ dual-frequency global positioning system receivers, operating in real-time kinematic mode. The horizontal control for this survey is based on a global positioning system control network designed and surveyed by Rogers Surveying, Inc., in support of the Hanford Site Mapping Project.

Elevations were determined using a Leica Geosystems N3003 electronic bar code reading level and bar code rod. The vertical control for these wells perpetuated from horizontal control monument HSWB044. All coordinates are referenced to the Washington Coordinate System, North American Datum of 1983/1991. Elevations are referenced to the North American Vertical Datum of 1988. All results are reported in metric units with a vertical accuracy of +/-0.001 m

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and horizontal accuracy of +/-0.001 m. Surveying was performed in accordance with the requirements of BHI-EE-01, Procedure 1.6, "Survey Requirements and Techniques."

3.0 SUBSURFACE DESCRIPTION

3.1 200 EAST AREA GEOLOGY

The stratigraphy of the ILAW disposal site consists of the Hanford formation and the Ringold Formation overlying the Columbia River Basalt Group (Reidel 2000). Surficial sediments are mainly eolian deposits consisting of reworked Hanford Site sands and silts.

3.1.1 Well C3826/299-E17-22 Borehole Geology

The first 6 ft consisted of fine sand and silt, and the sand-dominated sequence of the Hanford formation continued until 216 ft bgs. The sand was moist to about 6 ft, and then dry below that depth until near the top of groundwater. Trace amounts of caliche fragments were noted on the borehole log. The sediment was predominantly gravelly sand from 216 to 238 ft, sand from 238 to 274 ft, gravelly sand from 274 to 293 ft, basal-gravel (Hanford formation) from 293 to 352 ft, and sandy gravel (Ringold Formation) from 352 to 363 ft (TD).

Geologic borehole logs are included in Appendix B and stratigraphic information summarized in Table 6.

Table 6. Drilling Information.

Well Name	Well ID	Ground Surface Elevation[a] (Estimated) (m)	Top of Hanford Gravel Sequence (ft bgs)	Hanford/Ringold Contact (ft bgs)	Groundwater Depth[b] (ft bgs)	Total Depth (ft bgs)
299-E17-22	C3826	220.494	293	352	321.8	363
299-E17-23	C3827	223.370	272	Indistinct	332.5	372
299-E17-24	C3828	224.625	277	Indistinct	341.3[b]	383
299-E17-25	C3926	224.625	275	Indistinct	337.6	382.5

[a] North American Vertical Datum of 1988.

[b] Water level could be inaccurate due to off-vertical drill casing.

3.1.2 Well C3827/299-E17-23 Borehole Geology

At this location the surface deposit of silty sand extended to about 8 ft bgs, followed by basalt-rich sand from 8 to 23 ft. Gravelly sand with fine pebbles continued from 23 to 29 ft, and then Hanford sand from 29 to 233 ft. This sand was slightly moist until about 130 ft and then dry

below that depth. A gradational change to sandy gravel occurred from 233 to 236 ft, and then sand again to 254 ft. From 254 to 272 ft, the sediment alternated from gravelly sand to sandy gravel with fine- to medium-sized gravel pebbles. At 272 ft, the basal-gravel-dominated Hanford formation was encountered. There was not a clear contact noted between Hanford and Ringold gravel formations, but there was a possible contact at about 358 ft as sandy gravel continued until the total drill depth of 372 ft bgs.

Geologic borehole logs are included in Appendix B, and stratigraphic information is summarized in Table 6.

3.1.3 Well C3828/299-E17-24 Borehole Geology

Sediment from the surface to 33 ft bgs consisted of sand, with trace amounts of silt and fine gravel. Sand continued from 33 to 234 ft. The sand contained occasional fragments of silt and clay, which were moist and reacted strongly with 10% hydrochloric acid. A possible paleosol was noted in a split-spoon sample at 157 ft. The sand was slightly moist until about 220 ft, and dry below that depth. Gravelly sand with fine pebbles was encountered from 234 to 237 ft, and then sand to 244 ft. Sandy gravel, again mostly fine to very fine pebbles, extended from 244 to 262 ft, then sand to 277 ft. An abrupt contact with sandy gravel at 277 ft was the basal Hanford gravel sequence. The gravel was occasionally cobble to boulder in size, with several intervals with silt coatings on gravel. There was no clear contact between Hanford and Ringold Formations; no open-framework gravel was encountered at this borehole. A large basalt boulder was drilled through at 367 to 369 ft, and basalt-rich gravel extended to the total depth of 383 ft.

Geologic borehole logs are included in Appendix B, and stratigraphic information is summarized in Table 6.

3.1.4 Well C3926/299-E17-25 Borehole Geology

From the surface to 36 ft bgs, the sediment graded from slightly silty sand to gravelly sand and sand from 36 to 230 ft. This borehole also showed traces of silt, clay, and caliche fragments, but not to the extent seen in well C3828. The sand was slightly moist until about 220 ft and dry below that depth. Gravelly sand was seen from 230 to 235 ft, and then sand to 240 ft. Gravelly sand to sandy gravel was encountered from 240 to 259 ft, and then sand to 275 ft. The basal Hanford gravel sequence started at 275 ft, with gravel up to cobble and boulder size. There was no clear contact between Hanford and Ringold gravel, as sandy gravel continued to the total drill depth of 382.5 ft. At a depth interval of approximately 368 to 378 ft, the silt fraction in the gravel was a very dark brown (almost black) then back to a light brown, as seen earlier in this borehole and in other boreholes below the water table.

Geologic borehole logs are included in Appendix B, and stratigraphic information is summarized in Table 6.

3.2 HYDROGEOLOGY

The uppermost aquifer in the vicinity of the ILAW disposal site is within the fluvial gravels of the Ringold Formation and flood deposits of the Hanford formation. The Elephant Mountain Member of the Columbia River Basalt Group forms the base of the unconfined aquifer. Drawdown information from well development pumping is shown in Table 7. No other aquifer testing was performed.

Table 7. Pumping Information.

Well Name	Well ID	Groundwater Level (ft bgs)	Final Flow Rate (gal/min)	Drawdown[b] (ft)	Pumping Duration (minutes)	Recovery (minutes)
299-E27-22	C3826	321.8	13	0	99	0
299-E17-23	C3827	332.5	11	0	75	0
299-E17-24	C3828	341.3[a]	NA	NA	NA	NA
299-E17-25	C3926	337.6	12	0	88	0

[a] Water level could be inaccurate due to off-vertical drill casing.
[b] Pump was of insufficient size to generate a drawdown at these depths.
NA = not applicable

4.0 REFERENCES

BHI-EE-01, *Environmental Investigations Procedures,* Bechtel Hanford, Inc., Richland, Washington.

BHI-EE-02, *Environmental Requirements,* Bechtel Hanford, Inc., Richland, Washington.

BHI, 2002, *Data Quality Objective Summary Report for ILAW Well Installation – Waste Disposition*, BHI-01603, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1996, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, DOE/RL-96-12, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Reidel, S. P., 2000, *Second ILAW Site Borehole Characterization Plan*, PNNL-13283, Pacific Northwest National Laboratory, Richland, Washington.

Reidel, S. P., 2002, *Characterization Plan for Fiscal Year 2002 Immobilized Low-Activity Waste Site Characterization Boreholes*, PNNL-13283-1, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

Stocker, D. E., 2000, *Site Specific Waste Management Instruction Well Decommissioning, Maintenance and Sampling*, WMI-WELL001, Rev. 5, Bechtel Hanford, Inc., Richland, Washington.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended.

APPENDIX A

WELL SUMMARY SHEETS

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 3-29-02
Finish Date: 4-16-02
Page: 1 of 3

Well ID: C 3826		Well Name: 299-E17-22	
Location: SW of Purex, 200-East		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 4-16-02	Reviewed By: C.D. Walker	Date: 5/10/02
Signature: L.D. Walker		Signature: C.D. Walker	

CONSTRUCTION DATA

Description	Diagram
6" protective casing set 1.0' above 4" well casing	
Portland Cement Grout: 0' → 9.4'	
Temporary drill casing: 9 5/8" by 6" dual wall	
Permanent Well Casing: 4" sch. 5 304/304L Stainless steel +2.40' → 321.63'	
Granular Bentonite Annular Seal: 9.4' → 297.0'	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0' → 0.5': Gravel drill pad
		0.5' → 6': Silty SAND
25		
		6' → 216': SAND
50		
75		
100		
125		

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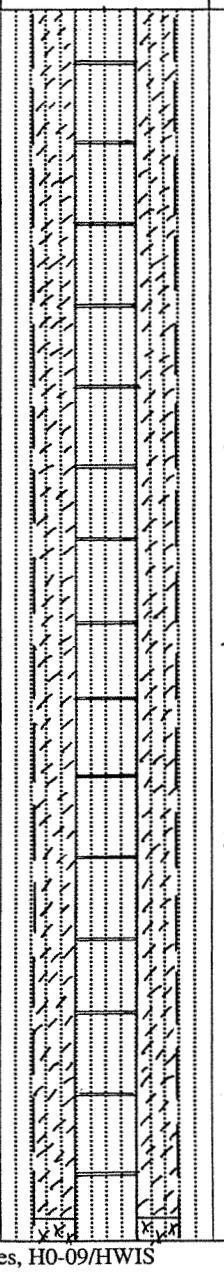
Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 3-29-02
Finish Date: 4-16-02
Page: 2 of 3

Well ID: C3826		Well Name: 299-E17-22	
Location: SW of Purex, 200 East		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 4-16-02	Reviewed By: C.S. Wright	Date: 5/10/02
Signature: L.D. Walker		Signature: C.S. Wright	

CONSTRUCTION DATA

Description	Diagram
	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
150		
175		
200		216' → 224': Gravelly SAND
225		224' → 231': SAND
		231' → 238': Gravelly SAND
250		238' → 274': SAND
		245': tr cobble
	LPLW NA	274' → 279': Gravelly SAND
275		
		279' → 283': SAND
		283' → 293': Gravelly SAND
		293' → 302': Sandy GRAVEL

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BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

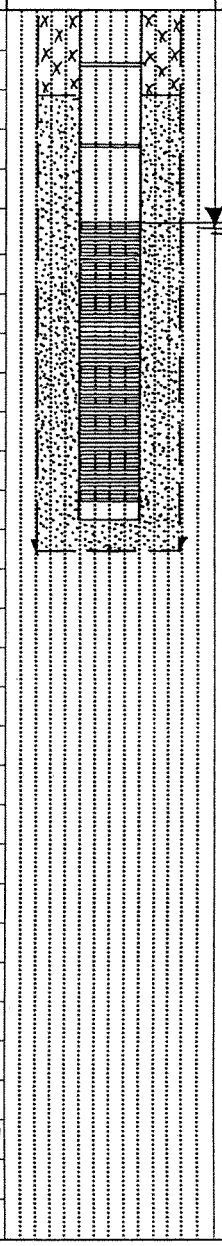
WELL SUMMARY SHEET

Start Date: 3-29-02
Finish Date: 4-16-02
Page: 3 of 3

Well ID: C3826		Well Name: 299-E17-22	
Location: SW of Purex, 200 East		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 4-16-02	Reviewed By: C.S. Wright	Date: 5/10/02
Signature: L.D. Walker		Signature: C.S. Wright	

CONSTRUCTION DATA

Description	Diagram
1/4" Bentonite Pellets: 297.0' → 306.3'	
Colorado Silica Sand, 10-20 mesh: 306.3' → 362.7'	
Wellscreen: 4" 304L Stainless Steel Cont. wire-wrapped 0.020-in slot 321.63' → 356.66'	
Tailpipe / Sump: 4" sch. 5 304/304L with welded endcap 356.66' → 358.66'	
Total length of stainless steel well is 361.06'	
All depths are in feet below ground surface	
All temporary casing was removed from ground	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
300		
		302' → 352': GRAVEL
325		
350		
		352' → 363': Sandy GRAVEL
375		TD = ~~263'~~ LW 363'
		Water Level = 321.82' (4-16-02)
		352': Possible Hanford / Ringold Fm contact
400		

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BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 4-17-02
Finish Date: 4-30-02
Page: 1 of 3

Well ID: C3827		Well Name: 299-E17-23	
Location: SW of Purex, on 200E fenceline		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 4-30-02	Reviewed By: CS Wright	Date: 4/15/02
Signature:		Signature:	

CONSTRUCTION DATA

Description	Diagram
Protective Surface Casing: 6" SS set 1.0' above the 4" well casing	
Portland Cement Grout: 0' → 9.9'	
Temporary drill casing: 9" by 6" dual wall	
Permanent Well Casing: 4" sch. 5 304/304L Stainless Steel +2.2' → 332.98'	
Granular Bentonite Annular Seal: 9.9' → 316.1'	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0' → 1.5': Sandy GRAVEL drill pad
		1.5' → 8': Silty SAND
25		8' → 23': SAND
		23' → 29': Gravelly SAND
		29' → 233': SAND
50		
75		
100		
125		

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BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 4-17-02
Finish Date: 4-30-02
Page: 2 of 3

Well ID: C3827		Well Name: 299-E17-23	
Location: SW of Purex on 200E Fenceline		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 4-30-02	Reviewed By: Charlene Martinez	Date: 05/29/02
Signature: L.D. Walker		Signature: Charlene Martinez	

CONSTRUCTION DATA

Description	Diagram
	N A

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
150	N A	
175		
200		
COW NA		233' → 236': Sandy GRAVEL
225		
		236' → 254': SAND
250		254' → 257': Gravelly SAND
		257' → 260': SAND
		260' → 264': Gravelly SAND
		264' → 268': Sandy GRAVEL
275		268' → 272': Gravelly SAND
		272' → 281': Sandy GRAVEL
		281 → 284: GRAVEL
		284' → 312': Sandy GRAVEL

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BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 4-17-02
Finish Date: 4-30-02
Page: 3 of 3

Well ID: C3827		Well Name: 299-E17-23	
Location: SW of Purex on 200E Fence		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 4-30-02	Reviewed By: Charlene Martinez	Date: 05/29/02
Signature: L.D. Walker		Signature: Charlene Martinez	

CONSTRUCTION DATA

Description	Diagram
1/4" Bentonite Pellets: 316.1' → 323.0'	
Colorado Silica Sand: 10-20 mesh 323.0' → 370.5'	
Slough: 370.5' → 372'	
Wellscreen: 4" 304L Stainless Steel Cont. wire wrap 0.020-in. slot 332.98' → 368.10'	
Tailpipe / Sump: 4" sch. 5 304/304L SS with welded endcap 368.10' → 370.11'	
Total length of stainless steel well is 372.31'	
All depths are in Feet below ground surface	
All temporary casing was removed from ground	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
300		
		312' → 358': GRAVEL
325		
350		
		358' → 372': Sandy GRAVEL
375		TD = 372'
		Water Level = 332.51' (4-30-02)
400		

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BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 5-10-02
Finish Date: 5-16-02
Page: 1 of 3

Well ID: C3926		Well Name: 299-E17-25	
Location: SW of Purex on 200E Fenceline		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 5-16-02	Reviewed By: CS Wright	Date: 5/23/02
Signature: L.D. Walker		Signature: C S Wright	

CONSTRUCTION DATA

Description	Diagram
Protective Surface Casing: 6" SS set 1.0' above the 4" well casing	
Portland Cement Grout: 0' → 10.8'	
Temporary drill casing 9" by 6" dual wall	
Permanent Well Casing: 4" ID 304/304L stainless steel +2.0' → 336.56'	
Granular Bentonite Annular Seal: 10.8' → 316.0'	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0' → 1.5': Crushed rock drill pad
		1.5' → 9': Slightly Silty SAND
25		9' → 11': Gravelly SAND
		11' → 15': SAND
		15' → 36': Slightly Silty SAND
50		36' → 230': SAND
75		
100		
125		

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Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 5-10-02
Finish Date: 5-16-02
Page: 2 of 3

Well ID: C3926
Well Name: 299-E17-25
Location: SW of Purex on 200E Fenceline
Project: CY 2002 ILAW Drilling
Prepared By: L.D. Walker
Date: 5-16-02
Reviewed By: CS Walker
Date: 5/29/02
Signature: LD Walker
Signature: CS Walker

CONSTRUCTION DATA

Description	Diagram

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
150		
175		
200		
225		230' → 235': Gravelly SAND
		235' → 240': SAND
		240' → 243': Gravelly SAND
250		243' → 259': Sandy GRAVEL
		259' → 275': SAND
275		275' → 382.5' Sandy GRAVEL

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BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 5-10-02
Finish Date: 5-16-02
Page: 3 of 3

Well ID: C3926		Well Name: 299-E17-25	
Location: SW of Purex on 200E fenceline		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 5-16-02	Reviewed By: CS Wright	Date: 5/24/02
Signature: LD Walker		Signature: CS Wright	

CONSTRUCTION DATA

Description	Diagram
1/4" Bentonite Pellets: 316.0' → 326.8'	
Colorado Silica Sand: 10-20 mesh 326.8' → 382.5'	
Well screen: 4" ID 304L Stainless Steel Cont. wire wrap 0.020-in slot 336.56' → 371.57'	
Tailpipe / Sump: 4" ID 304/304L SS with welded endcap 371.57' → 373.58'	
Total length of stainless steel well is 375.58'	
All depths are in feet below ground surface	
All temporary casing was removed from ground	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
300		
		8"
		275' → 382.5': Sandy GRAVEL
325		
350		
375		
		TD = 382.5'
400		
		Water level = 337.62' (5-16-02)

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BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 5-1-02
Finish Date: 5-10-02
Page: 1 of 3

Well ID: C 3828		Well Name: 299-E17-24	
Location: SW of Purex on 200E Fenceline		Project: CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	Date: 5-10-02	Reviewed By: CC Wright	Date: 4/15/02
Signature: L.D. Walker		Signature: CC Wright	

CONSTRUCTION DATA

Description	Diagram
Portland Cement Grout: 0' → 9.5'	
Granular Bentonite: 9.5' → 330.0'	
All temporary drill casing removed from the ground	
Depths are in feet below ground surface	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0 → 1.5': Crushed rock drill pad
		1.5' → 9': Slightly Silty SAND
25		9' → 13': SAND
		13' → 33': Slightly Silty SAND
50		33' → 234': SAND
75		
100		
125		

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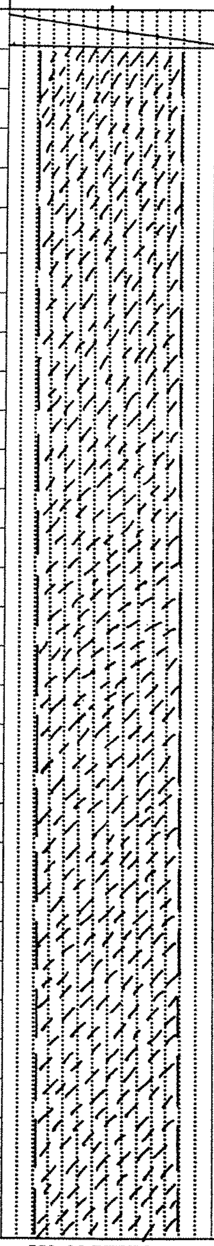
BHI-EE-189 (02-20-2002)

WELL SUMMARY SHEET

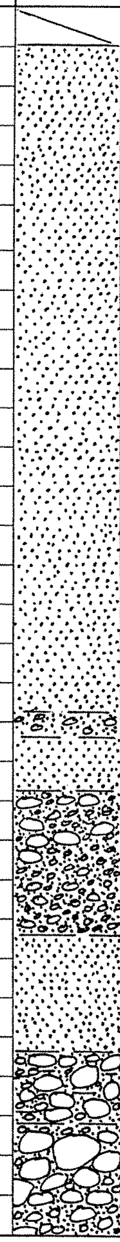
Start Date: 5-1-02
Finish Date: 5-10-02
Page: 2 of 3

Well ID: C3828		**Well Name:** 299-E17-24	
Location: SW of Purex on 200E Fenceline		**Project:** CY 2002 ILAW Drilling	
Prepared By: L.D. Walker	**Date:** 5-10-02	**Reviewed By:** CJ Wpwr	**Date:** 5/28/02
Signature: [illegible]		**Signature:** [illegible]	

CONSTRUCTION DATA — Description | Diagram



GEOLOGIC/HYDROLOGIC DATA — Depth in Feet | Graphic Log | Lithologic Description



Depth in Feet	Lithologic Description
150	
175	
200	
225	
	234' → 237': Gravelly SAND
	237' → 244': SAND
250	244' → 262': Sandy GRAVEL
	262' → 277': SAND
275	277' → 286': Silty Sandy GRAVEL
	286' → 318': Sandy GRAVEL

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Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

BHI-EE-189 (02-20-2002)

Appendix A - Well Summary Sheets

WELL SUMMARY SHEET

Start Date: 5-1-02
Finish Date: 5-10-02
Page: 3 of 3

Well ID:	C3828	Well Name:	299-E17-24
Location:	SW of Purex on 200E fenceline	Project:	CY 2002 ILAW Drilling
Prepared By:	L.D. Walker	Reviewed By:	CS Wright
Date:	5-10-02	Date:	5/28/02
Signature:	L.D. Walker	Signature:	C Wright

CONSTRUCTION DATA

Description	Diagram
Silica Sand: 330.0' → 383'	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
300		
325		318' → 325': GRAVEL
		325' → 383': Sandy GRAVEL
350		
375		
		TD = 383'
400		water level 341.3' 5-6-02
		Note: this borehole not straight enough to complete as a well. Deeper than expected water level probably due to off-vertical borehole.

