CHPRC ADMINISTRATIVE DOCUMENT PROCESSING AND APPROVAL

DOCUMENT TITLE: Groundwater Monitoring Plan for the Liquid Effluent Retention Facility	**OWNING ORGANIZATION/FACILITY:** S&GRP
Document Number: DOE/RL-2013-46	**Revision/Change Number:** 0

DOCUMENT TYPE *(Check Applicable)* [X] Plan [ ] Report [ ] Study [ ] Description Document [ ] Other

DOCUMENT ACTION *(Check One)* [X] New [ ] Revision [ ] Cancellation

RESPONSIBLE CONTACTS

	Name	Phone Number
Author:	G. S. Thomas	509-373-3907
Manager:	W. R. Faught	509-376-3139

DOCUMENT CONTROL

Is the document intended to be controlled within the Document Management Control System (DMCS)? [X] Yes [ ] No

Does document contain scientific and technical information intended for public use? [X] Yes [ ] No

Does document contain controlled-use information [ ] Yes [X] No

DOCUMENT REVISION SUMMARY

NOTE: Provide a brief description or summary of the changes for the document listed.

Initial Release

REVIEWERS **Others**

Name *(print)*	Organization
B. L. Cathel	ESHR
M. J. Hartman	Groundwater Science
F. A. Ruck III	Technical Services
J. G. Douglas	Sample Management

APPROVAL SIGNATURES

Author:		11/19/13	RELEASE / ISSUE
Name: (Print)	G. S. Thomas	Date	
Responsible Manager:		11-19-13	DATE: Nov 20, 2013 HANFORD RELEASE
Name: (print)	W. R. Faught	Date	
Other:			
Name: (print)	R. W. Oldham via email	Date 11/15/2013	
Name: (print)	S. L. Huggins via email	Date 11/14/2013	
Name: (print)	R. C. Brunke via email	Date 11/19/2013	

A-6005-184 (REV 4)

Flannery, Lori K

From: Oldham, Richard W
Sent: Friday, November 15, 2013 6:51 AM
To: Flannery, Lori K
Subject: Approve: DOE/RL-2013-46

Flannery, Lori K

From: Huggins, Stewart L
Sent: Thursday, November 14, 2013 7:28 AM
To: Flannery, Lori K
Subject: Approve: DOE/RL-2013-46

Flannery, Lori K

From: Brunke, Ronald C
Sent: Tuesday, November 19, 2013 2:32 PM
To: Flannery, Lori K
Subject: Approve: DOE/RL-2013-46

Date Received for Clearance Process (MM/DD/YYYY)
11/20/2013

INFORMATION CLEARANCE FORM

A. Information Category

- [ ] Abstract
- [ ] Journal Article
- [ ] Summary
- [ ] Internet
- [ ] Visual Aid
- [ ] Software
- [ ] Full Paper
- [x] Report
- [ ] Other _____

B. Document Number DOE/RL-2013-46

C. Title
Groundwater Monitoring Plan for the Liquid Effluent Retention Facility

D. Proposed Internet Address

E. Required Information (MANDATORY)

1. Is document potentially Classified? (●) No ( ) Yes

William R. Faught
Manager Required (Print and Sign)

If Yes _____
ADC Required (Print and Sign) (●) No ( ) Yes Classified

2. Official Use Only (●) No ( ) Yes Exemption No. ____
3. Export Controlled Information (●) No ( ) Yes OUO Exemption No. 3
4. UCNI (●) No ( ) Yes
5. Applied Technology (●) No ( ) Yes OUO Exemption No. 5
6. Other (Specify) _____

7. Does Information Contain the Following:
   a. New or Novel (Patentable) Subject Matter? (●) No ( ) Yes
      If "Yes", OUO Exemption No. 3
      If "Yes", Disclosure No.: _____
   b. Commercial Proprietary Information Received in Confidence, Such as Proprietary and/or Inventions?
      (●) No ( ) Yes If "Yes", OUO Exemption No. 4
   c. Corporate Privileged Information? (●) No ( ) Yes
      If "Yes", OUO Exemption No. 4
   d. Government Privileged Information? (●) No ( ) Yes
      If "Yes", Exemption No. 5
   e. Copyrights? (●) No ( ) Yes If "Yes", Attach Permission.
   f. Trademarks? (●) No ( ) Yes If "Yes", Identify in Document.
8. Is Information requiring submission to OSTI? (●) No ( ) Yes
9. Release Level? (●) Public ( ) Limited

F. Complete for a Journal Article

1. Title of Journal

G. Complete for a Presentation

1. Title for Conference or Meeting _____
2. Group Sponsoring _____
3. Date of Conference _____
4. City/State _____
5. Will Information be Published in Proceedings? ( ) No ( ) Yes
6. Will Material be Handed Out? ( ) No ( ) Yes

H. Information Owner/Author/Requestor
G. S. Thomas
(Print and Sign)

Responsible Manager
W. R. Faught
(Print and Sign)

Approval by Direct Report to President (Speech/Articles Only) _____
(Print and Sign)

I. Reviewers

	Yes	Print	Signature	Public Y/N (If N, complete J)
General Counsel	[x]	R. T. Swenson	via email 10/19/2013	(Y) / N
Office of External Affairs	[ ]			Y / N
DOE	[ ]			Y / N
Other	[ ]			Y / N
Other	[ ]			Y / N
Other	[ ]			Y / N

J. Comments

Information Clearance Approval

Approved for Public Release; Further Dissemination Unlimited

APPROVED
By Shauna Adams at 2:09 pm, Nov 20, 2013

Flannery, Lori K

From: Swenson, Raymond T
Sent: Tuesday, November 19, 2013 9:24 AM
To: Flannery, Lori K
Subject: Approve: DOE/RL-2013-46

DOE/RL-2013-46
Revision 0

Groundwater Monitoring Plan for the Liquid Effluent Retention Facility

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

CH2MHILL
Plateau Remediation Company
P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2013-46
Revision 0

Groundwater Monitoring Plan for the Liquid Effluent Retention Facility

Date Published
November 2013

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

CH2MHILL
Plateau Remediation Company
P.O. Box 1600
Richland, Washington 99352

APPROVED
By Shauna Adams at 2:10 pm, Nov 20, 2013

Release Approval Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

Addendum D

Groundwater Monitoring Plan

This page intentionally left blank.

Contents

D Groundwater Monitoring Plan, Liquid Effluent Retention Facility D-1

D1 Introduction D-1
D1.1 History of Groundwater Monitoring at the Liquid Effluent Retention Facility D-1
D1.2 Facility Description D-2
D1.3 Physical Structure D-2
D1.4 Operational History D-2
D1.5 Waste Characteristics D-3
D1.6 Basin 42 ..... D-3
D1.7 Basin 43 ..... D-4
D1.8 Basin 44 ..... D-5
D1.9 Potential Contaminate Indicator Parameters in Groundwater D-6
D2 Hydrogeology and Groundwater-Chemistry D-6
D2.1 Geology D-6
D2.2 Groundwater Hydrology D-10
D2.3 Groundwater Chemistry D-14
D2.4 Well Completions and Conditions D-15
D3 Groundwater-Monitoring Program D-16
D3.1 Objectives of Dangerous Waste Groundwater Monitoring and Past Monitoring Results D-17
D3.2 Dangerous Constituents D-17
D3.3 Concentration Limits D-17
D3.4 Groundwater Monitoring System and Point of Compliance D-18
D3.5 Compliance Period D-18
D3.6 Sampling and Analysis D-18
D3.7 Decontamination of Drilling and Sampling Equipment D-20
D3.8 Quality Objectives and Criteria D-20
D3.9 Analytical Procedures D-20
D3.10 Reporting and Recordkeeping D-24
D3.11 Evaluation and Notification D-24
D4 Compliance-Monitoring Program D-25
D5 Corrective-Action Program D-25
D6 References D-25

Figures

Figure D-1. LERF Location Map D-44
Figure D-2. LERF Well and Facility Description Map D-45
Figure D-3. LERF Location Map Showing Revised Unconfined Aquifer Thickness Based on Geophysical and Previous Borehole Data D-47
Figure D-4. Comparison of Sulfate at Wells 299-E34-7, 299-E26-14, and 299-E26-10 ..... D-49
Figure D-5. History of Total Organic Carbon and Nitrate at Well 299-E34-7 ..... D-49
Figure D-6. Comparison of Carbon Tetrachloride to Total Organic Halides D-50
Figure D-7. Comparison of Carbon Tetrachloride to Total Organic Carbon D-50
Figure D-8. Seismic Profile North of LERF extending from Well 299-E35-2 to Well 299-E26-11 and Including Well 299-E26-11 ..... D-51
Figure D-9. Conceptual Model of Buried Paleochannels Extending Through Gable Gap D-53
Figure D-10. Seismic Profile South of LERF with Focus on Area between Wells 299-E26-10 and 299-E26-11 ..... D-55
Figure D-11. Three Dimensional View from East of LERF Looking West-Northwest into the Soil Column D-57
Figure D-12. Three Dimensional View from East of LERF Looking West-Northwest into the Soil Column D-58
Figure D-13. West to East Geologic Cross Section Just North of LERF D-59
Figure D-14. West to East Geologic Cross Section Just South of LERF D-60
Figure D-15. AQTESOLV Moench Unconfined Aquifer Pumping/Recovery Test for Type-Curve Match to Well 299-E26-14 with Wellbore Skin Affects and Delayed Gravity Response D-61
Figure D-16. AQTESOLV Neuman Unconfined Aquifer Pumping/Recovery Test for Type-Curve Match to Well 299-E26-14 with Delayed Gravity Response D-62
Figure D-17. AQTESOLV Springer-Gelhar Critically Dampened Type-Curve Match to Well 299-E26-77 Second Slug Withdraw Test November 18, 2008 ..... D-63
Figure D-18. Comparison of Sulfate Concentration Results in Wells 299-E26-10, 299-E26-14, and 299-E26-79 ..... D-64
Figure D-19. History of Sulfate Increases in Wells 299-E26-10, 299-E26-77, and 299-E34-7 ..... D-64
Figure D-20. 2008 and 2013 Regional Sulfate Plume D-65
Figure D-21. Comparison of Sulfate Increases in Wells 299-E26-10, 299-E26-11, and 299-E34-7 ..... D-66
Figure D-22. Historical View of Changing Groundwater Conditions Beneath the Vicinity of LERF D-67
Figure D-23. Well Construction Diagram for Well 299-E26-10 in LERF Groundwater Monitoring Network D-69
Figure D-24. Well Construction Diagram for Well 299-E26-11 in the Past LERF Groundwater Monitoring Network D-70
Figure D-25. Well Construction Diagram for Well 299-E26-14 in LERF Groundwater Monitoring Network D-71
Figure D-25. Well Summary Sheet for Well 299-E26-14 in the LERF Groundwater Monitoring Network (Cont.) D-72

Figure D-26. Well Summary Sheet for Well 299-E26-77 in LERF Groundwater Monitoring Network D-73
Figure D-26. Well Summary Sheet for Well 299-E26-77 in LERF Groundwater Monitoring Network (Cont.) D-74
Figure D-27. Well Summary Sheet for Well 299-E26-79 in LERF Groundwater Monitoring Network D-74
Figure D-27. Well Summary Sheet for Well 299-E26-79 in LERF Groundwater Monitoring Network (Cont.) D-75
Figure D-28. Proposed LERF Well and Facility Description Map D-77

Tables

Table D-1. Constituent Results for 242-A Process Condensate Characterization Results and Basin 42 Characterization Results D-29
Table D-2. Basin 43 Constituent Characterization Results for Past 200-UP-1 and 200-ZP-1 Groundwater Waste Streams and Recent Waste Characterization Results For Basin 43 . D-33
Table D-3. ERDF Leachate D-35
Table D-4. LERF Well Attributes D-37
Table D-5. LERF Groundwater Gradient and Magnitude Calculations D-38
Table D-6. Geochemical Constituent Evaluation for Groundwater D-39
Table D-7. Dangerous Constituents and Indicators to be Analyzed as Indicators of Groundwater Contamination at the LERF Basins D-39
Table D-8. Quality Control Samples D-39
Table D-9. Preservation Techniques, Analytical Methods Used, and Current Required Quantitation Limits for Chemical Constituents D-40
Table D-10. Field and Laboratory Quality Control Elements and Acceptance Criteria D-41
Table D-11. Blind-Standard Constituents and Schedule D-43

Terms

bgs	below ground surface
Cr(VI)	hexavalent chromium
CRDL	contract-required detection limit
DQO	data quality objective
EB	equipment blank
Ecology	Washington State Department of Ecology
EMB	Elephant Mountain Member of the Saddle Mountains Basalt
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FTB	full trip blank
FXR	field transfer blank
GC	gas chromatography
HDPE	high-density polyethylene
ICP	inductively coupled plasma
HEIS	Hanford Environmental Information System
KGS	Kansas Geological Survey
LCS	laboratory control sample
LERF	Liquid Effluent Retention Facility
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
OU	operable unit
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RPD	relative percent difference
TBD	to be determined
TOC	total organic carbon
TOX	total organic halides
UPR	unplanned release
XRF	X-ray fluorescence

D Groundwater Monitoring Plan, Liquid Effluent Retention Facility

This document describes a groundwater monitoring program for the Liquid Effluent Retention Facility (LERF) (Figure D-1). LERF is a regulated unit under RCW 70.105, "Hazardous Waste Management," and is subject to groundwater monitoring requirements pursuant to WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

D1 Introduction

This plan describes the LERF groundwater monitoring program, including the monitoring network, constituent list, sampling schedule, sampling and analysis protocols, and data evaluation and reporting methods for LERF groundwater monitoring. Four monitoring wells at LERF (299-E26-10, 299-E26-14, 299-E26-77, and 299-E26-79) provide a monitoring network for establishing the groundwater gradient, and two monitoring wells (299-E26-14 and 299-E26-79) provide upgradient-downgradient comparisons for detection monitoring, respectively (Figure D-2).

D1.1 History of Groundwater Monitoring at the Liquid Effluent Retention Facility

A four-well groundwater monitoring program was established at LERF in 1990 before final construction of the regulated unit. One well (299-E26-11) was completed to the east of LERF as an upgradient monitoring well, and three wells (299-E26-9, 299-E26-10, and 299-E35-2) were completed west of LERF as downgradient monitoring wells. Well 299-E26-77, a replacement well for well 299-E26-9, was located approximately 5 m (15 ft) to the southeast of well 299-E26-9 and because of the scale for Figure D-2, only well 299-E26-77 is identified. Samples were collected quarterly from the four monitoring wells, and evaluation of indicator parameters began before waste was transferred to the basins. Analytes listed in Appendix III, "EPA Interim Primary Drinking Water Standards," of 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring," were sampled to establish the suitability of the groundwater as a drinking water supply, as well as several other site-specific constituents the first year of sample collection. Total organic carbon (TOC), total organic halides (TOX), pH, and specific conductivity (indicator parameters) also were analyzed during the first year to derive upgradient/downgradient comparison values for these parameters based on requirements of 40 CFR 265, Subpart F. Detection monitoring continued on a semiannual schedule. Two wells, 299-E26-9 and 299-E35-2, could no longer yield representative samples of groundwater in 1999 and 2001, respectively, due to declining water levels. As a result, inter-well statistical evaluation of LERF groundwater monitoring data has not been performed since 2001. Sampling continued at former downgradient well 299-E26-10 and former upgradient well 299-E26-11. Wells 299-E26-77 and 299-E26-79 were drilled and completed in 2008 to define the aquifer flow rate, flow direction, and hydrogeologic conditions (SGW-41072, *Liquid Effluent Retention Facility Characterization Report*) (Figure D-2). These wells are located west and south of LERF, respectively, and were sampled concurrently with existing wells beginning in January 2009. Water level measurements, after incorporation of the two new wells, demonstrated two different flow conditions, westerly when incorporating well 299-E26-11 and more southerly when data for well 299-E26-11 are not incorporated (SGW-41072). Because of the uncertainty in flow direction, another well, 299-E26-14, was installed north of LERF to clarify current groundwater flow direction. A geophysical investigation was employed to target the best hydraulic location for well 299-E26-14 as discussed further in Section D2.1.1 (Figure D-3). In September 2011, well 299-E26-14 was installed. After two years of water level measurements using well 299-E26-14 and the three other wells (299-E26-10, 299-E26-77, and 299-E26-79), the flow direction was considered southward (discussed further in Section 2.2.2). Various chemical analyses were completed over the past two years to provide an upgradient baseline for dangerous waste constituents specified in this permit.

D1.2 Facility Description

The following subsections provide an overview of the physical structures, operational history, and waste characteristics of LERF. Additional details are provided in Addendum B (Waste Analysis Plan) and Addendum C (Process Information).

D1.3 Physical Structure

LERF is located in the central portion of the Hanford Site on the eastern boundary of the 200 East Area (Figure D-1). Construction of LERF was completed in 1991. The LERF basins consist of three dangerous waste management units classified as surface impoundments: Basins 42, 43, and 44 (Figure D-2). The LERF design uses a dual confinement barrier concept (i.e., dual basin liners and pipe-in-a-pipe transfer piping system) to minimize human exposure and potential for accidental releases to the environment. A leachate detection, collection, and removal system and basin covers are designed to reduce possible environmental or personnel exposures. The leachate detection system is monitored, as required, by the LERF-Effluent Treatment Facility (ETF) permit conditions and Addendum I.

LERF is a 15.8 ha (39 ac) site with three 2.9×10^7 L (7.8 million gal) capacity basins (Figure D-2). The basins are arranged side by side with 18.2 m (60 ft) separations between each basin. The dimensions of each basin (cell) are 100.5 by 82.2 m (330 by 270 ft), with a maximum fluid depth of 6.7 m (22 ft). The side slopes of the basin have a slope ratio of 3:1.

The primary liner for each basin is a 60 mil, high-density polyethylene (HDPE) geomembrane laid directly over a manufactured geotextile/bentonite carpet layer. The secondary liner is also a 60 mil HDPE geomembrane laid directly on 0.9 m (36 in.) of a soil/bentonite mixture. The liners are separated by a synthetic drainage geonet laid on the sides of the basins, with 0.3 m (12 in.) of drainage gravel at the bottom. The sides slope to a sump, which is pumped when the liquid level reaches approximately 28 cm (11 in.) and shuts off when it drops to 18 cm (7 in.). Each basin has a mechanically tensioned cover of very low density polyethylene construction, which is anchored to the perimeter concrete ring wall of the basins with batten plates.

D1.4 Operational History

LERF was constructed for interim storage and treatment for aqueous waste streams prior to final treatment in the 200 Area ETF. Treatment at LERF consists of flow and pH equalization. The flow equalization allows for several smaller waste streams that are intermittently received at the LERF basins to accumulate for continuous higher volume campaign processing at ETF. The pH equalization allows for a uniform wastewater to optimize ETF process campaigns.

