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B. Document Number
SGW-41072 Revision 0

C. Title
Liquid Effluent Retention Facility Characterization Report

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F. Complete for a Journal Article

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1. Title for Conference or Meeting
2. Group Sponsoring
3. Date of Conference
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A-6001-401

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Sent: Wednesday, May 13, 2009 10:59 AM
To: Bratton, Gayla E
Cc: Davis, Susan C
Subject: FW: Rev. 0 of LERF Characterization Report attached (SGW-41072)

Gayla,

From Ray Swenson in legal.

That should be it,

John

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Cc: Swenson, Raymond T
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I see no legal objection to release of the document. Thanks.

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Ray,

Final edit of our report SGW-41072 for release. Hopefully we can get a compliant groundwater monitoring network back into the permit for LERF. We plan to meet with Ecology at 1 pm Wednesday, May 13, tomorrow.

Thanks,

John

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Gayla,

I had Dave Erb review for OUO. I will check with Swenson.

Thanks,

John

From: Erb, David
Sent: Wednesday, May 13, 2009 9:17 AM
To: Smoot, John L
Subject: Nothing OUO in Your LERF Report

ADMINISTRATIVE DOCUMENT PROCESSING AND APPROVAL

DOCUMENT TITLE:	**OWNING ORGANIZATION/FACILITY:**
Liquid Effluent Retention Facility Characterization Report	CHPRC Soil and Groundwater Remediation
Document Number: SGW-41072	**Revision/Change Number:** 0

DOCUMENT TYPE *(Check Applicable)*

☐ Plan ☒ Report ☐ Study ☐ Description Document ☐ Other

DOCUMENT ACTION ◉ New ○ Revision ○ Cancellation

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SGW-41072
Revision 0

Liquid Effluent Retention Facility Characterization Report

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Plateau Remediation Company

P.O. Box 1600
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SGW-41072
Revision 0

Liquid Effluent Retention Facility Characterization Report

Project No: SGW Document Type: TI

J. L. Smoot
Fluor Government Group

Date Published
May 2009

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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Terms

bgs	below ground surface
BWIP	Basalt Waste Isolation Project
CFR	*Code of Federal Regulations*
CSM	conceptual site model
Ecology	Washington State Department of Ecology
FY	fiscal year
gpm	gallons per minute
ID	identification
LERF	Liquid Effluent Retention Facility
MCL	maximum contaminant level
msl	mean sea level
LLWMA	low-level waste management area
NTU	nephelometric turbidity unit
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	U.S. Department of Energy, Richland Operations Office
S&GRP	Soil and Groundwater Remediation Project
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WAC	*Washington Administrative Code*

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Metric Conversion Chart

Into Metric Units			Out of Metric Units		
If you know	*Multiply by*	*To get*	*If you know*	*Multiply by*	*To get*
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0394	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles (statute)	1.609	kilometers	kilometers	0.621	miles (statute)
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.0929	sq. meters	sq. meters	10.764	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.591	sq. kilometers	sq. kilometers	0.386	sq. miles
acres	0.405	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces (avoir)	28.349	grams	grams	0.0353	ounces (avoir)
pounds	0.453	kilograms	kilograms	2.205	pounds (avoir)
tons (short)	0.907	ton (metric)	ton (metric)	1.102	tons (short)
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.034	ounces (U.S., liquid)
tablespoons	15	milliliters	liters	2.113	pints
ounces (U.S., liquid)	29.573	milliliters	liters	1.057	quarts (U.S., liquid)
cups	0.24	liters	liters	0.264	gallons (U.S., liquid)
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts (U.S., liquid)	0.946	liters	cubic meters	1.308	cubic yards
gallons (U.S., liquid)	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
Temperature			**Temperature**		
Fahrenheit	(°F-32)*5/9	Centigrade	Centigrade	(°C*9/5)+32	Fahrenheit
Radioactivity			**Radioactivity**		
picocurie	37	millibecquerels	millibecquerels	0.027	picocurie

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1. Introduction

The purpose of this document is to update the status of groundwater evaluation investigations near the Liquid Effluent Retention Facility (LERF) in the 200 East Area of the Hanford Site. A *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant groundwater monitoring network was established at the LERF with one upgradient well and three downgradient wells. Declining groundwater levels caused two of the downgradient wells to go dry; thus, the groundwater monitoring network was out of compliance. The U.S. Department of Energy, Richland Operations Office (RL), in collaboration with the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA), developed a series of four study questions about the uppermost aquifer as the basis for a groundwater evaluation and a series of activities to be conducted to address these questions. The four study questions are as follows:

1. What are the thicknesses, extent, and continuity of the uppermost aquifer that is continuous under the LERF basins and capable of yielding representative samples?
2. What are the geologic and/or stratigraphic characteristics of the uppermost aquifer continuous under the LERF basins?
3. What are the hydrologic properties of the aquifer?
4. What are the groundwater flow rates and directions in the aquifer?

The activities developed to satisfy the groundwater evaluation are listed below:

- Drill a minimum of two boreholes
- Perform further geologic characterization of the uppermost aquifer (Hanford formation and/or Elephant Mountain Member flow top) by collecting drill cuttings of the units encountered, observing drilling rates, and observing water production from the units penetrated
- Perform water-level evaluation of the uppermost aquifer (Hanford formation and/or Elephant Mountain Member flow top) using water-level data from the new characterization wells combined with water-level data from existing wells
- Further evaluate the structure of the basalt that forms the bottom of the uppermost aquifer
- Perform hydrologic and groundwater chemistry characterization of the uppermost aquifer (Hanford formation and/or Elephant Mountain Member flow top) in the new characterization wells
- Evaluate all hydrogeologic and groundwater chemistry information to develop a conceptual site model (CSM) of aquifer relationships and groundwater flow
- Publish the results of these activities.

This document describes the steps conducted to complete these activities.

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2. Evaluation Activities

A series of groundwater evaluation activities were developed near the LERF to better understand the potential for continued groundwater monitoring of the facility. The activities identified for this effort included drilling a minimum of two boreholes, performing further geologic characterization of the uppermost aquifer, performing water-level evaluation of the uppermost aquifer, evaluating the structure of the basalt that forms the base of the uppermost aquifer, evaluating the hydrologic and groundwater chemistry characterization of the aquifer, and developing a CSM of aquifer relationships and groundwater flow. The evaluation activities are described in this section. Section 3 presents the geologic analyses, Section 4 presents the hydrologic and geochemical analyses, and development of the CSM is discussed in Section 5.

2.1 Drill a Minimum of Two Additional Wells

A plan was developed to drill two additional wells, which were installed adjacent to the LERF in fiscal year 2008 (FY08). Three potential well locations were chosen: (1) 299-E26-77 west of LERF (immediately adjacent to the dry monitoring well 299-E26-9), (2) 299-E26-78 southwest of Basin 42 (on the outside of the LERF fenced area), and (3) 299-E26-79 inside the LERF fence (south of Basin 43). An algorithm was developed to guide drilling so if water was found in the basalt at 299-E26-77, then location 299-E26-79 would be drilled as the second hole; otherwise, location 299-E26-78 would be drilled. Water was found at location 299-E26-77; consequently, well 299-E26-79 was drilled. The locations of two new wells and the pre-existing LERF monitoring wells (299-E26-10 and 299-E26-11) are shown in Figure 2-1. The data collected during installation and subsequent monitoring of these two wells were evaluated in conjunction with historical hydrogeologic and analytical data from the site to support refinement of the CSM. This document discusses the evaluation and presents the updated CSM.

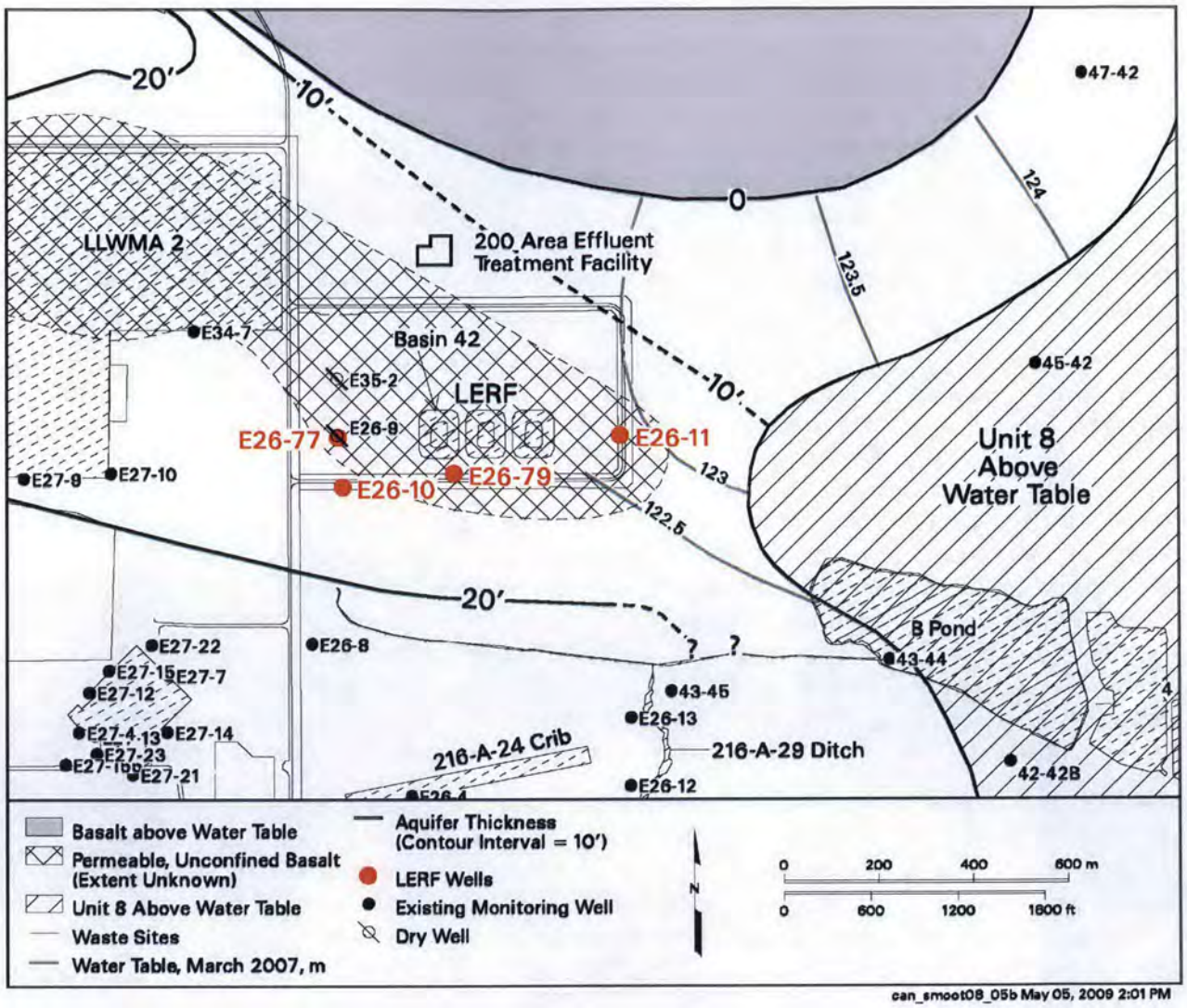
The data quality objectives process associated with installation of the two new wells is documented in *Liquid Effluent Retention Facility Data Quality Objectives, RCRA Replacement Well Siting and Sampling* (SGW-38464). The wells were installed and sampled in accordance with the *Sampling and Analysis Plan for the Liquid Effluent Retention Facility (LERF) Replacement RCRA Wells* (DOE/RL-2008-41). Installation, sampling, and logging of the two new wells is documented in the *Borehole Summary Report for the Installation of RCRA Wells 299-E26-77 (C6455), 299-E26-79 (C6826), 299-E25-236 (C6542), and 199-N-165 (C6693), FY2008* (SGW-39344).

2.2 Further Geologic Characterization of Uppermost Aquifer

The uppermost aquifer was further characterized during drilling. Drill cuttings were collected and analyzed, drilling rates were observed, and water production from the new wells was observed. These observations are discussed in Section 3.

2.3 Water-Level Evaluation of Uppermost Aquifer

Water levels have been carefully evaluated in the vicinity of the LERF basins, incorporating information from the new wells. The groundwater gradients in the vicinity of LERF are very small; therefore, significant efforts were taken to minimize measurement error, including resurveying the land surface elevation, performing gyroscope surveys of the holes to correct for borehole deviation from vertical, and performing precise measurement of the water levels. These activities are described in detail in Section 4. As part of an ongoing, larger effort to better define groundwater gradients at Hanford, the LERF wells will be enrolled in a regional analysis of groundwater gradients for the Low-Level Waste Management Area 2 (LLWMA-2)/LERF area. The results of this analysis will be published separately.



LERF = Liquid Effluent Retention Facility

LLWMA = Low-Level Waste Management Area

Figure 2-1. Location Map for the Liquid Effluent Retention Facility RCRA Monitoring Wells

2.4 Structural Evaluation of Basalt at Base of Aquifer

A structural analysis of the basalt was conducted in the vicinity of the LERF basins. The basalt dips gently to the south, but there appears to be some erosional remnants of Elephant Mountain Member flow top that form a local structural high on the basalt surface. This analysis is discussed in Section 3.

2.5 Hydrologic and Geochemical Characterization of Uppermost Aquifer

The hydrology and groundwater chemistry of the uppermost aquifer were also investigated. The relationship between groundwater flows in the vicinity of the LERF basins was investigated, as well as the geochemical properties of groundwater at each of the LERF wells. These results are discussed in Section 4.

2.6 Conceptual Model of Uppermost Aquifer

The final activity was to synthesize the geologic, hydrologic, and geochemical information into a revised CSM of the uppermost aquifer in the vicinity of the LERF basins. The revised CSM is presented in Section 5.

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3. Geologic Characterization

The objective of drilling the new wells was to characterize the uppermost aquifer. The specific objectives of the new wells are as follows:

- Characterize aquifer conditions near well 299-E26-9 by drilling a deeper well located near well 299-E26-9
- Characterize aquifer conditions south of the LERF basins with a new deeper well
- Drill both wells at least 4.6 m (15 ft) into basalt and screen the uppermost aquifer.

The drilling of these wells was conducted under provisions of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) Milestone M-24-61. Geologic characterization of the uppermost aquifer (Hanford formation and Elephant Mountain Member flow top) was completed by evaluating drill cuttings of the units encountered, observing drilling rates, observing water production from the units penetrated, and performing geophysical logging of the two boreholes prior to well completion. These data are presented and interpreted in the borehole summary report (SGW-39344) and are summarized in the following sections.