Original to: Document & Information Services, H0-09/HWIS
Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

BHI-EE-189 (02-20-2002)

APPENDIX B

BOREHOLE LOG SHEETS

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 1 of 13
Date: 3/27/02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200E
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0					Diesel Hammer
				0 → 0.5': 8" Crushed Gravel Drill pad surface	9"X6" dual wall casing
				0.5' → 6': Silty SAND (m S)	α,β,γ < detectable
				70% Sand (fn - v. fn) 30% Silt	
5	Grab Sample			10YR 5/3 (brn) sl moist, well	5 Ft: 1 pint
				sorted, predom qtz/Feld; no rxn HCl	grab sample
					For archive
				6' → 216': SAND (S)	
	Split Spoon #1	80% rec.		tr-5% Gravel, 95-100% Sand,	8.0' → 12.5': Split
10	Grab			tr silt. Gravel R-SR fn peb,	Spoon #1 For PNNL
				mainly basalt. Sand SA, salt-n-pepper	analysis
	Shoe			appearence 30% v.cse-cse, 40% med,	10': Grab for archive
	Split Spoon #2	90% rec.		30% fn - v. fn; 10YR 5/2 (grayish brown)	12.0' → 16.5': Split
15	Grab			dry; 40% basalt, 60% qtz/Feld	Spoon #2
	Shoe			no rxn HCl.	
	Split Spoon #3	100% rec.		16': Sand predom med-fn	15': Grab for archive while driving casing.
20	Shoe - Grab Samp.			Sand med - v. cse	16.0' → 20.5': Split Spoon #3.
	Split Spoon #4	75% rec.			20': Grab for archive α,β,γ < detect.
				Sand very loose, dry	
25	Shoe - Grab				20.5' → 25.0': Split Spoon #4
	Split Spoon #5	80% rec.			25': Grab For archive
					25.0 → 29.5': Split Spoon #5

Reported By: L.D. Walker | Reviewed By: C.S. Walker
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 3-29-02 | Signature: C.S. Walker | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 2 of 13
Date: 3-29-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 E
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
	Shoe - Grab	SS #5			Diesel hammer
30	Split Spoon #6	90% rec.		SAND (S) - similar to above. 100% sand, tr silt. 10% v. csc, 30% csc, 30% med, 30% fn-v. fn 10YR 5/2 (grayish brown) dry - salt and pepper look; mod sorted; SA - Angular; 30-40% basalt, 60-70% qtz/ Feld / other; tr mica; no rxn HCl	9" x 6" dual wall casing. 30': Grab for archive 29.5'→34.0': Split Spoon #6
	Shoe				
35	Split Spoon #7	80% rec.		Sand is loose and dry	35': Grab sample for archive while advancing the casing.
	Shoe				34.0'→38.5': SS #7
40	Split Spoon #8	100% rec.		Slight increase in moisture content	38.0'→42.5': SS #8 40' Grab Sample when advance casing.
	Shoe				
45	Split Spoon #9	100% rec.			42.5'→47': SS #9 45' Grab / archive
	Shoe				
50	Split Spoon #10	100% rec			47'→51.5': SS #10 50' grab - archive
	Shoe			decrease in sand size. predan med-fn	
55	Grab				55': Grab - archive
	SS #11	100% rec.			58.0'→62.5': Split Spoon #11

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: [signature] Date: 3-29-02 | Signature: [signature] Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 3 of 13
Date: 3-29-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 E
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
60	Grab / Split Spoon #11	100% rec.		SAND (S) - as above	Diesel Hammer 9"x6" dual wall 60': Grab sample for archive
	Shoe				
65	Grab / Split Spoon #12	100% rec.		SAND (S) similar to above 100% Sand, tr silt 10% v.cse, 40% cse, 40% med, 10% Fn - v. Fn. 10 YR 6/2 (lt. brownish gray) dry, mod sorted, SA - Angular, 30% basalt, 70% qtz/Feld, other; tr mica - Weak rxn HCl at edges of sample, light colored Fines	63.5 → 68': Split Spoon #12 For PNNL analysis 65': Grab for archive
	Shoe				
70	Grab / Split Spoon #13	100% rec.			68.0 → 72.5': Split Spoon #13.
	Shoe ← W.C. ⊗				Waste Charact. Sample from the drive shoe AE15 # B149P4, B149P3
75	Grab / Split Spoon #14	100% rec.		74-75': possible bedding < 1 cm thick in liner samples; or possibly just compaction from driving sampler.	70': Archive Grab 72' → 76.5': SS #14 75': Archive Grab
	Shoe				76.5' → 81.0': SS #15 Archive grab for 80' from shoe
80	Split Spoon #15	100% rec.			
	Shoe - Archive				α, β, γ < detect.
85	Grab - Archive			At 85', cemented sand Fragments weak rxn HCl - possible soil horizon? tr clay ⇒ check archive sample	85': Grab sample for archive
				Sand - similar to above	

Reported By: L.D. Walker | Reviewed By: C.S. Walker
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-1-02 | Signature: C.S. Walker | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

BOREHOLE LOG

Page: 4 of 13
Date: 4-1-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200E
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
90	Grab - Archive			SAND (S) similar to above	Diesel Hammer
	Diesel hammer ↓			100% Sand, tr silt; 20% v.cse	9" by 6" dual wall
				30% cse, 30% med, 20% fn - v. fn.	casing.
				10YR 6/2 (lt. brownish gray) dry,	90': Grab - archive
95	Grab - Archive			mod sorted, SA-A; 30% basalt, 70%	95': Grab - archive
				qtz/other, tr mica; predom. no rxn HCl	
	Split Spoon #16	100% rec.		occasional weak rxn	96.0' → 100.5': SS #16
					100': Archive sample
100	Shoe - Archive			Sand med - Fine	100': Archive sample
105	Grab - Archive				105': Archive sample
					α, β, γ < detect.
110	Grab - Archive			SAND (S) similar to above	110': Archive sample
				25% vcse, 30% cse, mineralogy	
				as above, no rxn HCl	
115	Grab - Archive				115': Archive sample.

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-1-02 | Signature: C.S. Wright | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 5 of 13
Date: 4-1-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 E
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample: Type & No.	Sample: Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	Split Spoon # 17	100% rec.		SAND (S) similar to above	Diesel Hammer
				100% sand, tr silt	9" x 6" dual wall
				122': Sand fn - v. fn, back to predom	casing
	Shoe			cse by 123'	119.0' → 123.5': Split
					Spoon # 17
125	Grab - Archive				120': Archive grab sample
					125': Archive grab sample
130	Grab - Archive				130': Archive sample
				SAND (S) 100% Sand	
				Salt and pepper appearance	
				cse-med, SA - Angular	
135	Grab - Archive			30-35% basalt, tr mica	135': Archive sample
				Max size ~ 2mm; mostly no rxn	
				to HCl - occasional very weak rxn	
140	Grab - Archive				140': Archive sample
145	Grab - Archive			SAND - as above	145': Archive sample

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 4-1-02 | Signature: C Wright | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 6 of 13
Date: 4-2-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 E
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
150	Split Spoon #18	95% rec.			Diesel hammer; 9"x 6" dual wall casing
				SAND (S) similar to above 100% Sand, tr silt	
	Shoe			20% cse - v.cse, ~~40%~~ 20% med, 40% fn, 20% v. Fn; overall 10YR 6/2 (lt. brnish gray) dry; loose in split spoon liners, mod-well sorted, SA-A, 20-30% basalt, other qtz/feld, tr mica no rxn HCl	149.0'→153.5': Split Spoon #18 for PNNL analysis
155	Grab - Archive				150': Grab sample for archive
					155': Grab - archive
					160': Grab - archive
160	Grab - Archive			Sand - slightly coarser than above	
					163.5'→168.0': SS #19
					165': Grab - archive
165	Split Spoon #19	90% rec.			
					168.0'→172.5': SS #20
	Shoe			SAND (S) slightly Finer than above 95-100% Sand, tr-5% Silt.	172.0-172.5' (shoe) Waste Charact. Sample
	Split Spoon #20	100% rec.		10% v.cse - cse, 40% med, 30% fn, 20% v.fn 10YR 6/2 (lt. brownish gray) dry, mod-well sorted, SA-A; 30% basalt, 70% qtz/feld/other, tr mica; weak HCl rxn.	HEIS #: B14975, B14986
170					170': Grab - archive
	Shoe ← W.C. ⊗				172.5'→177.0': SS #21
	Split Spoon #21	90% rec.			
175					175': Grab - Archive
	Shoe				
				178': tr v. Fn pebble	

Reported By: L.D. Walker | Reviewed By: C.S. Walker
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-3-02 | Signature: C.S. Walker | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 7 of 13
Date: 4-3-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 East
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
180	Grab Split Spoon #22	100% rec.		SAND (S) similar to above 95-100% Sand, tr-5% silt 10% v. cse, 20% cse, 40% med, 30% Fn-v. Fn. 10YR6/2 (lt. brn gray) dry to sl moist; Salt & pepper look; mod sorted; SA-A; ~30% basalt, 70% qtz/other, tr mica, no rxn HCl max size ~2 mm	Diesel hammer; 9" by 6" dual wall casing 179.0' → 183.5': Split Spoon #22
	Shoe				
185	Grab - Archive				180': Grab sample for archive when casing is advanced
	Diesel Hammer ↓				185': Grab - archive
190	Grab - Archive				190': Grab - archive
					195': Grab - archive
195	Grab - Archive			195': tr gravel (v. Fn - fn peb)	
				SAND (S) similar to above	200': Grab - archive
200	Grab - Archive			100% Sand, occasional tr v. fn peb, tr silt. Color as above, dry. 201': tr small caliche Fragment	
					205': Grab - archive
205	Grab - Archive			205' sand sl moist	

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-3-02 | Signature: C.S. Wright | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 8 of 13
Date: 4-3-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 East
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
210	Grab - Archive			SAND (S) similar to above 100% Sand, tr silt predom med - Fn.	Diesel hammer; 9" x 6" dual wall casing 210': Grab sample for archive
215	Grab - Archive			216' → 224': Gravelly SAND (gS) 10-15% Gravel, 85-90% Sand, tr silt. Gravel med - v. Fn peb, predom basalt, SR-SA; Sand similar to above.	215': Grab - archive 219.0' → 223.5': Split Spoon #23
220	Split Spoon #23	100% rec.		Sand is predom cse - v. cse, ~50% basalt	220': Grab - archive
225	Grab - Archive			Gravel content decrease to ~5%	225': Grab - archive
230	Grab - Archive			224' → 231': SAND (S) tr - 5% Gravel, 95-100% Sand, tr - 5% Silt.	230': Grab - archive
235	Grab - Archive			231 → 238': Gravelly SAND (gS) 20 - 30% Gravel, 70-80% Sand, tr silt Gravel med to v. Fn peb, Sand predom cse to med. 10YR5/2 (grayish brown) dry; poorly sorted; Gravel SA-SR, Sand SA Gravel 40-50% basalt, 50-60% granitic/qtzite; HCl rxn weak to none	235': Grab - archive

Reported By: L. D. Walker | Title: Geologist | Signature: LD Walker | Date: 4-3-02
Reviewed By: C. S. Wright | Title: Geologist | Signature: C Wright | Date: 7/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 9 of 13
Date: 4-3-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
240	Grab-Archive	Diesel hammer ↓		238'→274': SAND (S) tr-5% Gravel, 95-100% Sand, tr silt. Gravel v. fn peb; Sand 20% v. cse, 20% cse, 30% med, 30% fn-v. fn. 10YR5/2 (gr brn) dry, mod sorted, SA-A; 30-40% basalt, 60-70% qtz/other	Diesel hammer; 9" by 6" dual wall casing. 240': Grab sample for archive
245	Grab-Archive			245': tr cse peb to small cobble	245': Grab-archive
					250': Grab-archive
250	Grab-Archive				
				SAND (S) similar to above. 100% Sand, tr gravel (fn peb) tr silt	255': Grab-Archive
255	Grab-Archive			30% v. cse-cse, 40% med, 30% fn-v. fn. 10YR 5/2, "Salt-n-Pepper", dry, mod sort, SA-A, 35% basalt, 65% qtz/feld/other, tr mica, max size ~2mm, no rxn HCl	
					260': Grab-Archive
260	Grab-Archive				
					265': Grab-Archive
265	Grab-Archive			SAND (S) Similar to above 100% sand, tr silt predom cse-med, sl moist, mod-well sorted, SA-A, 40% basalt no rxn. HCl	

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 4-4-02 | Signature: C Wright | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 10 of 13
Date: 4-4-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 East
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
270	Grab-Archive			SAND - sl moist	Diesel hammer; 9" by 6" dual wall casing
	Diesel hammer ↓				270': Grab sample for archive
				274' → 279' : Gravelly SAND (gS) 20% Gravel, 80% Sand, tr silt. Gravel med-Fn peb, SR, Sand med-cse. 30-40% basalt, 60-70% qtzite, granitic/other, poorly sorted, no rxn HCl	
275	Grab-Archive				275': Grab-archive
280	Grab-Archive			279' → 283' : SAND (S) tr gravel, 100% Sand Similar to sand above; med-cse, Salt-n-Pepper dry to sl moist	280': Grab-archive
				283' → 293' : Gravelly SAND (gS) 20-25% Gravel, 75-80% Sand, tr silt Gravel med-cse peb, tr v.cse peb to sm cobble. Sand as above. Gravel SR, 40-50% basalt, 50-60% qtzite/granitic/other ~~metaite~~, poorly sorted, no rxn HCl; overall color 10YR5/2 (grayish brown), dry.	
285	Grab-Archive				285': Grab-archive
290	Grab-Archive				290': Grab-archive
				293' → 302' : Sandy GRAVEL (sG) 70% Gravel, 25-30% Sand, tr-5% silt. Gravel tr cobble, 30% v.cse peb, 40% cse, 30% med-Fn. poorly sorted, dry, basalt/qtzite/granitic no rxn HCl	
295	Grab-Archive				295': Grab-archive drill rate slows - air lost into formation

Reported By: L.D. Walker | Reviewed By: CS Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-4-02 | Signature: C.S. Wright | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 11 of 13
Date: 4-4-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 East
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
300	Grab - Archive			Gravel percentage and sizes increasing; a lot of air circulation lost into formation during drilling.	Diesel hammer; 9" by 6" dual wall casing
	diesel hammer ↓				300': Grab - archive
				302' → 352': GRAVEL (G)	
305	Grab - Archive			80-85% Gravel, 15-20% Sand, tr silt	
				306': drill has to break up basalt boulder of unknown size	305': Grab - archive
				Gravel tr lg. cob - boulder, 10% sm cobble, 30% v. cse peb, 30% cse, 30% med - v. fn; Sand med - fn; gray, dry;	
310	Grab - Archive			poorly sorted; gravel R-SA; basalt 30-40%, other qtzite, granitic, no rxn HCl	310': Grab - archive
				Sand fn - v. fn, predom. qtz	
315	Grab - Archive				315': Grab sample for archive
				~318': basalt boulder	
				Air lost into formation - open framework	
320	Grab - Archive			(slow drill rate) gravel ?	320': Grab sample - archive
				Cobbles of ~10 cm common	
					322': first wet gravel to surface
				324': increase in silt.	
325	Grab - Archive			~80% Gravel, 10% fn - v. fn sand, 10% silt	
					325': Grab - archive

Reported By: L.D. Walker | Reviewed By: CS Welch
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-10-02 | Signature: CS Welch | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 12 of 13
Date: 4-10-02

Well ID: C3826 | Well Name: 299-E17-22 | Location: SW of Purex / 200 East
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
330	Grab-Archive			GRAVEL (G) similar to above; water production increasing 85-90% Gravel, 10-15% Sand, tr Silt. Gravel 25% cobble, 30% v. cse peb, 25% cse peb, 20% med-fn; Sand predom Fn-v. Fn. Multicolored, wet, poorly sorted; most gravel SR-R; random mix basalt, qtzite, granitic, other tr fragments lg cobbles;	Diesel hammer 9" x 6" dual wall casing
335	Grab-Archive				330': Grab sample for archive
340	Grab-Archive			335-340' Sand med to cse sized no cementation noticed on gravels	335': Grab: Archive 340': Grab-Archive ⊗ With casing shoe at 339', WL = 322.3' bgs
345	Grab-Archive			Gravel - similar to above.	345': Grab-Archive
350	Grab-Archive			349-350': drilling indicates lg cobbles/ possible boulders	350': Grab-Archive
355	Grab-Archive			Sand increasing... 352' → 363': Sandy GRAVEL (sG) 70-75% Gravel, 25-30% Sand tr silt. Gravel similar to above Sand med-cse, SA; 60% qtz, 40% basalt, tr mica (~~biotite~~) w	~352': possible Hanford/Ringold Fm contact (?) 355': Grab-Archive
				Sand is med-fn, 80% qtz/20% basalt	or other

Reported By: L. D. Walker | Reviewed By: CS Walker
Title: Geologist | Title: Geologist
Signature: L D Walker | Date: 4-10-02 | Signature: C S Walker | Date: 5/20/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 13 of 13
Date: 4-10-02

Well ID: C3826	Well Name: 299-E17-22	Location: SW of Purex / 200 East	
Project: CY 2002 ILAW Drilling		Reference Measuring Point: Ground Surface	

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
360	Grab-Archive			Sandy GRAVEL (sG) As described above. 361': drilling indicates lg cobbles	Diesel Hammer 9"x6" dual wall casing
				TD = 363' bgs	360': Grab-Archive
365				4-11-02 Depth to water = 322.1', with casing shoe at 362.5'	
370					
375					
380					
385					

Not used CSW

Reported By: L.D. Walker		Reviewed By: C.S. Wright	
Title: Geologist		Title: Geologist	
Signature: L.D. Walker	Date: 4-11-02	Signature: C.S. Wright	Date: 6/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 1 of 13
Date: 4-17-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, along 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0					Diesel Hammer 9"x6" Dual Wall casing
				0' → 1.5' : Sandy GRAVEL Crushed rock drill pad	
				1.5' → 8' : Silty SAND (mS) tr-5% Gravel, 65-70% Sand, 30% Silt. Sand predom v. Fn; SA-A, 80-90% qtz; 10-20% basalt, other 10YR4/3 (brown) sl moist; mod rxn to HCl.	
5	Grab-Archive				5': Grab sample For archive
10	Grab-Archive			8' → 23' : SAND (S) 100% Sand, tr silt. Med-cse, 70-80% basalt, 20-30% qtz/other. 10YR3/1 (v.dk gray), moist, well sorted, SA; tr weak rxn HCl	10': Grab-archive
15	Grab-Archive			Size gradual decrease; predom med by 15' → 50-60% basalt, no rxn HCl.	15': Grab-archive
20	Grab-Archive			20': Gravel tr-5% predom v.Fn-Fn peb	20': Grab-archive
				23' → 29' : Gravelly SAND (gS) 10-20% Gravel, 80-90% Sand	
25	Grab-Archive			tr silt. Gravel v.Fn-med peb, SA-SR Sand similar to above.	25': Grab-archive.
				gravel content decrease to ~5%	

Reported By: L.D.Walker | Reviewed By: CS WRIGHT
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 4-17-02 | Signature: CS Wright | Date: 5/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 2 of 13
Date: 4-17-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, along 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
30	Grab-Archive			29' → 233': SAND (S) tr-5% Gravel, 95-100% Sand, tr silt. Gravel v. Fn peb, SA-SR, Sand 20% v.csc, 30% csc, ~~30%~~ 40% med, 10% fn-v.fn. 10YR5/2 (gry brn) sl. moist, mod-well sorted, 40-50% basalt, 50-60% qtz, Salt and pepper appearance. max size 3-4mm, no rxn HCl	Diesel Hammer 9"x6" dual wall casing
					30': Grab-archive
35	Grab-Archive				35': Grab-archive
					40': Grab-archive
40	Grab-Archive				
					45': Grab-archive
45	Grab-Archive			SAND - similar to above 100% Sand, tr v.fn pebble	
					50': Grab-archive
50	Grab-archive				
55	Split Spoon #1	80% rec.		SAND (S) similar to above tr silt	53.5' → 58.0': Split Spoon #1, For PNNL analysis
	Shoe Split Spoon #2				55': Grab-archive

Reported By: L.D. Walker | Reviewed By: CS Wright
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 4-17-02 | Signature: [signature] | Date: 5/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 3 of 13
Date: 4-17-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, along 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
60	SS #2	100% rec.			Diesel hammer
				SAND (S) similar to above tr gravel, 100% Sand, tr silt.	9" by 6" dual wall
	Shoe			Gravel Fn peb, R-SR basalt	casing
	SS #3	100% rec.		Sand v.cse-Fn; 10YR6/2 (lt. brnish	58.0'→62.5': Split
65				gray) dry to sl moist; mod sorted,	Spoon #2
	Shoe			SA-; 30-40% basalt, 60-70% qtz/feld	60': Grab-archive
				tr iron oxide, tr mod-strong rxn	
				to HCl	62.5'→67.0': Split
70	Grab-Archive				Spoon #3
				SAND- as above	65': Grab-archive
					70': Grab-archive
75	Grab-Archive				75': Grab-archive
	Split Spoon #4	100% rec.			~~78.0'→LW~~
					76.0'→80.5': Split
80	Shoe ← archive sample				Spoon #4
				80': Sand Fine to very Fine	Archive-80'
				100% Sand. 10% cse-med, 50%	
				Fine, 40% v. Fn. 10YR5/2 (grayish brn)	
				sl moist, mod-well sorted; SA;	85': Grab-Archive
85	Grab-Archive			20-30% basalt, 70%-80% qtz/Feld/other	
				tr mica, tr FeOx, no visible	
				rxn HCl	

Reported By: L.D. Walker | Reviewed By: CJ Whelchel
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 4-17-02 | Signature: 5/14/02 | Date: 5/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 4 of 13
Date: 4-17-02