LERF began receiving process condensate from the 242-A Evaporator in 1994. In 1995, several new liquid waste feeds were identified for treatment at LERF. These waste streams included Environmental Restoration Disposal Facility (ERDF) leachate, purge water from groundwater monitoring, B Plant waste, and 200-UP-1 groundwater remediation. Between 2000 and 2013, the majority of the liquid waste received at LERF was associated with the following in descending order: 200-UP-1/200-ZP-1 groundwater (181.4 million gal), ERDF leachate (16 million gal), process condensate from the 242-A Evaporator (7.3 million gal), Mixed Waste Burial Trenches leachate (2.9 million gal), K Basins (1.9 million gal), and purge water (1.8 million gal).

Projected ETF influent waste streams for 2010 through 2028 are presented in HNF-23142, *Engineering Study for the 200 Area Effluent Treatment Facility Secondary Waste Treatment of Projected Future Waste Feeds*.

D1.5 Waste Characteristics

As a unit of LERF, the 200 Area ETF was designed to treat a variety of aqueous wastes containing both chemical and radiological contaminants. This aqueous waste is collected in the three LERF basins before transfer to ETF for efficient operations. Before a liquid waste can be transferred to ETF or LERF by a waste generator, a waste profile of the subject waste must be developed. This waste profile is compared against the ETF/LERF acceptance criteria, as explained in Addendum B, "Waste Analysis Plan." Waste streams that have been approved are also periodically re-evaluated for waste characteristics. The results of these periodic re-evaluations (provided in this subsection) help identify reliable chemical contaminants that can be used as or for additional indicator parameters for detection monitoring (as described in WAC 173-303-645(9)(a)). Waste characteristics for liquid effluents that have been historically stored in the three LERF basins (Basins 42, 43, and 44) are provided in the following subsections.

D1.6 Basin 42

Various aqueous waste streams feed Basin 42; however, the 242-A Evaporator waste stream has been the largest volume waste stream associated with Basin 42. Over the past 13 years (1999 through 2012), the liquid volume associated with the 242-A Evaporator waste was 10 times that of any other waste streams sent to Basin 42. Maximum concentration limits for the 242-A Evaporator waste stream during initial startup were provided in WHC-SD-W105-SAR-001, *Final Safety Analysis Report 242-A Evaporator Liquid Effluent Retention Facility*. When the maximum concentrations for the 242-A Evaporator waste stream (Table 9.6 of WHC-SD-W105-SAR-001) were compared with the average contaminant concentration levels (2009 through 2010 weighted average liquid concentrations) in Basin 42 (Table D-1), nearly all of the average Basin 42 concentrations were lower. Constituents with greater concentrations were limited to two anions (chloride and sulfate), one cation (calcium), and four trace metals (barium, manganese, uranium, and zinc). These constituents appear to be associated with other waste streams such as the Mixed Waste Trenches 31 and 34 leachate and Hanford Site purge water which had the second and third largest waste streams by volume. The other 17 waste streams associated with Basin 42 make up approximately 2 percent of the volume.

The makeup of Basin 42 is similar to the groundwater wells upgradient of the Hanford Site or regional background groundwater concentrations, except for alkalinity, nitrogen, and sulfate. A comparison between Basin 42 wastewater and upgradient Hanford Site wells can be seen in the appropriate Table D-1 columns (e.g., 2009 Basin 42 Characterization Results and Basin 42 Average versus Regional Background Concentration of Table D-1). In general, regional groundwater background concentrations are similar to groundwater concentrations beneath LERF, except for anions. Although Basin 42 and groundwater beneath Basin 42 share a common suite of elevated constituents (anions), the source of the elevated anions in the groundwater is from a crossgradient/upgradient groundwater location. The crossgradient/upgradient groundwater location is shown by historical groundwater results at well 299-E34-7 prior to the start of LERF and more recently at the LERF upgradient well 299-E27-14 (Figure D-4). By comparison, the average concentration[1] of sulfate in Basin 42 (55.6 mg/L) is much less than the historical sulfate concentration at well 299-E34-7 of 671 mg/L (sample date 4/3/2003). Even characterization results from Basins 42, 43, and 44 (Tables D-1, D-2, and D-3) do not compare with the maximum groundwater results at well 299-E34-7. The same is true for nitrate in Basin 42 as compared with nitrate at the crossgradient/upgradient well 299-E34-7. Only the contributions of the 200-BP-5 perched water waste streams from Basin 43 and ERDF leachate exceed the groundwater results at well 299-E34-7. However, because of the nature of the elevated groundwater results at well 299-E34-7, including elevated TOC, and the relationship to past unplanned releases (UPRs) near well 299-E34-7

[1] All concentrations are reported as a weighted average.

(e.g., UPR-200-E-32 associated with the 216-B-2-1 Ditch and UPR-200-E-138 associated with the 216-B-2-2 Ditch [Figure D-1]), the elevated groundwater results at well 299-E34-7 appear to be from a source other than LERF (Figure D-5). The UPRs (e.g., UPR-200-E-32 and UPR-200-E-138) were associated with B Plant fractionation waste that had significant levels of nitrate, sulfate, and organic carbon. The nature of these UPRs appears more characteristic of the levels reported at well 299-E34-7. Well 299-E26-10, located to the west of LERF, appears to mimic the historical results at well 299-E34-7 (Figure D-4). As the nitrate and sulfate concentrations decrease over time, if concentrations follow the earlier trends at well 299-E34-7, these constituents may become more appropriate as indicator parameters at LERF. However, the concentration of these constituents in LERF Basins would not be distinguishable from current groundwater conditions beneath LERF. Because nitrate and sulfate may become more appropriate indicator parameters in the future, they will serve currently as groundwater quality parameters at the LERF monitoring wells. Because specific conductance is an indicator of nitrate and sulfate changes, specific conductance will be added as an indicator parameter for documentation of local changes and comparison between the upgradient and downgradient monitoring wells.

None of the toxicity characteristic of dangerous waste constituents received by Basin 42 exceed toxicity characteristics list threshold values (WAC 173-303-090(8)(c), “Dangerous Waste Regulations,” “Dangerous Waste Characteristics”). Six of the potentially dangerous waste metal constituent results in the basin were above groundwater background levels (Table D-1): chromium, copper, lead, mercury, nickel, and thallium. Although the results are above the groundwater background levels, the results would not be detectable at groundwater compliance points should there be a potential release into the upper aquifer because of the low waste stream concentrations and dispersive effect associated with infiltrating waste into the groundwater.

There were low levels of organics found in Basin 42 with 1-butanol (288 µg/L) having the highest weighted average. The chemical nature of 1-butanol (e.g., rapidly degrades in water and has a relatively high detection level 100 µg/L) makes this constituent an unlikely indicator parameter.

In conclusion, no reliable waste constituent indicator parameters are presently available for Basin 42 groundwater detection.

D1.7 Basin 43

The largest volume of waste waters received by Basin 43 was the contaminated groundwater from the 200-UP-1/200-ZP-1 operable units (OUs) groundwater pumping systems (Table D-2). The 200-UP-1/200-ZP-1 OUs waste stream had 20 times more volume sent to LERF than the next closest waste stream (ERDF leachate) over the past decade and a half. The 200-UP-1/200-ZP-1 OUs groundwater effluent waste characteristics are contained in Table D-2. Tables D-2 and D-3 provides characteristics of the ERDF leachate. Table D-2 provides characteristics of ERDF leachate in Basin 43 in 2012 after receipt of the 200-UP-1/200-ZP-1 OUs groundwater effluent waste was terminated, and Table D-3 provides the average ERDF leachate characterization results for Basin 44 from 2000 through September 2011. Overall, the waste characteristics in Basin 43 are most comparable to the waste streams from 200-UP-1/200-ZP-1 OUs groundwater pumping systems because of its significant volume compared with the other waste streams.

The 200-UP-1/200-ZP-1 OUs waste streams have a makeup similar to the groundwater well results near sources of B Plant liquid effluent disposal sites. These sites received and disposed of metal waste, uranium recovery waste, and cesium and strontium scavenging waste which have infiltrated into the aquifer. The highest ionic results are associated with nitrogen. The Basin 43 weighted average concentration was 101 mg/L (nitrogen in nitrate) compared to 10 mg/L in the groundwater beneath LERF. Some of the other waste streams (e.g., ERDF leachate and 200-BP-5 perched water) received at Basin 43

also exceeded regional background groundwater results for chloride, nitrogen, and sulfate, with concentrations as great as 224 mg/L, 220 mg/L, and 597 mg/L, respectively (Table D-2). However, these constituents are not likely to be distinguishable from current groundwater conditions beneath LERF, mainly because of the concentration of these constituents in the groundwater at crossgradient/upgradient locations to LERF, as discussed in Section D1.5.1. As also discussed in Section D1.5.1, as the groundwater concentrations from the crossgradient/upgradient direction decrease, these constituents may become more appropriate as indicator parameters at LERF. Because nitrate and sulfate may become more appropriate indicator parameters in time, they will serve currently as groundwater quality parameters at LERF monitoring wells. Because specific conductance is an indicator of nitrate and sulfate changes, specific conductance will be added as an indicator parameter for documentation of the expected local changes and comparison between the upgradient and downgradient monitoring wells.

None of the toxicity characteristic dangerous waste constituents received by Basin 43 exceed the toxicity characteristics list threshold values (WAC 173-303-090(8)(c)). However, several of the potentially dangerous waste metal constituent results for the basin were above groundwater background levels. Even so, the results appear too low to determine should a potential release reach the aquifer because of the scattering effect associated with infiltrating liquid waste effluents through the vadose zone into the groundwater. However, it may be possible to differentiate hexavalent chromium (Cr(VI)). This constituent will need to be monitored semiannually for two years to develop a local background basis before potentially adding it as an indicator parameter. Total chromium is not a reliable indicator parameter because of the potential concentrations associated with casing corrosion.

Of the 49 volatile and semivolatile constituents, analyzed at various frequencies from 2008 to 2011 for liquid wastes sent to Basin 43, only 3 (carbon tetrachloride, chloroform, and trichloroethene) were detectable. The most significant constituent was carbon tetrachloride, with concentrations ranging between 190 and 800 µg/L. The other two constituents had concentrations less than 10 µg/L. Since carbon tetrachloride is not normally occurring in the groundwater, it should be an excellent indicator parameter. TOC ranged between 0.3 and 2.45 mg/L for liquid waste in Basin 43. The concentrations do not appear to be significant enough to differentiate a groundwater quality impact should a release occur. TOC analyses are subject to a wide range of variability and can lead to a false positive error. A more valid indicator of carbon tetrachloride is TOX (Figures D-6 and D-7). Although not analyzed for in Table D-2, this indicator parameter has a lower level of detection than TOC, and, as shown in Figures D-6 and D-7, mimics the carbon tetrachloride level better than TOC. Thus, detection of both indicators (carbon tetrachloride and TOX) would be conclusive of a dangerous waste constituent impact. As a result, TOX and carbon tetrachloride will be added as indicator parameters for the LERF monitoring network.

D1.8 Basin 44

Basin 44 has received liquid waste dominated by ERDF leachate (7 million gal or 60 percent by volume). Other liquid waste streams include K Basin waste (1.9 million gal or 16 percent by volume), leachate from double-lined burial trenches, Mixed Waste Trenches 31 and 34 located in the 218-W-5 Burial Ground (1.2 million gal or 10 percent by volume), and purge water from well development (1.1 million gal or 10 percent by volume). The purge water and Mixed Waste Trenches 31 and 34 waste streams are lower in all constituents as compared with ERDF leachate. Therefore, waste in Basin 44 is most similar to the ERDF leachate because of volume and concentration.

ERDF waste streams are similar to groundwater well results downgradient from B Plant liquid effluent disposal sites. The most comparable results are associated with chloride, nitrate, and sulfate. The average concentrations were 250 mg/L, 327 mg/L, and 474 mg/L, respectively (Table D-3). However, these constituents are not likely to be distinguishable from current groundwater conditions beneath LERF, mainly because the concentration of these constituents are already present in the groundwater at similar

concentrations both crossgradient and upgradient of LERF, as discussed in Section D1.5.1. As also discussed in Section D1.5.1, as the groundwater concentrations from the crossgradient/upgradient direction decrease, these constituents may become more appropriate as indicator parameters at LERF. Because nitrate and sulfate may become more appropriate indicator parameters in time they will serve currently as groundwater quality parameters at the LERF monitoring wells. Because specific conductance is an indicator of nitrate and sulfate changes, specific conductance will be added as an indicator parameter for documentation of the expected local changes and comparison between the upgradient and downgradient monitoring wells.

None of the toxicity characteristic dangerous waste constituents received by LERF exceed the toxicity characteristics list threshold values (WAC 173-303-090(8)(c)). Several of the potentially dangerous waste metal constituents received at LERF were above groundwater background levels (Table D-3). Nevertheless, the results would not show a measurable difference should a potential release to the aquifer occur because of the low waste stream concentrations and the scattering effect associated with infiltrating of liquid waste effluents through the vadose zone into the groundwater.

The organic chemical analytical results associated with Basin 44 were at very low levels (<5 µg/L) and were only periodically detected. Therefore, the ability to detect a potential release in the aquifer for organic chemicals is not practicable for the same reason as discussed for the metals and anions. TOC averaged 13.2 mg/L in Basin 44. TOC concentrations seem to be correlated with the elevated oil and grease results. Because oil and grease are viscous, TOC does not appear to be a good indicator parameter. The concentrations do not appear significant enough to be detectable in groundwater should a release occur. As noted previously, TOC analyses are subject to a wide range of variability and can potentially lead to a false positive error.

In conclusion, no reliable waste constituent indicator parameters are presently available for Basin 44 groundwater detection.

D1.9 Potential Contaminate Indicator Parameters in Groundwater

Based on the projected LERF influent waste streams and concentration levels from 2010 through 2028 as presented in HNF-23142, there does not appear a significant change in waste streams expected. Thus, the indicator parameters identified above appear to be sufficient for future detection monitoring at LERF. From review of the waste stream characterization data for Basins 42, 43, and 44, one additional indicator parameter (carbon tetrachloride) has been identified as a reliable indication of the presence of a potential dangerous waste constituent release into the groundwater. Another potential indicator parameter may be Cr(VI), based on local background results collected during 2014 through 2016.

D2 Hydrogeology and Groundwater-Chemistry

This section describes the geology, hydrogeology, and groundwater chemistry beneath the LERF area. To date, seven wells have been installed for monitoring the groundwater quality beneath the LERF basins. Table D-4 provides the well attributes for reference when reviewing this section.

D2.1 Geology

The geology near LERF consists of Columbia River Basalt overlain by a series of sedimentary units of the Ringold Formation and Hanford formation. The interpretations are based on information from the following sources:

- *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington* (BHI-00184)

- *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington* (PNNL-12261)
- *Hydrogeologic Model for the Gable Gap Area, Hanford Site* (PNNL-19702)
- *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), FY 2008* (SGW-39344)
- *Liquid Effluent Retention Facility Characterization Report* (SGW-41072)
- *Landstreamer/Gimbaled GeoPhone Acquisition of High Resolution Seismic Reflection Data North of the 200 Area – Hanford Site* (SGW-43746)
- *Borehole Summary Report for the Installation of Two RCRA Groundwater Monitoring Wells in the 200 Areas, FY2011* (SGW-51467)
- *Seismic Reflection Investigation at the Liquid Effluent Retention Facility, 200 East Area, Hanford Site Richland, Washington* (SGW-52162)
- *Integrated Surface Geophysical Investigation Results at Liquid Effluent Retention Facility, 200 East Area, Hanford, Washington* (SGW-52467)
- *Site Characterization Report for the Liquid Effluent Retention Facility* (WHC-SD-EN-EV-024)
- *Borehole Completion Data Package for the Liquid Effluent Retention Facility* (WHC-MR-0235)

LERF lies in the Pasco Basin, between the axis of the Umtanum-Gable Mountain anticlinal ridge and the axis of the Cold Creek syncline. The terrain surrounding the LERF basins is flat to slightly undulating, and the average elevation is approximately 182 to 184 m (597 to 604 ft) above mean sea level.

The stratigraphy beneath LERF was interpreted from geologic observations during the drilling of seven boreholes, select analyses of sediment samples, aquifer tests, and geophysical investigations over the past two decades. The three principal stratigraphic units present near LERF, in ascending order, are the Elephant Mountain Member of the Saddle Mountains Basalt (EMB), the Ringold Formation, and the Hanford formation. The thickness of the suprabasalt sediments near the LERF basins ranges from 60 to 69 m (198 to 225 ft).

D2.1.1 Elephant Mountain Member

The nature and extent of the EMB, one of the youngest members of the Saddle Mountains Basalt and the uppermost basalt in this area, is based on result of observations and documentation of archive samples collected during drilling, X-ray fluorescence (XRF) analysis, seismic analyses, and hydraulic tests performed within the upper basalt flow top. The EMB in this area was characterized in WHC-SD-EN-EV-024 as consisting of only the oldest EMB flow (Elephant Mountain I). This flow is generally continuous throughout the area, with a thickness ranging from approximately 12 m (39 ft) where partially eroded, to greater than 35.1 m (115 ft) north of the 200 East Area. The EMB I flow contains three intraflow structures: colonnade, entablature, and flow top. The colonnade makes up the bottom third of the flow. The upper part of the colonnade grades from moderate- to well-developed columns into a platy cross-fractured colonnade and then into a hackly entablature. The entablature has numerous, irregular cross-fractures, vertical fractures, and small scattered vesicles near its top. The flow top is characterized by abundant vesicles and is brecciated and/or palagonitic (WHC-SD-EN-EV-024).

Observations during drilling near the LERF basins, when initially encountering the EMB surface, were described in WHC-MR-0235 as reddish weathered basalt with vesicles partially filled, except in

wells 299-E26-9 and 299-E26-10, located to the west. However, well 299-E26-77, located next to well 299-E26-9, was reported with heavy weathering and the presences of vesicles (SGW-41072). The drilling rate was moderate through the upper EMB to a depth of 2 to 3 m (6.5 to 9.8 ft) when drilling wells 299-E26-77 and 299-E26-79, respectively (SGW-39344). It was concluded in SGW-41072 that hydraulic communication of the uppermost aquifer (e.g., unconfined) extends from the suprabasalt sediments into the basalt, at least in the western half of LERF, because there was no impediment associated with the overlying Hanford formation sediments. The thickness of the flow top was interpreted to range from 2 m (6.5 ft) at well 299-E26-77 (west of LERF) to 3.2 m (10.5 ft) at well 299-E26-79 (south of LERF), and 1.5 m (5 ft) at well 299-E26-11 (east of LERF).