Basic information for the new and existing wells is summarized in Table 3-1. All four wells extend beyond 61 m (200 ft) in depth. Although the new wells extend 5.5 to 6.1 m (18 to 20 ft) into the Elephant Mountain Member basalt, the screened intervals in all four wells intercept the unconfined aquifer. Consequently, the new wells appear to have up to approximately 6.1 m (20 ft) of additional saturated thickness in the aquifer untapped by the older wells; however, the basalt appears to become less weathered with depth.

Table 3-1. Well Data Summary

Well Name	Well ID	Drill Date	Drill Depth (ft bgs)	Well Bottom Elevation (ft msl)	Screened Interval (ft bgs)	Elevation [a]	Northing [b]	Easting [b]
299-E26-77	C6455	8/12/08	232.8	376.0	200.85 to 225.6	184.771	137130.0	575579.0
299-E26-79	C6826	9/9/08	224.76	375.6	195.2 to 220.2	183.114	137051.5	575827.9
299-E26-10	A4799	8/28/90	206.6	398.3	190.5 to 206.1	184.420	137023.5	575589.0
299-E26-11	A4800	8/20/90	206.2	396.9	200.2 to 205.8	183.880	137134.6	576180.0

a. North American Vertical Datum of 1988 (NAVD88) values rounded to 0.001 m.

b. Northing and easting coordinates are based on Washington State Plane Coordinates North American Datum of 1983 (NAD83[91]).

bgs = below ground surface

ID = identification

msl = mean sea level

N/A = not applicable

3.1 Borehole 299-E26-77 (C6455)

Sediments encountered during the drilling of well 299-E26-77 consisted of Hanford formation gravels overlying the Elephant Mountain Member of the Columbia River Basalt Group.

The gravel drill pad was observed from 0 to 0.2 m (0 to 0.5 ft) below ground surface (bgs). Deposited gravelly silts were recently encountered from 0.2 to 1.5 m (0.5 to 5 ft) bgs. Silty gravel was encountered from 1.5 to 10.4 m (5 to 34 ft) bgs, consisting of mostly felsic gravels up to 15.2 cm (6 in.) in diameter; this layer showed a strong reaction to dilute hydrochloric acid. A layer of gravelly, silty sand was encountered from 10.4 to 11.6 m (34 to 38 ft) bgs; this layer consisted mostly of medium-sized felsic sand grains, and a moderate to strong reaction to hydrochloric acid was observed. A layer of silty sandy gravel was encountered from 11.6 to 15.8 m (38 to 43 ft) bgs, consisting of pebble-sized gravels of "50/50" mafic/felsic composition, and sands encountered were predominantly felsic and classified as medium grain; a slight reaction to hydrochloric acid was also observed. Gravelly sands and silty sands were identified from 13.1 to 15.8 m (43 to 52 ft) bgs. Sands were medium to coarse grain and predominantly felsic in composition, with gravels up to 5.1 cm (2 in.) in diameter, also of a felsic composition. A moderate to strong reaction to hydrochloric acid was noted at this depth. Gravels with varying amounts of silt and sand were encountered from 15.8 to 61.9 m (52 to 203 ft) bgs. Gravels were predominantly mafic, ranging in size from pebbles to boulders. Sands were predominantly felsic and classified as fine- to coarse-grained, and only a slight reaction to hydrochloric acid was seen at these depths. The change in lithology and reaction to hydrochloric acid suggests this layer consists of reworked Ringold Formation gravels.

The Elephant Mountain Member flow top was encountered at 62.6 m (205.5 ft) bgs. Basalt cuttings at this depth were vesicular with heavy weathering. In addition, moderate versus slow drilling rates extended to a total depth of approximately 70 m (230 ft) bgs. At the base of the hole, drilling slowed considerably, indicating a dense, more resistant portion of the Elephant Mountain Member basalt.

3.2 Borehole 299-E26-79 (C6826)

Sediments encountered during the drilling of well 299-E26-79 consisted of Hanford formation overlying the Elephant Mountain Member of the Columbia River Basalt Group.

The gravel backfill is present from 0 to 0.3 m (0 to 1.0 ft) bgs. Underlying the gravel drilling pad is the Hanford formation, which extends to a depth of 63.1 m (207 ft) bgs. Sandy, silty gravel was encountered from 0.3 to 8.2 m (1.0 to 27 ft) bgs, consisting of poorly sorted and unconsolidated fine to medium felsic-dominated sands and mafic-dominated pebbles and cobbles, exhibiting a grayish-brown (10YR 5/2) color. A strong reaction to dilute hydrochloric acid was observed at this depth. This was followed by two thin layers of sandy silt and silty gravel. Sandy silt was encountered from 8.8 to 9.8 m (29 to 32 ft) bgs, consisting of fine- to coarse-grained, felsic-dominated sand grains, yellowish-brown (10YR 5/6) in color. A layer of silty sand was encountered from 9.8 to 16.5 m (32 to 54 ft) bgs, consisting of fine- to coarse-grained, predominantly felsic sands with some small gravels. The color was noted as grayish-brown (10YR 5/2), with a slight reaction to hydrochloric acid increasing to a moderate reaction below 11.9 m (39 ft) bgs.

A combination of silty, sandy gravel and sandy, silty gravel was encountered from 16.5 to 41.1 m (54 to 135 ft) bgs. Silt and sand levels changed throughout the course of this layer, but gravels remained consistent at approximately 60%. Layers at these depths consisted of predominantly mafic cobbles with fine- to medium-grained felsic sands and were grayish-brown (10YR 5/2) in color, with slight reactions to hydrochloric acid throughout. A gravel layer consisting of large mafic cobbles was encountered from 41.1 to 46.3 m (135 to 152 ft) bgs. A small amount of sand and silt was also observed within this gravel

layer, as well as a slight reaction to hydrochloric acid. A thick layer of silty, sandy gravel was encountered from 46.3 to 61 m (152 to 200 ft) bgs. This layer consisted of mostly mafic cobbles and a small portion of felsic sand, moderately cemented together; however, no reaction to hydrochloric acid was noted. The color was observed to be grayish-brown (10YR 5/2). Silt content dropped off completely from 61 to 62.8 m (200 to 206 ft) bgs. A layer of sandy gravel was observed to 61.9 m (203 ft) bgs, consisting mainly of mafic gravel and felsic sand. At 61.9 m (203 ft) bgs, sand became more predominant, classifying this lower section a gravelly sand. Both layers were observed to be wet and brown in color (10YR 4/3). A highly modified clay layer was encountered from 62.8 to 63.1 m (206 to 207 ft) bgs. This clay layer consisted of a dark, reddish brown (2.5YR 3/3) silt with sporadic spots of white and/or yellow; some rock inclusions were also noted. There was no reaction to hydrochloric acid, and the clay was noted as being brittle rather than plastic.

At 63.1 m (207 ft) bgs, basalt was encountered. An apparent layer of flow top basalt was observed, as noted by the weathering rind and vesicles present in the drill cuttings. Based on cutting and drilling rates, the flow top appears to extend from 63.1 to 66.3 m (207 to 217.5 ft) bgs, making it approximately 3.2 m (10.5 ft) thick. The borehole was advanced nearly 2.1 m (7 ft) into the dense center portion of the basalt, and drilling was halted at a total depth of 68.3 m (224.2 ft) bgs.

3.3 Evaluation of Basalt Structure

The deep basalt at Hanford has been relatively well characterized during the Basalt Waste Isolation Project (BWIP). A number of studies conducted during the BWIP focused on the uppermost surface of the basalt at depth. Several of these studies resulted in maps of the uppermost basalt showing general structural and erosional features on the basalt surface. Compilation and overlay of several of these maps resulted in a composite picture that suggests a weathered, fractured basalt surface not fully eroded beneath the LERF basins.

In addition, several geophysical surveys were conducted in the 200-PO-1 Operable Unit during FY08, including the following: an airborne electromagnetic survey (SGW-39674, *Airborne Electromagnetic Survey Report, 200-PO-1 Groundwater Operable Unit, 600 Area, Hanford Site*), a seismic reflection survey (SGW-39675, *Reflection Seismic Survey Report, 200 East Area, Hanford Site*), and several seismic check-shot surveys (SGW-39676, *Check Shot Summary Report, 200 East Area, Hanford Site – Fiscal Year 2008*) to correlate borehole data (e.g., formation tops) to seismic surveys. The results of these surveys suggest a local basalt high near the LERF basins that may correlate to the partial to non-eroded, fractured basalt remnants in that area.

Observations during drilling at wells 299-E26-77 and 299-E26-79 indicated relatively easy drilling initially through the basalt. Drill cuttings revealed vesicular, fractured basalt; however, drilling slowed dramatically at approximately 5.5 to 6.1 m (18 to 20 ft) below the first encounter of basalt, suggesting that competent basalt colonnade or entablature was encountered. Drilling confirmed the presence of a section of saturated, permeable, unconfined basalt flow top near the LERF basins. No significant impediments to hydraulic communication between the basalt and the overlying Hanford formation sediments were observed. Therefore, it appears that the aquifer in this area includes the weathered, fractured flow top basalt of the Elephant Mountain Member. It appears that the bottom of the uppermost aquifer is located at contact between basalt flow top and the underlying competent basalt colonnade or entablature.

3.4 Thickness, Extent, and Continuity

Based on evaluations of drill cuttings, drilling rates, and water production noted during drilling, it appears that at least some portion of the Elephant Mountain Member flow top functions as a component of the unconfined aquifer beneath the LERF. The thickness of the flow top ranges from 2 m (6.5 ft) at well

299-E26-77 (west of the LERF), to 3.2 m (10.5 ft) at well 299-E26-79 (south of the LERF), and 1.5 m (5 ft) to the east as shown in the as-built diagram for well 299-E26-11 (SGW-39344).

Geologic cross-sections were prepared along the lines depicted in Figure 3-1. A north-south cross-section (A-A') is presented in Figure 3-2, and an east-west cross-section is presented in Figure 3-3. The cross-sections show the general relationships between the Hanford formation and the underlying basalt near the LERF.