Well ID: C3827	Well Name: 299-E17-23	Location: SW of Purex, along 200E Fence
Project: CY 2002 ILAW Drilling		Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
90	Grab-Archive			SAND (S) similar to above tr v. Fn pebble, 100% Sand v. Fn peb SA, predom basalt; Sand 20% v.cse, 30% cse, 30% med, 20% Fn. 10YR5/2 (grayish brn) sl moist, mod sorted; SA-A; ~30% basalt, 70% qtz/other tr mica; max size ~ 4 mm tr weak rxn HCl.	Diesel hammer 9" by 6" dual wall casing
95	Grab-Archive				90': Grab-archive
					95': Grab-archive
100	Split Spoon #5	100% rec.		(Salt & pepper)	98.0' → 102.5': Split Spoon #5
	Shoe				100': Grab-archive
					105': Grab-archive
105	Grab-Archive			SAND (S) similar to above predom medium size	
					110': Grab-archive
110	Grab-Archive				
					115': Grab-archive
115	Grab-Archive			Sand - med to cse, moist	

Reported By: L.D. Walker	Reviewed By: C.S. Wright
Title: Geologist	Title: Geologist
Signature: L.D. Walker Date: 4-17-02	Signature: C.S. Wright Date: 5/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 5 of 13
Date: 4-17-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, along 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	Split Spoon #6				Diesel hammer
					119.0' → 123.5': Split Spoon #6
	Shoe			SAND (S) similar to above	120': Archive grab
125	Grab-Archive			tr v. fn peb, 100% Sand, tr silt	
				Sand 10% v. cse, 20% cse, 40% med,	125': Grab-archive
				20% fn, 10% v. fn; 10YR 5/3 (brown)	
				slmoist, mod sorted; 20% basalt, 80% qtz/	
130	Grab-Archive			other, tr mica, weak rxn HCl	130': Grab-archive
				134': moisture content dropping	135': Grab-archive
135	Grab-Archive			SAND, med-cse, SA-A	
				slightly more basalt than above	
					140': Grab-archive
140	Grab-Archive			SAND (S)	
				tr v. fn peb - fn peb ⇒ usually	
				basalt, 100% Sand v. cse to fn	
				SA-A, 20-30% basalt, 70-80% qtz/	145': Grab-archive
145	Grab-Archive			other, tr mica, tr iron oxide	
				staining, very weak rxn to HCl.	
				Dry.	
					149': end of 4/17/02

Reported By: L.D. Walker | Reviewed By: C.J. Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-17-02 | Signature: C.J. Wright | Date: 5/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 6 of 13
Date: 4-18-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, on 200E Fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
150	Split Spoon #7	90% rec.		SAND (S) tr v. fn peb, 95-100% Sand, tr-5% Silt. 30% v.cse-cse, 40% med, 30% fn-v. fn. 10YR6/2 (lt. brownish gray) dry; mod sorted, SA-A, 20-30% basalt, max size 3-4 mm, mod rxn HCl.	Diesel hammer, 9" by 6" dual wall casing
	Shoe				
155	Split Spoon #8	100% rec		v.cse sand ~ 154'	149.0'→153.5': Split Spoon #7 150': Grab-archive
	Shoe				153.5'→158.0': Split Spoon #8
160	Split Spoon #9	100% rec.		SAND - similar to above fn to very fine, tr mica	155': Grab-archive 158.0'→162.5': Split Spoon #9
	Shoe				160': Grab-archive
165	Split Spoon #10	95% rec.			162.5'→167.0': Split Spoon #10
	Shoe				165': Grab-archive.
170	Grab-Archive			SAND (S) similar to above 100% Sand, tr silt 10% v.cse, 30% cse, 40% med, 20% fn-v. fn. 10YR6/2 (lt. brnish gray) dry; mod sorted, SA; 30% basalt, 70% qtz/feld/other, tr iron oxide max size ~ 2mm; weak rxn HCl.	170': Grab-archive
175	Grab-Archive				175': Grab-archive

Reported By: L.D. Walker | Reviewed By: CS Cwright
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 4-18-02 | Signature: CWright | Date: 5/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 7 of 13
Date: 4-18-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, on 200E Fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
180	Split Spoon #11	100% rec.		SAND (S) similar to above 95-100% Sand, tr-5% silt 25% v.cse-cse, 35% med, 40% fn-v.fn.; light brownish gray, dry; mod-well sorted, SA-A, ~30% basalt, 70% qtz/feld, tr mica, tr iron oxide staining; very weak rxn HCl	Diesel hammer 9" by 6" dual wall casing
	Shoe				179.0' → 183.5': Split Spoon #11
185	Grab-Archive				180': Grab-archive
					185': Grab-archive
190	Grab-Archive				190': Grab-archive
				SAND - as above similar ~~salt and pebble~~ salt and pepper appearance.	
195	Grab-Archive				195': Grab-archive
200	Grab-Archive			SAND (S) similar to above slightly coarser, slightly higher basalt percentage. very weak rxn HCl	200': Grab-archive
205	Grab-Archive				205': Grab-archive

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 4-18-02
Reviewed By: CS Wright | Title: Geologist | Signature: CS Wright | Date: 6/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 8 of 13
Date: 4-18-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, on 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
210	Grab-Archive				Diesel hammer; 9" by 6" dual wall casing
				SAND (S) similar to above	
				100% sand, tr silt	
				20% v.cse-cse, 30% med, 40% Fn,	
				10% v. Fn. 10YR6/2 (lt. brownish gray)	210': Grab sample
215	Grab-Archive			dry; mod-well sorted, SA-A,	For archive
				20-30% basalt, 70-80% qtz/feldspar	
				tr mica, max size ~2mm	215': Grab-archive
				very weak rxn HCl.	
220	Split Spoon #12	90% rec.			219'→223.5': Split Spoon #12
				222-223': tr pebble, v.Fn-med.	220': Grab-archive
	Shoe				
225	Grab-Archive				225': Grab-archive
				occasional v.Fn-Fn ~~peppy~~ pebble	
				225→233: Sand with 5-10% gravel	230': Grab-archive
230	Grab-Archive			predom. Fn peb. Sand cse-v.cse	
				233': Gravel increase	
				233'→236': Sandy GRAVEL (sG)	
				70% Gravel (v.Fn-med peb) 30% Sand	235': Grab-archive
235	Grab-Archive			(cse-v.cse sand) Gravel 60-70% basalt,	
				SA to angular.	
				237': tr cobble, then more sand	
				236': back to SAND	

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 4-19-02
Reviewed By: CJ Weiler | Title: Geologist | Signature: [signature] | Date: 5/14/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 9 of 13
Date: 4/9-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, on 200E Fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
240	Grab-Archive			236'→254': SAND (S)	Diesel hammer;
				5-10% Gravel, 90-95% Sand.	9" by 6" dual wall
				Sand 5% v.cse, 40% cse, 30% med, 25% fn.	casing
				Gravel v.fn-fn peb. 10YR6/2 (lt. brownish	240': Grab-archive
245	Grab-Archive			gray) dry; mod/well sorted, SA-Ang,	
				30-40% basalt, 60-70% qtz/other, tr mica	
				very weak rxn HCl.	245': Grab-archive
				248': Single goose egg (qtzite) in sand	
250	Grab-Archive				250': Grab-archive
				254'→257': Gravelly SAND (gS)	255': Grab-archive
255	Grab-Archive			20-30% Gravel (v.fn-fn peb, A-SA, basalt)	
				70-80% Sand (similar to sand above)	
				weak HCl rxn	
				257'→260': SAND (S) with ~5% fn peb.	
260	Grab-Archive				260': Grab-archive
				260'→264': Gravelly SAND (gS)	
				25% Gravel (v.fn-fn peb) 75% Sand	
				40-50% basalt, SA-A, weak rxn HCl	
265	Grab-Archive			264'→268': Sandy GRAVEL (sG)	265': Grab-archive
				40% Gravel, 55% Sand, 5% Silt.	
				Gravel fn-med peb; predom. basalt, SA.	
				Sand v.cse-v.fn; poorly sorted	
				Gravel size decrease from 264 to 268 Ft.	

Reported By: L.D. Walker | Reviewed By: CS Walker
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 4-19-02 | Signature: CS Walker | Date: 5/23/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 10 of 13
Date: 4-19-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, on 200E fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
270	Grab-archive			268'→272': Gravelly SAND (gS) 20% Gravel (v.fn-med peb., mainly basalt) 80% Sand (v.cse-fn, 30% basalt, 70% qtz/other, SA-A)	Diesel hammer 9" by 6" dual wall casing.
					270': Grab sample for archive
275	Grab-archive			272'→281': Sandy GRAVEL (sG) 40-50% Gravel, 50-60% Sand, tr silt. Gravel mostly fn-v.fn peb; Sand v.cse to med, SA-A; Gravel up to 50% basalt; poorly sorted; weak rxn HCl - occas. strong rxn.	275': Grab-archive
280	Grab-Archive				280': Grab-archive
				281'→284': GRAVEL (G) 80-90% Gravel, 10-20% Sand drilling indicates lg cobble to boulder size; air lost into formation.	285': Grab-archive
285	Grab-Archive				
				284'→ : Sandy GRAVEL (sG) 50-55% Gravel, 40% Sand to 45%, tr-5% silt; Gravel tr cobble, 10% v.cse peb, 40% cse peb, 40% med peb, 10% fn-v.fn; Sand mainly cse-med. 10YR6/2 (lt. brownish gray) dry, poorly sorted; Gravel SA-SR; 20-30% basalt, 70-80% qtzite/granitic/other; weak rxn HCl.	290': Grab-archive
290	Grab-Archive				295': Grab-archive
295	Grab-Archive				

Reported By: L.D. Walker | Reviewed By: CS Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 4-19-02 | Signature: C.S. Wright | Date: 5/23/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 11 of 13
Date: 4-19-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, 200 E. Fence line
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
300	Grab-Archive			Sandy GRAVEL (sG)	Diesel hammer; 9" by 6" dual wall casing
				40% Gravel, 60% Sand; weak HCl rxn	
				302': large cobbles/boulders	
				Sand predom cse.	300': Grab sample for archive.
305	Grab-Archive			60-70% Gravel, 30-40% Sand, tr silt	
				Gravel cse-med peb, R-SR; 40% basalt,	
				60% granitic/qtzite/other. Sand med-cse,	305': Grab-archive
				30% basalt;	
				309': drilling indicates large cobbles	
310	Grab-Archive			sand content drops to ~20%	310': Grab-archive
				312': drill rate slows considerably	
				large cobbles	
					315': Grab. archive
315	Grab-Archive			312' → 358': GRAVEL (G)	
				Gravel 80-90%, Sand 10-20%, tr	
				Silt. Fragments indicate up to 50%	
				cobble, 30% v.cse peb, 20% cse-fn peb.	
				Sand predom fn. Sand 80-90% qtz, 10-20	320': Grab-archive
320	Grab-Archive			% basalt, other. Gravel includes qtzite,	
				granitic, basalt, other	
					325': Grab-archive
325	Grab-Archive				
				328': Drilling indicates no large cobbles,	
				but more air lost into formation	

Reported By: L. D. Walker | Reviewed By: C S Walker
Title: Geologist | Title: Geologist
Signature: L. D. Walker | Date: 4-24-02 | Signature: C S Walker | Date: 5/23/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 12 of 13
Date: 4-24-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, on 200 E Fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
330	Grab-Archive			GRAVEL (G) similar to above 80-90% Gravel, 10-20% Sand, tr silt. 20% sm. cob, 50% v.cse-cse peb, 30% med-fn peb; Sand is predom med; dry becoming wet by 334'; when allowed to recover W.L.= 332.5'. poorly sorted, gravel SR-Round, Sand SA; Gravel a mixture of basalt, granitic, qtzite	Diesel hammer 9" by 6" dual wall casing
335	Grab-Archive				330': Grab sample for archive.
340	Grab-Archive			340': Silt tr-5%	335': Grab-archive
345	Grab-Archive			345-350': sand content appears to increase, still at or below 20%	340': Grab-archive ⊗ with casing at 349', Water level = 332.5'
350	Grab-Archive			GRAVEL - similar to above	345': Grab-archive
355	Grab-Archive			357'→358': sand increase, Gravel becomes Sandy Gravel	350': Grab-archive; 355': Grab-archive

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 4-25-02
Reviewed By: C.S. Walker | Title: Geologist | Signature: C.S. Walker | Date: 5/23/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 13 of 13
Date: 4-25-02

Well ID: C3827 | Well Name: 299-E17-23 | Location: SW of Purex, on 200E fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
360	Grab-Archive			358' → 372': Sandy GRAVEL (sG) 60-70% Gravel, 30-40% Sand, tr silt. Gravel 10% sm cob (tr lg cob) 40% v.cse-cse peb, 30% med peb, 20% fn-v.fn. Sand med-fn Gravel poorly sorted, SR-R, mix of basalt/qtzite/granitic/other. Sand 80-90% qtz, tr mica	Diesel hammer, 9" by 6" dual wall casing
365	Grab-Archive				360': Grab-archive
					365': Grab-archive
					370': Grab-archive
370	Grab-Archive			370-372', sand med-cse	372': Grab-archive and T.D.
	Grab-Archive			TD = 372' bgs.	
375					
380					
385					

Reported By: L.D. Walker | Title: Geologist | Signature: [signature] | Date: 4-25-02
Reviewed By: C.S. Walker | Title: Geologist | Signature: [signature] | Date: 5/27/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 1 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 East, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0	Diesel Hammer			0' → 1.5': Crushed rock drill pad	Diesel hammer, 9" x 6" dual wall casing.
				1.5' → 9': Slightly Silty SAND tr gravel, 85-90% SAND, 10-15% Silt Sand is med to Fn; brown, sl moist, mod sorted; 70% qtz/feld, 30% basalt	
5					
				9' → 11': Gravelly SAND (gS) 10-15% Gravel, 85-90% Sand, tr silt. grading to SAND with less than 10% gravel	10': Grab sample for archive
10	Grab - Archive				
				11' → 15': SAND (S) tr gravel, 100% Sand. Sand mainly cse, dark gray, moist	
15					
				15' → 36': Slightly Silty SAND (m) S) tr gravel, 85-90% Sand, 10-15% silt. 30% cse - v.cse, 40% med, 30% Fn - v. Fn. 10YR4/3 (brown), moist; mod sorted, SA-A; 40% basalt, 60% qtz/Feld/other, max size ~ 5 mm; mod rxn HCl	20': Grab sample for archive
20	Grab - Archive				
25					

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 5-10-02
Reviewed By: CS Wright | Title: Geologist | Signature: CS Wright | Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 2 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 East, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
30	Grab-Archive			Slightly Silty SAND - similar to above	Diesel Hammer 9" by 6" dual wall casing
	Diesel hammer				30': Grab sample for archive
35				36' → 230' : SAND (S) 95-90% Sand, 5-10% Silt tr gravel, 90-95% Sand, 5-10% Silt gravel is v. Fn peb; Sand predom cse, 10YR 4/2 (dark grayish brown), moist; mod sorted; SA-A ; 40% basalt, 60% qtz/feld ; max size 5-10 mm; mod rxn HCl.	
40	Grab-Archive				40': Grab sample For archive
45				46': lumps of silt/clay in the sand with strong HCl rxn	
				SAND - similar to above.	
50	Grab-Archive			50': tr gravel - med to cse peb, R	50': Grab - archive
55				Silt content decrease	

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 5/10/02
Reviewed By: C.S. Walker | Title: Geologist | Signature: C.S. Walker | Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 3 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 E, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
60	Grab-Archive				Diesel Hammer
				SAND (S) similar to above	9" by 6" dual
	Diesel hammer			tr gravel, 95% Sand, 5% Silt	wall casing
				Sand med to cse; 10YR4/2 (dk.	
				grayish brown) moist; mod sorted,	60': Grab Sample
65				SA-A; 30% basalt, 70% qtz/feld/	for archive
				other, tr mica; weak HCl rxn	
				tr silt fragments with strong rxn	
				HCl.	
70	Grab-Archive				70': Grab sample
				Silt content tr to none	for archive
75					
				SAND	
				100% Sand, tr silt	80': Grab-archive
80	Grab-Archive			40% cse, 50% med, 10% fn-v.fn	
				10YR5/2 (grayish brown) sl moist;	
				mod-well sorted, SA-A; 30% basalt	
				70% qtz/feld, tr mica; max size	
				2-4 mm; mod rxn HCl.	
85					

Reported By: L.D. Walker | Title: Geologist | Signature: [signature] | Date: 5-10-02
Reviewed By: CS Wright | Title: Geologist | Signature: [signature] | Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

BOREHOLE LOG

Page: 4 of 13
Date: 5-10-02

Well ID: C3926	Well Name: 299-E17-25	Location: 200 East, SW of Purex	
Project: CY 2002 ILAW Drilling		Reference Measuring Point: Ground Surface	

Depth (Ft.)	Sample: Type & No.	Sample: Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
90	Grab-Archive				diesel hammer;
				SAND (S)	9" by 6" dual wall
				100% Sand, tr gravel (fn-v.fn	casing.
				peb). Sand 10% v.cse, 40% cse,	
				30% med, 20% fn-v.fn; 10YR5/2	90': Grab sample
95				(gr brown), sl moist, SA-A, mod sorted	for archive
				20-30% basalt, 70-80% qtz/feld	
				tr mica. HCl rxn weak to mod.	
				tr occasional silt lumps	
100	Grab-Archive			possible caliche fragments	100': Grab sample
				(< 1cm) v. strong HCl rxn	for archive
				100':	
				Sand predom med to fn	
105					
				SAND (S) - similar to above	110': Grab-Archive
110	Grab-Archive			predom cse to med, moist,	
				weak rxn HCl	
115				114' → 116': Sand is fn-v.fn	

Reported By: L.D. Walker		Reviewed By: CS Wallent	
Title: Geologist		Title: Geologist	
Signature: [signature]	Date: 5-10-02	Signature: [signature]	Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 5 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 E, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	Grab-Archive; Diesel hammer			SAND (S) similar to above 100% sand, tr silt tr gravel (v. fu peb) Sand predom med, salt and pepper appearance; moist, mod sorted, SA-A; 30% basalt, 70% qtz/feld, tr mica; max size ~5 mm HCl rxn weak.	Diesel hammer, 9" by 6" dual wall casing 120': Grab sample For archive
125					
130	Grab-Archive				130': Grab sample for archive.
135				~135': tr silt fragments in sand 137': silt fragments; ~~tan~~ brown, moist, strong HCl rxn	
140	Grab-Archive			SAND (S) similar to above. 95-100% Sand, tr-5% Silt Sand cse to med; 10YR5/2 (gr brown) moist; mod sorted, SA-A; 30% basalt, 70% qtz/feld; HCl rxn weak.	140': Grab-archive
145					

Reported By: L.D. Walker | Reviewed By: CS Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-10-02 | Signature: C S Wright | Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 6 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 E, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
150	Grab-Archive				Diesel hammer, 9" by 6" dual wall casing
		diesel hammer		SAND - similar to above 100% Sand, tr silt, med to cse, moist, SA, mod-well sorted, 25-30% basalt, 70-75% qtz/feld	150': Grab sample for archive
155				156': Sand v. cse, with tr silt	
				158': Sand med, decrease in silt.	
160	Grab-Archive				160': Grab-archive.
				Silt/clay fragments - brown, strong HCl rxn	
165				SAND (S) 100% Sand, predom fn. sl moist, well sorted, sub angular; 20% basalt, 80% qtz/feldspar; tr mica, mod rxn HCl.	
170	Grab-Archive				170': Grab-archive
175				176': Silt fragments	

Reported By: L.D. Walker | Reviewed By: C.S. Walters
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-10-02 | Signature: C.S. Walters | Date: 6/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

BOREHOLE LOG

Page: 7 of 13
Date: 5-10-02

Well ID: C 3926 | Well Name: 299-E17-25 | Location: 200 E, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample: Type & No.	Sample: Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
180	Grab-Archive			SAND (S) similar to above predom fine to medium	Diesel hammer; 9" by 6" dual wall casing
					180': Grab sample for archive
185				186': single caliche fragment ~2 cm diameter sub round, yellowish brown. (in top of 180' archive jar)	
190	Grab-Archive			(Fine)	190': Grab-archive
195				SAND (S) 100% sand, tr silt 20% v.cse, 20% cse, 40% med, 20% fn-v.fn. 10YR 5/2 (grayish brown) sl moist, mod-well sorted, SA,	
200	Grab-Archive			30% basalt, 70% qtz/Feld, max size ~4 mm; weak rxn HCl (Coarse)	200': Grab sample for archive
205				Sand becoming slightly drier predom med-fn	

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 5-10-02
Reviewed By: CS Walker | Title: Geologist | Signature: CS Walker | Date: 5/7/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 8 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 E, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
210	Grab-Archive			SAND (S) similar to above 100% Sand, tr silt. predom med-cse sized; 10YR5/2 (grayish brown) sl moist; mod sorted; SA-A; 20-25% basalt, 75-80% qtz/other; HCl rxn weak to mod.	Diesel hammer, 9" by 6" dual wall casing 210': Grab sample For archive
215					
				218': Sand is dry; tr Fn pebbles	
220	Grab-Archive			Sand v. cse sized	220': Grab-archive
225				228': tr pebbles, Fine	
230	Grab-Archive			230' → 235': Gravelly SAND (gS) 20% gravel, 80% Sand, tr silt. Gravel predom v. Fn peb (basalt) Sand cse to med. 40% basalt/60% qtz/Fld; poorly sorted/mod sorted. Dry, weak Hcl rxn.	230': Grab-archive
235				235' → ~~EOH~~: SAND (S) 235' → 240' see next page. med-cse sand	

Reported By: L.D. Walker | Reviewed By: CS Wrucke
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-10-02 | Signature: C Wrucke | Date: 5/10/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 9 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 E, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample: Type & No.	Sample: Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
240	Grab-Archive			Gravel increase ...	Diesel Hammer, 9" by 6" dual wall casing
				240' → 243': Gravelly SAND (gS) 20-30% Gravel, 70-80% Sand. Gravel is Fn - v. Fn peb; Sand cse	240': Grab sample for archive
245				243' → 259': Sandy GRAVEL (sG) 50% Gravel, 50% Sand, tr silt. Gravel tr med peb, 40% fn peb, 60% v. fn. Sand is cse to v. cse. 50% basalt	
250	Grab-Archive			251': sand very moist, then back to sl moist	250': Grab-archive
255				Gravel SR - SA, poorly sorted, 10YR 5/2 (grayish brown) sl moist v. weak HCl rxn. occasional v. cse peb	
260	Grab-Archive			259' → 275': SAND (S) 10% Gravel, 90% Sand. Gravel v. Fn peb, Sand predom v. cse to cse. Grayish brown, sl moist, mod to well sorted;	260': Grab-archive
265				SA - SR; 40-50% basalt, 50-60% qtz/feld; very weak HCl rxn.	