The EMB surface expression in the immediate vicinity of the LERF basins forms a depression centered at the newest well 299-E26-14 (Figure D-3). The contours presented in Figure D-3 are based on a combination of basalt contact during drilling and various geophysical investigations (e.g., seismic reflection and refraction, electrical resistivity, and time-domain electromagnetic sounding). Seismic results to the east and west of well 299-E26-14 portray limited aquifer conditions above the basalt (Figure D-8). Paleochannels are interpreted to the north and northwest of well 299-E26-14 and continued to the south-southeast, as displayed in Figures D-3 and D-9. Seismic reflection results suggest an even deeper depression to the east of well 299-E26-79, centered almost directly south of Basin 43, with as much as 8 m (26 ft) of aquifer thickness (Figure D-10, black line in figure provides the interpreted top of basalt). Continuing east of this depression to the south of LERF, the basalt surface is interpreted to rise to the current water table level. The apparent contact with the water table is estimated to be just south of the west boundary of Basin 44. Further east, the basalt is interpreted to plateau beyond well 299-E26-11. West of well 299-E26-79, the basalt surface is interpreted to increase in elevation linearly to the elevation of 121.3 m (398 ft) at well 299-E26-10. Finally, Figure D-11 provides an angle view of the well casing extensions from ground surface to basalt in the LERF area and to the west/northwest, including remnant Ringold Unit A sediments and groundwater extent above basalt. The depiction of the groundwater implies flow through the basalt flow top as discussed further in Section D2.2. Figure D-12 provides an interpretation of the basalt surface and Ringold sediments without the groundwater overlay.

D2.1.2 Ringold Formation

The Ringold Formation represents ancient fluvial and lacustrine deposits associated with the ancestral Columbia River, and the formation exhibits consolidation and weathering. Where present, this Formation overlies the EMB (Figure D-12). According to WHC-SD-EN-EV-024, remnant muds associated with the Ringold period exist to the east and northwest of the LERF site at wells 299-E26-11 and 299-E35-2, respectively. *200 East Groundwater Aggregate Area Management Study Report* (DOE/RL-92-19) reported approximately 2.74 m (9 ft) of the Ringold Lower Mud Unit in well 299-E26-11 and mapped the Lower Mud Unit extending to this location from the east. BHI-00184 identified the Ringold muds east of the 200 East Area as paleosol-overbank deposits. WHC-SD-EN-EV-024 concluded that the sediment layer was a paleosol based on XRF analysis. BHI-00184 states that pedogenically altered silt- and clay-rich overbank-paleosol (facies association III) deposits of the Ringold Formation are easily distinguished from the basalt-rich sand and gravel of the Hanford formation. In 2000, PNNL-12261 defined the sediments near well 299-E26-11 hydraulically as the Ringold Formation Unit A and, more specifically, the hydrogeologic unit 9C (Figure D-12).

The Ringold sediment at well 299-E26-11, as described in WHC-MR-0235, consists of a slightly gravelly sandy mud (5 percent gravel, 30 percent sand, and 65 percent mud). The color was reported as very dark grayish brown (10YR3/2). The gravel content was described as 90 percent mafic, and the sand content was 50 percent mafic. The sediments had no reaction to hydrochloric acid.

During drilling of the new well 299-E26-14, low permeability sediments were encountered at 65.5 to 66.1 m (215.5 to 217 ft) below ground surface (bgs). The sediments were described as 95 percent silt and 5 percent gravel. Photographic review of this sediment layer, presented in SGW-51467, showed a distinct texture and color change from the overlying Hanford sandy gravels. The reddish brown hue and yellow tints associated with this layer correlate well with the distal overbank description provided in BHI-00184. Other characteristics associated with this layer included no reaction to hydrochloric, similar to Ringold sediments described at well 299-E26-11. An alternative explanation may be that the apparent Ringold sediments are rework, removed from one location and deposited at this location, possibly associated with cataclysmic glacial fluvial floods.

Most of the area beneath LERF is considered devoid of Ringold sediments because of the high energy scouring associated glacial fluvial flooding in the Pleistocene and the lack of reflectors in the suprabasalt section during 2011 seismic data reviews. PNNL-19702 presents a conceptual model of various paleochannels originating to the northwest (Figure D-9). Some of these paleochannels may have been formed during Ringold times, and isolated remnants of Ringold sediments are sometimes found within these older paleochannels.

D2.1.3 Hanford Formation

The Hanford formation near LERF ranges in thickness from approximately 59 to 66 m (193 to 215 ft) or more (Figures D-13 and D-14). The texture of the Hanford formation is loose to weakly cemented, sandy, pebble-cobble gravels to gravelly sand, with occasional layers of sand and/or muddy sand. Regionally, the Hanford formation is subdivided into an upper gravel sequence (H1), a sandy sequence (H2), and a lower gravel sequence (H3). The sandy sequence is present locally and, where it is missing, a single sequence of gravel-dominated facies exists, which is undifferentiated in cross-sections.

LERF is located along the southern flank of a major west-northwest/east-southeast trending cataclysmic flood channel. Because of multiple flood events and the turbulence and extremely high energy associated with these floods, it is difficult to correlate individual strata within flood sequences. In outcrops of the Hanford formation elsewhere in the Pasco Basin, for example, it is common to see changes from gravel-dominated sediments to sand and silt-dominated sediments over a distance of a few tens of meters.

In general, more silt or mud was present to the west and east than north or south of the LERF basins based on geologic logs for the seven wells drilled within the LERF vicinity. However, high silt and clay content to the north and south of LERF is present near the contact with the EMB within the aquifer. These silt and clay layers ranged in thickness between 0.3 to 1.5 m (1 to 5 ft) and appear to be of Ringold age as discussed in D.2.1.2. The basalt content in layers above the silt and clay indicates Hanford origin. Above these initial layers, the gravel content was generally about 60 percent, consisting of 40 to 70 percent mafics. Significantly more cobbles were described in the north and south boreholes than to the east and west throughout the borehole log descriptions. The grayish brown to very dark grayish brown color description of the sediments was consistent throughout the area. Calcium carbonate levels are low to within 21 m (70 ft) of ground surface, based on little to no reaction to hydrochloric acid. The upper zone with increased calcium carbonate levels correlates with low modeled velocities during refraction and resistivity modeling, as stated in SGW-52467, and may be a distinctive feature to differentiate the H1 and H3 in this area. Moisture observations ranged from dry to wet; however, the damp and wet descriptions in the vadose zone pertained to zones where water was added during drilling. In conclusion, based on the larger gravel content and size to the north and south of the LERF basins, the dominant flow during deposition appears to be from the northwest, aligning with the conceptual model in PNNL-19702 (Figure D-9). In addition, there were no significant zones of silt or clay above the aquifer indicating no perching horizons in the suprabasalt sediments beneath the LERF vicinity.

D2.2 Groundwater Hydrology

The vadose zone beneath LERF consists of the Hanford formation and portions of the EMB above the water table, as well as potentially some of the Ringold Formation near well 299-E26-11. There have been no observations indicating perched water table conditions near the LERF basins; however, perched conditions could be present west and northwest of the westernmost LERF monitoring wells.

The uppermost aquifer directly beneath LERF is thin to moderate in thickness (e.g., ranging from possibly not present to greater than 8 m (26.25 ft) and exists in the Hanford and EMB flow top (Figures D-13 and D-14). This aquifer is unconfined, except to the east where barometric analyses within well 299-E26-11 indicate semiconfined conditions. This is consistent with the rise in groundwater elevation when drilling advanced through the lower Ringold sediments, present at this well, causing the groundwater elevation to rise nearly 3.1 m (10 ft) in the temporary casing (WHC-MR-0235). The westward extent of the Ringold sediments is uncertain; however, it has been portrayed to pinch out west of well 299-E26-11 (Figure D-12). Although well 299-E26-11 is still capable of yielding representative samples from the same hydrostratigraphic unit as the other LERF wells, the chemical nature of the samples is different and has been more characteristic of groundwater to the east of LERF.

Well construction details are discussed in Section D2.4 and presented in Table D-4. To date, seven wells have been installed for detection monitoring since 1990. Three of the wells (299-E26-11, 299-E26-77, and 299-E26-79) were screened either entirely or primarily within the EMB flow top. The wells produce at a minimum 22.7 L/min (6 gal/min), which is sufficient for groundwater sampling, and the flow top is sufficiently permeable for adequate hydraulic connection with the overlying sediments.

Basalt flow top fracturing, brecciation, and/or weathering provide localized zones of higher permeability. Where these conditions exist and are in hydraulic communication with overlying saturated sediments, the basalt flow top is part of the overlying unconfined aquifer system. Based on evaluations of drill cuttings, drilling rates, and water production noted during drilling wells 299-E26-77 and 299-E26-79, the EMB flow top functions as a component of the unconfined aquifer and forms a laterally continuous aquifer beneath LERF.

The uppermost aquifer is thickest north of Basin 42 and appears to thicken south of Basin 43 (Figures D-8, D-10, D-13, and D-14) due to paleochannel development. The flow interior of the EMB represents the lower boundary of the uppermost aquifer. This was verified by observations during drilling at wells 299-E26-77 and 299-E26-79, as discussed in Section D2.1.1.

D2.2.1 Aquifer Properties

Hydraulic tests were conducted in 1990, 2003, 2008, and 2011 to derive representative hydraulic parameters for the various saturated formations beneath the LERF general vicinity. Slug tests were completed for each of the seven wells with a derived hydraulic conductivity value. The 1990 slug tests were completed in wells 299-E26-9, 299-E26-10, 299-E26-11, and 299-E35-2, which were constructed with a 10.2 cm (4 in.) diameter wire wrapped screen and 0.25 mm (0.010 in.) slot width. A 20-40 silica sand filter pack encases the screen interval. The following paragraphs summarize the results for each well, and WHC-SD-EN-EV-024 provides further detailed discussion. The 2003 hydraulic tests were completed at wells 299-E26-10 and 299-E26-11 and consisted of slug tests at each well and the following additional tests at well 299-E26-10: tracer test, tracer-pumpback test, and constant-rate pumping test. This subsection summarizes the results for each well, and PNNL-14804, *Results of Detailed Hydrologic Characterization Tests Fiscal Year 2003*, provides further discussion. The 2008 hydraulic slug tests were completed at wells 299-E26-77 and 299-E26-79, constructed with a 10.2 cm (4 in.) diameter wire wrapped screens and 0.5 mm (0.020 in.) slot width. A 10-20 silica sand filter pack encases the screen interval. A slug test at well 299-E26-11 also was included in 2008. This subsection summarizes the 2008

results for each well, and SGW-41072 provides further discussion. Finally, a 2011 constant rate pumping test was completed at well 299-E26-14, which was constructed with 10.2 cm (4 in.) diameter wire wrapped screens and 0.5 mm (0.020 in.) slot width. A 10-20 silica sand filter pack encases the screen interval. Because several of the well screens cross various formations, a summary of the screen interval is provided in the following text and in Table D-4. When heterogeneous conditions exist, the hydraulic results are an arithmetic average of the individual formational layers based on a weighted-thickness (PNNL-14804).

Well 299-E26-9 (now sample dry) was screened only in the Hanford formation. The 1990 slug test derived transmissivity values for well 299-E26-9 ranged from 11 to 230 m^2/day (118 to 2,476 ft^2/day). The derived hydraulic conductivity ranged between approximately 6 to 120 m/day (20 to 394 ft/day), assuming an aquifer thickness of 2 m (6.6 ft).

Well 299-E26-10 is screened primarily across the Hanford formation with a small section across the EMB flow top (0.5 m [1.6 ft]). Transmissivity values for well 299-E26-10 were not derived for the 1990 tests because of the fast recovery response (e.g., less than 3 seconds). In 2003, four hydraulic slug tests, two low and two high stress, were performed at well 299-E26-10. The results produced a hydraulic conductivity range, based on the Kansas Geological Survey (KGS) type-curve method, of 36.7 to 42.8 m/day for both stress-level tests (KGS, 1991, *Seismic-Reflection Processing Demonstration Using Eavesdropper*). The KGS type-curve method was used to derive the hydraulic conductivity as explained in PNNL-14804. The 2003 screened thickness across the saturated Hanford formation was 1.48 m (4.85 ft). Four additional hydraulic tests were completed at this well in 2003. The tracer-dilution test provided qualitative evidence that the overlying Hanford formation sediments had a considerably higher hydraulic conductivity than the EMB flow top. The tracer-pumpback test was used to derive the effective porosity; however, due to test complexities, the calculation did not appear representative of the aquifer conditions. The constant-rate pumping test provided another means of deriving the hydraulic conductivity, which was reported at 36.2 m/d with a transmissivity of 71.6 m^2/day. Based on the consistency of the 2003 results, the hydraulic conductivity ranges between 36.2 and 42.8 m/day.

Well 299-E26-11 is screened only across the EMB flow top. The 1990-derived transmissivity value for well 299-E26-11 was 6.1 m^2/d (20 ft^2/d) with a hydraulic conductivity of 11.2 m/day (120 ft/day). Five additional hydraulic slug tests were completed at well 299-E26-11 in 2003, which derived a range of hydraulic conductivity values from 5.85 to 6.8 m/day. Four additional slug tests were performed in 2008 producing a reported hydraulic conductivity value of 10 m/day. The hydraulic conductivity values for the three times range from 5.85 to 11.2 m/day. Because of the analysis methods used by PNNL-14804, the most representative value appears to be 6.3 m/day.

Well 299-E26-14 was completed in 2011 with 5.5 m (18 ft) of screen across the Ringold and Hanford sediments. Only a small portion (0.27 m or 0.9 ft) of the Ringold sediments are adjacent to the bottom of the well screen. A 27.3 gal/min constant pump test was completed on November 26, 2011. A transducer was installed to collect changing water table elevations during the 75 minute pumping test. In total, 2,048 gal were pumped during the test, as described in the field activity log. Because no hydraulic parameters were calculated from the field activity records, type-curve matching methods were used to derive transmissivity and hydraulic conductivity results for this well. The computer program AQTESOLV was used for curve matching. AQTESOLV uses a nonlinear least squares procedure to match a type-curve or straight-line solution for the data provided. Through a sequence of iterations, the procedure systematically adjusts the values of hydraulic properties to achieve the best statistical match between a solution (type-curve) and the test data. Each iteration seeks to minimize the sum of squared residuals. AQTESOLV provides five different solution methods for unconfined aquifer pumping tests. Initially, the Theis and Cooper-Jacob methods were evaluated against the field data, but the curve matching associated with these solution methods did not align (Theis, 1935, “The Relation Between the Lowering of the

Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage;" Cooper and Jacob, 1946, "A Generalized Graphical Method of Evaluating Formation Constants and Summarizing Well-Field History"). The Moench method provides independent parameters for wellbore storage, wellbore skin, and delayed gravity response in anisotropic unconfined aquifers (Moench, 1997, "Flow to a well of finite diameter in a homogeneous, anisotropic water table aquifer"). After manual manipulation of the independent parameter for the wellbore skin factor and delayed drainage parameter, the Moench derived curve nearly matched the field results as provided in Figure D-15. The derived hydraulic conductivity from this curve matching solution was 27.3 m/d. Another solution method, Neuman, with less independent parameters for manipulation, produced the type-curve in Figure D-16 (Neuman, 1974, "Effect of Partial Penetration on Flow in Unconfined Aquifers Considering Delayed Gravity Response"). The derived hydraulic conductivity from this curve matching solution was 24.4 m/day. These results agree with the slug results derived for the other wells in the LERF vicinity. The best estimate is considered 27.3 m/day.

Well 299-E26-77 was completed in 2008 with 6.1 m (20.1 ft) of screen across the EMB flow top and 0.71 m (2.3 ft) across the overlying silty sandy gravel Hanford formation. The 2008 derived hydraulic conductivity was reported in SGW-41072 at several tens of meters/day. Because there were no specific values presented in this report, the data from the two slug withdraw tests were retrieved and reanalyzed with type-curve methods, as discussed in PNNL-14804. Briefly, the type-curve method is useful for analyzing unconfined aquifer conditions because it uses all or any part of the slug test response. The computer program AQTESOLV was used for curve matching, as discussed previously. The automated matching option with default setting was applied to the KGS Model, KGS model with skin effects, and the Springer-Gelhar inertial effects method (Water-Resources Investigation Report 91-4034, *U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Monterey, California, March 11-15, 1991*). The most comparable slug test derived curve was the Springer-Gelhar critically dampened method. This method nearly matched the second slug withdraw results, as shown in Figure D-17. One of the assumptions for this type-curve is a quasi steady-state of the aquifer. A quasi steady-state flow neglects specific storage, unlike the Cooper-Bredehoeft-Papadopulos method (Cooper et al., 1967, "Response of a Finite-Diameter Well to an Instantaneous Charge of Water"). When the Cooper-Bredehoeft-Papadopulos method was run, it did not converge with the test data, indicating the aquifer conditions are more suitable for the Springer-Gelhar method. In addition, the Barker-Black fractured aquifer solution method failed to converge (Barker and Black, 1983, "Slug Test in Fissured Aquifers"). The Springer-Gelhar results derived a hydraulic conductivity of 134 m/d. For comparison, three additional methods (Bouwer-Rice, Hvorslev, and Barker-Black double porosity fractured aquifer method) also were analyzed; however, the curve-type matching alignment with the data was either significantly different and did not converge or only visually applied to the later recovering slug test results using line-matching, which produced much greater hydraulic conductivity results (Bouwer and Rice, 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells;" Hvorslev, 1951, *Time Lag and Soil Permeability in Ground-Water Observations*). As discussed in PNNL-14804, the semi-empirical nature of the Bouwer and Rice method for complex well/aquifer conditions can lead to declining levels of accuracy beyond 30 percent. Thus, the best estimate of the hydraulic conductivity for well 299-E26-77 is 134 m/d using the Springer-Gelhar solution. Because hydraulic conductivity results from other tests in the area produce much lower results for the Hanford formation, the fractured flow top appears to be the dominant flow regime at this well. If the fractured flow top is thinner and the borehole diameter within the basalt is smaller, the hydraulic conductivity value would be even higher. Conversely, if the flow top is thicker and the borehole diameter is larger, the hydraulic conductivity value would be smaller.