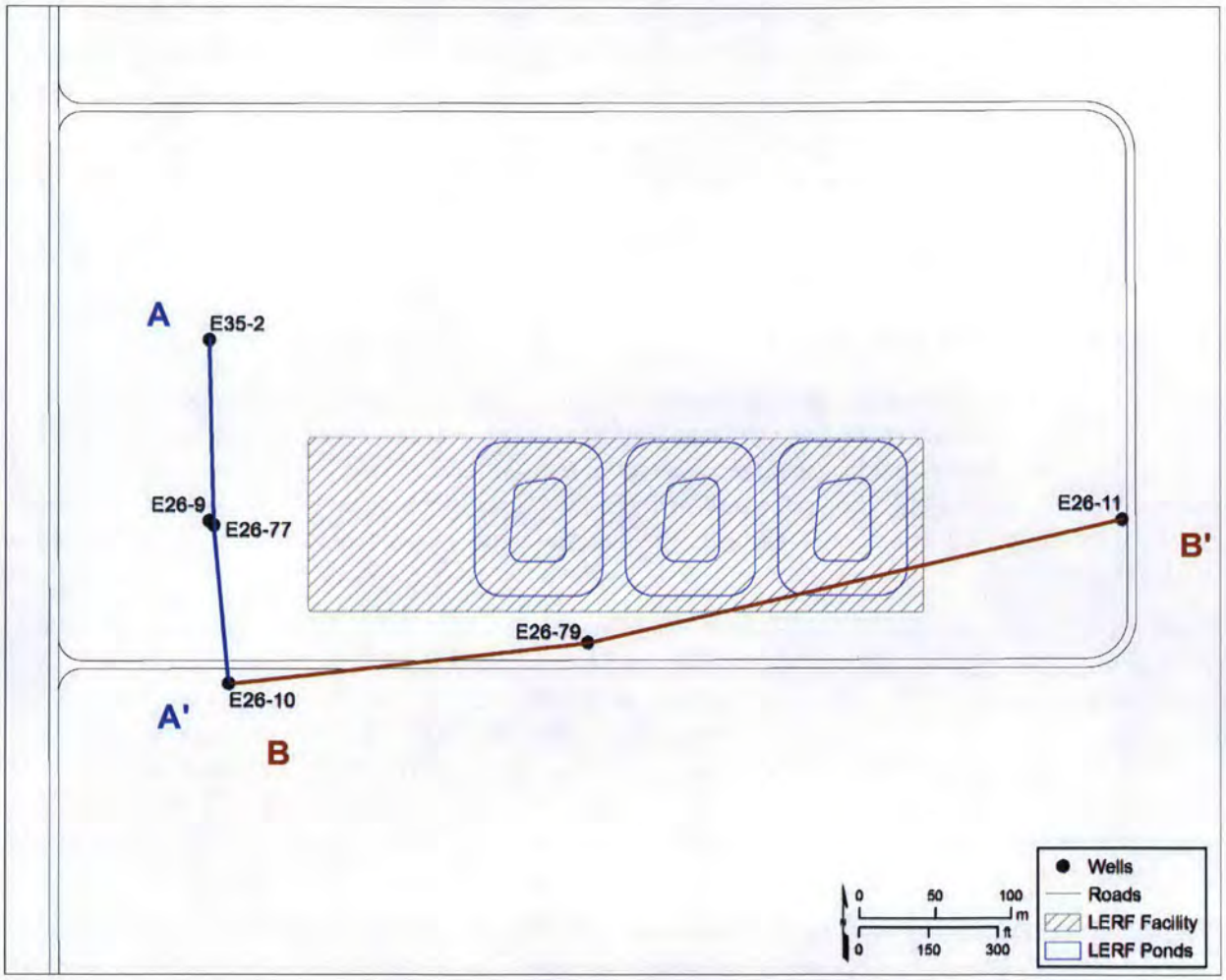


Figure 3-1. Location of Cross-Section Lines

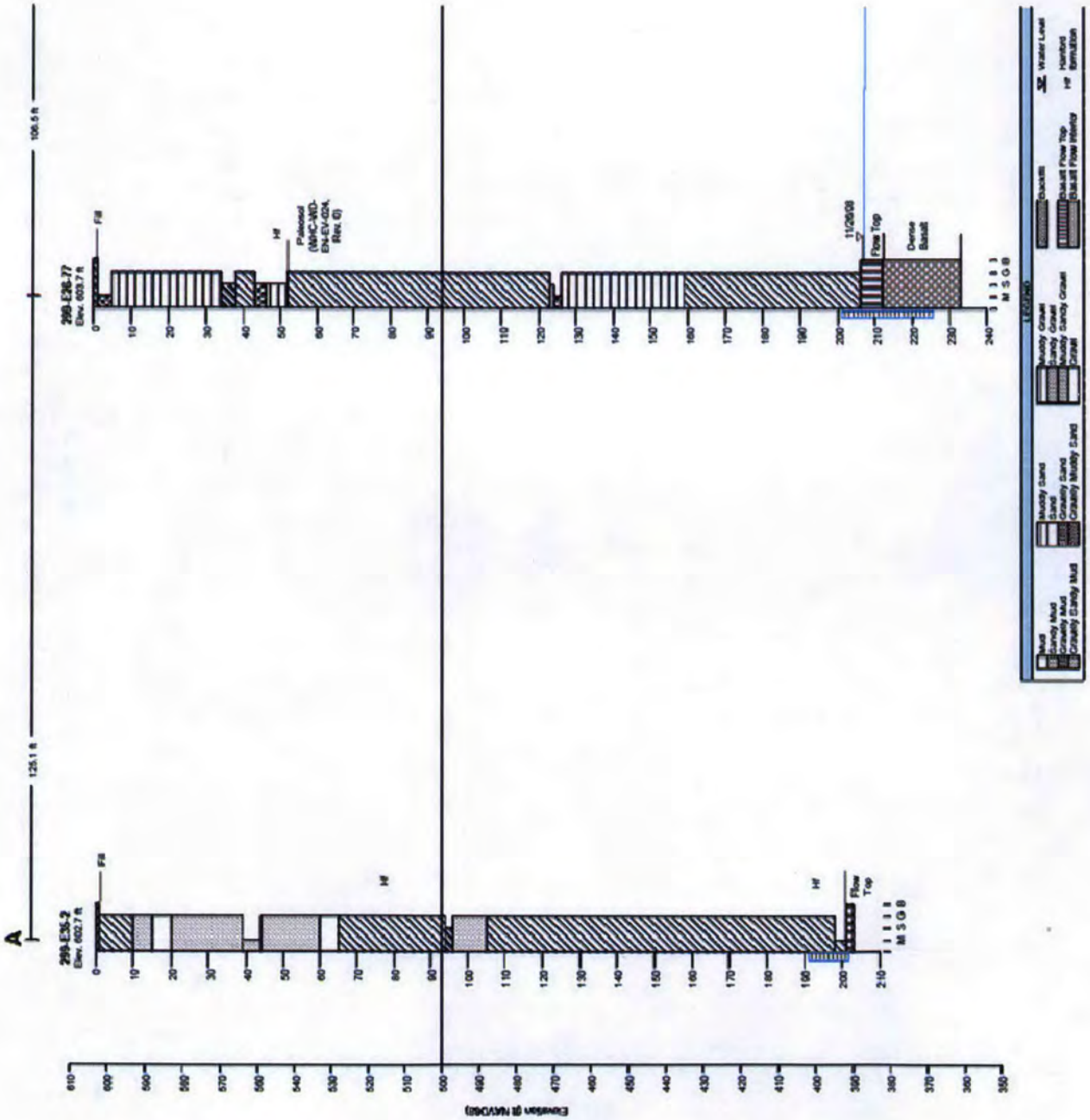


Figure 3-2. Cross-Section A-A'

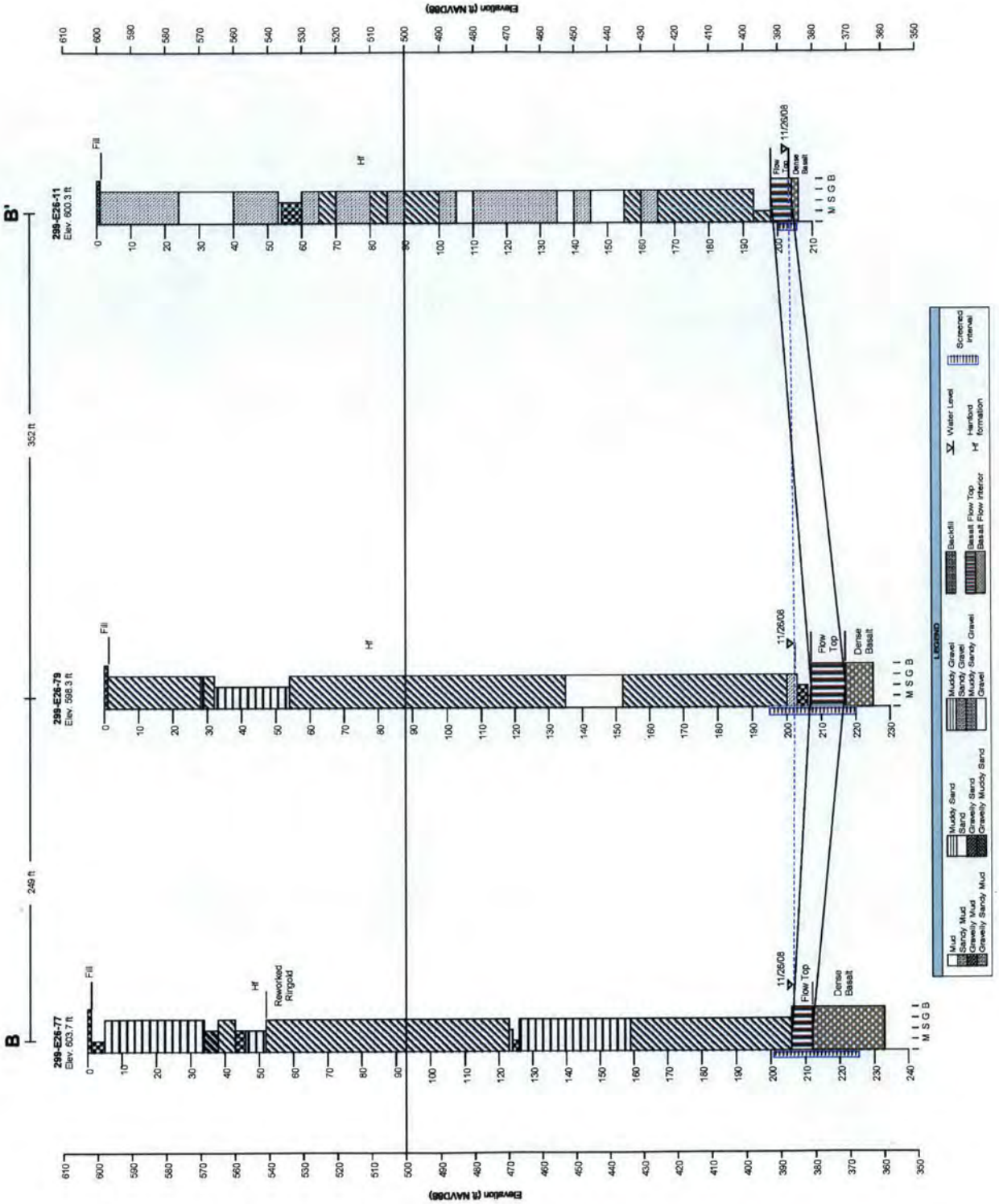


Figure 3-3. Cross-Section B-B'

4. Hydrogeologic and Chemical Characterization

Hydrologic and groundwater chemistry characterizations of the uppermost aquifer (Hanford formation and Elephant Mountain Member flow top) were conducted in the new characterization wells, and the results are discussed in this section. The data suggest that the permeable basalt flow top comprises much of the unconfined aquifer in the vicinity of the LERF basins. Additional work to be conducted during FY09 includes installing transducers in the four LERF wells to monitor potential responses in LERF wells to periodic discharges from the Treated Effluent Disposal Facility, as well as barometric responses.

4.1 Hydrologic Characterization

Hydrologic well characterization activities included water-level monitoring during well development, slug testing to provide an estimate of hydraulic parameters, and groundwater flow direction calculations. An additional component of this work was the collection of water samples during drilling and after well development. The sampling and analysis plan (DOE/RL-2008-41) describes the set of analytes that were collected from the groundwater during the drilling process and an expanded set of analytes (including the initial set of analytes, plus additional LERF-specific analytes).

4.1.1 Well 299-E26-77 (C6455)

4.1.1.1 Well Development

Well 299-E26-77 reached a total depth of 71 m (232.8 ft) bgs, encountering groundwater at approximately 63.4 m (208 ft) bgs. The static water level prior to well development was 61.5 m (201.9 ft) bgs. Water-level drawdown during development was monitored manually using an electronic water meter, with the intake located at a depth of 68.1 m (223.3 ft) bgs. Flow rate was initiated at 13.2 L/min (3.5 gallons per minute [gpm]) for a total of 11 minutes, and then increased to a rate of 22 L/min (5.8 gpm) for a total of 59 minutes. Overall 1,442 L (381 gal) were pumped from the borehole for the duration of the test. Drawdown observed ranged from 0.9 to 1.1 m (2.9 to 3.5 ft) at a rate of 22 L/min (5.8 gpm). Well development data, including field parameter measurements, are summarized in Table 4-1 and are documented in SGW-39344.

4.1.1.2 Slug Testing

Slug testing was performed at well 299-E26-77 in November 2008 (Figure 4-1). The results of the test were analyzed using the method in "Time Lag and Soil Permeability in Groundwater Observations" (Hvorslev 1951) and indicated hydraulic conductivities on the order of several tens of meters per day. This number is consistent with values of hydraulic conductivity for permeable basalt (*Groundwater* [Freeze and Cherry 1979]).

4.1.2 Well 299-E26-79 (C6826)

4.1.2.1 Well Development

Well 299-E26-79 reached a total depth of 68.5 m (224.8 ft) bgs, encountering groundwater at 61.5 m (201.7 ft) bgs. Water-level drawdown during development of the well was monitored continuously using a pressure transducer and data logger. The development stage was conducted with the pump intake at a depth of 65.8 m (216 ft) bgs. Flow rate was continuous at 30.2 L/min (8 gpm), and a total of 1,271.9 L (336 gal) was pumped over a period of 42 minutes. Drawdown observed ranged from 0.2 to 0.5 m (0.8 to 1.6 ft). Well development data, including field parameter measurements, are summarized in Table 4-1 and are documented in SGW-39344.

Table 4-1. Well Development Summary

Well Name/ Well ID	Water Level (ft bgs)	Date	Intake Depth (ft bgs)	Pumping Duration (minutes)	Final Turbidity (NTU)	Final Conductivity (µS/cm)	Final Temperature (°C)	Final Flow Rate (gpm)	Final Draw-Down (ft)	Total Gallons Pumped
299-E26-77 (C6455)	203.73	8/27/08	223.3	11/59	4.72	1020	19.7	3.5/5.8	3.45	380.7
299-E26-79 (C6826)	199.4	10/2/08	216	42	2.67	638	19.4	8	6.892	336

bgs = below ground surface
ID = identification
gpm = gallons per minute
NTU = nephelometric turbidity unit

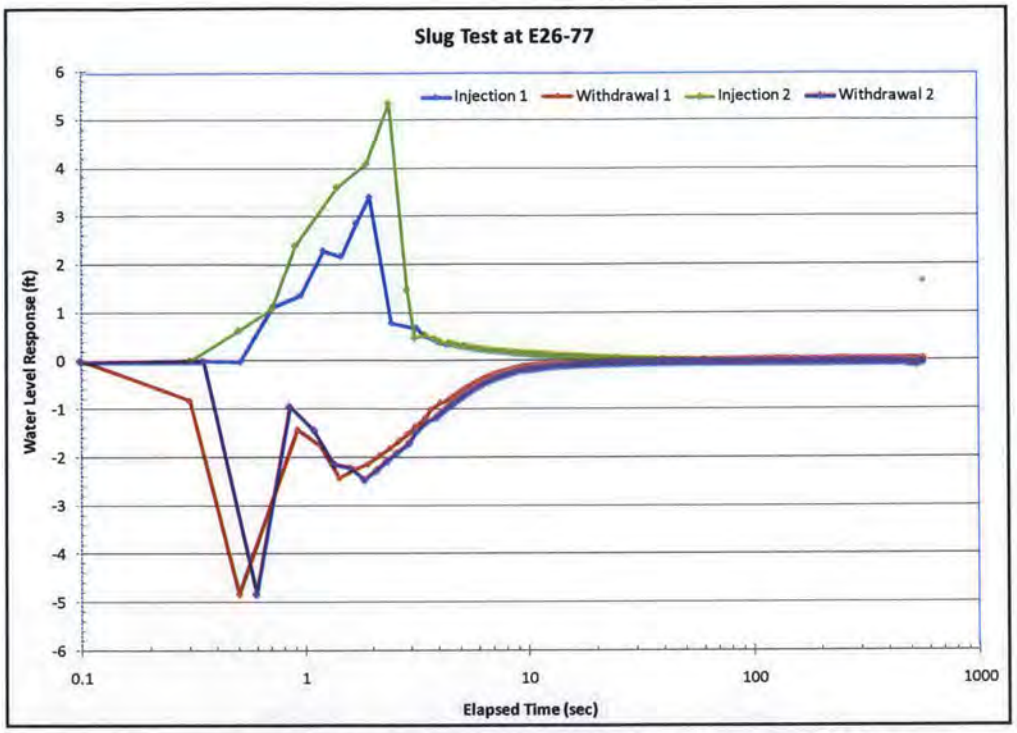


Figure 4-1. Slug Test Data for Well 299-E26-77 (November 2008)

4.1.2.2 Slug Testing

Slug testing was also performed at well 299-E26-79 in November 2008 (Figure 4-2). Again, the results of the test indicated hydraulic conductivities on the order of several tens of meters per day. This number is consistent with values of hydraulic conductivity for permeable basalt (Freeze and Cherry 1979).

4.1.3 Comparison with Slug Test at Well 299-E26-11

For comparison purposes, slug testing was also performed in well 299-E26-11 in November 2008. The well response is depicted in Figure 4-3. Results of this test indicated a hydraulic conductivity value of approximately 10 m/day (33 ft/day), which is somewhat lower the other tests performed in the new wells.