Reported By: L. D. Walker		Reviewed By: CS Wright	
Title: Geologist		Title: Geologist	
Signature: L D Walker	Date: 5-10-02	Signature: C S Wright	Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 10 of 13
Date: 5-10-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 East, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample: Type & No.	Sample: Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
270	Grab-Archive			SAND - dry	Diesel hammer, 9" by 6" dual wall
	diesel hammer			similar to above.	casing.
				100% sand	
					270': Grab Sample
275				275' → 382.5': Sandy GRAVEL	For archive
				(SG) 60-70% Gravel; 30-35%	
				Sand, tr-5% silt	
				Gravel sm. cob to Fn peb, Sand	
				predom Fine, to v. Fine.	
280	Grab-Archive			Gravel SR-SA; 30% basalt,	280': Grab-archive
				70% qtzite/granitic/other	
				Dry; no rxn HCl.	
285				285': basalt cobbles (Fragments)	
				dry, silt content ~ 5%	
					290': Grab-archive
290	Grab-Archive				
				Sandy GRAVEL - as above	
				75% gravel, 20% Sand, 5%	
				Silt	
295					

Reported By: L. D. Walker | Reviewed By: CS Wright
Title: Geologist | Title: Geologist
Signature: L D Walker | Date: 5-10-02 | Signature: C S Wright | Date: 5/11/02

Original to: Document and Information Services, H0-09/HW1S

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 11 of 13
Date: 5/10/02

Well ID: C3926 | Well Name: 299-E17-25 | Location: 200 East, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
300	Grab-Archive			Sandy GRAVEL (sG)	Diesel hammer, 9" x 6" dual wall casing
				Gravel 75%, Sand 20%, silt 5%	
				Gravel 20% sm. cob, 30% v. cse peb,	
				30% cse peb, 20% med-Fn peb.	300': Grab-archive
305				Sand predom. med-fn. Dry,	
				poorly sorted; gravel R-SR,	
				Sand SA; Gravel 30-40% baselt,	
				60-70% qtzite/granitic/other	
				weak HCl rxn	
310	Grab-Archive				310': Grab-archive
315					
					319': End of 5/10/02
				318'→320' Silt content increase	
320	Grab-Archive			sl moist, mod HCl rxn	
					320': Grab sample for archive
				Sandy GRAVEL	
				75% Gravel, 20% Sand, 5% silt	
				324'→325': large cobbles slow	
325				the drilling rate	
				poorly sorted, Gravel cobble to	
				v. Fn peb; Sand predom Fn - v. Fn.	

Reported By: L.D. Walker | Title: Geologist | Signature: [signature] | Date: 5-13-02
Reviewed By: CS Walker | Title: Geologist | Signature: [signature] 5/17/02 CW | Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 12 of 13
Date: 5-13-02

Well ID: C 3926 | Well Name: 299-E17-25 | Location: 200 East, SW of Purex
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
330	Grab-Archive			Sandy GRAVEL (sG)	Diesel hammer, 9" by 6" dual wall casing.
	diesel hammer			70% Gravel, 20% Sand, 10% silt	
				Gravel 20% cobble, 50% v.cse to cse peb, 30% med-v.fn peb. Sand	330': Grab sample for archive
335				is med-v.fn 10YR6/2 (lt. brownish gray), dry; poorly sorted; gravel R-SR, Sand SA	
				weak HCl rxn	
340	Grab-Archive				340': Grab-archive
				341': Gravel is wet	
				↳ Sand is med to coarse	
				↳ Water produced immediately	
345					
				345': decrease in water production	
				350' water increase	
350	Grab-Archive				350': Grab-Archive
				Sandy GRAVEL (sG)	
				70%, 30% Sand, tr silt.	
				Gravel 10% cobble, 40% v.cse peb,	
				30% cse peb, 20% med-fn.	
355				Sand med to cse; wet, poorly	
				sorted, Gravel R-SR, Sand SA;	
				Gravel 40% basalt, 60% qtzite/granitic	
				Sand 70% qtz/30% basalt/other	

Reported By: L.O. Walker | Reviewed By: CS Walker
Title: Geologist | Title: Geologist
Signature: LO Walker | Date: 5-13-02 | Signature: CS Walker | Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 13 of 13
Date: 5-13-02

Well ID: C3926 | Well Name: 299-E17-25 | Location: C3926
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
360	Grab-Archive; diesel hammer			Sandy GRAVEL (sG) tr-5% 65 % Gravel, 35 % Sand, tr silt, Gravel 20% cobbles (several large basalt cobbles just below 360'), 50% v.cse to cse peb, 30% med- v.fn peb; Sand med to cse; wet; poorly sorted; gravel R-~~SA~~ SR, Sand SA-Ang; Sand 70% qtz/Feld, 30% basalt/other tr mica. Gravel 40% basalt, 60% granitic / qtzite / other	Diesel hammer, 9" by 6" dual wall casing.
365					360': Grab Sample for archive
370	Grab-Archive			368': color in water (silt) change from light brown to very dark brown. ⇒ almost black (10YR 2/2)	370': Grab-archive
375				370': Gravel over 80% basalt silt ~ 5% Sand 60% qtz/Feld, 40% basalt/other 378': water color back to light brown.	375': large cob/ boulders - slow drilling
380	Grab-Archive			75% Gravel, 25% Sand, tr silt T.D. = 382.5'	380': Grab-archive With casing shoe at 382.5', water level is 337.2' bgs.

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 5-13-02
Reviewed By: G.S. Wright | Title: Geologist | Signature: G.S. Wright | Date: 5/17/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 1 of 13
Date: 5-1-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, on 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0				0'→1.5': Sandy GRAVEL (sG) Crushed rock drill pad.	9" by 6" dual wall casing, diesel hammer
				1.5'→9': Slightly Silty SAND (lm) S) 85-90% Sand, 10-15% Silt. Sand 20% med, 60% fn, 20% v. Fn. 10YR 5/3 (brown), sl moist, mod sorted, SA; 70% qtz, feld; 30% basalt, weak rxn HCl.	
5	Grab-Archive				5': Grab sample for archive
				9'→13': SAND (S) tr-5% gravel, 95-100% Sand. Sand v.cse-cse; 10YR 4/1 (dark gray) moist; SA, predom basalt (~90%)	
10	Grab-Archive				10': Grab-archive
				13'→33': Slightly Silty SAND tr gravel, 85-90% Sand, 15-10% Silt. 20% v.cse-cse, 50% med, 30% fn-v. Fn; 10YR 4/3 (brown), moist; mod sorted, SA-A; 40-50% basalt	
15	Grab-Archive				15': Grab-archive
				50-60% qtz/feld/other; max size ~10 mm, weak to mod rxn HCl	
20	Grab-Archive				20': Grab-archive
25	Grab-Archive				25': Grab-archive.
				27': trace gravel - med-fn peb.	
				28'-29': tr cobble	

Reported By: L.D. Walker		Reviewed By: C.S. Wright	
Title: Geologist		Title: Geologist	
Signature: L.D. Walker	Date: 5-1-02	Signature: C.S. Wright	Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 2 of 13
Date: 5-1-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, on 200E fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
30	Grab-Archive			Silt content decreasing...	9" by 6" dual wall casing, diesel hammer
				33' → 234': SAND (S) tr Gravel, 95-100% Sand, tr-5% Silt. Gravel SA basalt Fn peb, Sand 25% v.cse-cse, 50% med, 25% Fn-v.fn. 10YR5/2 (grey brown) sl moist, salt and pepper appearence, mod sorted, SA-A; 20-30% basalt, 70-80% qtz/other, max size ~ 1 cm, mod rxn HCl	30': Grab sample For archive
35	Grab-Archive				35': Grab-archive
40	Grab-Archive				40': Grab-archive
					45': Grab-archive
45	Grab-Archive				
					50': Grab-archive
50	Grab-Archive			SAND (S) similar to above trace clumps of silt/clay that show strong HCl rxn tr mica	53.5' → 58.0': Split Spoon #1 For PNNL analysis
55	Split Spoon #1	100% rec.			55': Archive collected from SS drive shoe
	Shoe-Grab SS #2				

Reported By: L.D. Walker | Reviewed By: C.S. Unklert
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-1-02 | Signature: C.S. Unklert | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 3 of 13
Date: 5-1-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, on 200E fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
60	SS #2	100% rec.			58.0' → 62.5': Split Spoon #2
	Shoe - Archive			60.5': moisture change from dry to moist - very clear in lexan liner. Possible thin paleosol	60' Archive Sample From SS drive shoe
	Split Spoon #3				
65				SAND (S) 100% Sand with tr silt/clay	62.5' → 67.0': Split Spoon #3
	Shoe - Grab/Archive				
	diesel hammer ↓			67': possible clastic dike fragment in split spoon drive shoe. → Silt with strong HCl rxn., moist	65' Archive from SS drive shoe
70	Grab - Archive				70': Grab sample For archive
75	Grab - Archive			75': tr silt and clay fragments moist	75': Grab - archive
					80': Grab - archive
80	Grab - Archive			SAND (S) similar to above 95-100% Sand, tr-5% Silt 20% v.cse, 20% cse, 30% med, 30% Fn-v.Fn; 10YR 5/2 (grayish brown) sl moist; mod sorted, SA; 25% basalt 75% qtz/feld/other, tr mica; max size ~5 mm; HCl rxn very weak	85': Grab - archive
85	Grab - Archive				

Reported By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 5-1-02
Reviewed By: C.S. Walker | Title: Geologist | Signature: C.S. Walker | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 4 of 13
Date: 5-1-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, 200E fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
90	Grab-Archive				Diesel hammer
				SAND (S) similar to above	9" by 6" dual
				95-100% Sand, tr-5% Silt.	wall casing
				Sand predom med-cse, 10YR5/2	
				(grayish brown) moist; SA-A	90': Grab sample
95	Grab-Archive			15-25% basalt, 75-85% qtz/Feld,	For archive
				tr mica, weak rxn HCl.	
					95': Grab-archive
				Sand med-fn, fragments of	
100	Grab-Archive			yellowish brown (10YR5/4) silt showing	100': Grab-archive
				up in drill cyclone. Silt has	
				strong rxn to HCl.	
					105': Grab-archive
105	Grab-Archive			105': Sand cse to very cse,	
				30-40% basalt, no silt.	
					110': Grab-archive
110	Grab-Archive			110': Sand predom med-cse, sl moist	
				115': lumps of moist silt in	115': Grab-archive
115	Grab-Archive			the sand in cyclone. tr bedding	
				Features, less than 1cm thick	

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-1-02 | Signature: C.S. Wright | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 5 of 13
Date: 5-1-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, on 200E Fence
Project: CY 2002 ILAW Drilling. | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	Grab-Archive			SAND (S) similar to above	Diesel hammer
					9" by 6" dual
					wall casing
				Many small silt layers/fragments	
					120': Grab sample
125	Grab-Archive			Sand predom med-fn, brown	for archive
				SA-A, 40% basalt 60% qtz/feld	
				tr iron oxide staining, moist	125': Grab sample
				Silt and clay fragments may be	For archive
				caliche - strong HCl rxn	
130	Grab-Archive				130': Grab-archive
				SAND - 100% Sand, med-cse	
				130-135': silt fragments	
					135': Grab-archive
135	Grab-Archive				
				SAND (S) 100% Sand, v.cse -	
				med, salt and pepper look, 30-40%	
				basalt, 60-70% qtz/Feld/other, tr	
				mica, 10YR5/2 (grayish brown) moist;	140': Grab-archive
140	Grab-Archive			SA-A, mod rxn HCl	
				140': silt fragments, small	
					145': Grab-archive
145	Grab-Archive			145': silt fragments - moist, brown,	
				strong HCl rxn.	
					148': end 5/1/02
				SAND - moist, 100% sand, med-cse	

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: L D Walker | Date: 5-2-02 | Signature: C Wright | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 6 of 13
Date: 5-2-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, on 200E fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
150	Grab-Archive			SAND (S) similar to above 100% Sand, tr silt. Med size, A-SA, 10YR5/3 (brown) moist; 20-30% basalt tr mica, mod rxn HCl.	Diesel hammer 9" by 6" dual wall casing
					150': Grab-archive
155	Split Spoon #4 SSW	80% rec.		moist ↓ Thin (1cm and less) silt/clay layers brown, strong rxn HCl, not horizontal	153.5' → 158.0': Split Spoon #4; PNNL
	Shoe - Archive			Sand similar to above. ⊗ Possible paleosol in liner 155.5' → 157.5'	157.5': Archive from SS drive shoe
160	Split Spoon #5	100% rec.		SAND - 100% Sand, tr silt Predom Fn sand, SA; 20% basalt, 80% qtz/other, tr mica; HCl rxn weak to none - tr silt Fragments strong HCl rxn	158.0' → 162.5': Split Spoon #5, PNNL
	Shoe - Archive				162': Archive
165	Split Spoon #6	100% rec.			162.5' → 167.0': Split Spoon #6, PNNL
	Shoe - Archive				167': Archive
170	Grab-Archive			SAND (S) similar to above 100% Sand, tr silt.	170': Archive grab sample
175	Grab-Archive				175': Grab-archive

Reported By: L.D. Walker | Reviewed By: CS. Unibar
Title: Geologist | Title: Geologist
Signature: LD Walker | Date: 5-2-02 | Signature: CS Unibar | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 7 of 13
Date: 5-2-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, 200 E Fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
180	Grab-Archive			SAND - sl moist, predom med.	Diesel hammer, 9" by 6" dual wall casing.
				186 - 187': silty, cemented sand	
				10YR5/4 (yellowish brown)	
				sl moist, only mod rxn HCl	180': Grab Sample for archive
185	Grab-Archive			20-30% basalt, 70-80% qtz/Feld tr mica, SA-A	
				Fragments very firm, difficult to break in hand	185': Grab-archive
190	Grab-Archive			190'- silt Fragments, trace	190': Grab-archive
195	Grab-Archive			SAND (S) 100% Sand	195': Grab-archive
				20% v.cse-cse, 60% med, 20% fn-v.fn, tr silt. 10YR5/2 (grayish brown) sl moist; mod-well sorted,	
200	Grab-Archive			SA; 25% basalt, 75% qtz/other, tr mica, max size ~ 2mm (basalt)	200': Grab-archive
				weak HCl rxn.	
205	Grab-Archive			SAND - as above.	205': Grab-archive

Reported By: L.D. Walker | Reviewed By: C.S. Walker
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-2-02 | Signature: C.S. Walker | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002).

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 8 of 13
Date: 5-2-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, on 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
210	Grab-Archive			SAND (S) 100% Sand, tr silt predom cse-med; 10YR6/3 (pale brown) sl moist, mod sorted, A-SA; 20-30% basalt, 70-80% feld/qtz/other, tr mica mod. rxn HCl. max size ~ 2mm	Diesel hammer, 9" by 6" dual wall casing 210': Grab sample For archive.
215	Grab-Archive				215': Grab-archive
				218': tr cemented sand Fragments.	
220	Grab-Archive			220': Sand is now dry; otherwise similar to above; cse tr Fn pebbles.	220': Grab-archive
225	Grab-Archive			SAND (S) tr gravel (Fn peb) 100% Sand. Med-cse; v-cse by 230 feet. 40% basalt / 60% qtz/other mod sorted, SA-A; max size ~ 1 cm, weak HCl rxn; dry	225': Grab-archive 230': Grab-archive
230	Grab-Archive				
				234' → 237': Gravelly SAND(gS) 25-30% Gravel, 70-75% Sand, tr silt. Gravel med-v. Fn peb, Sand predom. v-cse. 40-50% basalt, SA-A, poorly sorted / mod sorted	235': Grab-archive
235	Grab-Archive			back to SAND	

Reported By: L.D. Walker | Reviewed By: C.S. Winbow
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-2-02 | Signature: C.S. Winbow | Date: 6/6/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 9 of 13
Date: 5-2-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex, on 200E Fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
240	Grab-Archive			237' → 244': SAND (S) 100% Sand med-cse, 10YR 6/2 (lt. brownish gray), dry; mod-well sorted, SA, tr mica; HCl rxn v. weak.	Diesel hammer 9" by 6" dual wall casing
				244': moisture increase, start Fine pebbles	240': Grab-archive
245	Grab-Archive				245': Grab-archive
				244' → 262': Sandy GRAVEL (sG) 40-50% Gravel, 50-60% Sand Gravel is tr. med peb, 40% Fn peb, 60% v. Fn peb; Sand 50% v. cse, 40% cse, 10% med. Overall color 10YR 5/2 (grayish brown) sl moist to dry; mod sorted; SA; 40% basalt 60% qtz/Feld;	250': Grab-archive
250	Grab-Archive				
					255' Grab-archive
255	Grab-Archive				
				Sandy GRAVEL - gravel Fn to v. Fn pebble, Sand is cse to v. cse	260' Grab archive
260	Grab-Archive				
				262' → 277': SAND (S) tr gravel, 100% Sand. Sand is cse to v. cse. grayish brown; dry; mod sorted, SA-A; 30-40% basalt, 60-70% qtz/other; HCl rxn very weak.	265' Grab archive
265	Grab-Archive				

Reported By: L.D. Walker | Reviewed By: C.S. Walker
Title: Geologist | Title: Geologist
Signature: | Date: 5-2-02 | Signature: | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 10 of 13
Date: 5-2-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex on 200E fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
270	Grab-Archive			262'→277': SAND -as described above	Diesel hammer, 9" by 6" dual wall casing
					270: Grab sample For archive
275	Grab-Archive			277': Sandy GRAVEL 277'→286': Silty Sandy GRAVEL (msG) 60% Gravel, 20% Sand, 20% Silt.	275': Grab-archive
280	Grab-Archive			Gravel med peb to sm. cob; Sand predom v. Fn. dry, weak HCl rxn. -Loosing air circulation into formation -cobble Fragments	280': Grab-archive
					285': Grab-archive
285	Grab-Archive			286' silt content decrease to less than 5%	
				288': large cobbles/or single boulder -qtzite Fragments.	290': Grab-archive
290	Grab-Archive			286'→318': Sandy GRAVEL (sG)	292': drill rate increase
				75% Gravel, 25% Sand, tr silt	295': Grab-archive
295	Grab-Archive			Gravel 30% Cobble/boulder Fragments 50% v.cse-cse peb, 20% med-Fn peb. Sand cse-med; dry, poorly sorted; gravel R-SR; Basalt, granitic, metamorphic - just about anything; tr silt coating on gravel with v. weak HCl rxn.	