Well 299-E26-79 was completed in 2008 with 4 m (13.2 ft) of screen across the EMB flow top and 2.7 m (8.9 ft) across the overlying Ringold and Hanford sediments. The 2008 derived hydraulic conductivity was reported in SGW-41072 at several tens of meters/day. Because there were no specific values presented in this report, the two slug withdraw test data were retrieved and reanalyzed with type-curve methods, as discussed previously for well 299-E26-77. The early slug test data could not be fit by any of the AQTESOLV solution methods. Fitting the remaining portion of the data produced significantly larger hydraulic conductivity results by one to two orders of magnitude than at well 299-E26-77. Because the results are not consistent with the other LERF well results, the data do not appear to be useable; therefore, no hydraulic conductivity results were generated for this well.

Well 299-E35-2 (now sample dry) was screened mainly across the sediments above the EMB flow top (1.9 m [6.2 ft]) with a portion of the screen across the EMB flow top (0.4 m [1.3 ft]). The 1990 derived transmissivity value for well 299-E35-2 was 6 m^2/day (20 ft^2/day), with a hydraulic conductivity of 39.7 m/day (130 ft/day).

In summary, the multiple slug test results at six of the seven wells described in this subsection adequately define the hydraulic conductivity for the basalt flow top and Hanford sediments. The basalt flow top slug test data produced varying results of hydraulic conductivity. To the east, the results were low, while results to the south and west of LERF were significantly greater than the overlying Ringold and Hanford sediment results. The range of hydraulic conductivity beneath and west of LERF appears to exceed 100 m/day. A best estimate is 134 m/day. The overlying suprabasalt sediments were consistent with a hydraulic conductivity range of 24.4 to 42.8 m/day, with a best estimate of 39.5 m/day. These values will be used to derive the rate of flow for LERF. Although effective porosity was not derived from tests completed at LERF, the effective porosity to be used for flow rate calculations at LERF is 0.1. This value was chosen because of the evaluation process discussed in SGW-54508, *WMA C September 2012 Quarterly Groundwater Monitoring Report*.

D2.2.2 Flow Dynamics

Regional groundwater flow was initially from west to east but was impacted by groundwater mounding resulting from wastewater discharges primarily to the east. These impacts have diminished significantly and do not appear to contribute to the flow regime beneath LERF; however, they still appear to affect the groundwater quality at well 299-E26-11.

Recently, statistical methods have been applied to deriving the flow direction. Table D-5 provides the gradient and magnitude associated with the statistically corrected calculations since the installation and water level collection at well 299-E26-14. Although the p-value indicates the derived values have a moderate amount of uncertainty (e.g., 20 to 30 percent), the direction has been very constant ranging between 186 and 198 degrees from north (e.g., southwest of south flow). The average direction is 190 degrees from north. In addition, the gradient magnitude has been constant, ranging between 2.39E-04 and 2.98E-04, with an average of 2.7E-4. If these average values are applied to the following formula $V=(K*G)/n_e$ (Driscoll, 1986, *Groundwater and Wells*); where V is the flow rate, K is the hydraulic conductivity, G is the gradient, and n_e is the effective porosity, then the average flow rate in the suprabasalt sediments could be 0.11 m/day or 38.9 m/year. This value correlates with the movement of a sulfate plume originating to the northwest and west of LERF, as explained in Section 2.10.3.6 and displayed in Figure 2.10-42 of DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*.

Although the derived gradient magnitude and associated flow rate beneath LERF is consistent with other observances of migrating plume rates, as discussed in the previous paragraph, the 190 degree flow direction and increasing anion and cation concentrations at well 299-E26-14 (Figure D-18) do not correlate with the perceived source of anion and cation increases. One of the most distinguishable

constituents associated with the anion and cation increases is sulfate. Sulfate was initially observed increasing at significant levels at well 299-E34-7, located northwest of LERF, in the mid-1990s, as shown in Figure D-19. This well became sample dry in 2005, two years after concentrations had peaked at 671 mg/L. The extent and source of the sulfate is uncertain; however, various conceptual models have been discussed to a limited degree. Movement of the sulfate also has been discussed in several of the Hanford Site Groundwater Monitoring Reports over the past two decades, and an interpreted snapshot of the sulfate plume is provided for 2008 and 2013 (Figure D-20). Historically, sulfate increases along the west side of the LERF monitoring network appear to be associated with transverse dispersivity because of the lack of vadose zone moisture during drilling well 299-E26-77, the derived southward flow direction from monitoring network, and smaller slope of sulfate increase at well 299-E26-10 than at well 299-E34-7 (Figure D-19).

More recently, the rate and direction of groundwater flow appear to be in a state of change regionally. Sulfate concentrations leveled off between 2009 and 2011 near LERF, when the regional flow conditions were considered to be at a minimum compared to previous years (Figure D-18). Since the middle of 2011, when the Columbia River elevation began to exceed the 200 East groundwater elevations, concentrations have been increasing at a greater rate in wells farther east than at well 299-E26-10 (Figure D-18). Three explanations are provided for what may be occurring:

- The northwest sulfate source may be diminishing and because well 299-E26-10 is spatially closer to the source, it is beginning to decrease with the decreasing front, while wells 299-E26-14 and 299-E26-79, farther spatially from the proposed northwest source, are still within the increasing front of the sulfate plume.
- The flow direction has shifted to a southeast of east to an easterly flow direction, causing greater concentrations to migrate preferentially toward wells 299-E26-14 and 299-E26-79.
- The source of sulfate increases may be from a more regional source as sulfate increases have also been seen at well 299-E26-11, but to a smaller degree, and delayed compared to well 299-E26-10 (Figure D-21).

Because of the consistent flow direction derived by the current monitoring network and the larger influence of sulfate increases seen across the LERF monitoring network, the sulfate increases are considered to be from a larger regional source. As such, well 299-E26-14 provides a sufficient representation of the groundwater quality migrating into the area from the north. However, to ensure that conditions continue to reflect this conceptual flow model, well 299-E26-77 will be monitored but considered a crossgradient monitoring well and not included in upgradient statistical measurements. Water levels will continue to be collected at wells 299-E26-10 and 299-E26-77 to maintain statistical analyses of the flow direction. Should conditions change in the statistically derived flow direction or groundwater quality parameters at well 299-E26-77 suggest a change in sulfate migration, then the information will be relayed in the *Resource Conservation and Recovery Act of 1976* (RCRA) quarterly report with a proposed action.

Based on the accepted southward flow direction, well 299-E26-79 is the only downgradient well currently at LERF. Because the basalt flow top appears to be connected hydraulically to the suprabasalt sediments and provides a potentially more transmissive pathway, well 299-E26-79 does not appear to be sufficiently located to monitor the easternmost basin.

D2.3 Groundwater Chemistry

Groundwater chemistry in the uppermost aquifer beneath LERF was affected by several years of diluted liquid waste discharge to the 216-B-3 Pond System, which ceased in 1997. Figure D-22 provides an

illustration of the groundwater chemical facies at various LERF wells from the early 1990s to 2013 using Stiff Diagrams. As can be seen in the figure during the early to mid-1990s, the groundwater chemical facies was calcium-bicarbonate, except to the west of LERF where a calcium-bicarbonate-sulfate facies was present at well 299-E34-7. By 1999, the groundwater at well 299-E34-7 was a strong calcium-sulfate facies, and well 299-E26-10, located to the southeast of well 299-E34-7, was changing to a calcium-sulfate facies. In 2001, well 299-E26-10 was a calcium-sulfate facies.

In 2006, well 299-E26-11, located to the east of LERF, was beginning to show signs of changing from a calcium-bicarbonate facies. By 2011, well 299-E26-11 also had changed to a calcium-sulfate facies. Although well 299-E26-11 saw a change in the chemical nature of the groundwater after wells to the west, it has had a greater water elevation than the wells to the west. This indicates the water facies change must be from north of well 299-E26-11. Further east at well 699-45-42, located east of well 299-E26-11, a calcium-bicarbonate chemical facies was still present in 2012.

The wells to the north and south of LERF portray an intermediate chemical facies, which is between the strong calcium-sulfate facies to the west and the more dilute calcium-sulfate facies to the east. For comparison, the calcium and sulfate milliequivalents in well 299-E26-10 in January of 2013 were 6.4 to 5.5, respectively. The milliequivalents at well 299-E26-11 in January 2013 were 2.6 for both calcium and sulfate. The January 2013 milliequivalent results for wells 299-E26-14 and 299-E26-79 were 3.9 to 3.3 and 3.7 to 3.0, respectively. Thus, the chemical facies is slightly stronger to the north of LERF than south, which is downgradient of LERF.

The fact that all the wells near LERF are showing chemical facies changes to a calcium-sulfate indicates that the wells are hydraulically connected and that there is a sulfate source to the north of LERF. Water quality parameters will continue to be collected semiannually for purposes of further evaluation, as shown in Table D-6.

D2.4 Well Completions and Conditions

The basic well information is summarized in Table D-4 and in Figures D-23 through D-27. Five wells are provided for discussions related to the geology and hydrogeology; however, only four of the wells (299-E26-10, 299-E26-14, 299-E26-77, and 299-E26-79) are being used for monitoring the groundwater near LERF. The four wells allow use of statistical measures to derive a groundwater gradient and direction.

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 EMB, the screened intervals in all four wells intercept the unconfined aquifer as discussed in Section D2.2.1.

The initial LERF groundwater monitoring wells were installed in 1990 and included three downgradient wells on the west end of the facility boundary and one upgradient well at the east end of the facility. This configuration was based on the east-to-west groundwater flow direction, caused by the recharge mound created by years of liquid effluent disposal to B Pond. Wells 299-E26-9, 299-E26-10, and 299-E35-2 were originally installed as downgradient wells and well 299-E26-11 as an upgradient well. Wells 299-E26-77 and 299-E26-79 were installed in 2008. Well 299-E26-77 is adjacent to the location of well 299-E26-9, and well 299-E26-79 is south of LERF between Basins 42 and 43 (Figure D-2). Well 299-E26-10 (Figure D-23) has a 4.5 m (15 ft) screen, screening across the entire saturated suprabasalt sediments. The well screen in 299-E26-10 penetrates approximately 0.5 m (1.8 ft) into the basalt. Well 299-E26-11 (Figure D-3 and D.24) was completed with a 1.5 m (5 ft) long channel-pack screen placed completely within the basalt flow top and includes a sand pack that extends 1.3 m (4.4 ft) above the screen top.

Well 299-E26-14 encountered groundwater at approximately 60.5 m (198.4 ft) bgs and was drilled to a total depth of 73.3 m (240.6 ft) bgs (Figure D-25). The well is constructed with 6.1 m (20 ft) total length of screen installed across approximately 5.5 m (18 ft) of Ringold and Hanford sediments. Only a small portion (0.27 m or 0.9 ft) of the Ringold sediments are adjacent the bottom of the well screen. The screen is 10 cm (4 in.) in diameter, 20 slot, stainless-steel wire-wrap. The well has a 1 m (3 ft) blank sump below the screen. The casing from the top of the screen to land surface is 10 cm (4 in.) diameter stainless steel.

Well 299-E26-77 encountered groundwater at approximately 63.4 m (208 ft) bgs and was drilled to a total depth of 71 m (232.8 ft) bgs (Figure D-26). The well is constructed with 7.6 m (25 ft) total length of screen installed across approximately 1.4 m (4.6 ft) of sediments and 6.2 m (21.4 ft) of basalt flow top. Well 299-E26-79 encountered groundwater at 61.5 m (201.7 ft) bgs and was drilled to a total depth of 68.5 m (224.8 ft) bgs (Figure D-27). The well is constructed with 7.6 m (25 ft) total length of screen installed across approximately 3.7 m (12 ft) of sediments and 3.9 m (13 ft) of basalt flow top. The screens are 10 cm (4 in.) in diameter, 20-slot, stainless-steel wire-wrap. Both wells have a 1 m (3 ft) blank sump below the screens. The casing from the top of the screen to land surface is 10 cm (4 in.) diameter stainless steel.

The longevity of the operable monitoring lifetime for the remaining LERF wells is not a concern as water levels are only being collected from well 299-E26-10 and, based on recent water level declines, should be useable for decades. The other three wells have significant water for sample collection and should not go dry, based on pre-Hanford groundwater elevations.

D3 Groundwater-Monitoring Program

Groundwater monitoring at LERF is in detection monitoring and the indicator parameters are discussed further in Section D3.6.1. The indicator parameters were derived as summarized in Section D3.2 and discussed in further detail in Section D1.5. The detection monitoring sample frequency is semiannual as discussed in Section D3.6.2. Sampling procedures and required documentation is provided in Sections D3.6.3 and D3.6.4, respectively. The analytical procedures, analytical quality control (QC), data management are discussed in Sections D3.9, D3.9.1, and D3.9.2, respectively.

Statistical methods are employed to determine local background conditions for the upgradient well 299-E26-14 as provided in Section D3.9.3. Detection monitoring at LERF is discussed in Section D3.4. Should indicator parameter results exceed local background levels then resampling will be implemented for determining if a false positive result has occurred or if assessment monitoring must be undertaken as discussed in Sections D3.3, D3.9.3, and D3.11.

Reporting will be annually through the Hanford Site Annual Groundwater Monitoring Report unless a significant exceedance of the background values determined for the upgradient well 299-E26-14 is verified. If an exceedance is verified then the notification process discussed in Section D3.11 will be followed.

As discussed in Sections D1 and D2 and their subsections, the following characteristics describe the hydrogeology in the LERF area:

- Representative groundwater samples can be collected from the uppermost aquifer.
- Upgradient background samples at well 299-E26-14 are representative of unaffected groundwater from LERF.
- Groundwater samples collected at well 299-E26-79 are representative of the quality of groundwater passing the LERF point of compliances.

Hydraulic characterization tests conducted over the past two decades and the groundwater chemical facies changes indicate the hydrostratigraphic units underlying the LERF basins constitute an aquifer unit that is continuous beneath the LERF basins and is capable of yielding representative groundwater samples.

D3.1 Objectives of Dangerous Waste Groundwater Monitoring and Past Monitoring Results

A groundwater monitoring program, in accordance with the requirements of WAC 173-303-645, is designed to determine whether there is statistically significant evidence of contamination in the uppermost aquifer attributable to the LERF basins. The statistical parametric *t*-test approach at LERF compares two distinct statistical populations for true differences in population means as discussed further in Section D3.9.3.

By the date of this permit, the action leakage rate has not been exceeded during operations, and results of the LERF groundwater monitoring program indicate the LERF basins have not impacted groundwater quality beneath the site. Past monitoring results from former downgradient wells 299-E26-10 and 299-E26-11, and more recent results from newer wells 299-E26-77 and 299-E26-79, have not indicated dangerous constituents above background levels, with the exception of one positive carbon tetrachloride result at each well. Because the detections were followed by a series of non-detect values and the results were associated with out-of-limit QC samples, the reported concentrations appeared to be associated with a laboratory error and were flagged as suspect. As a result, a detection monitoring program in accordance with WAC 173-303-645(9) is appropriate for the site to provide compliance with the requirements of WAC 173-303-645.

D3.2 Dangerous Constituents

A list of dangerous and/or mixed aqueous waste that can be accepted in LERF is defined by the requirements of Addendum B (Waste Analysis Plan).

Dangerous constituents and suitable indicator parameters that provide a reliable indication of the presence of dangerous constituents in groundwater for purposes of groundwater monitoring were based on target parameter constituents from Addendum B (Waste Analysis Plan), and results of LERF basin water samples collected between July 1999 and June 2013. Several target parameters in the Waste Analysis Plan (Addendum B) occur in the LERF basin influent data and were evaluated relative to the dangerous waste characteristics (groundwater monitoring list in WAC 173-303-090, “Dangerous Waste Characteristics,” and Ecology Publication 97-407, *Chemical Testing Methods for Designating Dangerous Waste: WAC 173-303-090 & -100*, Appendix 5. As discussed in Section D1.5, dangerous waste constituents measured as part of routine liquid sampling in the LERF basins were included as indicator parameters.

Tables D-1 through D-3 present a list of dangerous constituents measured as part of routine liquid sampling in the LERF basins from as early as February of 2000 through 2011. The results were further evaluated to identify reliable parameters for the indication or identification of dangerous waste constituents in groundwater, as discussed in Section D1.5. The full list of groundwater monitoring indicator parameters is provided in Section D3.6.1.

D3.3 Concentration Limits

A series of events that triggers the shift from detection monitoring to compliance monitoring is prescribed in WAC 173-303-645. If there is statistically significant evidence of contamination, as required in WAC 173-303-645(9)(f), groundwater protection standards and concentration limits will be established subsequently in accordance with WAC 173-303-645(9)(g)(iv)(D). Section D3.11, Evaluation and Notification, provides the process and schedule for actions, notification, and permit modification, if necessary.

If a tolerance limit is exceeded at a statistically significant level, additional measurements will be conducted to verify that a detection event has occurred. If the detection of a dangerous constituent is verified, as discussed in Section D3.11, compliance monitoring will be implemented in accordance with WAC 173-303-645(10).

D3.4 Groundwater Monitoring System and Point of Compliance

The groundwater monitoring system for LERF uses existing wells, 299-E26-14 and 299-E26-79. Well 299-E26-14 is an upgradient well and well 299-E26-79 is a downgradient well based on the flow direction presented in Section D2.2.2. A third detection monitoring well will need to be installed just south of the open interval between Basin 43 and 44 in order to compare the groundwater quality downgradient of LERF Basin 44 (Figure D-28). All three of these wells will be monitored in accordance with the requirements provided in this permit. The additional well to be installed, 299-E26-15, will be planned through Tri-Party Agreement (Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*) Milestone M-024, which is updated on a yearly basis. The well is tentatively planned to be installed prior before fiscal year 2016.

D3.5 Compliance Period

The compliance period will be the number of years equal to the active life of the waste management area including any additional years required for corrective actions, if necessary. Any additional years associated with corrective actions will be completed after three consecutive years in which the groundwater protective standard for any specific dangerous waste constituent has not been exceeded in accordance with WAC 173-303-645(7).

D3.6 Sampling and Analysis

This section describes the groundwater detection sampling and analysis program for the three LERF regulated units (Basins 42, 43, and 44), including monitoring parameters, analytical methods, monitoring frequency, and sampling protocols.

D3.6.1 Monitoring Parameters

Monitoring parameters include the indicator and geochemical parameters. The monitoring of these two parameters is similar, and sampling and analysis frequencies are the same and will be done concurrently on a semiannual basis.

As identified in Section D1.5, carbon tetrachloride and TOX are reliable indicator parameters for the presence of dangerous constituents associated with LERF. In addition, the standard parameters of pH, specific conductance, and TOC provide the requirements of detection monitoring in accordance with WAC 173-303-645(9)(a). Table D-7 provides a list of these constituents and the frequency of sampling.

Samples will also be collected semiannually and analyzed for major anions, cations, and alkalinity to evaluate groundwater geochemistry, as discussed in Table D-6.