A comparison of these results with the results from the two new wells suggests that the basalt in well 299-E26-11 exhibits somewhat similar characteristics to those observed wells 299-E26-77 and 299-E26-79. Wells 299-E26-77 and 299-E26-79 have very similar responses in terms of duration and shape of the recovery curves (Figures 4-1 and 4-2); likewise, the differences in the responses for an injection or a withdrawal slug are very similar. The injection slug (the water level is raised in the hole and allowed to recover to static level) tends to recover much more quickly than the withdrawal slug (water level is lowered in the well and allowed to recover to static level), which indicates higher hydraulic conductivity above the water table than below the water table. The response in well 299-E26-11 is consistent with a lower hydraulic conductivity in that portion of the aquifer, given the longer times for water levels to return to static levels.

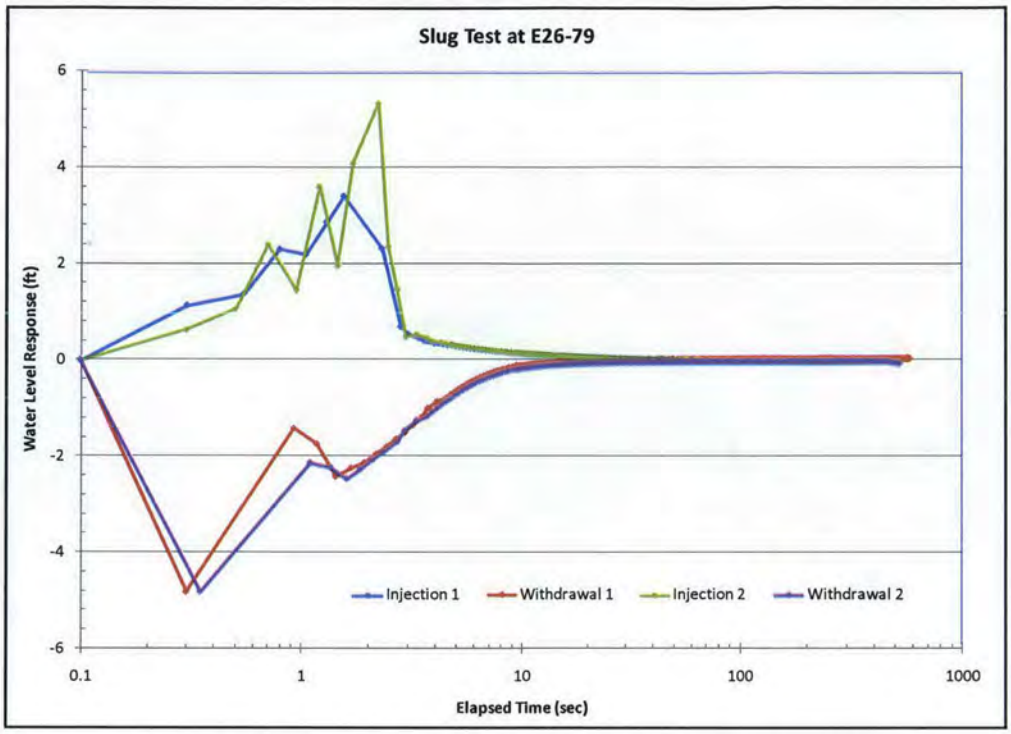


Figure 4-2. Slug Test Data for Well 299-E26-79 (November 2008)

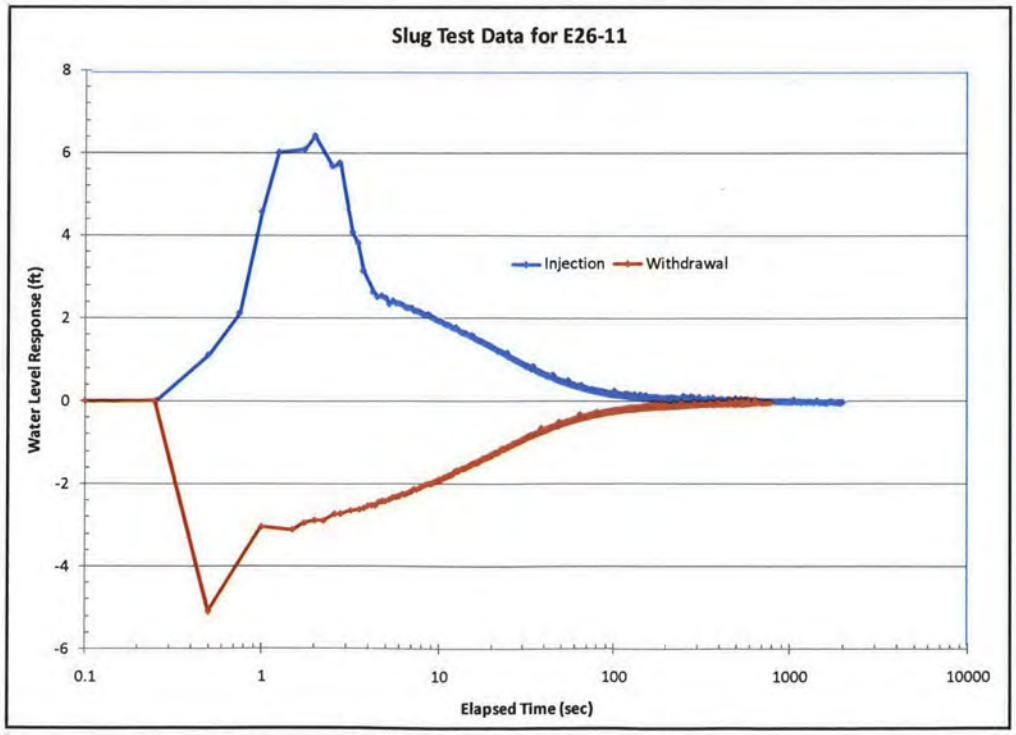


Figure 4-3. Slug Test Data for Well 299-E26-11 (November 2008)

4.1.4 Water-Level Evaluations

A preliminary evaluation of water levels in the uppermost aquifer (Hanford formation and/or Elephant Mountain Member flow top) was conducted using static water levels measured at the four LERF wells during the first and second quarters of FY09. The results of the evaluation are presented in this section. The evaluation included gyroscope surveys in the completed wells to determine the deviation of the holes from vertical. The water level in a deviated borehole would appear to be deeper than it actually is because it is measured at an angle to vertical. In addition, the wells have been surveyed at the highest precision practical and tied into the local surveying network to minimize error in the surface elevation.

Previous evaluations of groundwater flow directions prior to installing the new wells indicated a heading of 266 degrees, which is consistent with current results. A more refined analysis will be included in a study for the LLWMA-2/LERF local area.

Hydrographs of the four wells (Figure 4-4) indicate that the two existing wells continue to reflect a declining water table. The new wells have been measured several times, and the observed water levels suggest that the wells are within the same local water table surface. The slightly depressed values shown are prior to correction for borehole deviation.

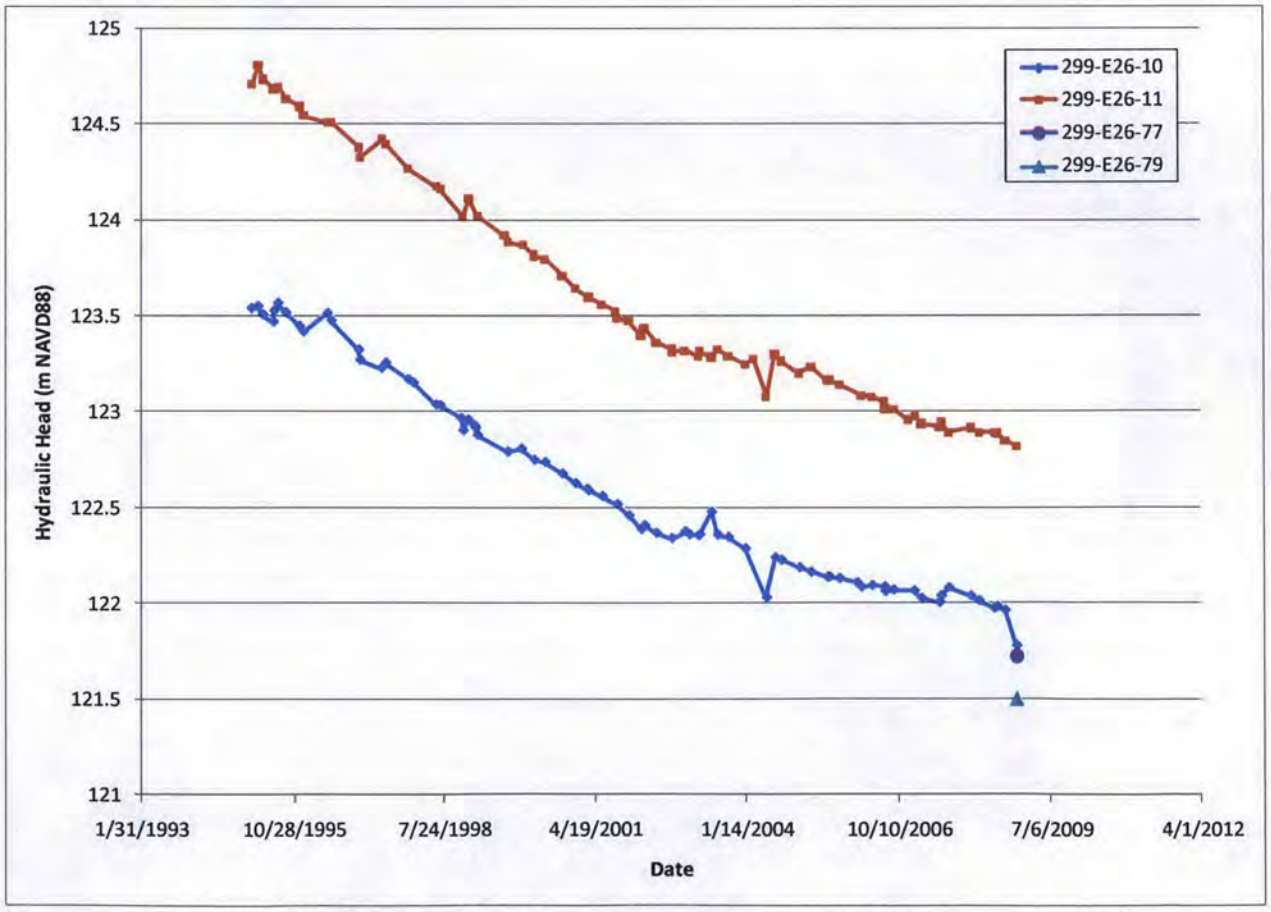


Figure 4-4. Hydrograph of Liquid Effluent Retention Facility Wells (November 2008)

To determine the hydraulic gradient at the LERF, three-point computations were made using recent water-level measurements collected from the three downgradient wells: 299-E26-10, 299-E26-77, and 299-E26-79. Upgradient well 299-E26-11 has an unusually higher water-level elevation compared to the other three wells (SGW-35756, *Water-Level Barometric Response Analysis for the Liquid Effluent Retention Facility Monitoring Wells*). Calculations with water levels from well 299-E26-11 result in a westerly flow direction because this well has a higher elevation than the other three wells. In addition, this well exhibits barometric responses similar in character to a semi-confined unit, which appears to be consistent with well completion primarily in basalt that is overlain by low-permeability material. However, given the lateral continuity of the basalt, this well is unlikely to be in a different aquifer.

Well bore deviation surveys and highly accurate casing elevation surveys were performed on the downgradient wells to minimize error in water-level measurements. The elevation surveys were conducted using a leveling instrument and a one-piece invar rod. The surveys were performed using a gyroscope and were indexed to a single benchmark. Survey data are included in Appendix A. The results indicated the difference between the *measured* depth to water and the *true* vertical depth to water, which allowed the water-level measurements to be corrected for deviations of the well bores from vertical. For well 299-E26-10, the difference between the measured and true depth to water was 1.2 cm (0.5 in.). The difference was larger for the two new wells: 26 cm (10.2 in.) for well 299-E26-77, and 46.9 cm (18.5 in.) for well 299-E26-79.

Water-level measurements were collected during November 2008 and also in February and March 2009. The measurements from November contained an outlier, so the gradient computation was only performed on the February and March measurements. The results for February indicated a direction of 254 degrees azimuth (west-southwest) and a magnitude of 9.7×10^{-5} m/m. The results for March were 177 degrees azimuth (south) at a magnitude of 2.1×10^{-4} m/m. The difference between these results reflects the uncertainty remaining in the measurements, which may be partly due to barometric pressure fluctuations. Water-level measurements will continue to be collected at the LERF, and a barometric pressure analysis is planned to reduce the uncertainty in the results and determine an average hydraulic gradient.

4.2 Chemical Characterization

Groundwater samples were collected at the new LERF wells during drilling and also during regular semi-annual sampling of the LERF wells, which included all four wells during the January 2009 sampling. Several groundwater samples taken during drilling allow an estimate of chemistry variation with depth in the aquifer. The analytical results for these samples are discussed in this section. First, the major ion and anion concentrations and the overall water type and the similarities/differences between wells are presented. Second, plots depicting analytical results for selected constituents and water quality parameters are presented. These plots depict historical data for wells 299-E26-10 and 299-E26-11 and include the analytical results for wells 299-E26-77 and 299-E26-79, beginning with the January 2009 sampling of all four LERF wells.

4.2.1 Stiff Diagrams

Figure 4-5 provides a stiff diagram for the January 2009 LERF samples. Figures 4-6 and 4-7 provide stiff diagrams depicting depth-discrete data from wells 299-E26-77 and 299-E26-79, respectively.