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-3-02 | Signature: C.S. Wright | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 11 of 13
Date: 5-3-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex; 200E fence
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
300	Grab-Archive			Sandy GRAVEL (sG)	Diesel hammer, 9" by 6" dual wall casing
				similar to above	
				75-80% gravel, 20-25% Sand, tr silt. Gravel tr lg cobble,	300': Grab sample For archive
305	Grab-Archive			20% sm. cob, 50% v.cse-cse peb, 30% med-fn peb.; Sand mainly fine; dry; poorly sorted; gravel SR, Sand SA; largest size ~20 cm ?	305': Grab-archive
				30-40% basalt in gravel	
310	Grab-Archive			no rxn HCl	310': Grab-archive
315	Grab-Archive			Sand and silt content increase slightly	315': Grab-archive
				318': Gravel/cobbles coated with moist silt - light brown, mod-strong HCl rxn	
320	Grab-Archive				320': Grab-archive
				318' → 325': GRAVEL (G)	
				80-90% Gravel, 10-15% Sand, tr-5% Silt. Gravel predom cse-v.cse peb,	
				tr cobble	325': Grab-archive
325	Grab-Archive				
				Sand (v. Fn) increase...	
				325' → 383': Sandy GRAVEL (sG)	
				60% Gravel, 35% Sand, 5% Silt	

Reported By: L.D. Walker | Reviewed By: C.J. Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-3-02 | Signature: C.J. Wright | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 12 of 13
Date: 5-3-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex on 200E Fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
330	Grab-archive			Sandy GRAVEL (sG)	Diesel hammer, 9" by 6" dual wall casing
				60-80% 70% Gravel, 25-30% Sand, tr-5% silt. Gravel 20% cobble, 40% v. cse peb, 40% cse-fn peb; Sand is med- v. fn. 10YR 6/2 (light brownish gray), dry; poorly sorted; Gravel R-SR, Sand SA; Gravel 25% basalt,	330': Grab sample for archive
335	Grab-Archive			75% qtzite/granitic/other, Sand predom qtz; no rxn HCl.	335': Grab-archive
340	Grab-Archive				340': Grab-archive
				Sandy GRAVEL (sG) 70% Gravel, 30% Sand, tr silt Sand is predom. med to fn, moist Sand 80% qtz, 20% basalt/other	
345	Grab-Archive				345': Grab-archive
				water produced below 345'	
				Sandy GRAVEL (sG)	
350	Grab-Archive			75% Gravel, 25% Sand (sand med)	350': Grab-archive
				352': drill rate slows, decrease in water produced during drilling.	355': Grab-archive
355	Grab-archive			355': water increase	
				Sandy GRAVEL	

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: geologist
Signature: [signature] Date: 5-6-02 | Signature: [signature] Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

Appendix B - Borehole Log Sheets

BOREHOLE LOG

Page: 13 of 13
Date: 5-6-02

Well ID: C3828 | Well Name: 299-E17-24 | Location: SW of Purex on 200E Fenceline
Project: CY 2002 ILAW Drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type & No.	Sample Blows & Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Maximum Particle Size, Reaction to HCL	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
360	Grab-Archive			Sandy GRAVEL (sG)	Diesel hammer, 9" by 6" dual wall casing
				75% Gravel, 25% Sand, tr silt. Gravel blend of qtzite, basalt, granitic; Sand predom qtz, tr mica. Gravel R-SR, Fn-cse peb.	360': Grab-archive
365	Grab-Archive			365-366': slow drilling. Fragments indicate granitic cobbles (lg cob.)	365': Grab sample for archive
	Grab-Archive			367': large fragments of basalt.	368': Grab/archive basalt fragments
				@ 367' → 369': One basalt boulder	
370	Grab-Archive			Below 370', gravel is predom. basalt	370': Grab-archive
				Sandy GRAVEL (sG)	375': Grab-archive
375	Grab-Archive			60% Gravel, 40% Sand	
				Gravel tr lg. cob to boulder, 25% sm. cob, 40% v. cse ~~gravel~~ peb. 35% cse-Fn peb.	
				Sand cse-v.cse; dark gray, wet;	
				poorly sorted, gravel SR, 80% basalt	380': Grab-archive
380	Grab-Archive			20% qtzite/granitic/other	
	Grab-Archive				382': Grab-archive
				Sand med-cse, 70% qtz, 30% basalt/other	with casing shoe at 383': W.L. = 341.3'
				TD = 383'	
385					

Reported By: L.D. Walker | Reviewed By: C.S. Wright
Title: Geologist | Title: Geologist
Signature: L.D. Walker | Date: 5-6-02 | Signature: C.S. Wright | Date: 5/16/02

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-183 (02-20-2002)

APPENDIX C

WELL DEVELOPMENT AND TESTING DATA

Appendix C - Well Development and Testing Data

WELL DEVELOPMENT AND TESTING DATA

Well Name: 299-E17-22	Well ID: C3826	Well Location: SW of Purex / 200E	Date: 5/21/02

Reference Measuring Point (unless otherwise noted): GROUND LEVEL

Has the well been surveyed? ☐ Yes ☒ No | Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:	TOC
Start of Job	325.36'
End of Job	325.30'
DEPTH TO BOTTOM:	TOC
Start of Job	~~368~~ 362.30' low
End of Job	362.40'

PART 2

WELL DEVELOPMENT DATA

Pump Model	Grundfos, 16S30-24
Intake Depth	~~358'~~ 355' (TOC) / 338'
Starting Turbidity	968 NTU

Pump Start	Stop	Flow Rate
0813	0920	11 gpm
0938	1010	13 gpm

Total Pumped	~1150 gallons
Final Turbidity	2.66 NTU
Transducer Range (PSI)	10 psi

PART 3

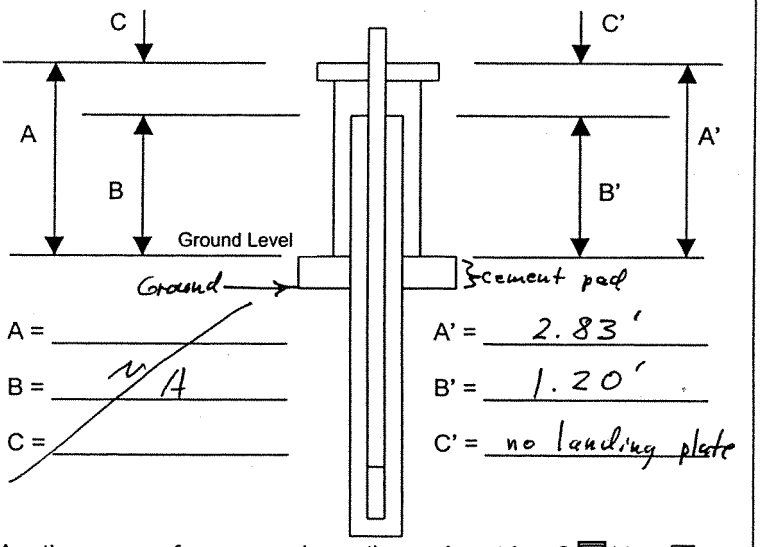
INSTANTANEOUS SLUG TEST

Static Water Level (TOC)	
Transducer Depth	
Baseline Start	
Injection Start	
Baseline Start	NA
Withdrawal Start	
Slug Volume	
Transducer Range (PSI)	

PART 4

Last Recorded Measurements Date: New Well

Current Measurements Date:



A = ____

B = NA

C = ____

A' = 2.83'

B' = 1.20'

C' = no landing plate

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

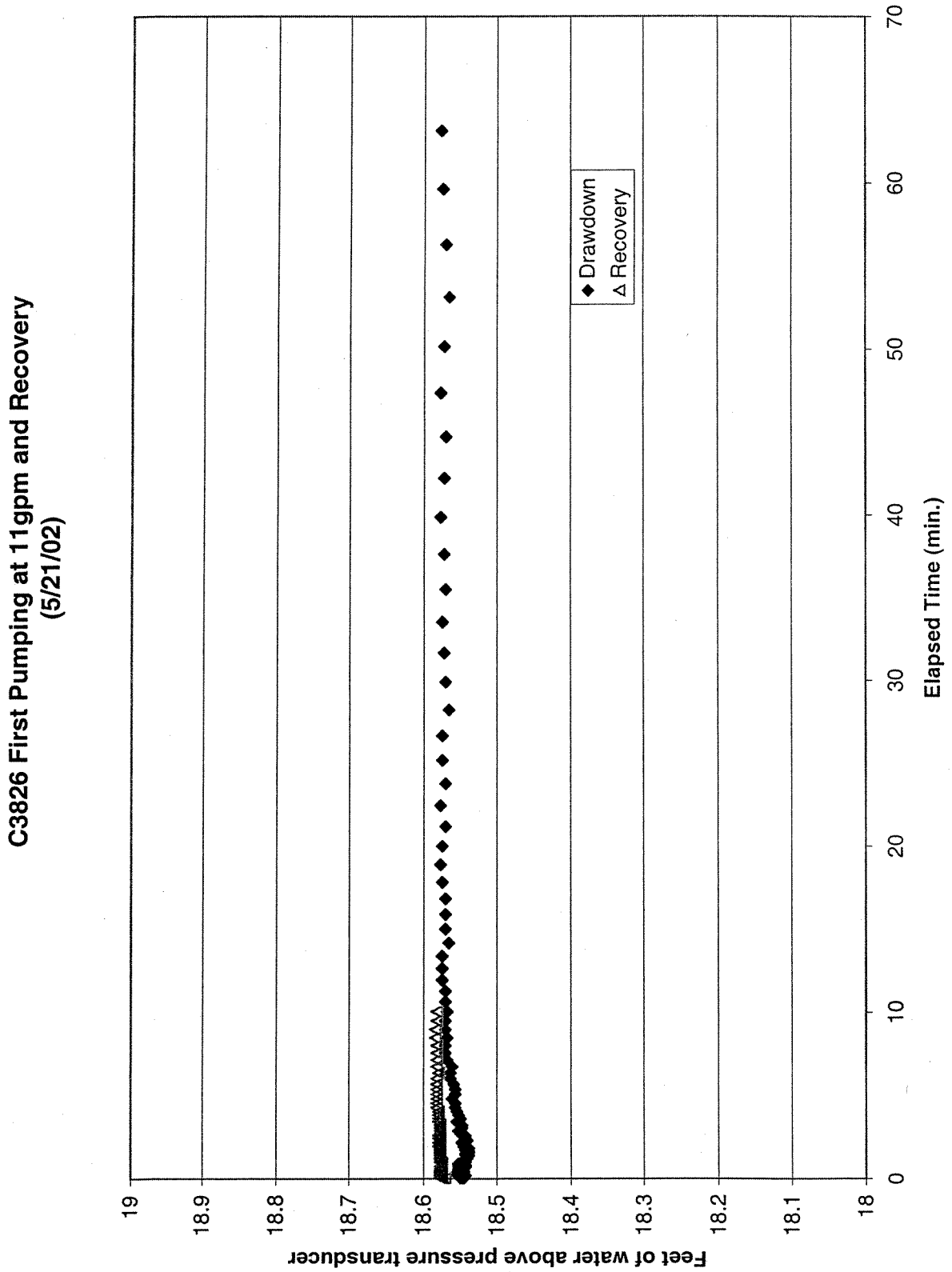
COMMENTS: Initial XD = 18.524 when pump after intake at 355'. No drawdown at 11 gpm. Get turbidity to 4.20 NTU. Screen interval ~ 325 → 360' below TOC. Move pump intake up to 338', initial XD = 2.161. Pump at 13 gpm, no drawdown. Turb. down to 2.66 NTU.

Prepared by (print name):	L.D. Walker	Signature:	L.D. Walker
Reviewed by (print name):	CJ Wright	Signature:	C.J. Wright

TO CHECK A BOX: Double click the box; select "Default Value – Checked"

BHI-EE-112 (12/97)

Appendix C - Well Development and Testing Data



Appendix C - Well Development and Testing Data

WELL DEVELOPMENT AND TESTING DATA

Well Name: 299-E17-23	Well ID: C3827	Well Location: SW of Purex/200E	Date: 5-20-02

Reference Measuring Point (unless otherwise noted): GROUND LEVEL

Has the well been surveyed? ☐ Yes ☒ No | Does the well have a cement pad? ☒ Yes ☒ No cw

PART 1

STATIC WATER LEVEL:	TOC.
Start of Job	335.88'
End of Job	335.82
DEPTH TO BOTTOM:	TOC.
Start of Job	373.0'
End of Job	373.10'

PART 2

WELL DEVELOPMENT DATA

Pump Model	Grundfos, Type 16530-24
Intake Depth	369' (TOC) / 355'
Starting Turbidity	> 1000 NTU

Pump Start	Stop	Flow Rate
1353	1436	12 gpm
1453	1525	11 gpm

Total Pumped	870 gal.
Final Turbidity	4.34
Transducer Range (PSI)	10 psi

PART 3

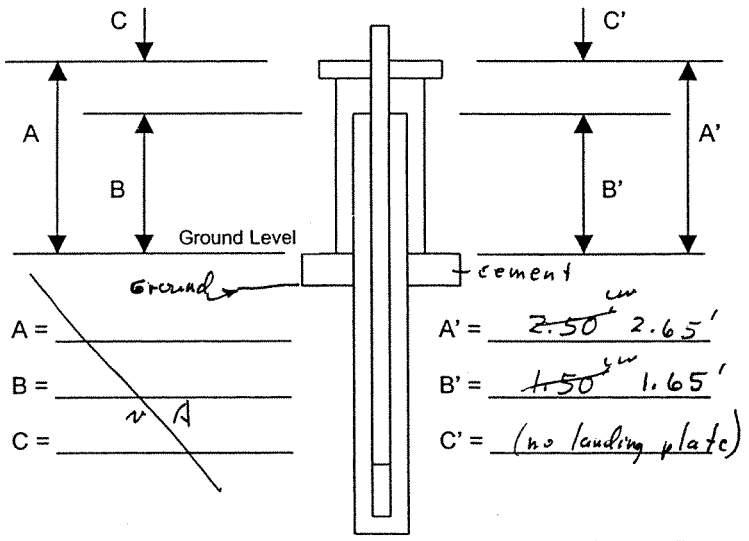
INSTANTANEOUS SLUG TEST

Static Water Level (TOC)	
Transducer Depth	
Baseline Start	
Injection Start	NA
Baseline Start	
Withdrawal Start	
Slug Volume	
Transducer Range (PSI)	

PART 4

Last Recorded Measurements Date: new well

Current Measurements Date: 5/20/02



A = N/A

B =

C =

A' = ~~2.50'~~ cw 2.65'

B' = ~~1.50'~~ cw 1.65'

C' = (no landing plate)

Are there any reference marks on the casing strings? ☐ Yes ☒ No

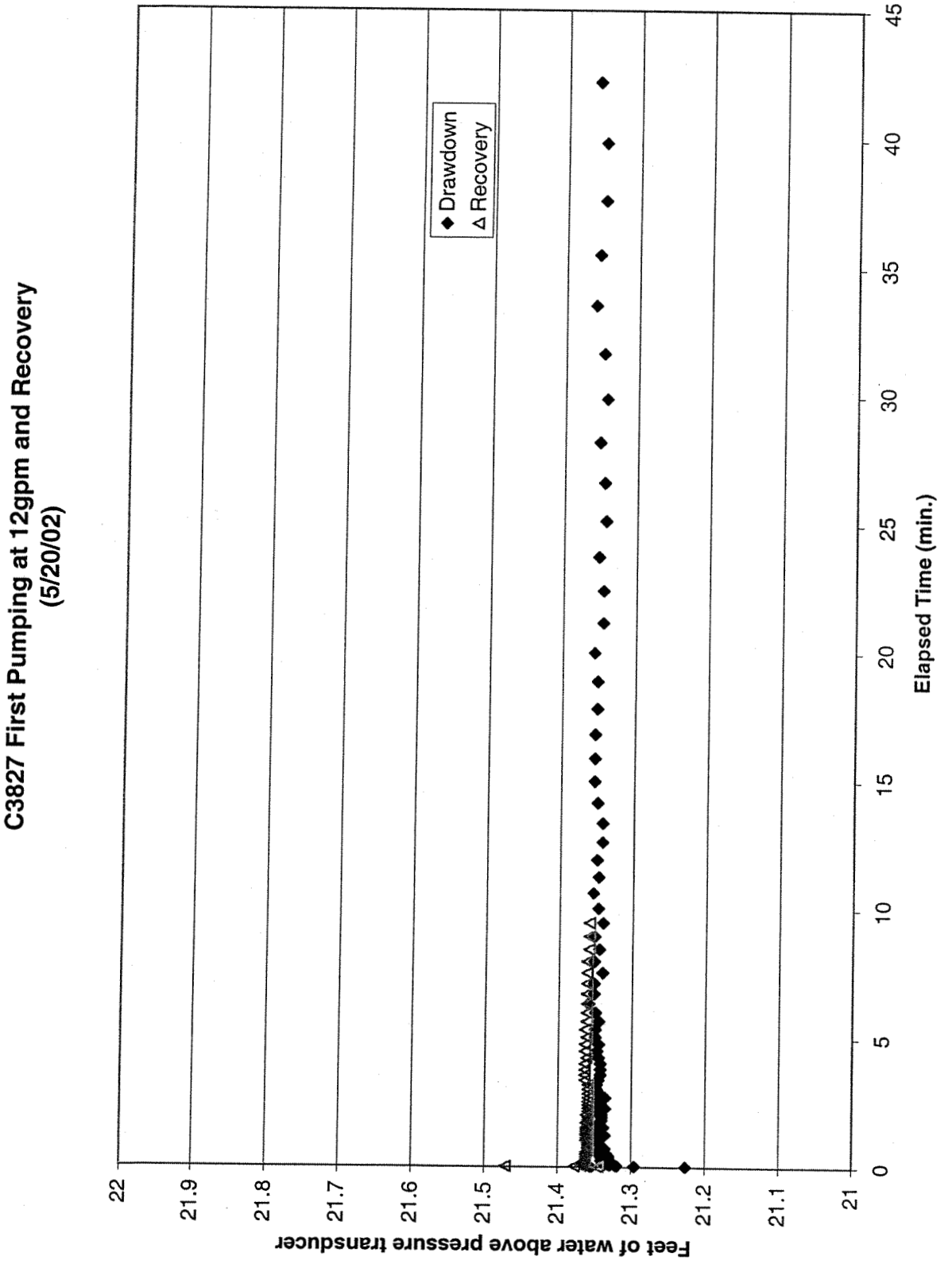
PART 5

COMMENTS: With pump intake at 369', initial XD = 21.331 ⇒ no drawdown at 12 gpm (XD = 21.316). Turb. down to 4.12 NTU. Raise pump intake to 355' (TOC) initial XD = 7.488. No drawdown (7.441) Turbidity down to 4.34.

Prepared by (print name):	L.D. Walker	Signature:	LD Walker
Reviewed by (print name):	C.S. Wright	Signature:	C.S. Wright

TO CHECK A BOX: Double click the box; select "Default Value – Checked"

BHI-EE-112 (12/97)


C3827 First Pumping at 12gpm and Recovery
(5/20/02)
◆ Drawdown
Δ Recovery
Feet of water above pressure transducer
22
21.9
21.8
21.7
21.6
21.5
21.4
21.3
21.2
21.1
21
Elapsed Time (min.)
0
5
10
15
20
25
30
35
40
45

Appendix C - Well Development and Testing Data

WELL DEVELOPMENT AND TESTING DATA

Well Name: 299-E17-25	Well ID: C3926	Well Location: SW of Purex/200E	Date: 5-20-02

Reference Measuring Point (unless otherwise noted): GROUND LEVEL

Has the well been surveyed? ☐ Yes ☒ No | Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL: (TOC)

Start of Job	340.62'
End of Job	340.63'

DEPTH TO BOTTOM:

Start of Job	376.10'
End of Job	376.08

PART 2

WELL DEVELOPMENT DATA

Pump Model Grundfos, 16S30-24

Intake Depth 369 (TOC)/355'

Starting Turbidity 41.1 NTU

Pump Start	Stop	Flow Rate
0741	0830	11 gpm
0853	0932	11-12 gpm

Total Pumped about 1020 gal.

Final Turbidity 4.32

Transducer Range (PSI) 10 psi

PART 3

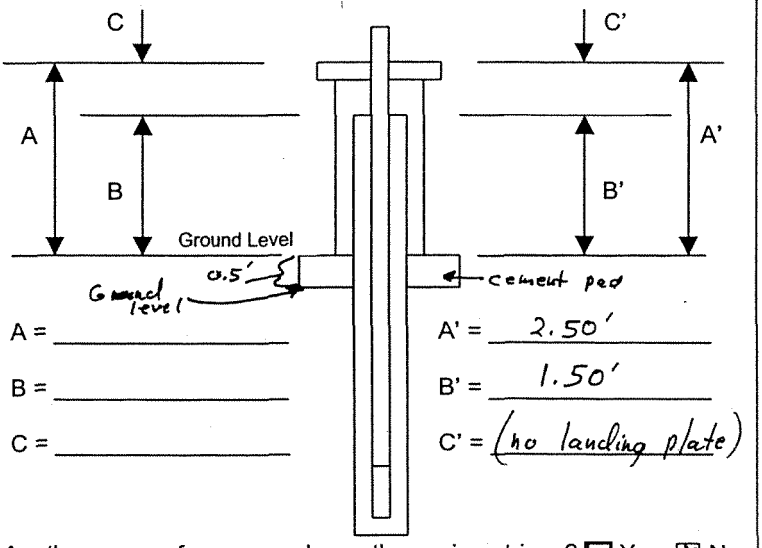
INSTANTANEOUS SLUG TEST

Static Water Level (TOC)	
Transducer Depth	
Baseline Start	
Injection Start	NA
Baseline Start	
Withdrawal Start	
Slug Volume	
Transducer Range (PSI)	

PART 4

Last Recorded Measurements Date: NA - New well

Current Measurements Date:



A = _____ A' = 2.50'

B = _____ B' = 1.50'

C = _____ C' = (no landing plate)

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

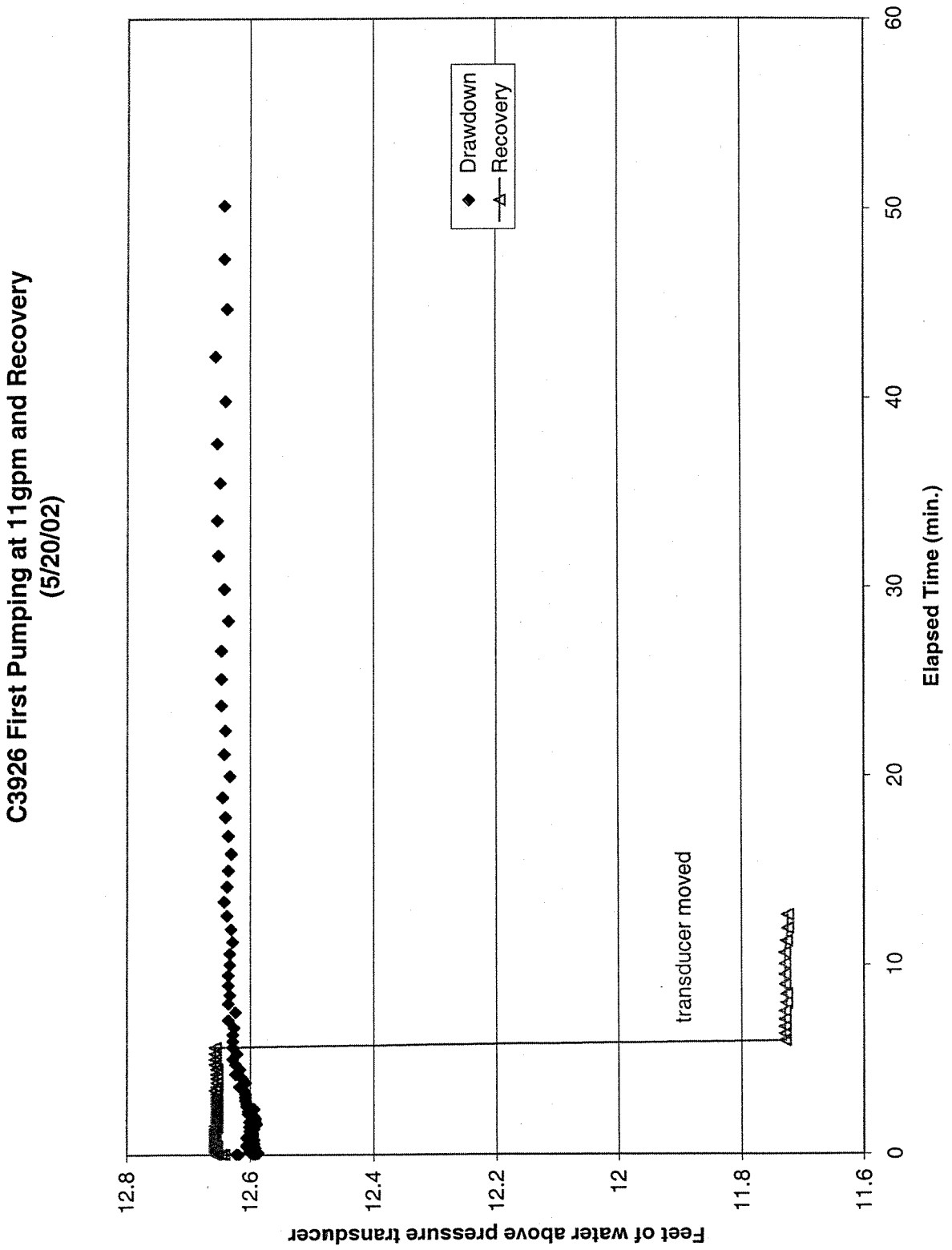
COMMENTS: 12.598 - initial XD.
→ no drawdown at 11 gpm, intake 369' (TOC)
~~Raise pump~~ tw NTU down to 3.58.
Raise pump to 355' (intake)
Start at ~15 gpm, see XD go from 0.030 to -0.020, then up to ~0.050 when flow rate cut back to 11-12 gpm. Final turbidity 4.32.