Samples also will be collected for Cr(VI) for evaluation as an additional indicator parameter, as discussed in Section D1.5.

D3.6.2 Sampling Frequency

Samples will be collected semiannually from wells 299-E26-14 and 299-E26-79 to determine whether there is statistically significant evidence of contamination for the indicator parameters established in Section D3.6.1.

Samples will be collected semiannually and analyzed for major anions, cations, and alkalinity to evaluate groundwater geochemistry, as discussed in Section D2.3 and shown in Table D-6.

Finally, samples will be collected semiannually for Cr(VI) evaluation as an indicator parameter, as discussed in Section D1.5 and Table D-7.

D3.6.3 Sampling Procedures

Groundwater sampling procedures, sample collection documentation, sample preservation and shipment, and chain-of-custody requirements are described in this subsection. The Permittees will develop, maintain, and conduct work according to procedures consistent with, and no less stringent than, those described to be conducted. The Permittees will maintain current copies of these procedures in the Hanford Facility Operating Record, LERF, and 200 Area ETF file, as required by Permit Condition II.I.1.

Samplers fill out groundwater sample report forms as they purge and sample each well. Field personnel measure water levels in each well before sampling and then purge stagnant water from the well. Field personnel also record time of sampling, which allows correlation with barometric pressure measurements at the Hanford Meteorological Station. Water levels are typically measured with laminated-steel electrical sounding tapes with a precision of 2 mm. Procedures require sample collection after three casing volumes of water have been purged from the well and after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized. Field parameters are measured in a flow-through chamber. Both filtered and unfiltered samples are collected for metals analyses. Filtering is performed in the field with 0.45-micron, in-line, disposable filters to ensure that results represent dissolved metals and do not include particulates. Dissolved trace metals analysis (from filtered samples) will be used for statistical analyses of trace metal arsenic.

Sample preservation techniques will follow generally accepted practices (e.g., U.S. Environmental Protection Agency [EPA]-approved guidelines such as SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, Table 11-1, or equivalent) and will be documented in sample authorization forms generated by the Sample and Data Management organization. Chemical preservatives are added to collection bottles before use in the field. A chemical preservative label is affixed to the sample container listing the specific preservative. The preservative's brand name, lot number, concentration, and date opened are recorded. As part of sample preservation, samples may be refrigerated or stored on ice as necessary prior to delivery to the analyzing laboratory.

D3.6.4 Sample Chain-of-Custody

Groundwater samplers use chain-of-custody forms to document the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during scheduling and are managed through a documented procedure. Required information recorded on the forms includes the following:

- Sampler's name
- Method of shipment and destination
- Collection date and time
- Sample identification numbers
- Analysis methods
- Preservation methods

Samples are labeled and sealed with evidence tape, wrapped with bubble wrap, and placed in a U.S. Department of Transportation-approved container with ice, as appropriate. The packaging parameters for samples are determined by associated hazards. Samples for offsite laboratories are shipped according to U.S. Department of Transportation regulations. A chain-of-custody form accompanies all samples.

When samples are transferred from one custodian to another (e.g., from sampler to shipper, or from shipper to analytical laboratory), the receiving custodian inspects the form and the samples, noting any deficiencies. Each transfer of custody is documented by the printed names and signatures of the custodian relinquishing the samples and the custodian receiving the samples, as well as the time and date of transfer. Commercial shippers do not sign chain-of-custody forms, but the forms are signed by the receiving laboratory, and sample integrity is verified by inspecting the bottle seals.

D3.7 Decontamination of Drilling and Sampling Equipment

The following information is included relative to well drilling equipment for new wells installed at LERF for this Permit. Well drilling equipment is decontaminated using high temperature and pressure washing. The equipment then is rinsed with clean water.

Equipment for collecting soil samples during drilling for later chemical analysis is decontaminated. Equipment is washed with phosphate-free detergent, rinsed three times with de-ionized water, rinsed once with nitric acid (glass or stainless-steel equipment only), rinsed three more times with de-ionized water, and then finally rinsed with hexane. After heat drying, equipment is wrapped in unused aluminum foil and sealed with tape until needed. The tape shall not come into contact with the equipment to avoid any contamination from the materials in the tape.

Monitoring wells for LERF shall be equipped with dedicated sampling pumps. Sample pumps are placed at approximately mid-depth within the screen interval. Water-level measuring tapes are cleaned with potable or deionized water and a clean towel. Sample manifolds used at the well head require decontamination as follows: wash with a phosphate-free detergent, rinse three times in high-purity water, rinse in a 1 M solution of nitric acid, rinse three more times in high-purity water, then rinse in hexane, and finally dry in drying chamber. These are done in accordance with established procedures.

D3.8 Quality Objectives and Criteria

The QC program is designed to assess and assure the reliability and validity of groundwater data, and to document whether the resulting data are of the quantity and quality necessary for the intended decision-making purpose. In groundwater detection monitoring, the primary decision-making purpose is to determine whether a statistically significant increase in a dangerous constituent concentration is observed in groundwater downgradient from the permitted site. Consequently, data quality is monitored by evaluating the results of QC samples, conducting audits, validating groundwater data, and comparing these results to data quality requirements established in this groundwater monitoring plan. Accuracy, precision, and detection are the primary parameters used to assess data quality. Data for these parameters are obtained from two categories of QC samples: field QC samples that provide checks on field and laboratory activities, and laboratory QC samples that monitor laboratory performance. Table D-8 summarizes the types of samples in each category and the sample frequencies and characteristics evaluated.

D3.9 Analytical Procedures

All field and laboratory instrumentation are calibrated using approved procedures, and analytical measurements are generated according to approved procedures. These procedures include quality checks to ensure the resulting analytical values are of known quality.

Instruments for field measurements (e.g., pH, specific conductance, temperature, and turbidity) are verified using standard solutions before use. These include, for pH, 4, 7, and 10 buffer/standard solutions; for specific conductance, 445 µS/cm and 1,413 µS/cm solutions; and for turbidity, Gelex standards 0-10, 0-100, and 0-1,000 nephelometric turbidity units. Instruments are operated in accordance with the

manufacturer's instructions. Each instrument is assigned a unique number that is tracked via calibration documentation and field logbooks and sampling reports.

Laboratory analytical methods are specified in Table D-9 and are generally specified in contracts with the laboratories. Laboratory methods for chemical parameters are typically standard methods from SW-846; EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes*; or APHA/AWWA/WEF, 2012, *Standard Methods for the Examination of Water and Wastewater*. Analytes, analytical methods, and required maximum practical quantitation limits are shown in Table D-9.

D3.9.1 Quality Control

QC data are evaluated based on acceptance criteria for each QC sample type, as summarized by constituent in Table D-10. These criteria limits are intended to provide confidence that the analytical and field methods are in control and provide data of known quality. For field and method blanks, the acceptance limit is two times the instrument detection limit (metals) or method detection limit (other chemical parameters), except for the common laboratory contaminants 2-butanone, acetone, methylene chloride, toluene, and phthalate esters where the limit is five times the method detection limit. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are given a review qualifier of "Q" in the Hanford Environmental Information System (HEIS) database to indicate a potential problem, and then recorded in the Hanford Facility Operating Record, LERF, and 200 Area ETF file pursuant to Permit Condition III.3.D.1.b.

Field duplicates must agree within 20 percent (as measured by relative percent difference) to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit shall be evaluated. In the case where one result is a non-detect, the detection limit is used to calculate the relative percent difference. Unacceptable field duplicate results are given a review qualifier of "Q" in the database and recorded in the Hanford Facility Operating Record, LERF, and 200 Area ETF file.

The specified frequency for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are defined in Table D-10 in accordance with SW-846. The acceptance criteria for the associated parameter data shall be analyzed and recorded in accordance with Section D3.10.2.

Sample holding times depend on the analyte and are specified in the Environmental Quality Assurance Program Plan. Data associated with exceeded holding times are given a review qualifier of "H" in the HEIS database and noted in the Hanford Facility Operating Record, LERF, and 200 Area ETF file. Data exceeding holding times shall be maintained but potentially may not be used in statistical analyses.

Table D-11 lists the acceptable accuracy for the blind standards for carbon tetrachloride and TOX. These samples are prepared by spiking Hanford background well water (currently, wells 699-19-88 and 699-49-100C) with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper limit of concentration determined in groundwater on the Hanford Site. Investigations shall be conducted for blind standards that are outside of acceptance limits. The results from these standards shall be used to determine acceptability of the associated parameter data.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies shall be incorporated into the Hanford Facility Operating Record, LERF, and 200 Area ETF file as appropriate to substantiate data quality objectives (DQOs) and data acceptance criteria.

D3.9.2 Data Management

This section describes data management practices.

Loading Data

The contract laboratories report analytical results electronically and in hardcopy. The electronic results shall be loaded into the HEIS database as they are received from the laboratories. The appropriate sections of the HEIS shall be incorporated by reference into the Hanford Facility Operating Record, LERF, and 200 Area ETF file to satisfy Permit Condition III.3D.1.b. Field data (e.g., specific conductance, pH, temperature, turbidity, and depth to water) are recorded on field records. Data management staff enter field data into the HEIS database manually through data-entry screens and verify each value against the hardcopy. An electronic field data collection system may be implemented soon, which would replace the manual field data collection and the manual data entry process when it is implemented.

Data not available electronically may include well logbooks, borehole videos, geologic descriptions, field screening data, or other information.

Data Review, Verification, Validation, and Usability

The final data review shall determine whether data meet the criteria specified in this subsection. The work activities shall follow documented procedures and processes for data validation and verification. Validation of groundwater data involves assessing whether the data collected and measured meet contractual quality requirements. Verification involves assessing data accuracy, completeness, consistency, availability, and internal control practices to determine overall reliability of the data collected. Other DQOs that shall be met include the proper chain-of-custody, sample handling, use of proper analytical techniques for each constituent, and the quality and acceptability of the laboratory analyses conducted.

Groundwater monitoring staff performs checks on laboratory electronic data files for formatting, allowed values, data flagging (qualifiers), and completeness. A percentage of hardcopy results are verified to check for completeness; notes on condition of samples upon receipt by the laboratory; notes on problems that arose during the analysis of the samples; and correct reporting of results. If data are incomplete or deficient, staff will work with the laboratory to correct the problem discovered during the analysis.

The data validation process provides the requirements and guidance for validating groundwater data that are routinely collected. Validation is a systematic process of reviewing verified data against a set of criteria (listed in Table D-10) to determine whether the data are acceptable for their intended use.

Results of laboratory and field QC evaluations, blind sample results, laboratory performance evaluation samples, and holding-time criteria are considered when determining data usability. Staff review the data to identify whether observed changes reflect changes in groundwater quality or potential data errors, and they may request data reviews of laboratory, field, or water-level data for usability purposes. The laboratory may be requested to check calculations or reanalyze the sample, or the well may be resampled. Results of the data reviews are used to determine what appropriate review qualifier should be applied to the analytical results in the HEIS database (e.g., “R” for reject, “Y” for suspect, or “G” for good) and/or to add comments.

Upon final data acceptance, both the raw data and the accepted/validated data shall be incorporated into the Hanford Facility Operating Record, LERF, and 200 Area ETF file.

Data Review Corrective Actions

The responses to data quality defects are identified through the verification/validation process. Corrective actions are shown in Table D-8.

D3.9.3 Statistical Analysis of Groundwater Monitoring Data

Groundwater monitoring constituents have been identified for the LERF basins and are listed in Table D-10. The dangerous constituents and indicator parameters used to indicate the presence of contamination (WAC 173-303-645(9)(a)) and subject to statistical evaluation are listed in Table D-7 and include carbon tetrachloride, pH, specific conductance, TOC, and TOX.

To establish background conditions, the previous data collected over the past two years will be used. Every year, background results will be evaluated for updating the critical mean for each indicator parameter identified in Table D-8. Sample collection and analysis will continue on a semiannual basis.

The statistical method for comparing baseline (background) groundwater quality with compliance-point groundwater quality is the Welch's *t*-test in accordance with WAC 173-303-645(8)(h)(i), and it is recommended for detection monitoring when population variances might differ between two groups, as stated in EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*. Applying this parametric *t*-test provides a reasonably robust statistical procedure and assurance when background data are at a minimum and the underlying populations may not meet normality. However, normality can usually be met by log transforming the data. As more background data is generated for well 299-E26-14, additional tests may be applied if spatial variability becomes an issue, such as the Wilcoxon Rank-sum Test.

The Welch's *t*-test procedure can be implemented as follows:

I. Compute the sample mean $\bar{x}$, standard deviation s, and variance s^2, in each of the background and compliance well data sets.

II. Compute Welch's *t*-statistic using the following equation $t = (\overline{X_c} - \overline{X_{BG}})/\sqrt{\frac{s^2_{\mathrm{BG}}}{n_{\mathrm{BG}}} + \frac{s^2_{\mathrm{c}}}{n_c}}$

III. Compute the approximate degrees of freedom using the following equation

$$df = \left[\!\left[\frac{s^2_{\mathrm{BG}}}{n_{\mathrm{BG}}} + \frac{s^2_{\mathrm{c}}}{n_{\mathrm{c}}}\right]\!\right] / \left[\!\left[\frac{(s^2_{\mathrm{BG}}/n_{\mathrm{BG}})^2}{n_{\mathrm{BG}} - 1} + \frac{(s^2_{\mathrm{c}}/n_{\mathrm{c}})^2}{n_{\mathrm{c}} - 1}\right]\!\right]$$

IV. Use Table 16-1 of Appendix D in EPA 530/R-09-007 to assign the upper 95 percent critical mean based on the degrees of freedom.

V. Compare the t-statistic against the critical point, t_{cp}. When the condition $t \leq t_{cp}$, conclude there is no statistically significant difference between the background and compliance point population means. If, however, $t > t_{cp}$, conclude that the compliance point population mean is significantly greater than the background mean at the α level of significance.

As monitoring continues and the process is shown to be in control (i.e., there is no statistically significant evidence of facility impact to groundwater), the baseline mean and standard deviation should be updated periodically (e.g., every 1 or 2 years) to incorporate the new data (EPA 530/R-09-007). This reduces uncertainty in the background and helps adjust for groundwater influences from outside sources. This updating process should continue for the lifetime of the monitoring program.

If an exceedance occurs, resampling will be undertaken to verify or refute the original exceedance. The analytical result from the resample is substituted into the previous formulas in place of the original value obtained, and the Welch's *t*-test statistic is updated. If resampling does not confirm the exceedance, and *if the exceedance can be shown to be a measurement in error or a confirmed outlier, it should be excluded from the revised background. Otherwise, any disconfirmed exceedances (including any*

resamples that exceed the background limit but are disconfirmed by other resamples) should probably be included when updating the background. The reason is that background limits designed to incorporate retesting are computed as low as possible to ensure adequate statistical power (EPA 530/R-09-007).

D3.10 Reporting and Recordkeeping

Reporting of monitoring evaluations for LERF will be carried out through the Hanford Site Annual Groundwater Monitoring Report.

Pertinent information for groundwater monitoring and electronic files for groundwater data shall be maintained in the Hanford Facility Operating Record, LERF, and 200 Area ETF file required by Permit Condition II.I.1. Records may be stored in either electronic or hardcopy format.

The Hanford Facility Operating Record, LERF, and 200 Area ETF file will also include, consistent with Permit Condition III.3.D.1.b, the following items:

- Groundwater sample reports
- Chain-of-custody forms
- Sample receipt records

D3.11 Evaluation and Notification

Groundwater flow rate and direction in the uppermost aquifer will be evaluated and reported annually. Groundwater indicator parameter data collected under this permit will be reviewed semiannually to determine if there is statistically significant evidence of contamination (in accordance with WAC 173-303-645(9)(f)) using the statistical method provided in Section D3.9.3. The results of the statistical evaluation and associated information will be submitted to the Washington State Department of Ecology (Ecology) annually through the Hanford Site Annual Groundwater Monitoring Report (WAC 173-303-645(9)(c)).

If statistically significant evidence of contamination is determined for one or more of the dangerous constituents or indicator parameters, at any monitoring well at the compliance point, the owner or operator may resample within one month and repeat the analysis for the detected compounds in accordance with WAC 173-303-645(9)(g)(ii). The resample data will be compared with the control limit. If resampling confirms statistically significant evidence of contamination, the following actions will be performed in accordance with WAC 173-303-645(9)(g):

- Notify Ecology in writing within seven days of the finding, indicating which chemical parameters have shown statistically significant evidence of contamination.

- Sample the groundwater in all monitoring wells and determine if constituents included in Ecology Publication 97-407, *Chemical Testing Methods for Designating Dangerous Waste: WAC 173-303-090 & -100*, Appendix 5, are present, and if so, in what concentration. For any of these compounds detected, the owner or operator may resample within one month of receiving the results and repeat the analysis for those compounds detected. If the constituents are detected in the second analysis, they will form the basis for compliance monitoring.

- If dangerous constituent(s) are detected, submit an application for a Permit modification to Ecology within 90 days to establish a compliance monitoring program in accordance with WAC 173-303-645(9)(g)(iv).

- If dangerous constituents are not detected, continue to monitor in accordance with the detection monitoring program.

If a source other than LERF caused the contamination or the detection is an artifact caused by an error in sampling, analysis, or statistical evaluation or natural variation in groundwater (as allowed by WAC 173-303-645(9)(g)(vi), the following guidelines will apply:

- Notify Ecology in writing within seven days of the finding (i.e., exceedance) and indicate the intent to make a demonstration to this effect.
- Submit a report to Ecology within 90 days. The report should demonstrate that a source other than the regulated unit caused the contamination, or that the contamination resulted from an error in sampling, analysis, evaluation, or natural variation in groundwater chemistry.
- Continue monitoring in accordance with the detection monitoring program.

If it is determined, in accordance with WAC 173-303-645(9)(h), that the detection monitoring program no longer satisfies the requirements of WAC 173-303-645(9), submit an application to Ecology for a Permit modification within 90 days to make any appropriate changes to the program.

D4 Compliance-Monitoring Program

Reserved.

D5 Corrective-Action Program

Reserved.

D6 References

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol25/xml/CFR-2010-title40-vol25-part265-subpartF.xml.

APHA/AWWA/WEF, 2012, *Standard Methods For the Examination of Water and Wastewater*, 22nd Edition, American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, D.C.

Barker, John A. and John H. Black, 1983, "Slug Tests in Fissured Aquifers," *Water Resources Research* 19(6):1558-1564. Available at: http://onlinelibrary.wiley.com/doi/10.1029/WR019i006p01558/pdf.

BHI-00184, 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

Bouwer, Herman and R.C. Rice, 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells," *Water Resources Research* 12(3):423-428. Available at: http://www.cof.orst.edu/cof/fe/watershd/fe538/Watershed_10_HillslopeModule/Bouwer_Rice_slug_test_hydraulic_conductivity_WRR1976.pdf.