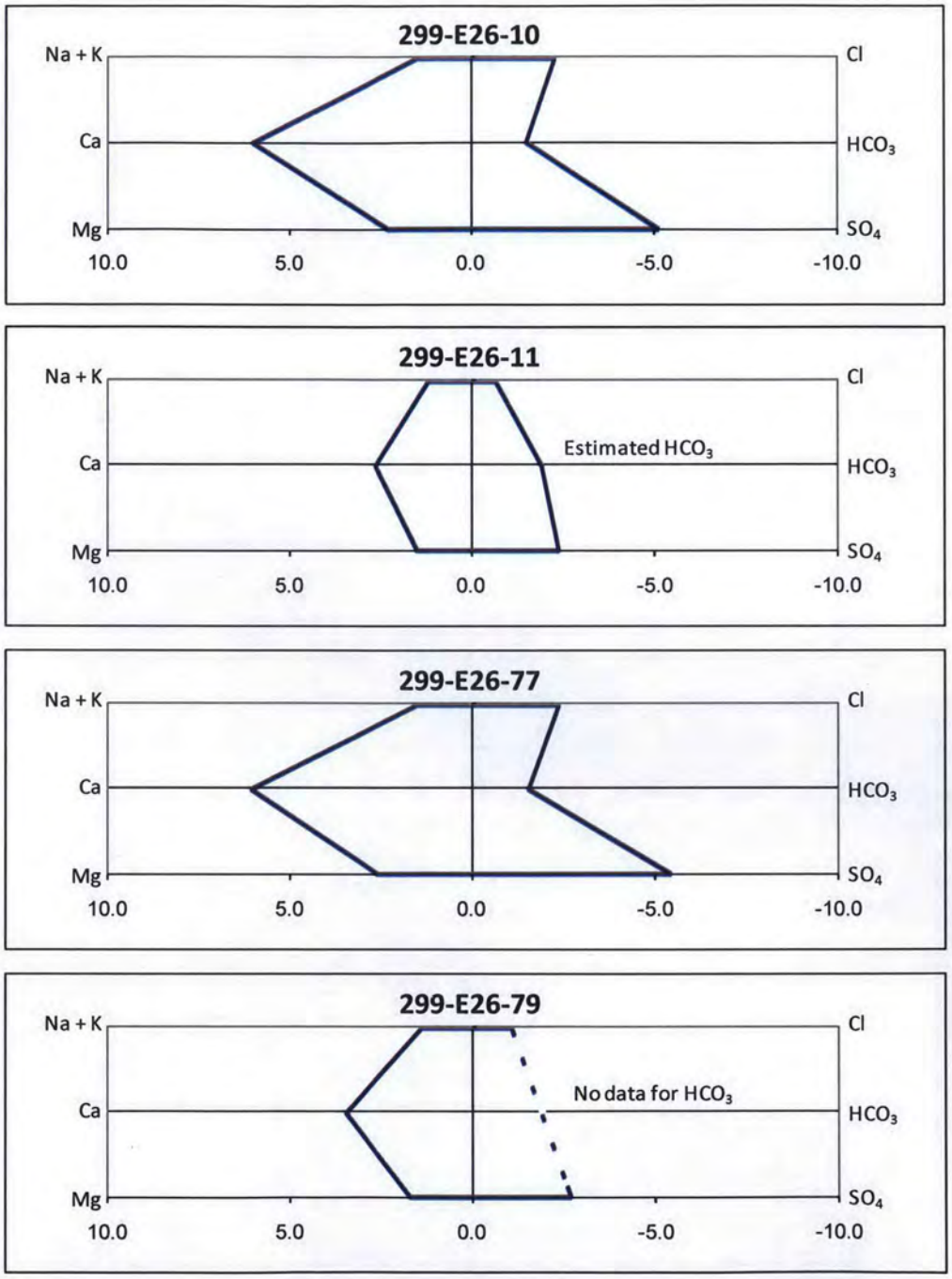
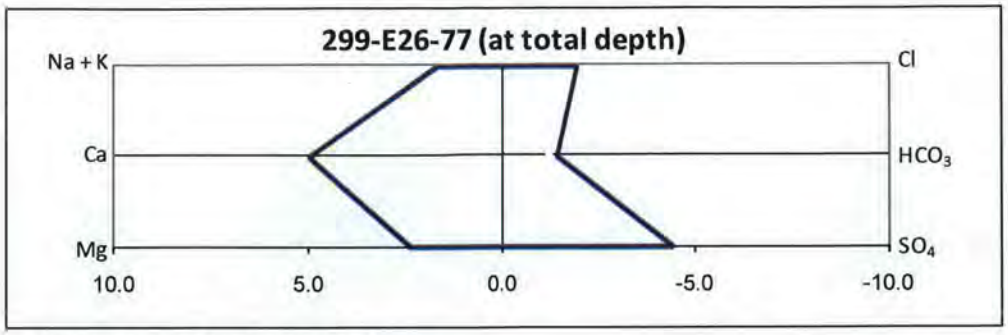
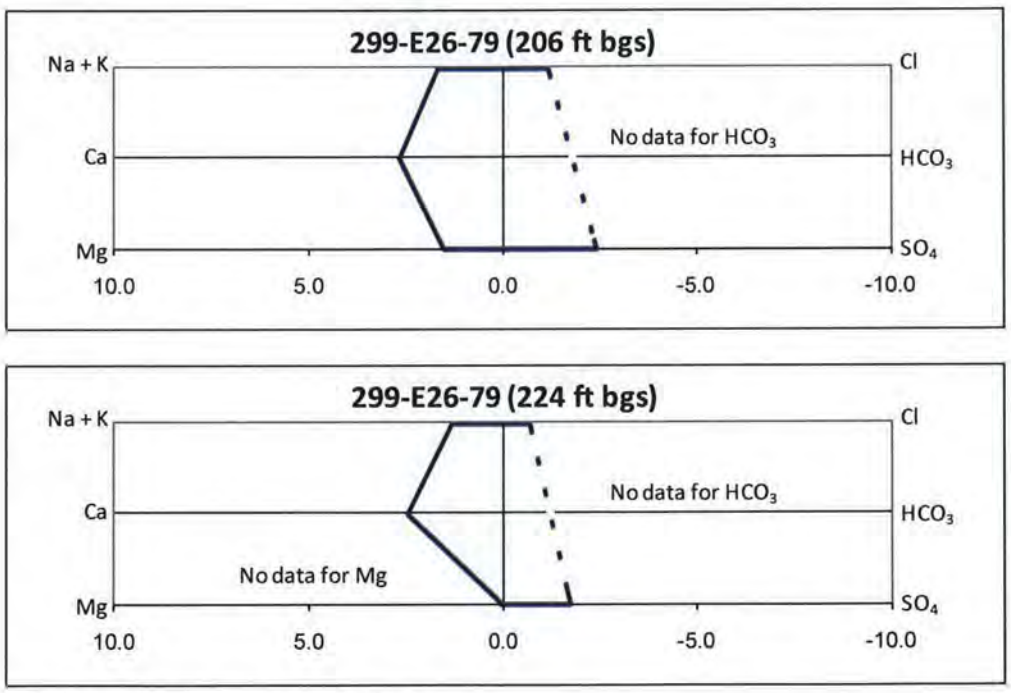


Figure 4-5. Stiff Diagrams for the January 2009 Liquid Effluent Retention Facility Sampling Results



NOTE: Data collected during drilling.

Figure 4-6. Stiff Diagram Depicting Depth-Discrete Data from Well 299-E26-77



NOTE: Data collected during drilling.

Figure 4-7. Stiff Diagrams Depicting Depth-Discrete Data from Well 299-E26-79

4.2.1.1 Routine Sampling

Water quality parameters in the January 2009 samples from well 299-E26-11 (upgradient) and 299-E26-79 (new well easternmost of the downgradient wells) show a clear correlation. Stiff diagrams for these two wells (Figure 4-5) are very similar, showing relatively low levels of the major cations and anions and a sodium-carbonate-type signature; the similarity suggests substantial hydraulic communication.

Stiff diagrams for the January 2009 samples at the other two downgradient wells (299-E26-10 on the southwest, and 299-E26-77 to the west) are also depicted in Figure 4-5. These two wells show the same basic signature as the first two wells, with one clear distinction: the additional overprinting of calcium sulfate.

The area west of the LERF includes a large regional sulfate plume (DOE/RL-2008-66, *Hanford Site Groundwater Modeling for Fiscal Year 2008*). The origin of the sulfate is unclear, but it may have resulted from natural infiltration through the large area of disturbed surface at the 218-E-12B low-level waste burial ground (northwest of the LERF). The disturbed surface (roughly 24.7 ha [61 ac]) may allow up to 10 cm/yr (3.9 in./yr) or more of deep percolation, which would leach natural calcium sulfate in the soil column into groundwater. In a natural, undisturbed groundwater basin, a slow increase in major cations and anions would be expected as the groundwater moves downgradient. There appears to be some other factor impacting groundwater in the wells in a large region west of the LERF, because the sulfate concentrations in groundwater are higher than those generally reported for the LERF leachate in the collection sumps for the first liner. Any small volumes that might conceivably escape the second LERF liner would likely have sulfate concentrations less than the observed groundwater concentrations and have minimal impact on the groundwater chemistry.

Water quality parameters for the four wells show substantial similarities. The identified disparity (i.e., higher calcium sulfate content in the two westernmost downgradient wells) may readily be explained by the presence of a regional sulfate plume (DOE/RL-2008-66) originating somewhere to northwest of the LERF site. Thus, available data can support a conclusion that the four wells are completed in the same aquifer.

4.2.1.2 Depth-Discrete Sampling

Depth-discrete groundwater samples were collected in boreholes 299-E26-77 and 299-E26-79 prior to well construction. Stiff diagrams depicting the analytical results are presented in Figure 4-6 (299-E26-77) and Figure 4-7 (299-E26-79).

Only one depth-discrete sample was analyzed for multiple parameters at well 299-E26-77, and the sample was collected at total depth (approximately 68.3 m [224 ft] bgs). Comparison of the stiff diagram for this sample and the January 2009 sample indicates almost no difference. Samples were collected at one other depth in well 299-E26-77 but were only analyzed for alkalinity. Comparison of analytical results indicated that alkalinity was the highest in the shallow sample (88,000 µg/L at 62.8 m [206 ft] bgs), decreasing to 74,000 µg/L at the bottom of the borehole (approximately 69.2 m [227 ft] bgs).

4.2.2 Contaminant Concentration Plots

Table 4-2 lists the constituents to be analyzed in the new LERF wells. The analytical results depicted in Figures 4-8 through 4-20 identified only one contaminant at concentrations above national drinking water standards (40 *Code of Federal Regulations* [CFR] 141, "National Primary Drinking Water Regulations") maximum contaminant level (MCL). Nitrate (MCL = 44.3 mg/L) was found at 47.4 mg/L in wells 299-E26-10 and 299-E26-77. In both instances, the sample had been diluted (laboratory qualifier "D") to facilitate analysis. Sulfate is also present at the west end of the site in fairly high concentrations, near the 250 mg/L secondary drinking water standards (40 CFR 143, "National Secondary Drinking Water Regulations"). Together with the nitrate, the resulting specific conductance is correspondingly high in the area west of the LERF. The concentrations in groundwater exceed the values for nitrate and sulfate in the small volumes of LERF leachate extracted from inside the first liner. It is unlikely that significant quantities are passing through the second liner, and any LERF leachate would be expected to be diluted to much lower concentrations in groundwater. Consequently, the LERF is not a likely/potential/credible source for the observed nitrate and sulfate concentrations.

Furthermore, the historical data for wells 299-E26-10 and 299-E26-11 indicate small but discernable differences for barium, nitrate, sulfate, total organic halides, and specific conductance. Analytical results for these constituents at well 299-E26-77 correlate with those from well 299-E26-10, and the results for well 299-E26-79 correlate with those from well 299-E26-11. These observations provide some additional discrimination of the general overall similarity in groundwater chemistry between the four wells.

Table 4-2. Constituents to Be Analyzed for in New Liquid Effluent Retention Facility Wells

Parameters Collected During Drilling:
Alkalinity
Total dissolved solids, total organic carbon, and total organic halides
Gross alpha and gross beta
Major anions: Cl, SO_4, NH_3, NO_3, and HNO_3
Major cations: Ca, K, Mg, and Na
pH
Specific conductance
Temperature
Turbidity
Parameters Collected After Well Development:
All drilling parameters listed above, plus the following:
Metals: As, Ba, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn, and Hg
Selected volatile organic analytes: carbon tetrachloride, trichloromethane, dichloromethane, and trichloroethene
Selected semi-volatile organic analytes: bis(2-ethylhexyl)phthalate, cresol, and lindane

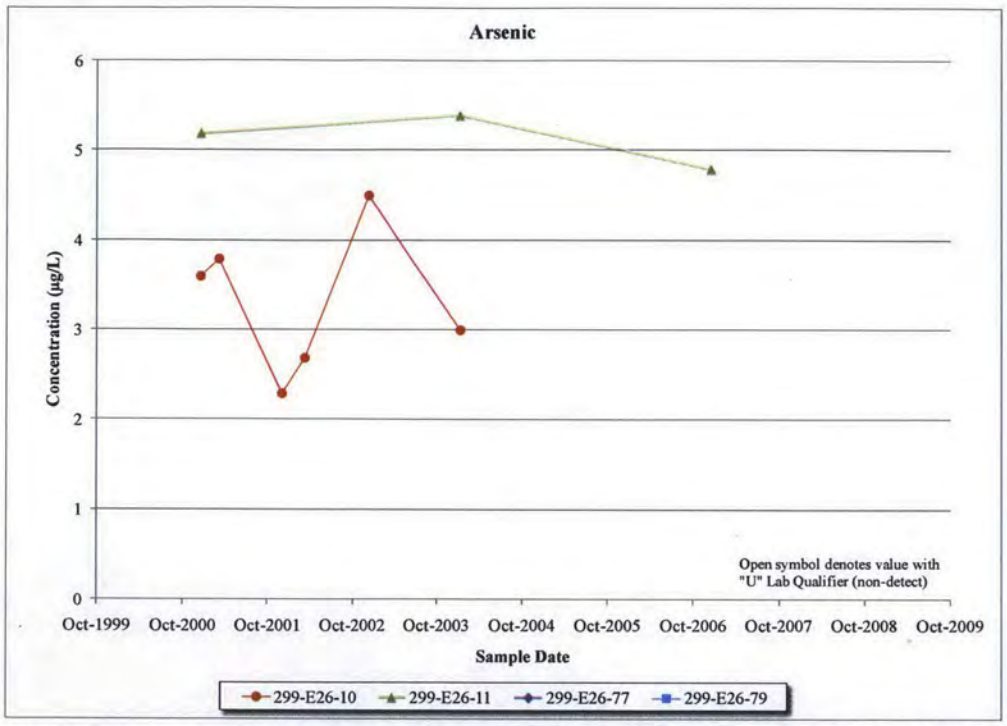


Figure 4-8. Analytical Results for Arsenic in Liquid Effluent Retention Facility Wells

Figure 4-9. Analytical Results for Barium in Liquid Effluent Retention Facility Wells