Prepared by (print name):	L.D. Walker	Signature:	L.D. Walker
Reviewed by (print name):	CS Walker	Signature:	CS Walker

TO CHECK A BOX: Double click the box; select "Default Value – Checked"

BHI-EE-112 (12/97)

Appendix C - Well Development and Testing Data



APPENDIX D

SURVEY DATA REPORT SHEETS

Appendix D - Survey Data Report Sheets

WELL SURVEY DATA REPORT

ERC Project: 22192	**Prepared By:** Gary B. Wagner, P.L.S. **Company:** Rogers Surveying, Inc.
Date Requested: April 11, 2002	**Requestor:** Robert Bone
Date of Survey: May 1, 2002	**Surveyor:** Rogers Surveying, Inc.
ERC Point of Contact: Mr. Robert Bone	**Survey Co. Point of Contact:** Gary B. Wagner, P.L.S.
Description of Work: Twenty-five Wells in the 100K, 100D & 200West (PFP) Areas of Hanford	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Metric
	Hanford Area Designation: 200E

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
"PUG" & RSI GPS #36

Vertical Control Monuments:
EXISTING WELL BRASS CAP AT WELL B8500 (299-E17-21) PREVIOUS WELL SURVEY DATA REPORT

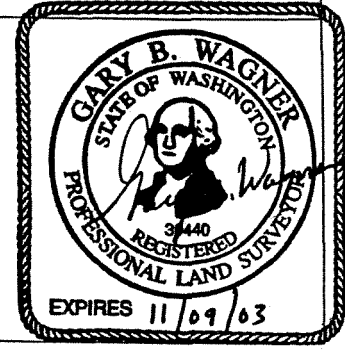
Well Name	Well ID	Easting	Northing	Elevation	
299-E17-22	C3826	574841.090	135195.537		**Center of Casing**
				221.458	**"X" on Rim**
		574841.067	135195.921	220.589	**Brass Cap**

Notes:

Surveyor Statement:

I, Gary B. Wagner, a professional land surveyor registered in the state of Washington (Registration No. 30440), hereby certify that this report is based on a field survey performed in May, 2002 under my direct supervision, and that the data contained here is true and correct.

Certification Seal



BHI-EE-202 (09/98)

Appendix D - Survey Data Report Sheets

WELL SURVEY DATA REPORT	
ERC Project: 22192	**Prepared By:** Gary B. Wagner, P.L.S. **Company:** Rogers Surveying, Inc.
Date Requested: April 11, 2002	**Requestor:** Robert Bone
Date of Survey: May 1, 2002	**Surveyor:** Rogers Surveying, Inc.
ERC Point of Contact: Mr. Robert Bone	**Survey Co. Point of Contact:** Gary B. Wagner, P.L.S.
Description of Work: Twenty-five Wells in the 100K, 100D & 200West (PFP) Areas of Hanford	**Horizontal Datum:** NAD83(91) **Vertical Datum:** NAVD88 **Units:** Metric **Hanford Area Designation:** 200E
Coordinate System: Washington State Plane Coordinates (South Zone)	
Horizontal Control Monuments: **"PUG" & RSI GPS #36**	
Vertical Control Monuments: **EXISTING WELL BRASS CAP AT WELL B8500 (299-E17-21) PREVIOUS WELL SURVEY DATA REPORT**	

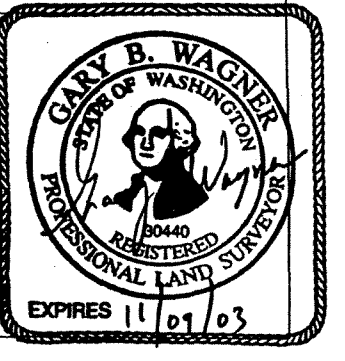
Well Name	Well ID	Easting	Northing	Elevation	
299-E17-23	C3827	574694.483	134842.439		**Center of Casing**
				224.659	**"X" on Rim**
		574694.485	134842.766	223.843	**Brass Cap**

Notes:

Surveyor Statement:

I, Gary B. Wagner, a professional land surveyor registered in the state of Washington (Registration No. 30440), hereby certify that this report is based on a field survey performed in May, 2002 under my direct supervision, and that the data contained here is true and correct.

Certification Seal



BHI-EE-202 (09/98)

Appendix D - Survey Data Report Sheets

WELL SURVEY DATA REPORT	
ERC Project: 22192	**Prepared By:** Gary B. Wagner, P.L.S. **Company:** Rogers Surveying, Inc.
Date Requested: April 11, 2002	**Requestor:** Robert Bone
Date of Survey: May 1, 2002	**Surveyor:** Rogers Surveying, Inc.
ERC Point of Contact: Mr. Robert Bone	**Survey Co. Point of Contact:** Gary B. Wagner, P.L.S.
Description of Work: Twenty-five Wells in the 100K, 100D & 200West (PFP) Areas of Hanford	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Metric
	Hanford Area Designation: 200E
Coordinate System: Washington State Plane Coordinates (South Zone)	
Horizontal Control Monuments: **"PUG" & RSI GPS #36**	
Vertical Control Monuments: **EXISTING WELL BRASS CAP AT WELL B8500 (299-E17-21) PREVIOUS WELL SURVEY DATA REPORT**	

Well Name	Well ID	Easting	Northing	Elevation	
299-E17-25	C3926	574515.185	134845.567		**Center of Casing**
				225.791	**"X" on Rim**
		574515.171	134845.913	225.028	**Brass Cap**

Notes:

Surveyor Statement:	**Certification Seal**
I, Gary B. Wagner, a professional land surveyor registered in the state of Washington (Registration No. 30440), hereby certify that this report is based on a field survey performed in May, 2002 under my direct supervision, and that the data contained here is true and correct.	

BHI-EE-202 (09/98)

Appendix D - Survey Data Report Sheets

WELL SURVEY DATA REPORT

ERC Project: 22192	**Prepared By:** Gary B. Wagner, P.L.S. **Company:** Rogers Surveying, Inc.
Date Requested: April 11, 2002	**Requestor:** Robert Bone
Date of Survey: May 1, 2002	**Surveyor:** Rogers Surveying, Inc.
ERC Point of Contact: Mr. Robert Bone	**Survey Co. Point of Contact:** Gary B. Wagner, P.L.S.
Description of Work: Twenty-five Wells in the 100K, 100D & 200West (PFP) Areas of Hanford	**Horizontal Datum:** NAD83(91)
	Vertical Datum: NAVD88
	Units: Metric
	Hanford Area Designation: 200E

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
"PUG" & RSI GPS #36

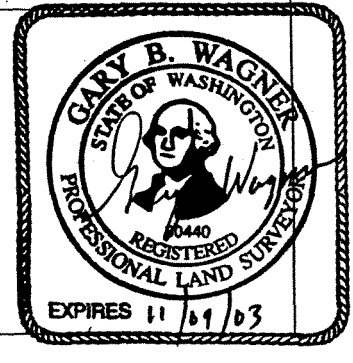
Vertical Control Monuments:
EXISTING WELL BRASS CAP AT WELL B8500 (299-E17-21) PREVIOUS WELL SURVEY DATA REPORT

Well Name	Well ID	Easting	Northing	Elevation	
ABANDONED	C3828				
		574518.125	134845.545	224.801	**BRASS CAP**

Notes:
C3828 IS AN ABANDONED WELL WITH NO CASING.

Surveyor Statement:
I, Gary B. Wagner, a professional land surveyor registered in the state of Washington (Registration No. 30440), hereby certify that this report is based on a field survey performed in May, 2002 under my direct supervision, and that the data contained here is true and correct.

Certification Seal



BHI-EE-202 (09/98)

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Distribution

Appendix B

Description of Core from Borehole C3826

Appendix B

Description of Core from Borehole C3826

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
0’ to 8’	No core recovered.
8’ to 9’	25% recovered—not opened. Moist, loose, no internal structure preserved. Medium- to coarse-grained sand; 75% basalt and 25% felsic; subrounded to subangular; poorly sorted; color 10YR5/2.
9’-10’	55% recovered. Slightly moist, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Coarse to medium-grained sand: 50% coarse, 40% medium-grained, 7% fine-grained, 3% very coarse, with pebbles up to 0.4 in (diameter); well-cemented zone 1.2 to 1.6 in wide (previously wider?) in the middle of the core (at 9’6”); material above this zone is also slightly cemented with $CaCO_3$; material below this zone is slightly more moist, finer-grained, and shows only a moderate reaction to HCl; 40% basalt and 60% felsic; subangular to subrounded; color 10YR5/2.
10’ to 11’	70% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Coarse to very coarse sand: 5-10% gravel, with rounded to subrounded pebbles up to 1 in (diameter), 30% very coarse, 45% coarse, 15% medium-grained, trace of silt; 50% basalt and 50% felsic; subangular to angular; color 10YR5/2.
11’ to 12’	95% recovered. Moist, loose, undisturbed. Coarse-grained sand with minor silt, grains up to 0.15 in (diameter); 50-60% basalt and 40-50% felsic; subangular; fairly sorted; color 10YR5/2. At 11’7” is a 0.8-in--thick layer of silt and clay (possible soil?), separating coarse material above from finer material below.
12’ to 13’	50% recovered—not opened. Moist, loose, no internal structure preserved. Medium- to coarse-grained sand; 50-70% basalt and 30-50% felsic; subrounded to subangular; poorly sorted; color 10YR5/2.
13’ to 14’	75% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Coarse- to medium-grained sand: 45% coarse, 45% medium- and fine-grained, 10% very coarse, with grains up to 0.16 in (diameter); 45% basalt and 55% felsic; angular to subangular (large grains mostly angular); color 10YR5/2.
14’ to 15’	95% recovered. Slightly moist, undisturbed, compact. Three color bands apparent. From 14’ to 14’2”: color band of medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; unsorted. From 14’2” to 14’7.5”: fine- to medium-grained sand; compacted, with graded bed fining upwards, each ~0.8 in thick; subangular to subrounded, well-sorted. At the base of this band is a very fine clay zone 0.08 in thick that effervesces. From 14’7.5” to the bottom of the core: coarse sand, with grains up to 0.2 in (diameter); 60% basalt and 40% felsic; subangular; poorly sorted. Color 10YR5/2.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
15’ to 16’	95% recovered. Dry, slightly compact. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; 10YR5/2. Bands of fine- to medium-grained sand are apparent, and spaced every 1 to 2 in. The most prominent bands are at 15’8” and 15’9”. A fairly compact zone is found between 15’6.5” and 15’9.5”.
16’ to 17’	50% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to fine-grained sand: 55% fine-grained, 40% medium-grained, 5% coarse, 2% very coarse, with grains of basalt up to 0.16 in (diameter); 30-35% basalt and 65-70% felsic; subangular to subrounded; 10YR5/2.
17’ to 18’	90 to 95% recovered. Dry, loose, undisturbed. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; 10YR5/2. Pebble layers ~0.5 in thick are found at 17’2.5” and 17’5.5”; both are basalt-dominated, with pebbles up to 1 in (diameter).
18’ to 19’	90 to 95% recovered. Dry, uncompacted, slightly disturbed. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; 10YR5/2. Layers of coarser sand present.
19’ to 20’	60% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium-grained sand: 75% medium-grained, 10% fine-grained, 10% coarse, 5% very coarse, with granitic pebbles up to 0.1 in (diameter); 30 to 40% basalt and 60 to 70% felsic; angular to subangular; moderately well-sorted; 10YR5/2.
20’ to 20’6”	No recovery.
20’6” to 21’6”	30% recovered—not opened. Dry, loosely packed, internal structure not preserved. Medium-grained sand, grains up to 0.15 in (diameter); 50% basalt and 50% felsic; subrounded to subangular; color 10YR5/2.
21’6” to 22’6”	90% recovered. Dry, partially disturbed, uncompacted. Medium- to coarse-grained sand with minor silt, grains up to 0.6 in (diameter); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. Some coherent silty nodules present.
22’6” to 23’6”	80% recovered. Dry, disturbed, loose. Medium-grained sand with some silt present; 50% basalt and 50% felsic; subangular to subrounded; poorly sorted; color 10YR5/2.
23’6” to 24’6”	90% recovered. Very slightly moist, loose, undisturbed. Medium- to coarse-grained sand, grains up to 0.15 in (diameter); 50% basalt and 50% felsic; subangular to subrounded; fairly well-sorted; color 10YR5/2. Color band at 23’7” composed of a 0.4-in thick silt-rich (up to 50% silt) layer; effervesces.
24’6” to 25’	No recovery.
25’ to 26’	Partially recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to coarse-grained sand: 58% coarse, 40% medium-grained, 2% very coarse; 50% basalt and 50% felsic; subangular to angular; color 10YR5/2.
26’ to 27’	85% recovered. Dry, loose. Medium-grained sand with minor silt; 50% basalt and 50% felsic; subangular to subrounded; poorly sorted; color 10YR5/2.
27’ to 28’	85-90% recovered. Dry, loose. Medium- to coarse-grained sand, grains up to 0.07 in (diameter); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. From 17’8.8” to 17’9.5” is a light color band that is finer (contains more silt) than the rest of the core, and is not compact or coherent.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
28’ to 29’	Partially recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to coarse-grained sand: 55% medium-grained, 40% coarse, ~2% very coarse, ~2% fine-grained; 40% basalt and 60% felsic; subangular to angular; moderately well-sorted; color 10YR5/2.
29’ to 29’6”	No recovery.
29’6” to 30’6”	80-85% recovered—not opened. Dry, loose, disturbed. Medium- to coarse-grained sand with minor silt; subangular to subrounded; poorly sorted; color 10YR5/2.
30’6” to 31’6”	95% recovered. Dry, undisturbed, well-compacted. From 30’6” to 30’10”: calcareous zone, cemented, fine-grained silt to sand with sparse coarse sand, layered; paleosol? From 30’10” to 31’7.5”: medium-grained sand with some coarse bands (apparent at 31’ and 31’0.5”); 50% basalt and 50% felsic (fine-grained zones are more felsic); subangular to subrounded; well-sorted. From 31’7.5” to 31’8.2”: silt layer. Color 10YR5/2
31’6” to 32’6”	100% recovered. Dry, but slightly moist in silty layers, relatively undisturbed. Medium- to coarse-grained sand; 50% basalt and 50% felsic; well-sorted; color 10YR5/2. Coherent layers of silt and sand are at 31’7.1”, 31’8”, 31’8.8” to 31’11.9”, 32’0.5” to 21’1”, 32’2.5”, and 32’3.5”. These layers are silty with sand, and are each ~0.4 in thick. Silty layers are calcareous, as is silt along the core rim, and barely cemented.
32’6” to 33’6”	75% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to coarse-grained sand: 60% medium-grained, 35% coarse, 5% fine-grained; 40% basalt and 60% felsic; subangular to angular; moderately well-sorted; color 10YR5/2.
33’6” to 34’	No recovery.
34’ to 35’	85% recovered. Dry, loose, uncompacted. Coarse to very coarse sand: 30% very coarse, 60% coarse, 10% medium-grained; 50% basalt and 50% felsic; subangular to angular; moderately well-sorted; color 10YR5/2.
35’ to 36’	85% recovered. Dry, loose. Coarse sand: 10% very coarse, 80% coarse, 10% medium-grained; 40% basalt and 60% felsic; moderately well-sorted; 10YR5/2 color 10YR5/2.
36’ to 37’	90% recovered. Dry, very loose. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well sorted; 10YR5/2 color 10YR5/2.
37’ to 38’	85% recovered. Dry, loose, uncompacted. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
38’ to 39’	85% recovered. Dry, compacted. Fine- to medium-grained sand; 50% basalt and 50% felsic; well sorted; 10YR5/. Numerous layers of $CaCO_3$-rich zones, from 0.1 to 1.5 in wide. Color 10YR5/2
39’ to 40’	90% recovered. Fairly compacted. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well sorted. Layer of silt and $CaCO_3$ about 0.4 in thick at 39’5.5” separating darker (more black and fresh?) material above from more brownish-reddish (more clayey and weathered?) material below. Color 10YR5/2
40’ to 41’	100% recovered. Intact, not disturbed, well compacted. Medium- to coarse-grained sand with trace of silt; 50% basalt to 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
41’ to 42’	90% recovered. Very slightly moist, moderately compact in the middle of core. Medium- to coarse-grained sand: 5% very coarse, 75% coarse, 20% medium-grained. Between top of core and 41’3.1”, disturbed and loose, mostly medium-grained sand; between 41’3.1” and 41’6.7” is a fining-upwards sequence (mostly coarse sand between 41’3.1” and 41’4.7”, and an obvious band of very coarse sand between 41’4.7” and 41’6.7”, with angular to subangular grains up to 0.2 in (diameter); between 41’6.7” and 41’10.6” is another upwards-fining sequence, from medium-grained to medium- and coarse-grained sand; core from 41’10.6” to the bottom is empty. 40 to 50% basalt and 50 to 60% felsic; subangular to angular; moderately well-sorted; color 10YR5/2.
42’ to 42’6”	No recovery.
42’6” to 43’6”	60% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to coarse-grained sand: 30% coarse, 60% medium-grained, 10% very coarse; 40 to 50% basalt and 50 to 60% felsic; subangular to angular; fairly well-sorted; color 10YR5/2.
43’6” to 44’6”	90% recovered. Slightly moist, slightly compact. Coarse sand: 70% coarse, 20% medium-grained, 10% very coarse; possible color bands ~1.2 to 1.6 in wide (upwards-fining sequences from very coarse to medium-grained sand); distinct pebble layer between 43’11.7” and 44’0.6”, with grains up to 0.24 in (diameter); 50% basalt and 50% felsic; mostly angular, with some subangular grains; fairly well-sorted; color 10YR5/2.
44’6” to 47’	No recovery.
47’ to 48’	90% recovered. Slightly moist, slightly compact. Medium-to coarse-grained sand: 15% very coarse (mainly in the upper half of core, with grains up to 0.1 in diameter), 35% coarse, 50% medium-grained; 40 to 50% basalt and 50 to 60% felsic; angular to subangular; fairly sorted; color 10YR5/2.
48’ to 49’	95% recovered. Compact. Medium-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well sorted; color 10YR5/2. Silty $CaCO_3$-rich layer from 48’6.7” to 48’8.7”.
49’ to 50’	80% recovered. Very slightly moist, very slightly compact, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to coarse-grained sand, with grains up to 0.16 in (diameter); 50% basalt and 50% felsic; angular to subangular; moderately sorted; color 10YR5/2.
50’ to 51’	95% recovered. Compact. Medium-grained sand, with basalt clasts up to 0.4 in (diameter); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. Some color banding, with basalt-rich layers appearing slightly darker.
51’ to 58’	No recovery.
58’ to 59’	85% recovered. Loose, uncompacted. Medium-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well sorted; color 10YR5/2.
59’ to 60’	90% recovered. Loose, uncompacted. Medium-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
60’ to 61’	85% recovered. Moderately compact. Medium-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. Color bands and fining-upward sequences 0.4 to 0.8 in thick.
61’ to 62’	90% recovered. Compact. Medium-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. Faint color banding.
62’ to 664’6”	Not opened, physical properties testing.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
64’6” to 65’6”	80% recovered. Slightly moist, slightly compact in middle of core, disturbed. (Opened previously for LBL oxygen isotope study.) Fine- to medium-grained sand: 55% medium-grained, 40% fine-grained, 5% coarse; 35 to 40% basalt and 60 to 65% felsic; subangular to angular; well-sorted; color 10YR5/2.
65’6” to 66’6”	Not opened, physical properties testing.
66’6” to 67’6”	90% recovered. Loose, not compact. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well sorted; color 10YR5/2.
67’6” to 68’	No recovery.
68’ to 69’	85% recovered. Not compact. Medium-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. Contains $CaCO_3$-rich nodules up to 0.8 in (diameter) between 68’2” and 68’4”.
69’ to 70’	85% recovered. Fairly compact. Between 69’ and 69’4”, medium-grained sand in 0.2-in-thick bands; from 69’4” to 70’ is medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
70’ to 71’	90% recovered. Dry, loose, uncompacted. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
71’ to 72’	90% recovered. Moderately compact. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. From 71’7” to 71’9” is a silty layer containing color bands ~0.4 in wide.
72’ to 73’	85% recovered. Dry, loose. Medium- to coarse-grained sand; fine- to medium-grained sand with silt between 72’10’ and 73’; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
73’ to 74’	90% recovered. Moderately compacted. Paleosol? Medium- to fine-grained sand, cemented with $CaCO_3$ between 73’ and 73’4”; lower part of core is composed of medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
74’ to 75’	85% recovered. Loose, uncompacted. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
75’ to 76’	95% recovered. Fairly compact. Medium- to coarse-grained sand (mostly coarse), with fining-upwards bands about 0.8 to 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
76’ to 76’6”	No recovery.
76’6” to 77’6”	80% recovered. Uncompacted. Uppermost 2.5 in is empty; from 76’8.5” to 77’3” is medium- to fine-grained, $CaCO_3$-cemented sand, poorly sorted; from 77’3” to the bottom of the core is medium- to coarse-grained sand. All material is fairly well-sorted; subangular to subrounded; color 10YR5/2.
77’6” to 78’6”	80% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to coarse-grained sand: 65% medium- to fine-grained; 35% coarse; 30% basalt and 70% felsic; angular to subangular; moderately sorted; color 10YR5/2.
78’6” to 79’6”	95% recovered. Very compact. Medium- to coarse-grained sand, with bands of fining-upwards sequences 1.2 to 1.6 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
79’6” to 80’6”	95% recovered. Well-compacted. Medium- to coarse-grained sand, with subtle fining-upwards sequences ~0.8 in wide each; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
80’6” to 96’	No recovery.
96’ to 97’	80% recovered. Slightly moist, uncompacted. Medium- to coarse-grained sand (mainly medium-grained); subangular to subrounded; well-sorted; color 10YR5/2.
97’ to 98’	85% recovered. Slightly moist, not compact. Medium- to fine-grained sand, with fining-upward sequences about 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
98’ to 99’	85-90% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Medium- to fine-grained sand: 50% medium, 50% fine; 40% basalt and 60% felsic; angular to subangular; well-sorted; color 10YR6/2.
99’ to 100’	90% recovered. Moderately compact. Fine- to medium-grained sand between 99’ and 99’8.7”; medium- to coarse-grained sand between 99’8.7” to 99’11.8”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
110’ to 119’	No recovery.
119’ to 120’	90% recovered. Not compact. One large fining-upward sequence: medium-grained sand in lower part, fine-grained sand in uppermost 2.4 in of core; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
120’ to 121’	95-100% recovered. Medium-grained sand, with 0.8-in-wide fining-upwards bands apparent; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; 10YR5/2.
121’ to 122’	85% recovered. Dry, slightly compact, disturbed. (Opened previously for LBL oxygen isotope study.) Fine to very fine sand, thin (<0.1 in wide) coherent layers visible between 121’2.4” and 121’8.3” of very fine-grained sand between darker, basalt-rich medium-grained layers; 60% fine-grained, 40% medium-grained; very fine-grained loose sand between 121’8.7” and 121’11”; lowermost 1 in of core empty; no HCl reaction; 45% basalt and 55% felsic; well-sorted; color 10YR5/2.
122’ to 123’	98% recovered. Compact. From the top of the core to 122’0.6” is fine-grained sand; from 122’0.6” to 122’3.5” is very coarse sand with color banding; from 122’3.5” is a 0.08-in-wide very fine clay layer, iron-stained at the top; from 122’3.5” to 122’10.2” is the top of another fining-upwards sequence, medium-grained sand; from 122’10.2” to 122’11.8” is coarse-grained sand at the bottom of this sequence; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
123’ to 149’	No recovery.
149’ to 150’	90% recovered. Slightly compact. Medium- to coarse-grained sand, with fining-upwards sequences about 0.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. A transition from sand above to more silt below occurs at 149’10.2”. Pebbles about 0.8 in (diameter) occur at 149’4”.
150’ to 151’	90% recovered. Well-compacted. Medium- to coarse-grained sand, some coarse basalt-rich layers fining upwards in layers ~0.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted. Color 10YR5/2
151’ to 152’	90% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Sand: 70% medium-grained, 30% fine-grained, coarse layer with grains up to 0.12 in (diameter) between 151’5.5” and 151’5.9”; 40% basalt and 60% felsic; subangular to subrounded; moderately sorted; color 10YR6/2.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
152’ to 153’	90% recovered. Moderately compact. Medium- to fine-grained sand, with subtle fining-upwards sequences ~3.5 in wide; subangular to subrounded; well-sorted; color 10YR5/2.
153’ to 163’6”	No recovery.
163’6” to 164’6”	80% recovered. Loose, uncompacted, poorly consolidated. Medium- to fine-grained sand, one fining-upwards sequence; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
164’6” to 165’6”	95 recovered. Compact. Medium- to fine-grained sand, with subtle upward-fining sequences ~2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
165’6” to 166’6”	95% recovered. Compact. Fine- to medium-grained sand, with fining upward sequences ~3 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
166’6” to 167’6”	90% recovery. Moderately compact. Medium- to fine-grained sand; with fining upward sequences ~2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted. The zone between 167’2.5” and 167’2.9” is lined at the top and bottom by brownish silt stringers <0.04 in wide. Color 10YR5/2
167’6” to 168’	No recovery.
168’ to 169’	85% recovered. Compact. Mainly medium- to coarse-grained sand; at 168’4.7” is a caliche zone ~1.1 in thick showing soft-sediment deformation, with a lobe protruding 3 to 7.5 in out of the band; at 168’10.6” is a 0.11-in-wide clay layer at the top of an upward-fining sequence; fine sand between 168’10.6” to 168’11.8”.
169’ to 170’	98% recovered. Well-compacted. Medium- to fine-grained sand, one large fining-upwards sequence; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. Contact between one fining-upwards sequence above and another below at 169’10.6”.
170’ to 171’	95% recovered. Compact. Medium- to coarse-grained sand, with fining-upward sequences 1-2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
171’ to 172’6”	Not opened, physical properties testing.
172’6” to 173’6”	80% recovered. Loose, uncompacted, poorly consolidated. Coarse- to medium-grained sand, mostly coarse, with pebbles up to 0.4 in (diameter) in a layer between 173’0.3” to 173’1.9”; subangular to subrounded; fairly sorted; color 10YR5/2.
173’6” to 174’6”	95% recovered. Compact. Medium- to coarse-grained sand, with fining upwards sequences (coarse to fine) each ~0.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
174’6” to 175’6”	95% recovered. Well-compacted. Medium- to coarse-grained sand, with upward fining sequences ~0.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
175’6” to 176’6”	95% recovered. Compact. Medium- to coarse-grained sand, with color bands of upward-fining sequences about 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
176’6” to 179’	No recovery.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3826
179’ to 180’	90% recovered. Moist, moderately compact. Medium- to coarse-grained sand, with fining-upwards sequences ~3.5 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
180’ to 181’	95% recovered. Well-compacted. Medium- to coarse-grained sand, with upwards-fining sequences 2 to 2.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. At 180’1.6” is a layer of clay ~0.04 in wide.
181’ to 182’	90% recovered. Well-compacted. Medium- to coarse-grained sand, containing fining-upwards sequences mostly ~1 in but up to 5.5 in wide, with 0.4-in-wide sequences within the thicker bands; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
182’ to 183’	85% recovered. Dry, loose, disturbed. (Opened previously for LBL oxygen isotope study.) Sand: 75% medium- and fine-grained, 25% coarse; 40% basalt and 60% felsic; subangular to subrounded; moderately well-sorted; color 10YR6/2.
183’ to 219’	No recovery.
219’ to 220’	95% recovered. Moderately compact. Coarse- to very coarse-grained sand, with a pebbly zone between 219’4.7” and 219’6.3” containing pebbles mainly of basalt up to 0.8 in (diameter); 60% basalt and 40% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
220’ to 221’	90% recovered. Compact. Medium- to very coarse-grained sand, with pebbles up to 0.4 in (diameter) and fining-upwards sequences ~3 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
221’ to 222’	95% recovered. Compact. Coarse- to very coarse-grained sand, with clasts up to 0.8 in (diameter); coarse basalt-rich bands and upward-fining sequences 2 to 2.5 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.