Cooper, H.H. and C.E. Jacob, 1946, "A Generalized Graphical Method of Evaluating Formation Constants and Summarizing Well-Field History," *Trans. Am. Geophys. Union* 27(4):526-534. Available at: http://core.ecu.edu/geology/spruill/spruill/Groundwater%20Notes%20No.%207.pdf.

Cooper, Hilton H., Jr., John D. Bredehoeft, and Istavros S. Papadopulos, 1967, "Response of a Finite-Diameter Well to an Instantaneous Charge of Water," *Water Resources Research* 3(1):263-269. Available at: http://onlinelibrary.wiley.com/doi/10.1029/WR003i001p00263/pdf.

DOE/RL-92-19, 1993, *200 East Groundwater Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196136305.

DOE/RL-96-61, 1997, *Hanford Site Background: Part 3, Groundwater Background*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197226378.

DOE/RL-2008-01, 2008, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098824.

Driscoll, Fletcher G., 1986, *Groundwater and Wells*, Second Edition, Johnson Division, St. Paul, Minnesota.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

Ecology Publication 97-407, 2009, *Chemical Testing Methods for Designating Dangerous Waste: WAC 173-303-090 & -100*, Appendix 5, "Appendix IX of 40 CFR 264," Washington State Department of Ecology, Olympia, Washington. Available at: http://www.ecy.wa.gov/pubs/97407.pdf.

EPA 530/R-09-007, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, Office of Resource Conservation and Recovery, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/sitechar/gwstats/unified-guid.pdf.

EPA-600/4-79-020, 1983, *Methods for Chemical Analysis of Water and Wastes*, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196019611.

Hanford Environmental Information System, Hanford Site database, Richland, Washington.

HNF-23142, 2004, *Engineering Study for the 200 Area Effluent Treatment Facility Secondary Waste Treatment of Projected Future Waste Feeds*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

Hvorslev, M. Juul, 1951, *Time Lag and Soil Permeability in Ground-Water Observations*, Bulletin No. 36, Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi. Available at: http://www.csus.edu/indiv/h/hornert/Geol_210_Summer_2012/Week%203%20readings/Hvorslev%201951.pdf.

KGS, 1991, *Seismic-Reflection Processing Demonstration Using Eavesdropper*, Open-File Report 91-27, Kansas Geological Survey, Lawrence, Kansas. Available at: http://www.kgs.ku.edu/Geophysics/Reports2/EavesTutorial.pdf.

Moench, Allen F., 1997, "Flow to a well of finite diameter in a homogeneous, anisotropic water table aquifer," *Water Resources Research* 33(6):1397-1407. Available at: http://onlinelibrary.wiley.com/doi/10.1029/97WR00651/pdf.

Neuman, Shlomo P., 1974, "Effect of Partial Penetration on Flow in Unconfined Aquifers Considering Delayed Gravity Response," *Water Resources Research* 10(2):303-312. Available at: http://onlinelibrary.wiley.com/doi/10.1029/WR010i002p00303/abstract.

PNNL-12261, 2000, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0906180659.

PNNL-14804, 2004, *Results of Detailed Hydrologic Characterization Tests Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14804.pdf.

PNNL-19702, 2010, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: www.pnl.gov/main/publications/external/technical_reports/PNNL-19702.pdf.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.105.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epa.gov/epawaste/inforesources/online/index.htm.

SGW-39344, 2008, *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), FY 2008*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0906180658.

SGW-41072, 2009, *Liquid Effluent Retention Facility Characterization Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0906160165.

SGW-43746, 2009, *Landstreamer/Gimbaled GeoPhone Acquisition of High Resolution Seismic Reflection Data North of the 200 Areas – Hanford Site*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/968021.

SGW-51467, 2012, *Borehole Summary Report for the Installation of Two RCRA Groundwater Monitoring Wells in the 200 Areas, FY2011*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-52162, 2012, *Seismic Reflection Investigation at the Liquid Effluent Retention Facility, 200 East Area, Hanford Site Richland, Washington*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-52467, 2012, *Integrated Surface Geophysical Investigation Results at Liquid Effluent Retention Facility, 200 East Area, Hanford, Washington*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

SGW-54508, *WMA C September 2012 Quarterly Groundwater Monitoring Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0089297.

SW-846, 2007, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B*, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Theis, C. V., 1935, "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage," *American Geophysical Union Transactions* 16(2):519-524.

WAC 173-303-090, "Dangerous Waste Regulations," "Dangerous Waste Characteristics," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-090.

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-645.

Water-Resources Investigation Report 91-4034, 1991, *U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Monterey, California, March 11-15, 1991*, U.S. Geological Survey, Reston, Virginia. Available at: http://pubs.usgs.gov/wri/1991/4034/report.pdf.

WHC-MR-0235, 1990, *Borehole Completion Data Package for the Liquid Effluent Retention Facility*, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-EV-024, 1994, *Site Characterization Report for the Liquid Effluent Retention Facility*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196090383.

WHC-SD-W105-SAR-001, 1991, *Final Safety Analysis Report 242-A Evaporator Liquid Effluent Retention Facility*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Table D-1. Constituent Results for 242-A Process Condensate Characterization Results and Basin 42 Characterization Results

Sample Location	2009 Basin 42 Characterization Results					Basin 42 Average[b]		Process Condensate to LERF[c]		Process Condensate Cold Run[c]	Process Condensate to LERF[c]		Process Condensate to LERF[c]		Regional Groundwater Background Concentration[d]		Constituents
Sample Date	Units	Wtd Avg[a]		Max[b]		2009 - 2010		6/16/2009			8/31/2010		10/5/2010			Units	
Volume	gal	6.76E+06		6.87E+06		5.19E+06		5.36E+05		3.14E+05	3.61E+05		3.61E+05				
Nitrogen in ammonium	mg/L	111.41		140.00		127		140		0.02	26.3		22.1		NL	mg/L	Nitrogen in ammonium
Bromide	mg/L	0.07	U	0.09	U	0.08	U	0.05	U	0.05	0.05	U	0.05	U	0.151	mg/L	Bromide
Chloride	mg/L	5.37		7.75		6.91		0.04	U	1.30	0.04	U	0.04	U	19.58	mg/L	Chloride
Fluoride	mg/L	0.05		0.06		0.05	U	0.03	U	0.03	0.06		0.04	U	1.298	mg/L	Fluoride
Nitrogen in Nitrate	mg/L	0.08		0.10		0.09		0.03	U	0.12	0.0097	U	0.01		9.42	mg/L	Nitrogen in Nitrate
Nitrogen in Nitrite	mg/L	0.03	U	0.04	U	0.03	U	0.02	U	0.02	0.02	U	0.02	U	0.045	mg/L	Nitrogen in Nitrite
Phosphorus in phosphate	mg/L	0.19		0.27		0.22		0.07	U	0.07	0.07	U	0.07	U	0.072	mg/L	Phosphorus in phosphate
Sulfate	mg/L	55.36		80.20		71.50		0.07	U	10.10	0.08	U	0.08	U	54.95	mg/L	Sulfate
Aluminum	µg/L	17.78	U	34.00	U	17.00	U	34	U	0.15	19	U	19	U	170	µg/L	Aluminum
Antimony	µg/L	0.29	U	0.30	U	0.30	U	0.3	U		0.3	U	0.3	U	69.8	µg/L	Antimony
Arsenic	µg/L	3.59		5.20		4.55		0.4	U	0.60	0.4	U	0.4	U	11.8	µg/L	Arsenic
Barium	µg/L	9.43		12.30		10.90		8	U		4	U	4	U	149	µg/L	Barium
Beryllium	µg/L	0.05	U	0.05	U	0.05	U	0.05	U		0.05	U	0.05	U	3.38	µg/L	Beryllium
Cadmium	µg/L	0.10	U	0.10	U	0.10	U	0.1	U	0.10	0.1	U	0.1	U	1.29	µg/L	Cadmium
Calcium	µg/L	10,691.93		14,400.00		12830.00		78	U	18000.00	27	U	27	U	58389	µg/L	Calcium
Chromium	µg/L	5.52		7.90		7.06		0.5	U	0.09	0.5	U	0.5	U	3.17	µg/L	Chromium
Cobalt	µg/L	4.13	U	8.00	U	4.00	U	8	U		4	U	4	U	1.29	µg/L	Cobalt
Copper	µg/L	4.60		6.96		5.30		4.52		0.74	0.469		2.04		1.04	µg/L	Copper
Cyanide	µg/L	3.81	U	4.00	U	4.00	U	4	U		4	U	4	U	9.52	µg/L	Cyanide
Iron	µg/L	51.87		58.10		49.50		36	U	150.00	38	U	38	U	1104	µg/L	Iron
Lead	µg/L	1.33		9.01		0.30		9.01		1.60	3.52		2.32		1.3	µg/L	Lead

Table D-1. Constituent Results for 242-A Process Condensate Characterization Results and Basin 42 Characterization Results

Sample Location	2009 Basin 42 Characterization Results					Basin 42 Average[b]		Process Condensate to LERF[c]		Process Condensate Cold Run[c]	Process Condensate to LERF[c]		Process Condensate to LERF[c]		Regional Groundwater Background Concentration[d]		Constituents
Sample Date	Units	Wtd Avg[a]		Max[b]		2009 - 2010		6/16/2009			8/31/2010		10/5/2010			Units	
Magnesium	µg/L	2,533.13		3,380.0		2986.67		32	U	5100.0	14	U	14	U	31051	µg/L	Magnesium
Manganese	µg/L	5.69		8.00		5.27		8	U	8.00	6	U	6	U	86.4	µg/L	Manganese
Mercury	µg/L	0.09		0.12		0.11		0.1		0.05	0.05	U	0.05	U	0.006	µg/L	Mercury
Nickel	µg/L	7.53		10.60		8.40		8	U	0.55	4	U	4	U	1.98	µg/L	Nickel
Potassium	µg/L	1,498.00		2,060.0		1826.67		586		900.00	73	U	73	U	11089	µg/L	Potassium
Selenium	µg/L	0.60		0.87		0.69		0.3	U	0.32	0.3	U	0.3	U	20.7	µg/L	Selenium
Silicon	µg/L	3,453.02		4,610.0		4120.00		275		5300.0	43		388		43904	µg/L	Silicon
Silver	µg/L	5.38	U	10.00	U	5.00	U	10	U		7	U	7	U	5.98	µg/L	Silver
Sodium	µg/L	18,276.24		26,700.00		23633.33		260		2500.0	11	U	11	U	32919	µg/L	Sodium
Thallium	µg/L	43.83		148.00		35.00	U	148		0.02	49	U	49	U	1.87	µg/L	Thallium
Titanium	µg/L	4.13	U	8.00	U	4.00	U	8	U		4	U	4	U	30	µg/L	Titanium
Uranium	µg/L	8.54		13.40		11.12		0.05	U		0.05	U	0.05	U	14.4	µg/L	Uranium
Vanadium	µg/L	2.93	U	24.00	U	12.00	U	24	U		17	U	17	U	19.3	µg/L	Vanadium
Zinc	µg/L	12.93		17.60		14.97		12	U	1.40	4	U	4	U	48.9	µg/L	Zinc
Specific Conductance	µS/cm	430.52		583.00		533.00		113		168.00	45.1		42.6		TBD	µS/cm	Specific Conductance
pH Measurement	unitless	9.65		10.40		9.65		10.4		8.20	9.87		9.54		TBD	unitless	pH Measurement
Alkalinity	mg/L	490.00		500.00		473.33		ND		71.20	ND		ND		156367	mg/L	Alkalinity
Total dissolved solids	mg/L	113.17		162.00		136.33		10	U	100.00	31		27		277190	mg/L	Total dissolved solids
Total suspended solids	mg/L	2.49		10.00		2.20		2	U		10	U	2	U		mg/L	Total suspended solids
Total organic carbon	mg/L	7.10		9.59		7.69		9.59			3.78		4.39		TBD	mg/L	Total organic carbon
1-Butanol	µg/L	287.66		1,700.0		163.33		680			1700		330		0	µg/L	1-Butanol
2-Butanone	µg/L	6.17		10.00		6.83		8.0			4.4		1	U	0	µg/L	2-Butanone
2-Pentanone	µg/L	3.34		5.70		3.70		1	U		5.7		2.1		0	µg/L	2-Pentanone
Acetone	µg/L	220.09		1,700.0		83.33		1700			260		140		0	µg/L	Acetone

Table D-1. Constituent Results for 242-A Process Condensate Characterization Results and Basin 42 Characterization Results

Sample Location	2009 Basin 42 Characterization Results					Basin 42 Average[b]		Process Condensate to LERF[c]		Process Condensate Cold Run[c]	Process Condensate to LERF[c]		Process Condensate to LERF[c]		Regional Groundwater Background Concentration[d]		Constituents
Sample Date	Units	Wtd Avg[a]		Max[b]		2009 - 2010		6/16/2009			8/31/2010		10/5/2010			Units	
Benzene	µg/L	0.95	U	1.0	U	1.0	U	1.0	U		1.0	U	1.0	U	0	µg/L	Benzene
Carbon tetrachloride	µg/L	0.95	U	1.0	U	1.0	U	1.0	U		1.0	U	1.0	U	0	µg/L	Carbon tetrachloride
Chloroform	µg/L	0.95	U	1.0	U	1.0	U	1.0	U		1.0	U	1.0	U	0	µg/L	Chloroform
Methylene chloride	µg/L	1.16		1.60		1.27		1	U		1	U	1	U	0	µg/L	Methylene chloride
Tetrahydrofuran	µg/L	36.89		84.00		30.33		74			84		61		0	µg/L	Tetrahydrofuran
2-Butoxyethanol	µg/L	50.95		330.00		18.33		220			34		330		0	µg/L	2-Butoxyethanol
2-Methylphenol (cresol, o-)	µg/L	1.26		4.30		1.00		0.8	U		3.8		4.3		0	µg/L	2-Methylphenol (cresol, o-)
Benzyl alcohol	µg/L	3.06		23.00		0.70		23			6.7		6.4		0	µg/L	Benzyl alcohol
n-Nitrosodimethylamine	µg/L	176.61		290.00		190.00		290			67		79		0	µg/L	n-Nitrosodimethylamine
Total cresols	µg/L	0.95		4.30		0.60	U	0.5	U		4.3		4.2		0	µg/L	Total cresols
Tributyl phosphate	µg/L	47.73		72.00		62.00		0.5	U		1	U	1	U	0	µg/L	Tributyl phosphate
Formate	pCi/L	0.00	U	0.01		ND	U	0.00467	U		0.00467	U	0.00629		0	pCi/L	Formate
Gross alpha	pCi/L	136.24		190.00		176.67		4.7		0.60	2.3	U	2.3	U	0	pCi/L	Gross alpha
Gross beta	pCi/L	23,218.16		34,000.00		30000.00		930		2.80	2100		140		4.15	pCi/L	Gross beta

Note: Spreadsheet data were provided by Effluent Treatment Facility personnel.

a. Weighted average for Basin 42 based on samples collected in Risers 2, 4, and 7 from June 2009, August 2010, and October 2010, respectively.

b. Maximum and average results are derived from the three sample dates June 2009, August 2010, and October 2010.

c. Process condensate results are associated with characterization results collected at 242-A Evaporator.

d. Results based on Hanford Site Background: Part 3, Groundwater Background (DOE/RL-96-61).

gal = gallons
mg/L = milligrams per liter
µg/L = micrograms per liter
µS/cm = microSiemens per centimeter
u = less than detection
Wtd Ave = weighted average

This page intentionally left blank.

Table D-2. Basin 43 Constituent Characterization Results for Past 200-UP-1 and 200-ZP-1 Groundwater Waste Streams and Recent Waste Characterization Results For Basin 43

Constituent	Units	200-UP-1 and 200-ZP-1 Groundwater[a]		Basin 43 Characterization Results[c]		ERDF Leachate[d]		200-BP-5 Perched Water[e]	
Volume	gal	7.03E+7[b]		9.13E+05					
Added Vol.	gal			1.26E+06		5.62E+05		2.36E+04	
Ammonium (N)	mg/L	0.064		0.1		0.1			
Bromide	mg/L	0.4		1.2		1.5		1.2	
Chloride	mg/L	22.1		176.9		224.0		83.7	
Fluoride	mg/L	2.7		1.2		0.2		22	
Nitrate (N)	mg/L	101		63.8		64.6		219.7	
Nitrite (N)	mg/L	0.036	U	3.4	U	7.6	U	0.2	U
Phosphate (P)	mg/L	0.12	U	0.2	U	0.3	U	0.3	
Sulfate	mg/L	57.2		404.4		597.0		556.4	
Aluminum	µg/L	44		17.5		19.7	U	125	
Antimony	µg/L	0.3	U	3.3	U	6.0	U	31	U
Arsenic	µg/L	5.5		6.9		7.7		7.5	
Barium	µg/L	71.1		96.7		129.1		62.1	
Beryllium	µg/L	0.05	U	0.8	U	1.3	U	3	U
Cadmium	µg/L	0.1	U	0.5		0.3		4.4	
Calcium	µg/L	56861.5		181161.2		248000.0		167000	
Chromium	µg/L	121.1		36.1		29.2		143.9	
Cobalt	µg/L	4	U	67.7		145.0		9	
Copper	µg/L	0.15		121.1		145.0		21.7	
Hexavalent Chromium	µg/L	113							
Iron	µg/L	18	U	21.2		14.3		130.4	
Lead	µg/L	0.1	U	5.1		10.9			
Magnesium	µg/L	18361.5		44035.4		53750.0		71300	
Manganese	µg/L	4	U	7.1		6.9		129.7	
Mercury	µg/L	0.05	U	0.1		0.2	U		
Nickel	µg/L	4	U	6.7		6.3		19.9	U
Potassium	µg/L	5536.2		13579.6		17138.0		10100	
Selenium	µg/L	4.8		5.7		8.0			
Silicon	µg/L	21300		17465.4		21750.0			
Silver	µg/L	5	U	5.5		5.0		33	U
Sodium	µg/L	161846.2		187496.6		191250.0		391000	
Thallium	µg/L	36	U	27.7		5.0	U		
Titanium	µg/L	4	U	4.4		4.0			
Uranium	µg/L	25.6		2249.2		1100.6		43500	
Vanadium	µg/L	38.5		32.9		45.1		17.4	
Zinc	µg/L	37.5		25.5		27.2		92.2	
Specific Conductance	µS/cm	1206.2		2041.7		2483.8		2592	
pH Measurement	unitless	7.95		6.9		7.8		7.7	
Alkalinity	mg/L	151		224.9		296.0		231	
Total dissolved solids	mg/L	906.8		1351.1		1688.8			
Total suspended solids	mg/L	1.62		9.7		19.4			
Total organic carbon	mg/L	0.64		6.0		6.4			
Carbon tetrachloride	µg/L	490.7		12.1		5.0	U	1.0	U
Chloroform	µg/L	8.5		0.6	U			1.0	U
Tetrahydrofuran	µg/L	2	U	1.1	U			1.0	U
Gross alpha	pCi/L	29.4		1510.2		587.6		38800	
Gross beta	pCi/L	2830.8		8065.1		394.8		34600	

a. 200-UP-1 and 200-ZP-1 Average Groundwater Characterization Results Based on up to 14 samples collected between 2008 and 2011.

b. Total volume of 200-UP-1 and 200-ZP-1 groundwater received between 2008 and 2011.

c. Characterization results of the Basin 43 after removal of the 200-UP-1 and 200-ZP-1 groundwater from the basin.

d. Represents the dominant waste stream for Basin 43 since 200-UP-1 and 200-ZP-1 groundwater transfers have ceased (2012 total gallons to Basin 43 were 2,770,000).

e. Represents the third most dominant waste stream received at Basin 43 (2012 total gallons to Basin 43 were 130,000).