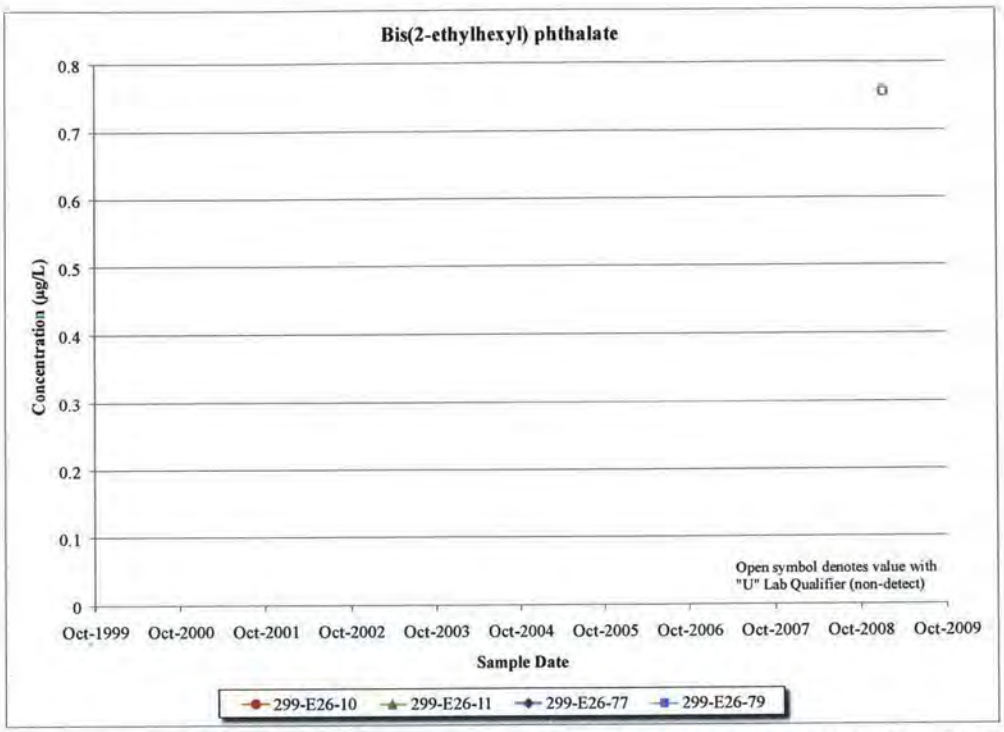


Figure 4-10. Analytical Results for Bis(2-ethylhexyl)phthalate in Liquid Effluent Retention Facility Wells

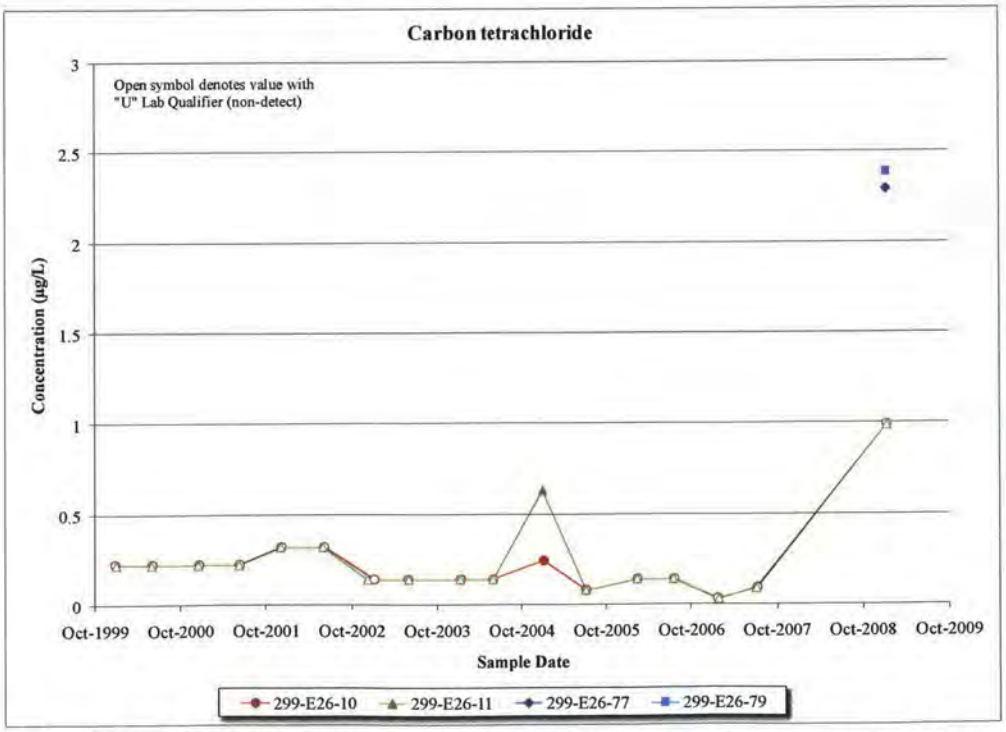


Figure 4-11. Analytical Results for Carbon Tetrachloride in Liquid Effluent Retention Facility Wells

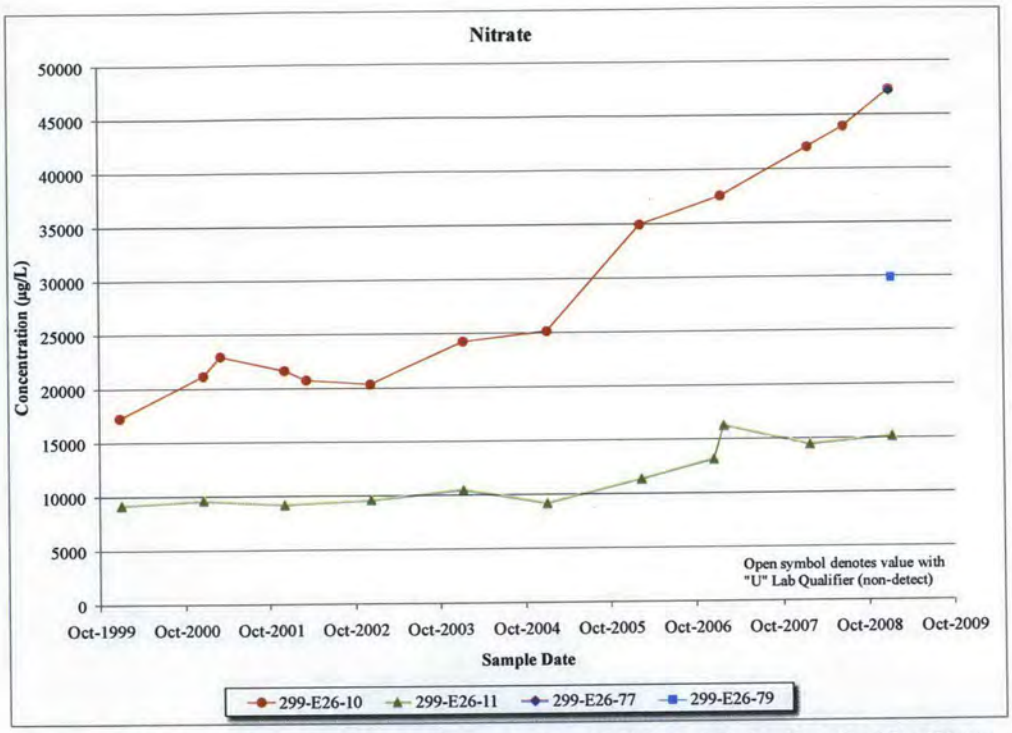


Figure 4-12. Analytical Results for Nitrate in Liquid Effluent Retention Facility Wells

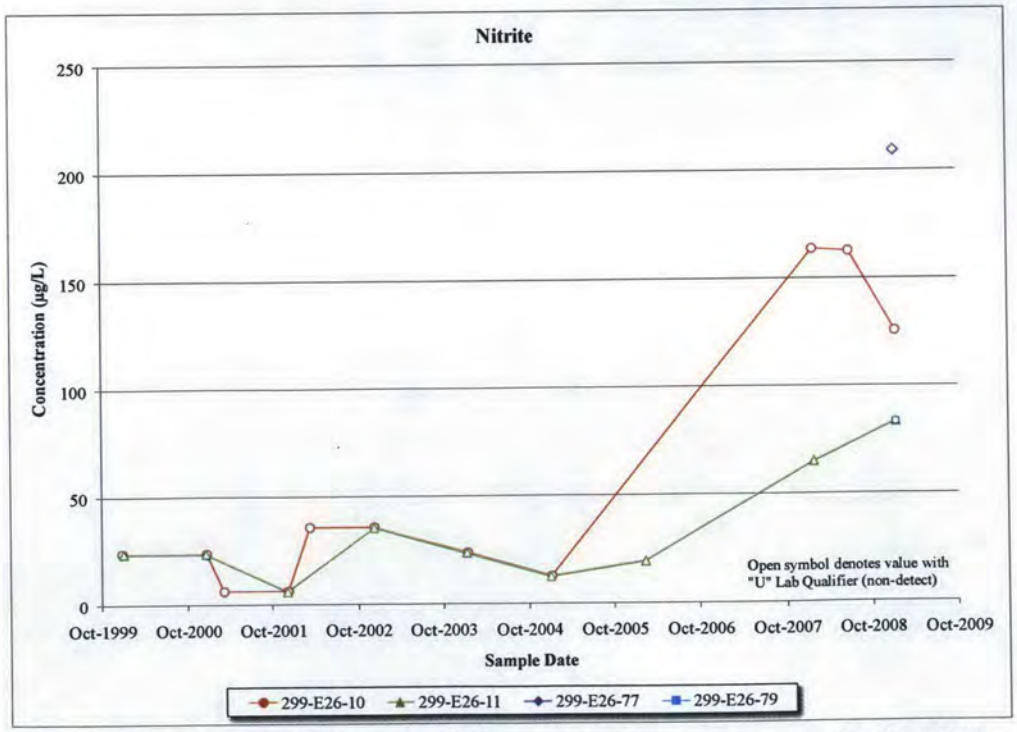


Figure 4-13. Analytical Results for Nitrite in Liquid Effluent Retention Facility Wells

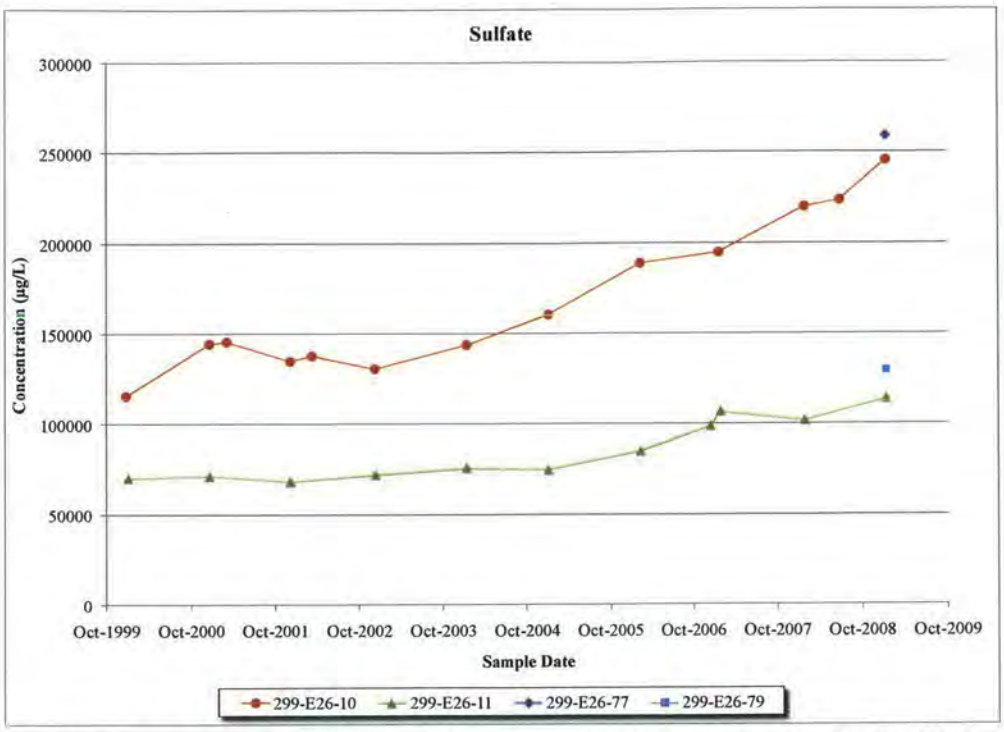


Figure 4-14. Analytical Results for Sulfate in Liquid Effluent Retention Facility Wells

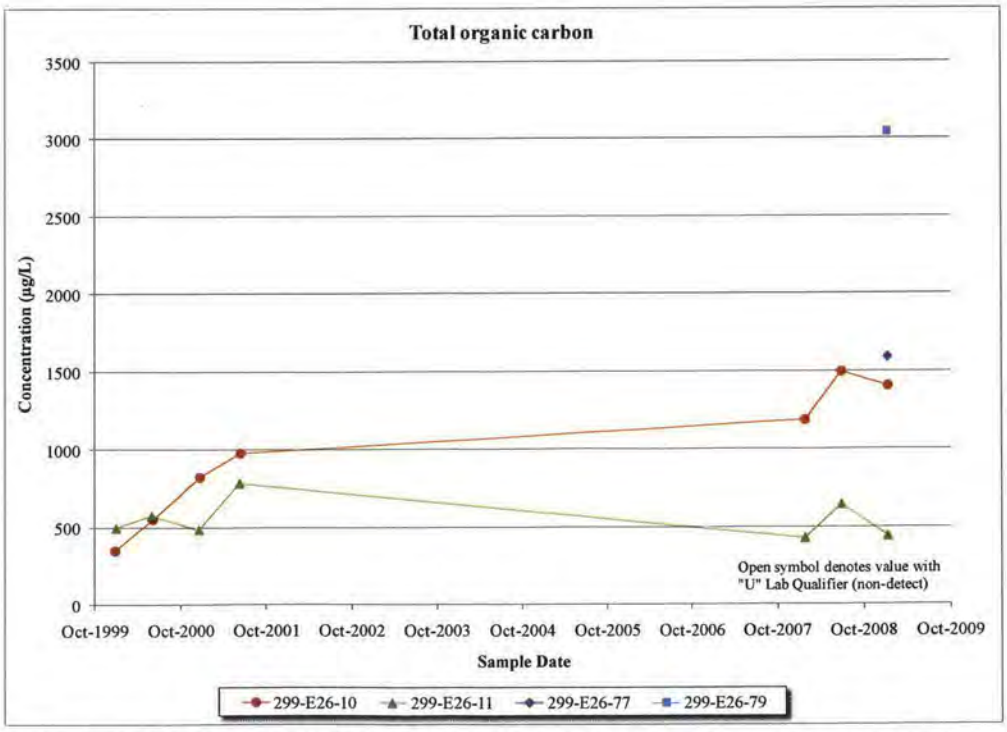


Figure 4-15. Analytical Results for Total Organic Carbon in Liquid Effluent Retention Facility Wells