Appendix C

Description of Core from Borehole C3827

Appendix C

Description of Core from Borehole C3827

Depth Below Surface (feet and inches)	Description of Core from Borehole C3827
0’ to 53.5’	No recovery.
53’6” to 54’6”	45% recovered. Moist, compact. Medium- to coarse-grained sand: 15% very coarse, 30% coarse, 60% medium-grained, with grains up to 0.1 in (diameter); 50% basalt and 50% felsic; angular to subangular; moderately well-sorted; color 10YR5/2.
54’6” to 55’6”	95% recovered. Moist, compact. Medium- to coarse-grained sand, with upwards-fining sequences ~0.8 in wide; 50% basalt and 50% felsic, subangular to subrounded; well-sorted; color 10YR5/2.
55’6” to 56’6”	100% recovered. Moist, compact. Medium- to coarse-grained sand with crude, subtle upwards-fining sequences ~ 2 in wide; medium- to coarse-grained sand between 56’5.4” and 56’5.8”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2. A fine-grained sand to silt lens between 56’4.2” and 56’5.4” has a 0.04 in layer of clay at the bottom and top.
56’6” to 57’6”	93% recovered. Moist, compact. Coarse sand from top of core to 56’7.8”; very coarse sand between 56’7.8” and 56’11.5”’ medium-grained sand between 56’11.5” and 57’0.3”, a dark band containing ~60% basalt; continued coarsening downward, from 57’0.3” to 57’5.8”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
57’6” to 58’	No recovery.
58’ to 59’	95% recovered. Moist, moderately compact. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
59’ to 60’	96% recovered. Moist, moderately compact. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
60’ to 61’	99% recovered. Moist, compact. Medium-grained sand from the top of core to 60’6.7”, with color bands 0.8 to 1.2 in wide; coarse to very coarse sand between 60’6.7” and 60’9.4”, with pebbles up to 0.8 in (diameter) at 60’9.4”; coarse sand between 60’9.4” and bottom of core; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
61’ to 62’	95% recovered. Slightly moist, compact. Medium- to coarse-grained sand, with upwards-fining sequences (very coarse to medium-grained sand) ~2.8 in wide and pebbles up to 0.6 in (diameter); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
62’ to 62’6”	No recovery.
62’6” to 63’6”	95% recovered. Compact. Moist, medium-grained sand from top of core to 62’8”; bioturbated, calcareous paleosol, medium- to fine-grained between 62’8” and 62’11.9”; dry, coarse-grained sand with disseminated $CaCO_3$ and pebbles up to 0.2 in (diameter) between 62’11.9” and 63’5”. Color 10YR5/2.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3827
63’6” to 65’6”	Not opened, physical properties testing.
65’6” to 66’6”	92% recovered. Moist, compact. Very coarse-grained sand from the top of core to 65’11.5”; coarse sand between 65’11.5” and the bottom of core; subangular to subrounded; well-sorted; color 10YR5/2.
66’6” to 76’	No recovery.
76’ to 77’	100 recovered. Moist, slightly compact (more compact near the bottom of core). Medium- to coarse-grained sand, with faint color banding 0.8 to 1.2 in wide in the bottom half of core; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
77’ to 78’	100% recovered. Moist, compact. Medium- to coarse-grained sand, with upwards-fining sequences 1.2 to 2.8 in wide; a prominent upwards-fining sequence between 77’7.9” and 77’11.8”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
78’ to 79’	100% recovered. Moist, compact. From the top of core to 78’3.5”, coarse to very coarse sand at the top to medium-grained sand at the bottom, with color bands ~0.4 in wide; from 78’3.5” to 78’5.3”, a fine sand-silt band; from 78’5.3” to 78’9.1”, coarse to very coarse sand; from 78’9.1”to the bottom of core, coarse sand at the top to medium-grained sand at the bottom, with a band of fine material at 78’9.4”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
79’ to 80’	95% recovered. Moist, compact. Two prominent fining-upwards sequences: between 79’0.4” and 79’7.7”, a sequence of medium- to fine-grained sand; between 79’7.7” and 79’11.8”, a sequence of medium- to very fine-grained sand; color banding due to basalt between 79’4.7” and 79’7.5”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
80’ to 98’	No recovery.
98’ to 99’	95% recovered. Moist, coarse to very coarse sand from the top of core to 98’7”; drier, medium- to coarse-grained sand fining upwards between 98’7” and the bottom of core; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
99’ to 100’	100% recovered. Slightly moist, compact. Medium-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
100’ to 101’	100% recovered. Slightly moist, compact. Fine- to coarse-grained sand, in one large fining-upwards sequence; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
101’ to 102’	95% recovered. Slightly moist, well-compacted. Medium-to coarse-grained sand, with a band of finer-grained sand between 101’7.5” and 101’8.7”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
102’ to 119’	No recovery.
110’ to 120’	100% recovered. Moist, compact. Medium- to coarse-grained sand, with the uppermost 2.8 in of core slightly more coarse, and containing color bands 1.5 to 2 in wide, probably upwards-fining; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
120’ to 121’	100% recovered. Slightly moist, compact. Medium- to coarse-grained sand, with color bands ~0.8 in wide and subtle upwards-fining sequences(?); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3827
121’ to 122’	100% recovered. Slightly moist, compact. Medium- to coarse-grained sand, with color bands ~0.8 in wide and subtle upwards-fining sequences(?); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
122’ to 123’	90% recovered. Slightly moist, compact. Medium- to coarse-grained sand, with color bands ~0.8 in wide and subtle upwards-fining sequences(?); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
123’ to 149’	No recovery.
149’ to 150’	93% recovered. Dry, slightly compact, fairly loose. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
150’ to 151’	90% recovered. Dry, moderately compact. Medium-grained sand, with grains up to 0.2 in (diameter); subangular to subrounded; well-sorted; color 10YR5/2.
151’ to 152’	90% recovered. Dry, moderately compact. Medium- to fine-grained sand, with upwards-fining bands ~1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
152’ to 153’	90% recovered. Dry, moderately compact. Medium- to fine-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
153’ to 153’6”	No recovery.
153’6” to 154’6”	95% recovered. Moderately moist, uncompacted. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
154’6” to 155’6”	95% recovered. Dry, moderately compact. Medium- to coarse-grained sand from the top of core to 154’11.5”; from 154’11.5” to the bottom of core, very coarse sand with pebbles up to 1 in (diameter); most pebbles are found in a layer at 155’3.8”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
155’6” to 156’6”	95% recovered. Dry, slightly compact. Coarse sand with pebbles up to 0.4 in (diameter) from the top of core to 155’11.5” ; medium- to coarse-grained sand between 155’11.5” and 156’5.8”; pebbles up to 1.6 in (diameter) at 156’3.8”; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
156’6” to 157’6”	95% recovered. Dry, slightly compact. Fine- to medium-grained sand, with fining-upwards sequences ~1.2 in side; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
157’6” to 158’	No recovery.
158’ to 159’	95% recovered. Dry, slightly compact. Uppermost 1.6 in of core is empty; fine-grained, compact paleosol cemented with CaCO3 between 158’1.6” to 158’5.1”; less cemented medium- to fine-grained sand between 158’5.1” and 158’8.7”; from 158’8.7” to the bottom of core, slightly cemented, compact medium- to fine-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
159’ to 160’	98% recovered. Moist, compact. Medium- to coarse-grained sand with upwards-fining sequences 0.8 to 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
160’ to 161’	97% recovered. Dry, moderately compact. Medium- to fine-grained sand, with fining-upwards sequences ~0.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3827
161’ to 162’	96% recovered. Dry, slightly compact. Medium- to fine-grained sand, with fining-upwards sequences (possibly fining-downwards?) 0.8 to 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
162’ to 162’6”	No recovery.
162’6” to 163’6”	90-95% recovered. Dry, slightly compact. Fine- to medium-grained sand: 65% fine-grained, 35% medium-grained, trace of coarse sand. From the top: to 162’8” down, disturbed and loose; between 162’7.2” and 162’8” down, possible layer of well-cemented (with $CaCO_3$), fine- to very fine-grained sand, but mostly disturbed; between 162’8” and 163’0.9”, mainly fine-grained sand with faint color bands 0.8 to 1.6 in wide; between 163’0.9” and 163’4.2”, mainly medium-grained sand with faint color bands 0.4 to 0.8 in wide; between 163’4.2” and bottom of core is disturbed and loose. 40% basalt and 60% felsic; subangular to angular; well-sorted; slight HCl reaction; color 10YR6/2.
163’6” to 164’6”	Not opened, physical properties testing.
164’6” to 165’6”	95% recovered. Dry, loose, uncompacted. Medium- to fine-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
165’6” to 166’6”	90% recovered. Dry, moderately compact. Fine-to medium-grained sand, with upwards-fining sequences ~0.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
166’6” to 179’	No recovery.
179’ to 180;	95% recovered. Dry, loose. Uppermost 1.2 in of core empty; coarse to very coarse sand between 179’1.2” and 179’2.8”; very coarse sand between 179’2.8” and 179’6.5”; medium- to coarse-grained sand from 179’6.5” to bottom of core; pebbles up to 0.8 in (diameter) in upper 6.5 in of core; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
180’ to 181’	98% recovered. Dry, compact. Medium- to coarse-grained sand, with color bands (upwards-fining sequences) 0.8 to 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
181’ to 182’	96% recovered. Dry, well-compacted. Medium- to coarse-grained sand, with color bands (upwards-fining sequences) 0.8 to 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
182’ to 183’	99% recovered. Dry, well-compacted. Medium- to coarse-grained sand, with color bands (upwards-fining sequences) 0.8 to 1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
183’ to 219’	No recovery.
219’ to 220’	75% recovered. Dry, not compact. Coarse to very coarse sand, with pebbles, mainly of basalt, up to 0.8 in (diameter); 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
220’ to 221’	96% recovered. Dry, compact. Uppermost 1.2 in of core is empty; between 220’1.2” to 220’6.3”, very coarse sand; between 220’6.3” and 220’7.1”, medium- to coarse-grained sand; between 220’7.1” and bottom of core is coarse and very coarse sand; pebbles mostly 0.8 in (diameter) but up to 0.8 in; subtle color bands (fining-upwards sequences) ~1.2 in wide throughout core; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
221’ to 222’	95-100% recovered—not opened.

Depth Below Surface (feet and inches)	Description of Core from Borehole C3827
222’ to 223’	85% recovered. Dry, moderately compact (especially in lower part of core). Uppermost 0.8 in of core is empty; between 222’0.8” and 222’6.3”, very coarse sand, with pebbles up to 0.8 in (diameter), containing a 0.2-in-wide medium-grained sand layer at 222’5.1”; between 222’6.3” and 222’10.6”, medium- to coarse-grained sand; core is empty between 222’10.6” and the bottom; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.

Appendix D

Description of Core from Borehole C3828

Appendix D

Description of Core from Borehole C3828

Depth Below Surface (feet and inches)	Description of Core from Borehole C3828
0’ to 53’6”	No recovery.
53’6” to 55’6”	99% recovered. Moist, compact. Medium- to coarse-grained sand, with a 0.2-in-wide silt band at 54’0.7” and subtle upwards-fining sequences ~1.2 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
55’6” to 57’6”	90% recovered. Moist, compact. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
57’6”’ to 58’	No recovery.
58’ to 60’	95% recovered. Moist, compact. Medium- to coarse-grained sand; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
60’ to 62’6”	No recovery.
62’6” to 64’6”	97% recovered. Moist, compact. Medium- to coarse-grained sand, with subtle upwards-fining sequences; 50% basalt and 50% felsic; well-sorted; color 10YR5/2.
64’6” to 65’6”	97% recovered. Moist, compact. Medium- to coarse-grained sand, with upwards-fining sequences ~1.1 in wide, scattered pebbles up to 0.8 in (diameter) and a silt layer 0.11 in wide at 65’4”; 50% basalt and 50% felsic; subangular to subrounded; color 10YR5/2.
65’6” to 153’	No recovery.
153’ to 155’	60% recovered. Moist. Empty between 153’ and 153’9.4”; silt layer from 153’2” to 153’2.4” separating medium- to fine-grained sand below from medium- to coarse-grained sand above; silt lens ~0.4 in wide at 153’11”. Medium- to coarse-grained sand’ 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
155’ to 158’	Not opened, physical properties testing. Sample interval 155’6” to 157’6” is compact and contains a clastic dike, 1.2” wide and composed of very fine to fine-grained sand, cutting through medium-grained sand that is 20% basaltic and 80% felsic (light-colored) on one side and 50% basaltic and 50% felsic (dark-colored) on the other side of the dike.
158’ to 160’	100% recovered. Moist, compact. Layered: 158’ to 158’3.5”, silt lens; 158’3.5” to 159’1.8”, upwards-fining sequence; 159’1.8” to 159’3”, banded layers of finer and coarser material; 159’3” to 159’4.1”, band of sand with fine-grained clay at the top and bottom; 159’4.1” to 159’8”, upwards-fining sequence; 159’8” to 159’8.3”, layer of clay at the top of the lowermost upwards-fining sequence; 159’8.3” to the core bottom, fine- to medium-grained sand. Color 10YR5/2.
160’ to 162’	96% recovered. Moist, compact. Medium- to coarse-grained sand, with a possible paleosol between 161’5.7” and 161’9.7” 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
162’ to 162’6”	No recovery.
162’6” to 164’6”	100% recovered. Moist, compact. Medium-grained sand, with crude banding ~0.8 in wide; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.
164’6” to 166’6”	96% recovered. Moist, compact. Medium- to fine-grained sand, with subtle upwards-fining sequences; 50% basalt and 50% felsic; subangular to subrounded; well-sorted; color 10YR5/2.

Appendix E

Summary of Spectral Gamma Logging
2002 Immobilized Low Activity Waste Well Installation

Appendix E

Summary of Spectral Gamma Logging
2002 Immobilized Low Activity Waste Well Installation

RG McCain
Stoller – Grand Junction Team

E.1 Introduction

High-resolution spectral gamma logging was performed in three boreholes (299-E17-22, 299-E17-23, and 299-E17-25) in the vicinity of the proposed site for the Immobilized Low Activity Waste (ILAW) disposal site. High-resolution spectral gamma logging provides a total gamma log, as well the distribution of naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th). This information provides some indication as to the nature of the surrounding sediments and is useful for stratigraphic correlation. In addition, any man-made gamma-emitting radionuclides (^{137}Cs, ^{60}Co, $^{152/154}$Eu, $^{235/238}$U) that may be present can be identified and quantified.