Notes: The second and fourth dominant waste streams were MODU-Tanks and Hanford purge water (2012 total gallons to Basin 43 were 291,500), which are the same streams and contain significantly less contaminant concentrations than the ERDF leachate and 200-BP-5 perched water. Spreadsheet data were provided by Effluent Treatment Facility Personnel.

This page intentionally left blank.

Table D-3. ERDF Leachate

CAS #	Constituent	Average Concentration between February 2000 and September 2012	Units	Regional Groundwater Background Concentration*	Units
7429-90-5	Aluminum	31	µg/L	170	µg/L
7440-36-0	Antimony	1	µg/L	69.8	µg/L
7440-38-2	Arsenic	9	µg/L	11.8	µg/L
7440-39-3	Barium	97	µg/L	149	µg/L
	Beryllium	0	µg/L	3.38	µg/L
7440-70-2	Calcium	213,735	µg/L	58,389	µg/L
7440-47-3	Chromium	27	µg/L	3.17	µg/L
7440-50-8	Copper	20	µg/L	1.04	µg/L
7439-89-6	Iron	35	µg/L	1,104	µg/L
7439-92-1	Lead	2.8	µg/L	1.3	µg/L
7439-95-4	Magnesium	69,580	µg/L	31,051	µg/L
7440-02-0	Nickel	13	µg/L	1.98	µg/L
7440-09-7	Potassium	20,573	µg/L	11,089	µg/L
7782-49-2	Selenium	5	µg/L	20.7	µg/L
7440-21-3	Silicon	20,063	µg/L	43,904	µg/L
7440-23-5	Sodium	254,237	µg/L	32,919	µg/L
7440-31-5	Tin	1	µg/L	23.6	µg/L
	Thallium	0	µg/L	1.87	µg/L
7440-62-2	Vanadium	26	µg/L	19.3	µg/L
7440-66-6	Zinc	14	µg/L	48.9	µg/L
56-23-5	Carbon Tetrachloride	0	µg/L	0	µg/L
67-56-1	Trichloroethene	0	µg/L	0	µg/L
75-69-4	Methyl Alcohol	0	µg/L	0	µg/L
	Trichlorofluoromethane	3.2	µg/L	0	µg/L
pH	pH	7 to 8	unitless	TBD	unitless
CONDUCT	Specific Conductance	2509	µmS/cm	TBD	µmS/cm
24959-67-9	Bromide	1242	µg/L	151	µg/L

Table D-3. ERDF Leachate

CAS #	Constituent	Average Concentration between February 2000 and September 2012	Units	Regional Groundwater Background Concentration*	Units
16887-00-6	Chloride	249,638	µg/L	19,580	µg/L
16984-48-8	Fluoride	521	µg/L	1,298	µg/L
14797-55-8	Nitrate	327,241	µg/L	41,723	µg/L
14797-65-0	Nitrite	500U	µg/L	130	µg/L
14808-79-8	Sulfate	473,776	µg/L	54,950	µg/L
TOC	Total Organic Carbon	13,148	µg/L	TBD	µg/L
OIL/GREASE	Oil and Grease	3,213	µg/L	0	µg/L
TDS	Total Dissolved Solids	1,926,897	µg/L	TBD	µg/L
TSS	Total Suspended Solids	15,686	µg/L	TBD	µg/L
12587-46-1	Alkalinity	264,813	µg/L	156,367	µg/L
12587-47-2	Gross alpha	965	pCi/L	0	pCi/L
14762-75-5	Gross beta	643	pCi/L	4.15	pCi/L

* Results are based on *Hanford Site Background: Part 3, Groundwater Background* (DOE/RL-96-61).

Note: Spreadsheet data were provided by Effluent Treatment Facility personnel.

TBD = to be determined

Table D-4. LERF Well Attributes

Wells	299-E26-9	299-E26-10	299-E26-11	299-E26-14	299-E26-77	299-E26-79	299-E35-2
Date Drilled	August, 1990	August, 1990	August, 1990	September, 2011	October, 2008	September, 2008	August, 1990
Top of Casing Elevation (m/ft)	184.854/606.48	184.418/605.05	183.88/603.281	183.224/601.129	184.782/606.24	183.115/600.771	184.611/605.679
Ground Surface Elevation (m/ft)	183.941/603.48	183.512/602.07	182.979/600.325	182.494/598.734	184.011/603.371	182.356/598.281	183.712/602.73
Total Depth Drilled (m/ft)	61.722/202.5	62.972/206.6	61.417/201.5	73.334/240.6	70.957/232.8	68.507/224.76	61.661/202.3
Elevation of Total Depth Drilled (m/ft)	122.219/400.98	120.54/395.47	121.562/398.825	109.16/358.134	113.054/370.571	113.849/373.521	122.051/400.43
Depth to Top of Basalt (m/ft)	61.271/201.02	62.271/204.3	60.35/198	67.361/221	62.636/205.5	63.094/207	60.991/200.1
Top of Basalt Elevation (m/ft)	122.67/402.46	121.241/397.77	122.629/402.325	115.133/377.734	121.375/397.871	119.262/391.281	122.722/402.63
Bottom of Sump Elevation (m/ft)	None	None	None	115.773/379.834	114.334/374.771	114.325/375.081	None
Fill Below Bottom of Sump/Screen	20-40 Sand	20-40 Sand	20-40 Sand	Bentonite Pellets/ 10-20 Sand[d]	10-20 Sand	10-20 Sand	20-40 Sand
Bottom of Screen Elevation (m/ft)	122.707/402.58	120.693/395.97	120.251/394.525	116.688/382.834	115.248/377.771	115.239/378.081	122.295/401.23
Top of Screen Elevation (m/ft)	125.937/413.18	125.448/411.57	121.958/400.125	122.784/402.834	122.792/402.521	122.859/403.081	125.526/411.83
Sand Pack	20-40 Sand	20-40 Sand	20-40 Sand	10-20 Sand	10-20 Sand	10-20 Sand	20-40 Sand
Water Table Elevation After Drilling (m/ft)	124.444/408.28[a]	124.594/408.773[b]	125.097/410.425[c]	121.922/400[e]	121.987/400.22[f]	121.976/400.184[g]	124.611/408.83[h]
Water Table Elevation 4/10/2013 (m/ft)	Dry	121.81/399.639	122.602/402.238	121.878/399.862	121.825/399.688	121.808/399.633	Dry
Water Height Across Screen 4/10/2013 (m/ft)	Dry	1.117/3.67	2.351/7.713	5.19/17.028	6.577/21.917	6.569/24.552	Dry
Water above Basalt 4/10/2013 (m/ft)	Dry	0.569/1.87	None	6.745/22.128	0.45/1.817	2.546/8.352	Dry
Ringold Present	No	No	Yes	Yes	No	Yes	Yes[i]
Depth to Top of Ringold (m/ft)	NA	NA	57.607/189	65.532/215	NA	62.789/206	Not Provided
Top of Ringold Elevation (m/ft)	NA	NA	125.372/411.325	116.962/383.734	NA	119.567/392.281	Uncertain
Thickness of Ringold Across Screen 4/10/2013 (m/ft)	NA	NA	NA	0.274/0.9	NA	0.3048/1	Uncertain
Best Estimate of Hydraulic Conductivity (m/day)	6 to 120	36.2 to 42.8	6.3	27.3	134		39.7

a. Date 8/1/1990
b. Date 9/4/1990
c. Date 8/13/1990
d. Bentonite pellets to 0.7 ft below bottom of sump
e. Date 12/29/2011
f. Date 11/26/2008
g. Date 11/26/2008
h. Date 8/2/1990
i. Basis: WHC-SD-EN-EV-024, *Site Characterization Report for the Liquid Effluent Retention Facility*
NA = not applicable

Table D-5. LERF Groundwater Gradient and Magnitude Calculations

Well Name	December, 2011	February, 2012	April, 2012	August, 2012	September, 2012	November, 2012	December, 2012	January, 2013
	New RP, Gyro Correction & BP Adjustment	New RP, Gyro Correction & BP Adjustment	New RP, Gyro Correction & BP Adjustment	New RP, Gyro Correction & BP Adjustment	New RP, Gyro Correction & BP Adjustment	New RP, Gyro Correction & BP Adjustment	New RP, Gyro Correction & BP Adjustment	New RP, Gyro Correction & BP Adjustment
299-E26-10	121.838	121.834	121.816	121.808	121.809	121.828	121.830	121.825
299-E26-14	121.911	121.895	121.890	121.878	121.878	121.898	121.899	121.891
299-E26-77	121.844	121.843	121.824	121.820	121.822	121.839	121.841	121.835
299-E26-79	121.847	121.835	121.818	121.813	121.816	121.830	121.837	121.839
Range (m):	0.073	0.061	0.074	0.070	0.069	0.070	0.069	0.066
Gradient Magnitude (m/m):	2.75E-04	2.49E-04	2.98E-04	2.77E-04	2.69E-04	2.85E-04	2.67E-04	2.39E-04
Direction (azimuth):	195	186	188	188	189	186	190	198
R^2:	0.92	0.93	0.91	0.94	0.95	0.93	0.94	0.96
p-Value:	0.2858	0.2670	0.2928	0.2348	0.2132	0.2569	0.2355	0.2071
Statistically Significant?:	No	No	No	No	No	No	No	No

RP = Reference Point

BP = Barometric Pressure

In order to minimize the measurement error associated with the monitoring network, steps were taken that included deviation correction from vertical of the well bore, barometric corrections completed within each well and correlated with barometric conditions measured at weather station in 200 Areas; precision geodetic surveys to a common benchmark; dedicated e-tape measurements for depth-to-groundwater from the dedicated point associated with the precision survey at each well; dedicated person for measuring water levels all groundwater level measurements completed on same day per month. Further discussion on these corrections is provided in *Calculations in Support of the Low Hydraulic Gradient Evaluation Study for the 200 East Area Unconfined Aquifer* (ECF-200EAST-12-0086).

After these corrections have been applied, a least square regression of the plane to elevations associated with the well locations is completed to derive the gradient. The gradient, azimuth, R2 ratio, the p-value are provided in the lower part of the table. Briefly, the R2 ratio is the goodness of fit coefficient. Basically, it is the ratio of the sum of squares because of the regression to the total sum of squares. If the ratio of the two sums is close to 1, indicating unity, then the fit is considered good. Likewise, the p-value is the probability that the degree of an apparent spatially dependent trend observed in the data (or a trend of even greater degree) would occur solely by random chance. Thus, if the p-value is less than 0.05, the fitted trend surface is deemed statistically significant. Again, further details of this process calculation are provided in ECF-200EAST-12-0086.

Table D-6. Geochemical Constituent Evaluation for Groundwater

Constituent	Sample Frequency	Comment
• Major anions • Major cations • Alkalinity	Semiannually	Aid geochemical evaluation

Table D-7. Dangerous Constituents and Indicators to be Analyzed as Indicators of Groundwater Contamination at the LERF Basins

Constituent	Sample Frequency	Comment
• Carbon tetrachloride • pH • Specific conductance • Total organic carbon • Total organic halides	Samples collected semiannually for detection monitoring.	Subject to statistical evaluation, based on the standard sampling plan outlined in WAC 173-303-645(8)(g)(i) and WAC 173-303-645(8)(h)(i). Analyze hexavalent chromium as potential indicator parameter.

Source: WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

Notes: Wells 299-E26-14 and 299-E26-79 are sampled as upgradient and downgradient compliance wells semiannually.

Well 299-E26-77 will be sampled semiannually for geochemical and field parameters, but not used for background calculations.

Table D-8. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field Quality Control		
Full trip blank	Contamination from containers or transportation	One per 20 well trips
Field transfer blank	Airborne contamination from the sampling site	One each day volatile organic compound samples are collected
Equipment blank	Contamination from non-dedicated sampling equipment	As needed[a]
Duplicate samples	Reproducibility	One per 20 well trips
Laboratory Quality Control		
Method blank	Laboratory contamination	One per batch
Laboratory duplicates	Laboratory reproducibility	[b]
Matrix spike	Matrix effects and laboratory accuracy	[b]
Matrix spike duplicate	Laboratory reproducibility and	[b]

Table D-8. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
	accuracy	
Surrogates	Recovery/yield	[b]
Laboratory control sample	Method accuracy	One per batch

a. For portable Grundfos pumps, equipment blanks are collected 1 per 10 well trips. Whenever a new type of non-dedicated equipment is used, an equipment blank is collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.

b. As defined in the laboratory contract or quality assurance plan and/or analysis procedures.

Table D-9. Preservation Techniques, Analytical Methods Used, and Current Required Quantitation Limits for Chemical Constituents

Constituent	Collection & Preservation[a,b]	Analysis Methods[c]	Method Quantitation Limit (µg/L)[d]
Metals			
Calcium	P, HNO_3 to pH<2	SW-846[e] Method 6010,or EPA/600 Method 200.8	1,000
Magnesium			750
Potassium			4,000
Sodium			500
Anions by Ion Chromatography			
Nitrate	P, none	EPA/600 Method 300.0[f]	250
Sulfate			500
Chloride			200
Nitrite			250
Volatile Organics			
Carbon Tetrachloride	G, no headspace	SW-846 8260	2
Total Organic Halides			
Total Organic Carbon	G, no headspace	SW-846 9060A	140
Total Organic Halides			
Total Organic Halides	G, no headspace	SW-846 9020B	20
Hexavalent Chromium			
Hexavalent Chromium	P, none	EPA/7196A	10
Alkalinity			

Table D-9. Preservation Techniques, Analytical Methods Used, and Current Required Quantitation Limits for Chemical Constituents

Constituent	Collection & Preservation[a,b]	Analysis Methods[c]	Method Quantitation Limit (µg/L)[d]
Alkalinity	G/P, none	EPA Standard Method[g] 2320 EPA/600 Method 310.1 EPA/600 Method 310.2	5,000

a. P = plastic; G = glass.

b. All samples will be cooled to 4ºC upon collection.

c. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

d. Detection limit units, except where indicated.

e. SW-846, *Methods for Evaluation of Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

f. Analytical method adapted from Method 300.0, *Test Methods for Determination of Inorganic Anions in Water by Ion Chromatography* (EPA-600/4-84-017).

g. *Standard Methods for the Examination of Water and Wastewater* (APHA /AWWA/WEF, 2012).

EPA = U.S. Environmental Protection Agency

N/A = not applicable

Table D-10. Field and Laboratory Quality Control Elements and Acceptance Criteria

Constituent[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity	MB	<MDL	Flagged with “C”
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	<20% RPD[c]	Data reviewed[d]
	MS[e]	75-125% recovery[c]	Flagged with “N”
	EB, FTB	<2 times MDL	Flagged with “Q”
	Field duplicate	<20% RPD[f]	Flagged with “Q”
Anions			
Anions by IC	MB	<MDL	Flagged with “C”
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	<20% RPD[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with “N”
	EB, FTB	<2 times MDL	Flagged with “Q”
	Field duplicate	<20% RPD[f]	Flagged with “Q”

Table D-10. Field and Laboratory Quality Control Elements and Acceptance Criteria

Constituent[a]	QC Element	Acceptance Criteria	Corrective Action
Metals			
ICP metals	MB	<CRDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	MSD	<20% RPD[c]	Data reviewed[d]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	<20% RPD[f]	Flagged with "Q"
Volatile Organic Compounds			
Carbon tetrachloride	MB	<MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB, FXR	<2 times MDL	Flagged with "Q"
	Field duplicate	<20% RPD[f]	Flagged with "Q"
Hexavalent Chromium			
Hexavalent Chromium	MB	<2 times MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	<20% RPD[f]	Flagged with "Q"

Table D-10. Field and Laboratory Quality Control Elements and Acceptance Criteria

Constituent[a]	QC Element	Acceptance Criteria	Corrective Action

a. Refer to Table D-7 for specific analytical methods.

c. Laboratory-determined, statistically derived control limits may also be used. Such limits are reported with the data.

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect ("Y" flag) or rejected ("R" flag).

e. Applies to total organic carbon and total organic halides only.

f. Applies only in cases where one or both results are greater than 5 times the detection limit.

g. Determined by the laboratory based on historical data. Control limits are reported with the data.

Data flags:

B, C = possible laboratory contamination (analyte was detected in the associated method blank)

N = result may be biased (associated matrix spike result was outside the acceptance limits)

Q = problem with associated field QC sample (blank and/or duplicate results were out of limits)

Abbreviations:

CRDL = contract-required detection limit
DUP = laboratory matrix duplicate
EB = equipment blank
FTB = full trip blank
FXR = field transfer blank
GC = gas chromatography
ICP = inductively coupled plasma
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference
SUR = surrogate

Table D-11. Blind-Standard Constituents and Schedule

Constituents	Frequency	Accuracy (%)[a]	Precision (% RSD)[a]
Carbon Tetrachloride	Quarterly	±25%	<25%
Total Organic Halides[b]	Quarterly	±25%	<25%

a. If the results are less than 5 times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.

b. Two sets of spikes for total organic halides will be used. The spiking compound for one set should be 2,4, 5-trichlorophenol. The spiking compound for the second set should include the constituents used for the volatile organic compounds sample (carbon tetrachloride).