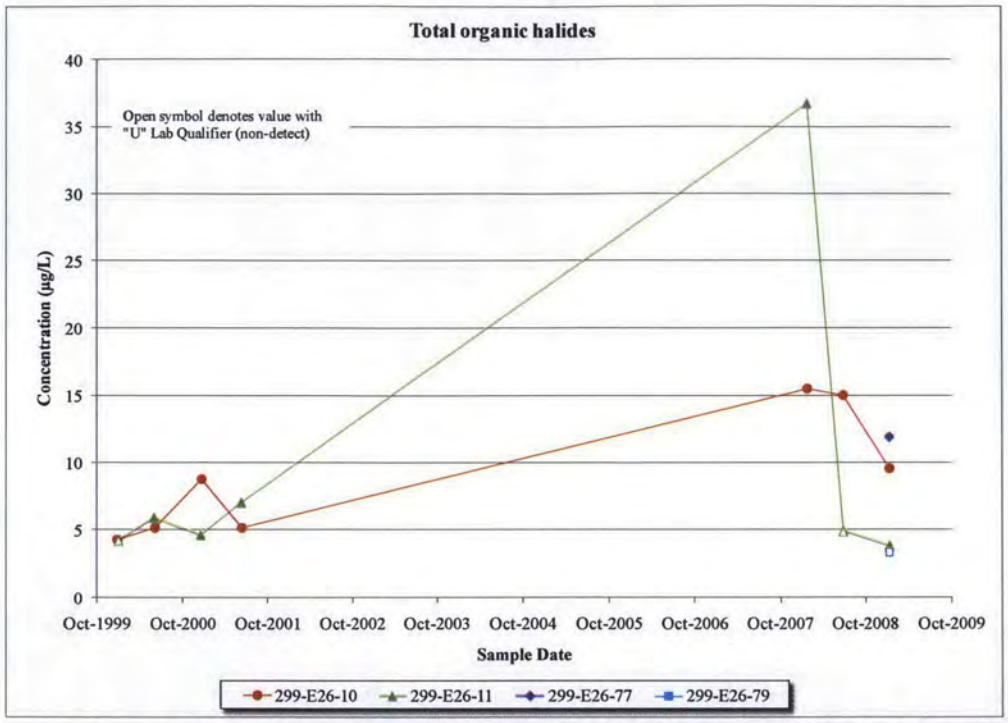


Figure 4-16. Analytical Results for Total Organic Halides in Liquid Effluent Retention Facility Wells

Figure 4-17. Analytical Results for pH in Liquid Effluent Retention Facility Wells

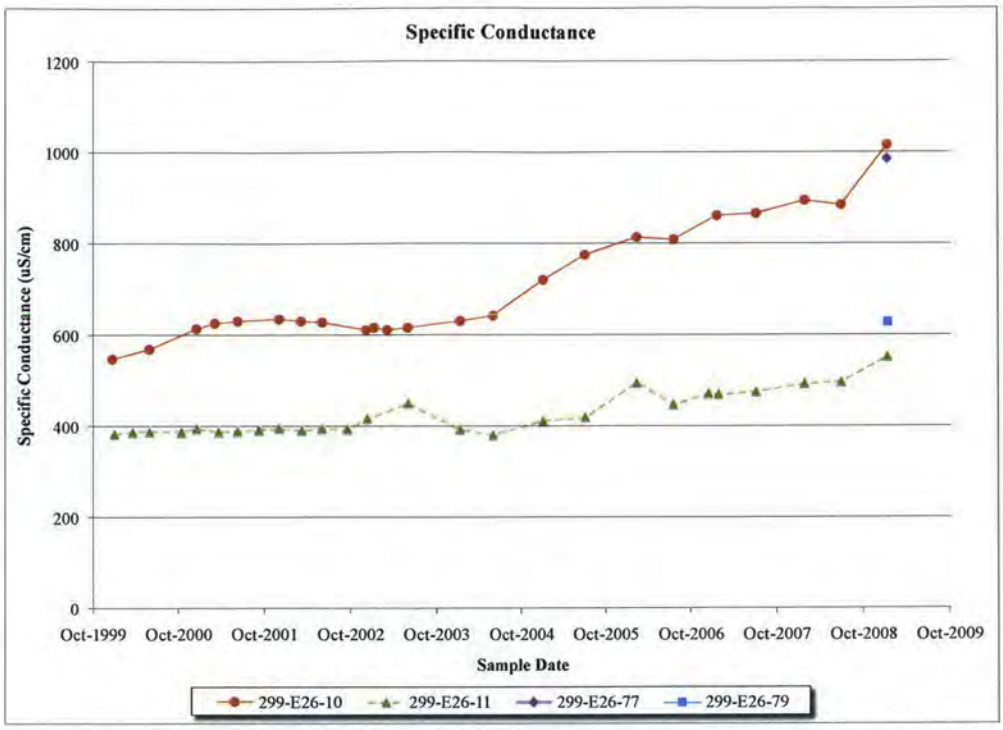


Figure 4-18. Analytical Results for Specific Conductance in Liquid Effluent Retention Facility Wells

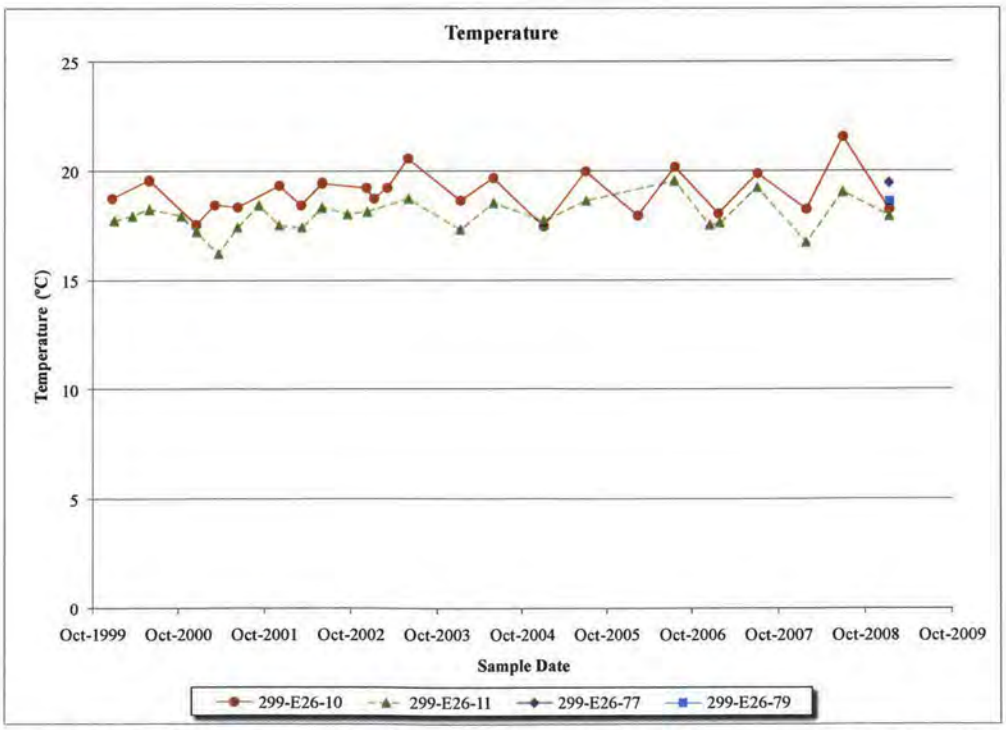


Figure 4-19. Analytical Results for Temperature in Liquid Effluent Retention Facility Wells

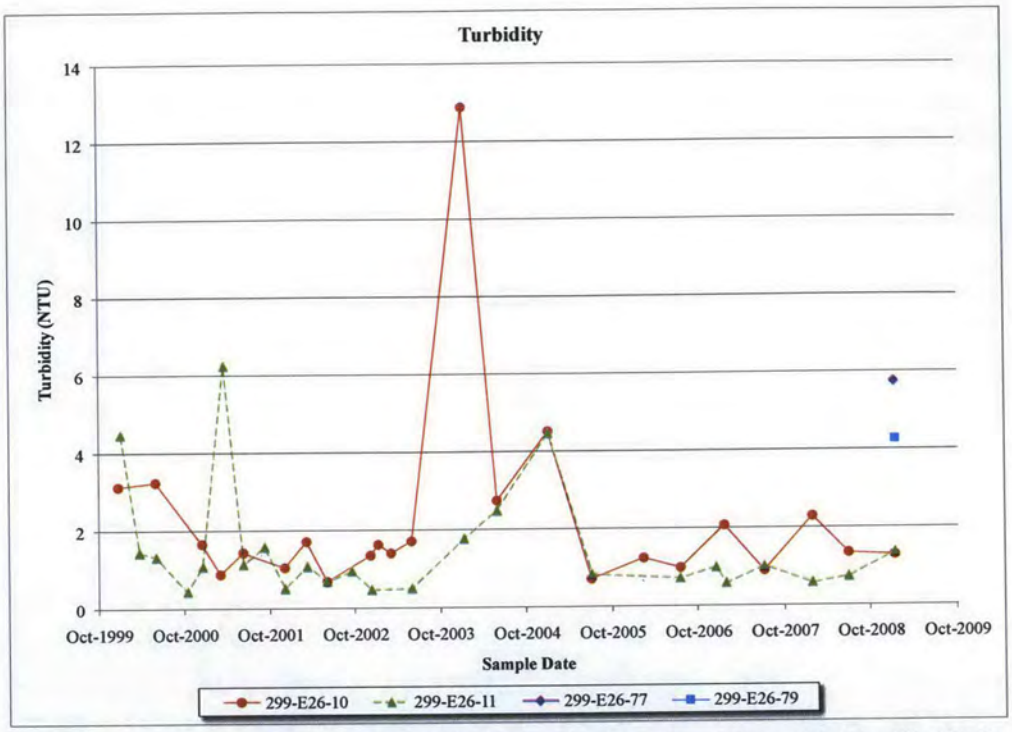


Figure 4-20. Analytical Results for Turbidity in Liquid Effluent Retention Facility Wells

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5. Integrated Analysis and Conceptual Site Model

A groundwater evaluation was conducted at the LERF and included the following activities: (1) drilling a minimum of two additional wells, (2) performing further geologic characterization of the uppermost aquifer, (3) conducting a water-level evaluation of the uppermost aquifer, (4) conducting a structural evaluation of the basalt at the base of the aquifer, (5) performing hydrologic and geochemical characterization of the uppermost aquifer, and (6) refining the conceptual model of the uppermost aquifer. The groundwater evaluation identified the information needs and provided a characterization approach for groundwater assessment in the vicinity of the LERF basins. The results of the characterization answered the following questions in regard to the uppermost aquifer:

- What are the thickness, extent, and continuity of the aquifer?
- What are the hydrologic properties of the aquifer?
- What are the groundwater flow rates and directions in the aquifer?
- Can the aquifer support wells to meet requirements for monitoring pursuant to *Washington Administrative Code* (WAC) 173-303-645?

Based on the evaluation, the thickness, extent, and continuity of the aquifer are now better understood. The new data support the concept of a multi-formational aquifer, as well as the concept that the unconfined aquifer at the LERF includes not only Hanford formation sediments but also fractured Elephant Mountain Member basalt flow top that forms the basal section of saturated thickness. Existing well 299-E26-11 and new wells 299-E26-77 and 299-E26-79 all produce water primarily from the basalt. The drilling report and hydraulic testing results indicate 3.0 to 6.1 m (10 to 20 ft) of saturated fractured basalt in the vicinity of the LERF basins. Geochemical evidence suggests that the aquifer is continuous.

No significant barrier to hydraulic communication was encountered during drilling. Some weathered material was noted at the top of basalt, which would be expected to form as part of a weathering rind on the uppermost surface of the basalt. The basalt itself was vesicular and fractured based on observations of drill cuttings. The initial 3.0 m (10 ft) of basalt drilled relatively easily, and then drilling became successively more difficult until 5.5 to 6.1 m (18 to 20 ft) into the basalt, where slow and difficult drilling indicated the presence of competent basalt flow entablature or colonnade. This portion of the basalt structure forms the base of the unconfined aquifer. In both new wells, the water table was encountered within a few feet above contact between the sedimentary Hanford formation and the Elephant Mountain Member basalt. Drilling with air-rotary tools evacuated water from the hole, but the static water table elevation recovered overnight. During development of the new wells, steady pumping rates of <37.9 L/min (10 gpm) were observed.

Groundwater flow rates and directions were determined as part of the evaluation. Given the very low gradients in the vicinity of the LERF basins, groundwater is discharging through the aquifer at relatively low flow rates (on the order of 5×10^{-4} to 5×10^{-3} m/day). The direction of flow, based on the best available water-level values that include precision surveying and vertical deviation correction, is westerly when incorporating well 299-E26-11 water-level data and more southerly when data for well 299-E26-11 are not incorporated.

The aquifer can support wells for monitoring purposes. Well development at the new locations produced 22.7 to 30.3 L/min (6 to 8 gpm) at the new wells, which is a sufficient amount for collection of water samples for geochemical analysis. The slug test data are consistent with the observed hydrogeology.

The calculated hydraulic conductivities of several tens of meters day are consistent with values for permeable basalt (Freeze and Cherry 1979).

The geochemical data also provide additional evidence for the continuity of the unconfined aquifer. The stiff diagrams of the major cations and anions clearly showed a correlation between the groundwater chemistry at wells 299-E26-11 and 299-E26-79 on the east and south sides of the LERF, suggesting strong hydraulic communication in the aquifer between these wells completed in different formations. The stiff diagrams show water with relatively low levels of the major cations and anions and a sodium-carbonate-type signature. To the west of the LERF, the water in wells 299-E26-10 and 299-E26-77 shows the same basic signature, with the additional overprinting of calcium sulfate added to the water. The area west of the LERF includes a large regional sulfate plume (DOE/RL-2008-66). The origin of the sulfate is unclear. The sulfate concentrations in groundwater are higher than those generally reported for the LERF leachate in the collection sumps for the first liner. Any small volumes that might conceivably escape the second LERF liner would likely have sulfate concentrations less than the observed groundwater concentrations and would have minimal impact on the groundwater chemistry.