E.2 Methods

The ILAW boreholes were logged by the spectral gamma logging system (SGLS), which uses a cryogenically cooled high purity germanium (HPGe) detector with an intrinsic efficiency of approximately 35 percent.

With the SGLS, gamma energy spectra are collected in "move-stop-acquire" mode where the detector sonde is held stationary for each measurement and then moved a specified depth increment to the next measurement point. For the ILAW boreholes, a depth increment of 1 ft was used. System gain is adjusted as necessary to maintain a consistent channel relationship for a marker peak (typically the ^{40}K peak at 1461 keV). Typical count times were 200 seconds. Individual gamma energy spectra are recorded using 4096 channels, where channel number is related to gamma energy level. Pre-run and post-run verification measurements are made at the beginning and end of each logging day to provide the channel-to-energy calibration and to assess system performance.

Evaluation of gamma energy spectra provides identification and quantification of naturally occurring and man-made radionuclides on the basis of characteristic energy emissions associated with their decay. Only gamma rays of sufficient energy to penetrate the steel borehole casing and sonde housing can be detected by the SGLS. Radionuclides that emit one or more gamma rays at energies between about 150 and 2,800 keV are detectable with the SGLS. The minimum detection level (MDL) is dependent upon

detector efficiency at the appropriate energy level, background activity, and the yield (gamma rays emitted, on average, per decay). Factors such as casing, water, shielding, and the presence of other radionuclides also have an effect. Tables E.1 and E.2 summarize naturally occurring and man-made radionuclides that can be detected with the SGLS. The terms "primary gamma ray" and "secondary gamma ray" are used to differentiate between the more prominent gamma energy peaks and other, less prominent peaks that may be useful for confirmation. The values indicated in bold are those generally used to calculate concentrations.

Conventional gamma spectra analysis software is used to detect gamma energy peaks, identify the source radionuclide, and determine the net count rate, counting error, and minimum detectable activity. From the net count rate ($P_{n,}$ cps) for a specific energy peak, the apparent concentration of the source radionuclide ($C_{a,}$ pCi/g) is determined by:

$$C_a = \frac{27.027}{Y} \times I(E) \times DTC \times K_c \times K_w \times K_s \times P_n ,$$

where Y is the radionuclide yield, I(E) is the logging system calibration function, DTC is the dead time correction, and K_c, K_w, and K_s are energy-dependent correction factors for casing, water, and shielding. The calibration function, I(E), is unique for each combination of sonde and logging vehicle. Corrections for dead time and shielding were not applicable to the ILAW data. Values of the calibration function are updated annually and documented in calibration certificates and a calibration report (Koizumi 2002). Concentration error and MDL are calculated from count error and minimum detectable activity using similar equations. The reported concentration error is based on only the estimated counting error. No effort is made to include the effects of errors in the calibration function or correction factors. These errors

Table E.1. Naturally Occurring Gamma-Emitting Radionuclides

Radionuclide	Primary Gamma Rays			Secondary Gamma Rays[(a)]		
	Daughter	E (keV)	Y (%)	Daughter	E (keV)	Y (%)
^{40}K		1460.83	10.67			
^{232}Th	^{212}Pb	238.63	43.30	^{228}Ac	911.21	26.60
	^{208}Tl	2614.53	35.64	^{228}Ac	968.97	16.17
	^{208}Tl	583.19	30.36	^{228}Ac	338.32	11.25
^{238}U[(b)]	^{214}Bi	609.31	44.79	^{214}Pb	295.21	18.50
	^{214}Pb	351.92	35.80	^{214}Bi	1120.29	14.80
	^{214}Bi	1764.49	15.36			

(a) Secondary gamma rays with yields less than 10% are not shown
(b) Attainment of secular equilibrium between ^{238}U and ^{214}Bi/^{214}Pb requires long time periods on the order of a million years. Activities of both ^{214}Bi and ^{214}Pb are commonly assumed to be equal to the activity of naturally occurring ^{238}U. However, these radionuclides are short-term daughter products of ^{222}Rn, and accumulations of radon gas inside the casing may temporarily elevate the decay activities of ^{214}Bi/^{214}Pb relative to the decay activity of ^{238}U.

Table E.2. Man-Made Gamma-Emitting Radionuclides

Radionuclide	Half Life (Years)	Primary Gamma Rays		Secondary Gamma Rays	
		E (keV)	Y (%)	E (keV)	Y (%)
^{60}Co	5.2714	1332.50 1173.24	99.98 99.90		
^{106}Ru	1.0238	511.86	20.40	621.93	9.93
^{125}Sb	2.7582	427.88	29.60	600.60 635.95 463.37	17.86 11.31 10.49
^{126}Sn	1.E+5	414.50	86.00	666.10 694.80	86.00 82.56
^{134}Cs	2.062	604.70	97.56	795.85	85.44
^{137}Cs	30.07	661.66	85.10		
^{152}Eu	13.542	1408.01	20.87	121.78 344.28	28.42 26.58
^{154}Eu	8.593	1274.44	35.19	123.07 723.31	40.79 20.22
^{155}Eu	4.7611	105.31	21.15		
^{235}U	7.038E+08	185.72	57.20	205.31	5.01
^{234m}Pa (^{238}U[(a)])	4.47E+09	1001.03	0.84	811.00 766.36	0.51 0.29
^{239}Pu	24110	129.30 375.05 413.71	0.0063 0.0016 0.0015		
^{241}Am	432.2	59.54[(b)]	35.90	102.98 335.37 368.05 662.40 772.01	0.02 0.0005 0.0002 0.0004 0.0002

(a) ^{234m}Pa is a short-term daughter of ^{238}U. Secular equilibrium is achieved relatively quickly. Because of the relatively low gamma yield, this peak is not observed when only background levels of naturally occurring ^{238}U are present. Hence, the presence of gamma peaks associated with ^{234m}Pa without corresponding peaks associated with ^{214}Pb and ^{214}Bi indicates the presence of chemically processed uranium.
(b) The 59.54-keV gamma ray may not be detectable in thick casing.

are discussed in the calibration report (Koizumi 2002). The term “apparent concentration” is used because the calibration model is based on an effectively infinite, homogeneous distribution uniformly distributed about the borehole axis.

The MDL for a radionuclide represents the lowest concentration at which the positive identification of a gamma-ray peak for that radionuclide is statistically defensible. A description of the MDL calculation is included in the data analysis manual (manual in revision).

On the Hanford Site, ^{137}Cs is the most commonly detected man-made radionuclide. In routine analysis, spectral regions of interest are “forced” for the 662-KeV peak associated with ^{137}Cs, and an

MDL is calculated for each depth, whether or not ^{137}Cs is actually detected. For other man-made radionuclides, MDLs are calculated only when a photon energy peak is detected.

The MDL for ^{137}Cs is typically about 0.2 pCi/g. The MDL differs slightly for each spectrum depending upon count time, background activity and concentrations of other radionuclides at the data point, as well as casing thickness. The MDL for ^{60}Co is about 0.1 pCi/g; the MDL for ^{154}Eu is approximately 0.5 pCi/g; and the MDL for ^{238}U is approximately 14 pCi/g.

Natural and man-made radionuclide concentrations, total gamma count rate, and dead time are plotted as a function of depth. These plots are included in a Log Data Report that also summarizes borehole construction details, logging conditions, analysis notes, and log plot notes, as well as a brief discussion of results and interpretations.

E.3 Results

Log plots for the three ILAW boreholes are included as Figures E.1, E.2 and E.3. The borehole log data were acquired inside a 4-inch diameter stainless steel casing with 0.125-inch wall thickness, which had been installed in the 9-inch diameter borehole. The annular space between the casing and the borehole wall was filled with granular bentonite. This completion method resulted in relatively poor detection conditions for naturally occurring radionuclides. Gamma rays originating in the surrounding formation are attenuated by the annular seal between the casing and the borehole wall, and there is interference with gamma rays originating from natural radionuclides (particularly ^{40}K) in the bentonite, with the result that total gamma activity is somewhat reduced and the use of potassium, uranium and thorium logs for stratigraphic correlation is impaired.

No man-made radionulcides were detected in the ILAW boreholes. Isolated occurrences of ^{137}Cs at the MDL are shown on the log plots, but these are the result of "forcing" a region of interest for the 661.62 KeV peak in each spectra. Examination of individual spectra in which ^{137}Cs appeared to have been detected failed to provide any evidence of an energy peak at 661.62 KeV. These isolated occurrences are most likely the result of statistical fluctuations in the counting process and do not represent credible contamination.

Some difficulties with equipment were encountered during logging. Logging activities began with one SGLS (Gamma 2B) in borehole 299-E17-22, but post-run verification spectra began to fall outside the acceptance criteria. Verification spectra were examined and no immediate cause for the degradation of performance could be determined. Experimental log runs were made with another sonde and it was determined that the source of the problem was most likely in the logging cable or surface data collection system. Repeat logging sections showed significant discrepancies in the ^{232}Th concentration determined from the 2614.53 KeV peak. Comparison of spectra indicated that there appeared to be a loss of efficiency beginning at approximately 2000 KeV, and increasing with increasing energy level. All man-made gamma-emitting radionuclides commonly encountered at Hanford are detected and quantified by gamma rays with energies less than 1500 KeV. Therefore, the degradation of sensitivity experienced by Gamma 2B does not appear to have a significant effect on detection and identification of man-made radionuclides.

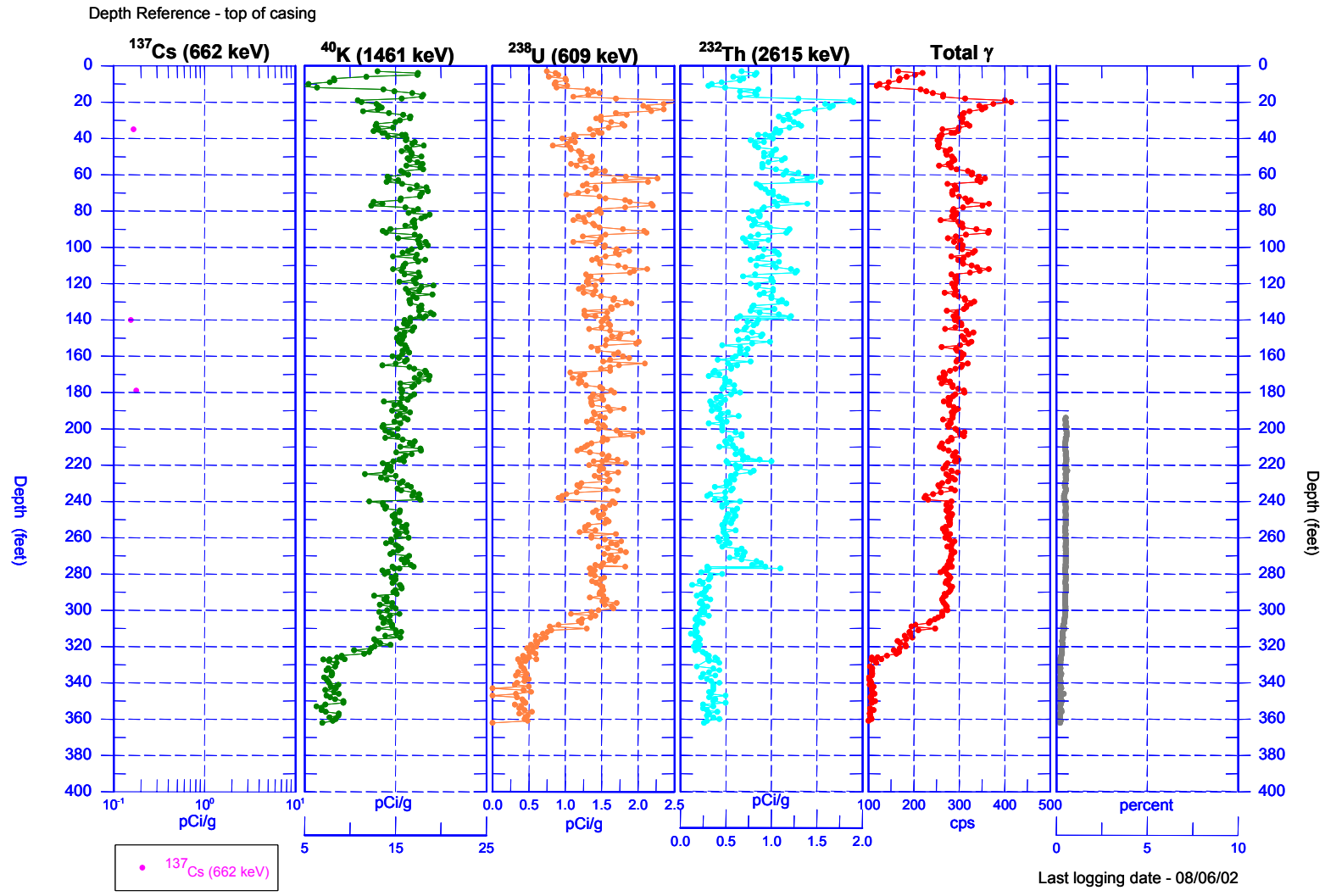

Figure E.1. 299-E17-22 (C3826) Combination Plot

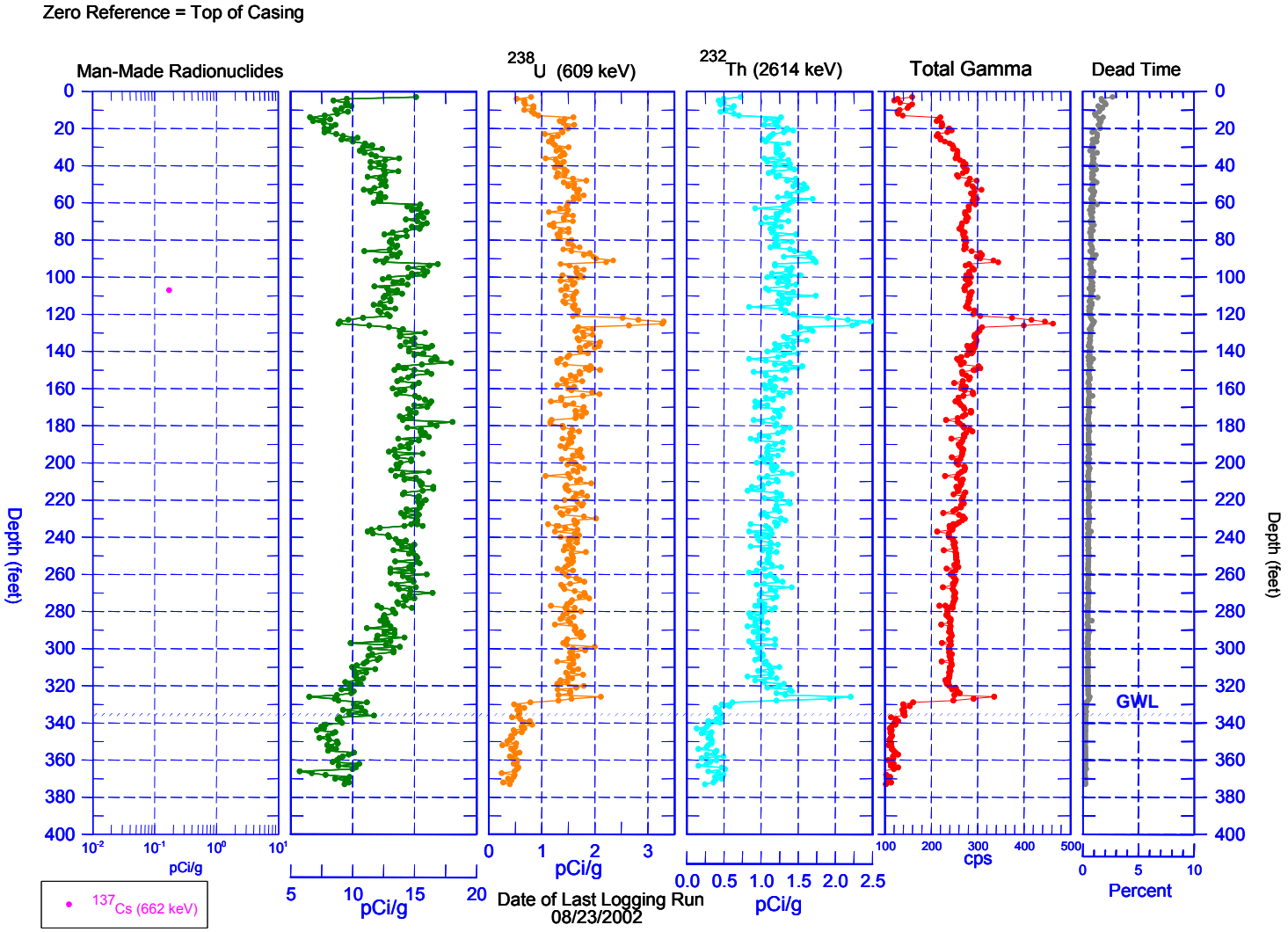

Figure E.2. 299-E17-23 (C3827) Combination Plot

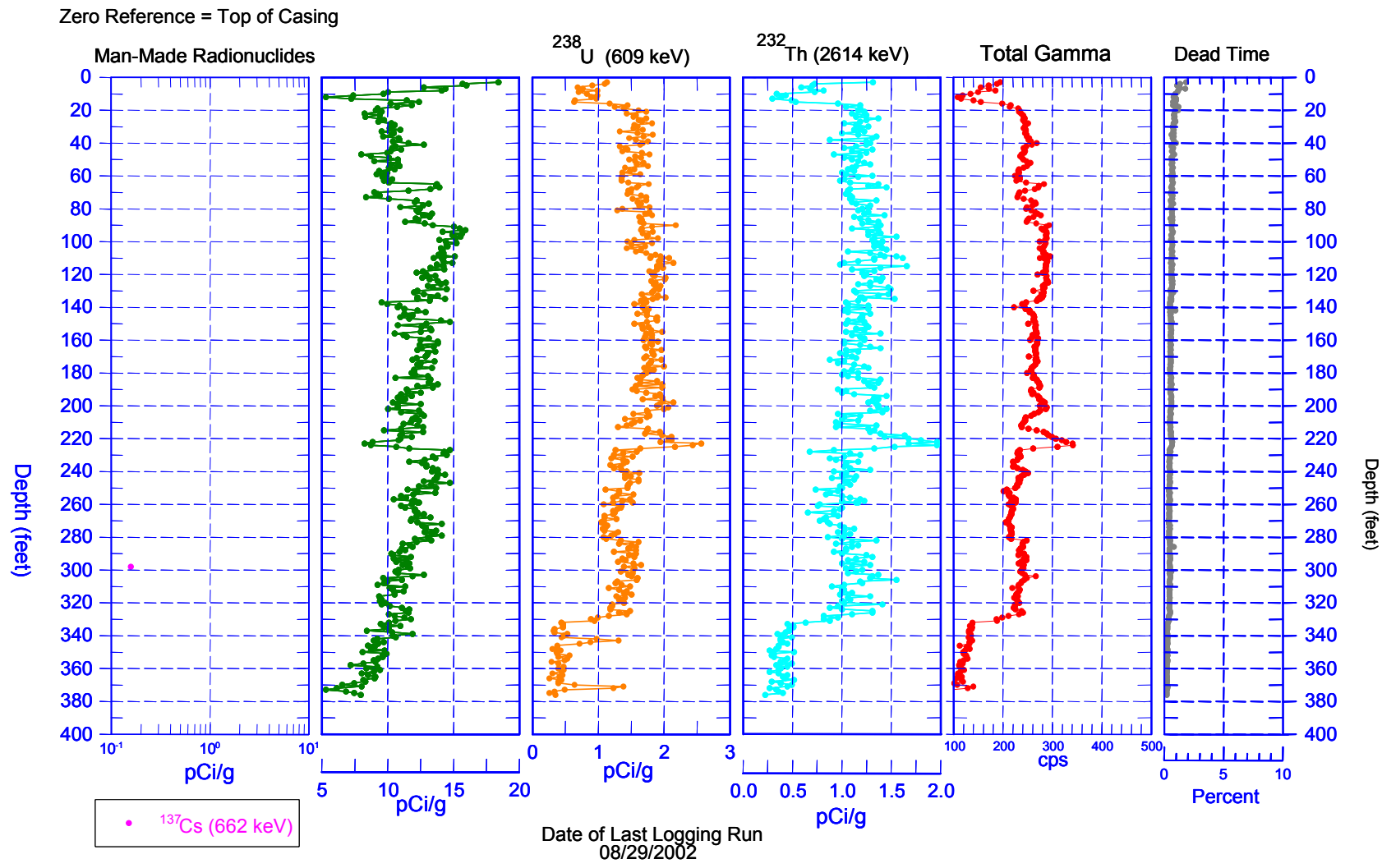

Figure E.3. 299-E17-25 (C3926) Combination Plot

Another SGLS (Gamma 1D) was used to complete logging in 299-E17-22, and to collect data in 299-E17-23 and 299-E17-25.

E.4 Conclusions

Spectral gamma logging in three boreholes at the ILAW site provided plots of total gamma, ^{40}K, ^{238}U, and ^{232}Th as a function of depth. Except for a few scattered false positive indications of ^{137}Cs, no evidence of man-made gamma emitting radionuclides was detected. The annular seal of crushed bentonite (or the sand pack) between the borehole casing and the borehole wall tended to obscure log response, and the usefulness of the logs for stratigraphic correlation was somewhat limited.

E.5 Reference

Koizumi, C. J. 2002. Recalibration of Logging Systems for Characterization of Subsurface Contamination at the Hanford Site; GJO-2002-328-TAR; prepared by MACTEC-ERS for the Grand Junction Office, Grand Junction, Colorado, April.

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