The flow chart in Figure 5-1 outlines the general process and logic for evaluating groundwater for monitoring at the LERF, as generated collaboratively between RL, EPA, and Ecology. Following the logic in the chart, it seems reasonable that the four wells together can provide an adequate system for monitoring at the LERF. The refined water-level evaluation indicates that the distribution of new and existing wells at the LERF provides a reasonable well network to monitor groundwater impacts from the LERF under RCRA. The hydrogeologic and the geochemical data point to the continuity of the unconfined aquifer near the LERF, with portions of the aquifer within the Hanford formation and portions within the fractured Elephant Mountain Member basalt flow top. As the basalt dips to the south, the portion of saturated sediment increases. Careful evaluation of groundwater flow data suggests that flow is either westerly or southerly, depending on the inclusion of the upgradient well 299-E26-11 in the calculation. Therefore, the wells around the LERF are well positioned in order to monitor any significant impacts to groundwater resulting from the LERF. If flow is more westerly, wells 299-E26-10 and 299-E26-77 will monitor impacts; if flow is more southerly, well 299-E26-79 will monitor impacts.

The main potential weakness of the well configuration for monitoring would be for constituents to sink and transport below well 299-E26-10 because the well is not fully penetrating (as noted in the discussion of geometric relationships between the wells). The monitored constituents, however, are generally not characterized as likely to exhibit sinking behavior, so well 299-E26-10 should be adequate for monitoring. Even though this well was previously part of the permitted well network, the new characterization does suggest a potential weakness for this well, but it does not appear to be a fatal flaw.

The Soil and Groundwater Remediation Project (S&GRP) believes that, based upon the evidence presented in this report, the four wells at the LERF can form a reasonable, RCRA-compliant monitoring well network. While these wells do not form a "perfect" network, these wells cover the range of anticipated flow directions based on the evaluation and should intercept the types of indicator constituents that might be derived from the LERF. Therefore, S&GRP is requesting that Ecology allow these wells to be incorporated into Part III of the Hanford Site Dangerous Waste Permit (Permit WA7890008967) to place LERF into compliant status with respect to groundwater monitoring.

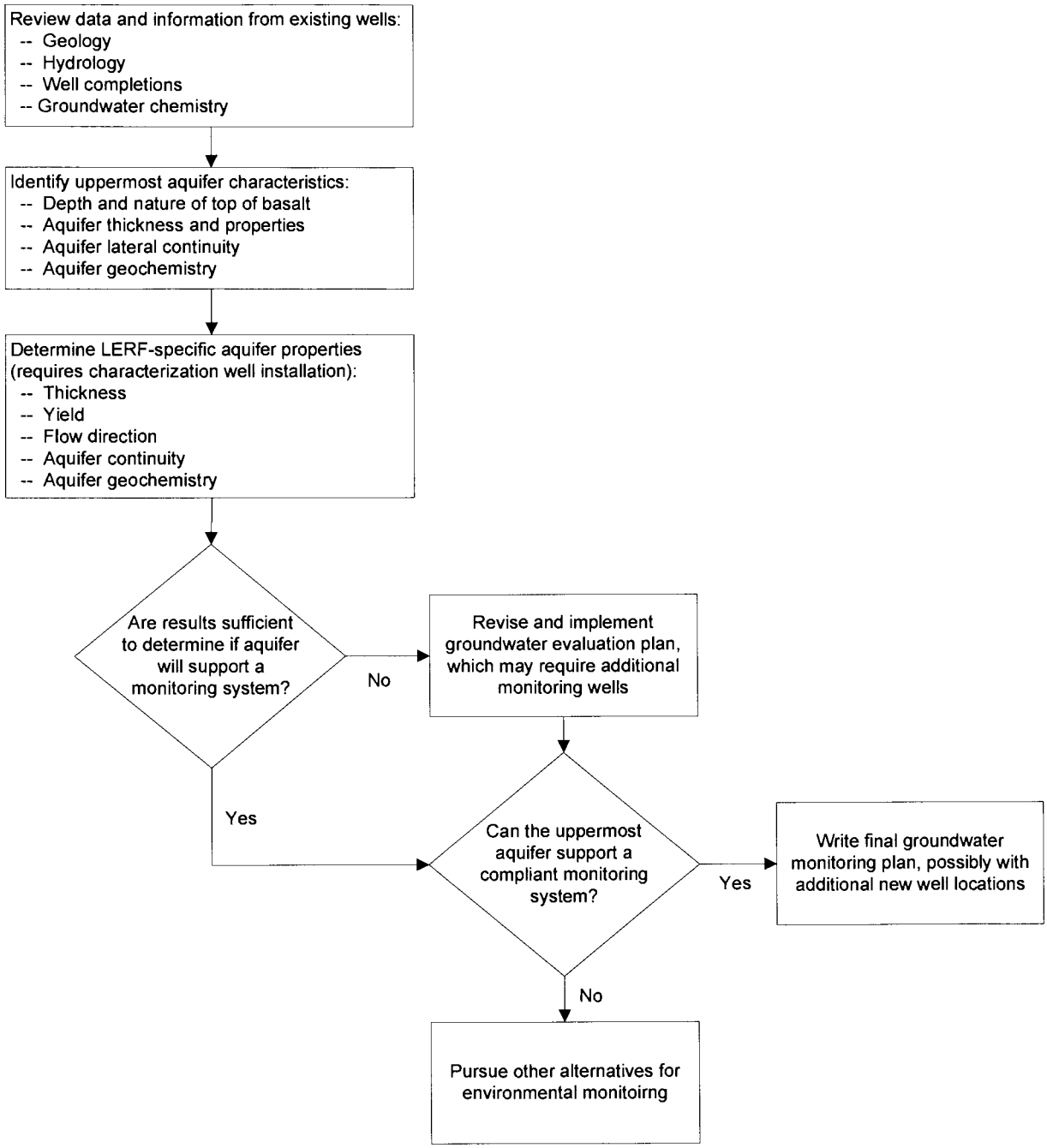

Figure 5-1. General Flow Chart Indicating Characterization and Evaluation Process

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6. Conclusions

The following conclusions can be made based on the outcome of the LERF groundwater evaluation:

- Four study questions were developed and six characterization activities were completed (Section 1).
- The thickness, extent, and continuity of the aquifer are better understood.
- New data support the concept of a multi-formational aquifer, as well as the concept that the unconfined aquifer at the LERF includes not only Hanford formation sediments but also fractured Elephant Mountain Member basalt flow top that forms the basal section of saturated thickness.
- No significant barrier to hydraulic communication was encountered during drilling until very competent basalt was reached approximately 6.1 m (20 ft) into the basalt.
- Groundwater flow rates and directions were determined.
- The permeable basalt portion of the aquifer can support wells for monitoring purposes.
- The evaluation suggests that groundwater data from new wells exhibit characteristics similar to existing wells 299-E26-10 and 299-E26-11:
  - All four wells exhibit a sodium-bicarbonate chemical profile.
  - Wells 299-E26-10 and 299-E26-77 exhibit an overprint of calcium sulfate well in excess of the available calcium sulfate in LERF leachate.
  - Wells 299-E26-10 and 299-E26-77 are completed in different formations within the aquifer; yet the similarity of their chemical signature suggests significant hydraulic communication between the two wells.
- The evaluation suggests that the two new wells, plus the two existing wells, are sufficient to constitute a groundwater monitoring network for the LERF that meets the requirements of WAC 173-303-645.

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Appendix A

Elevation Survey Data for Downgradient Wells

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Stoller
Hanford Office

HGLP-LDR-352, Rev. 0

299-E26-10 (A4799)
Log Data Report

Borehole Information:

Borehole:	299-E26-10	Well ID:	A4799	Site:	South of LERF gate
North	East	Elevation	Depth Reference		Total Depth (ft)
			Top of Casing		205.96

Log Run Information:

Logging System:	Borehole Deviation	Model:	DG69-0901-4 #4654
Effective Calibration	1/21/2008	Calibration Reference:	HGLP-CC-026
		Logging Procedure:	HGLP-PRO-005, Rev. 0

Log Date:	4/6/2009	Engineer:	MJ LEGLER	Start File:	299-E26-10.raw	Finish File:	299-E26-10.rpt

Measured Depth (feet)	Course Inclin. fromVert.	Course Direction (deg)	Closure Direction (deg)	TrueVert. Depth (feet)	Rectangular Coordinates +N/-S	+E/-W	Dogleg Severety °/100 f	Closure Distance (feet)	Vertical Section (feet)
0	0.39	138.4	0	0	0	0	0	0	0
20	0.59	246.4	208.45	20	-0.09	-0.05	4	0.1	-0.1
40	0.18	282.8	234.18	40	-0.13	-0.18	2.3	0.22	-0.1
60	0.26	273.7	245.05	60	-0.12	-0.25	0.4	0.28	-0.1
80	0.81	240.3	246.26	80	-0.18	-0.42	3.1	0.46	-0.2
100	1.1	249	245.84	100	-0.32	-0.72	1.6	0.79	-0.3
120	0.54	241.1	245.98	119.99	-0.44	-0.98	2.8	1.08	-0.4
140	0.73	178.6	240.11	139.99	-0.61	-1.06	3.4	1.22	-0.6
160	1.47	182.5	227.14	159.99	-0.99	-1.07	3.7	1.46	-1
180	1.62	169.6	214	179.98	-1.53	-1.03	1.9	1.84	-1.5
200	2.31	159.8	201.02	199.97	-2.18	-0.84	3.8	2.34	-2.2
206	2.5	161.1	197.32	205.96	-2.42	-0.75	3.2	2.54	-2.4
206	2.5	160.9	197.32	205.96	-2.42	-0.75	3.2	2.54	-2.4

Analysis Notes:

Analyst:	Legler	Date:	4/6/2009

List of Log Plots:

Borehole Deviation

Stoller
Hanford Office

HGLP-LDR-349, Rev. 0

299-E26-77 (C6455)
Log Data Report

Borehole Information:

Borehole:	299-E26-77	Well ID:	C6455	Site:	LERF
North	East	Elevation	Depth Reference		Total Depth (ft)
			Top of Casing		223.92

Log Run Information:

Logging System:	Borehole Deviation	Model:	DG69-0901-4 #4654
Effective Calibration:	1/21/2008	Calibration Reference:	HGLP-CC-026
		Logging Procedure:	HGLP-PRO-005, Rev. 0

Log Date:	4/2/2009	Engineer:	MJ LEGLER	Start File:	299-E26-77.raw	Finish File:	299-E26-77.rpt

Measured Depth (feet)	Course Inclin. from Vert.	Course Direction (deg)	Closure Direction (deg)	TrueVert Depth (feet)	Rectangular Coordinates -N/-S	+E/-W	Dogleg Severety /100 f	Closure Distance (feet)	Vertical Section (feet)
0	0.3	55.3	0	0	0	0	0	0	0
20	0.76	119.1	102.16	20	-0.03	0.16	3.4	0.16	0
40	1.39	90.2	100.94	40	-0.1	0.52	4	0.53	-0.1
60	1.86	95.7	97.03	59.99	-0.13	1.08	2.5	1.09	-0.1
80	3.17	99.8	97.59	79.97	-0.26	1.95	6.6	1.97	-0.3
100	4.17	90.2	96.32	99.93	-0.36	3.22	5.9	3.24	-0.4
120	5.09	87.6	93.81	119.86	-0.32	4.83	4.7	4.84	-0.3
140	6.07	95.3	93.22	139.77	-0.38	6.77	6.2	6.78	-0.4
160	7.13	104.7	95.02	159.63	-0.79	9.03	7.5	9.06	-0.8
180	8.31	111.1	97.99	179.45	-1.63	11.57	7.3	11.69	-1.6
200	8.83	119.3	101.47	199.23	-2.9	14.26	6.6	14.55	-2.9
220	9.28	117.4	104.44	218.98	-4.39	17.04	2.7	17.59	-4.4
225	9.36	117	105	223.92	-4.76	17.76	1.8	18.38	-4.8
225	9.35	116.7	105	223.92	-4.76	17.76	1.8	18.38	-4.8

Analysis Notes:

Analyst:	Legler	Date:	4/2/2009

List of Log Plots:

Borehole Deviation

Stoller
Hanford Office

HGLP-LDR-350, Rev. 0

299-E26-79 (C6826)
Log Data Report

Borehole Information:

Borehole:	299-E26-79	Well ID:	C6826	Site:	LERF (near road by fence)
North	East	Elevation	Depth Reference		Total Depth (ft)
			Top of Casing		218.04

Log Run Information:

Logging System:	Borehole Deviation	Model:	DG69-0901-4 #4654
Effective Calibration Date:	1/21/2008	Calibration Reference:	HGLP-CC-026
		Logging Procedure:	HGLP-PRO-005, Rev. 0

Log Date:	4/2/2009	Engineer:	MJ LEGLER	Start File:	299-E26-79.raw	Finish File:	299-E26-79.rpt

Measured Depth (feet)	Course Incln. from Vert.	Course Direction (deg)	Closure Direction (deg)	True Vert. Depth (feet)	Rectangular Coordinates +N/-S	+E/-W	Dogleg Severity °/100 ft	Closure Distance (feet)	Vertical Section (feet)
0	0.48	99.5	0	0	0	0	0	0	0
20	0.55	73.3	85.48	20	0.01	0.18	1.2	0.18	0
40	1.39	87.6	84.2	40	0.05	0.51	4.3	0.51	0.1
60	2.39	102.9	91.53	59.99	-0.03	1.16	5.6	1.16	0
80	3.85	105.7	97.88	79.95	-0.31	2.21	7.3	2.23	-0.3
100	5.11	117.2	103.79	99.89	-0.9	3.65	7.7	3.76	-0.9
120	7.24	125.4	110.38	119.78	-2.03	5.47	11.5	5.84	-2
140	9.12	136	117.19	139.57	-3.9	7.6	12.1	8.54	-3.9
160	10.5	142.3	123.46	159.28	-6.49	9.82	8.7	11.77	-6.5
180	11.26	146	128.45	178.92	-9.55	12.02	5.1	15.35	-9.5
200	12.06	150	132.5	198.51	-12.98	14.16	5.7	19.21	-13
220	12.86	151.3	135.8	218.04	-16.74	16.28	4.2	23.35	-16.7
220	12.84	151.2	135.8	218.04	-16.74	16.28	4.2	23.35	-16.7

Analysis Notes:

Analyst:	Legler	Date:	4/2/2009

List of Log Plots:

Borehole Deviation

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