RSD = relative standard deviation

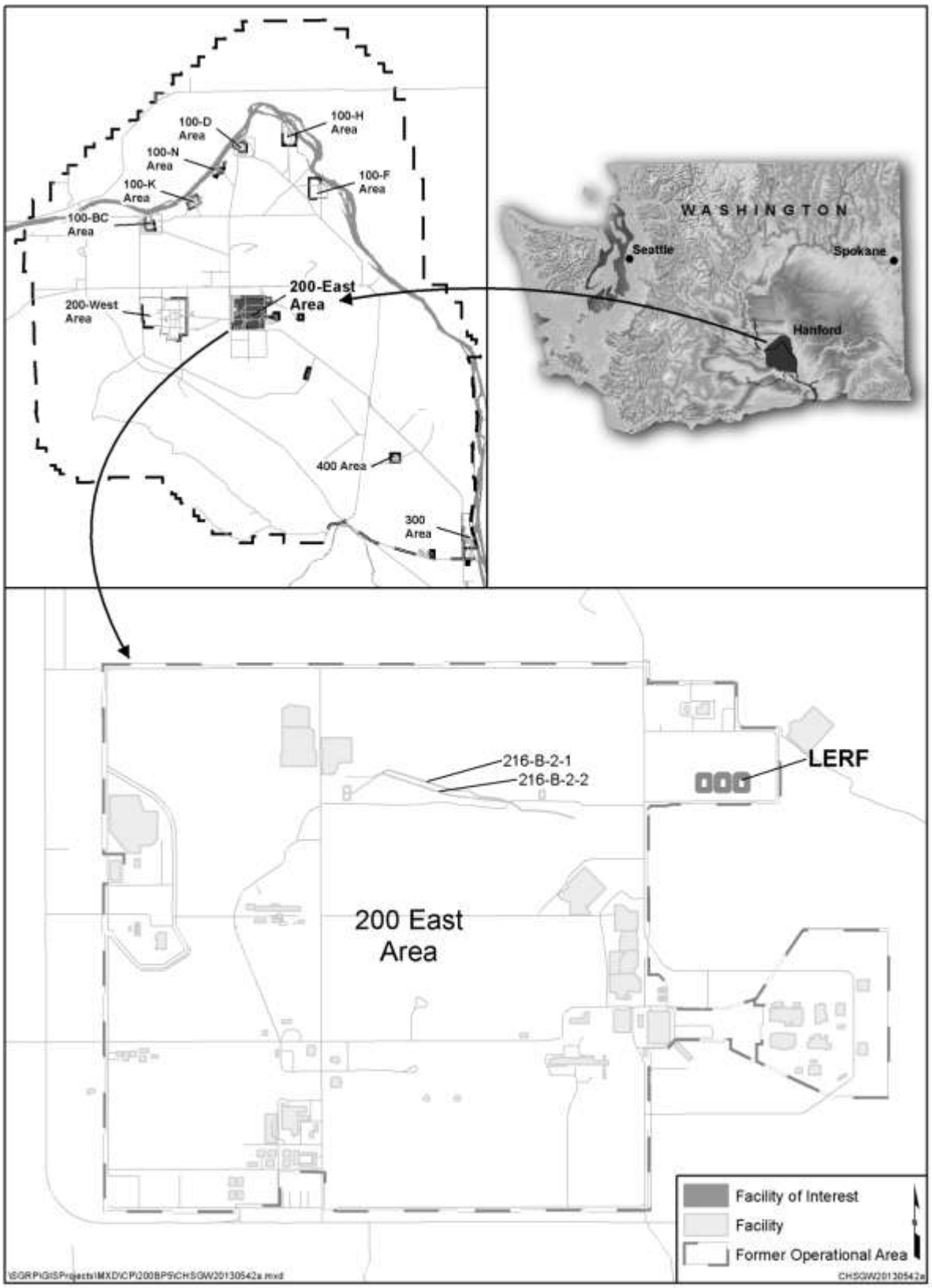


Figure D-1. LERF Location Map

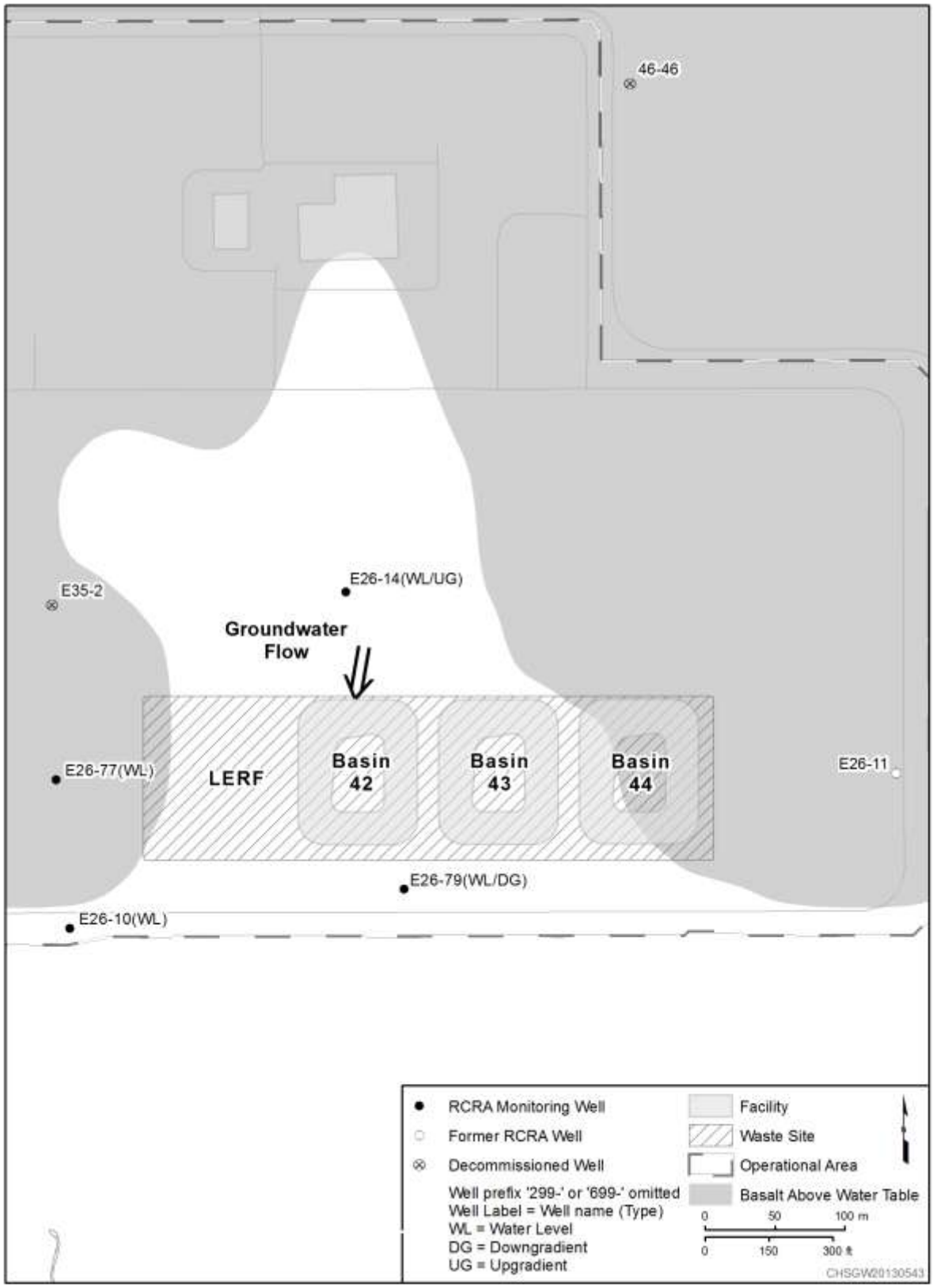


Figure D-2. LERF Well and Facility Description Map

This page intentionally left blank.

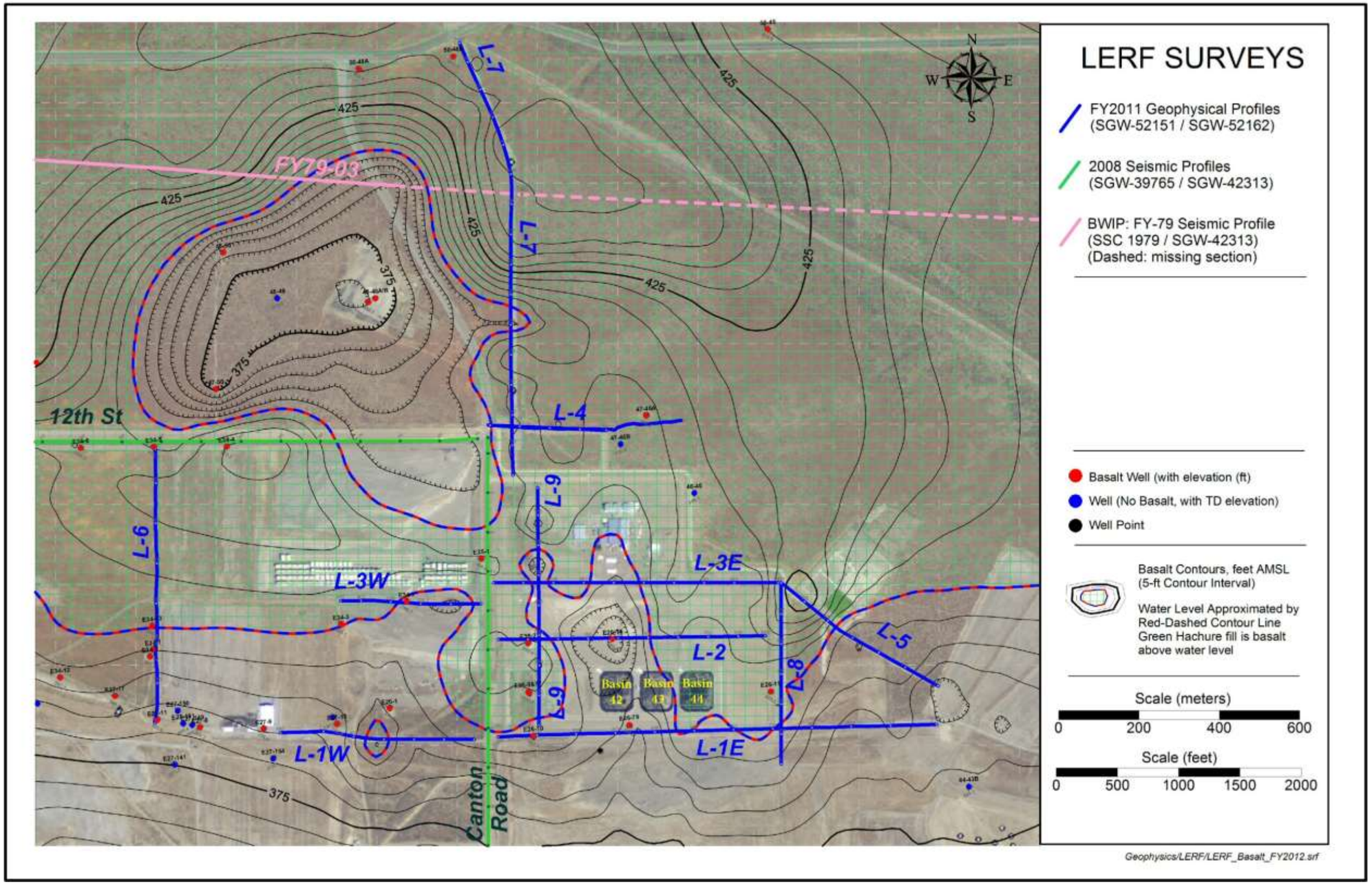


Figure D-3. LERF Location Map Showing Revised Unconfined Aquifer Thickness Based on Geophysical and Previous Borehole Data

This page intentionally left blank.

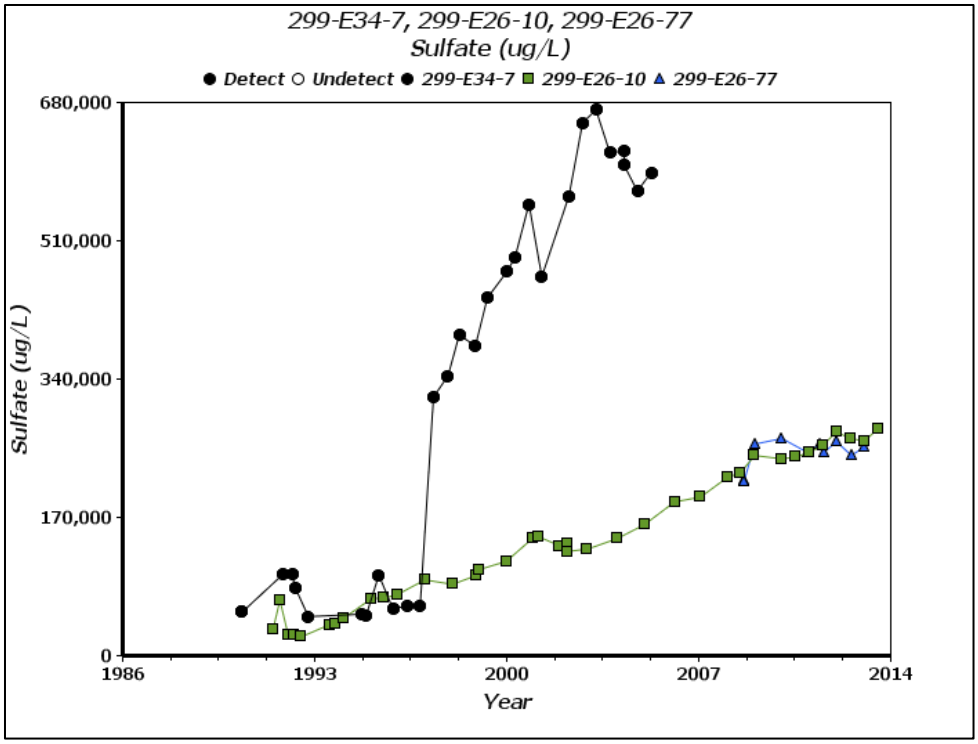


Figure D-4. Comparison of Sulfate at Wells 299-E34-7, 299-E26-14, and 299-E26-10

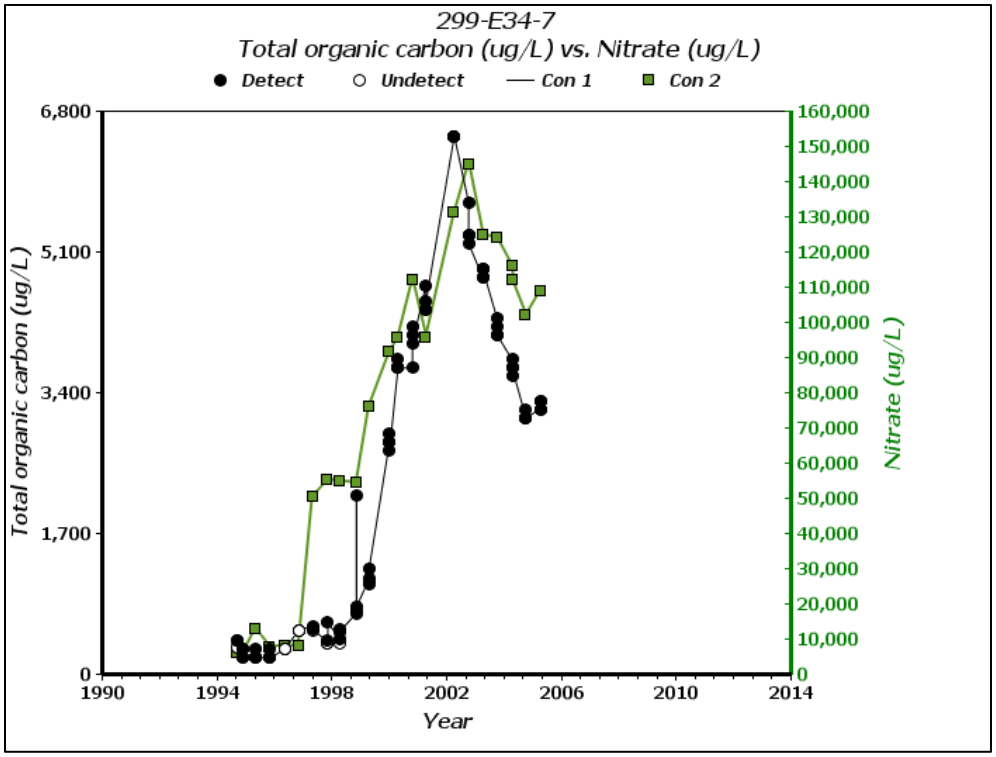


Figure D-5. History of Total Organic Carbon and Nitrate at Well 299-E34-7

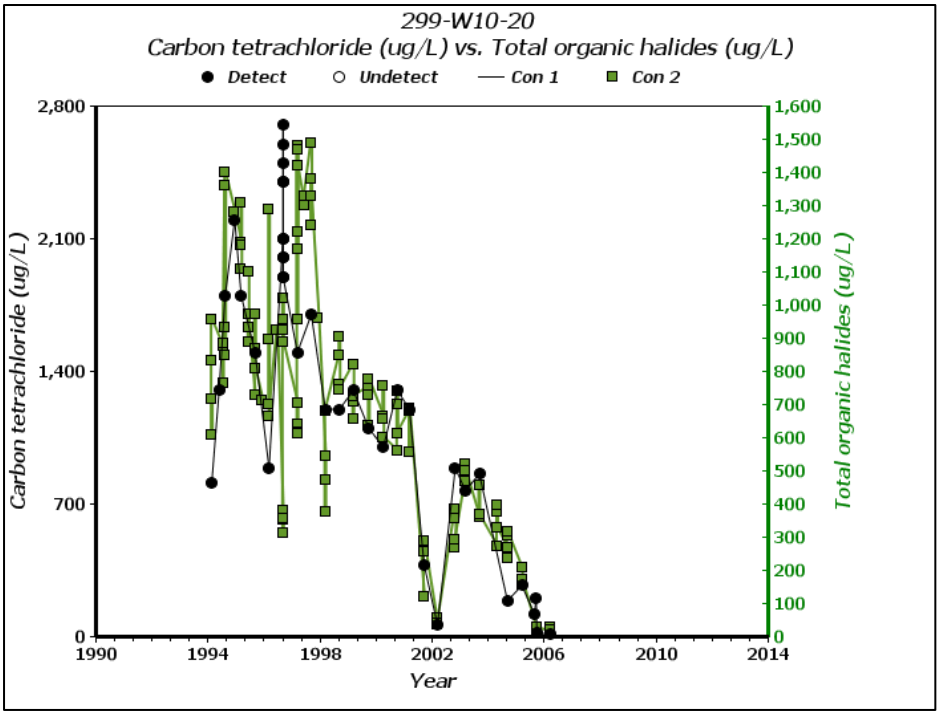


Figure D-6. Comparison of Carbon Tetrachloride to Total Organic Halides

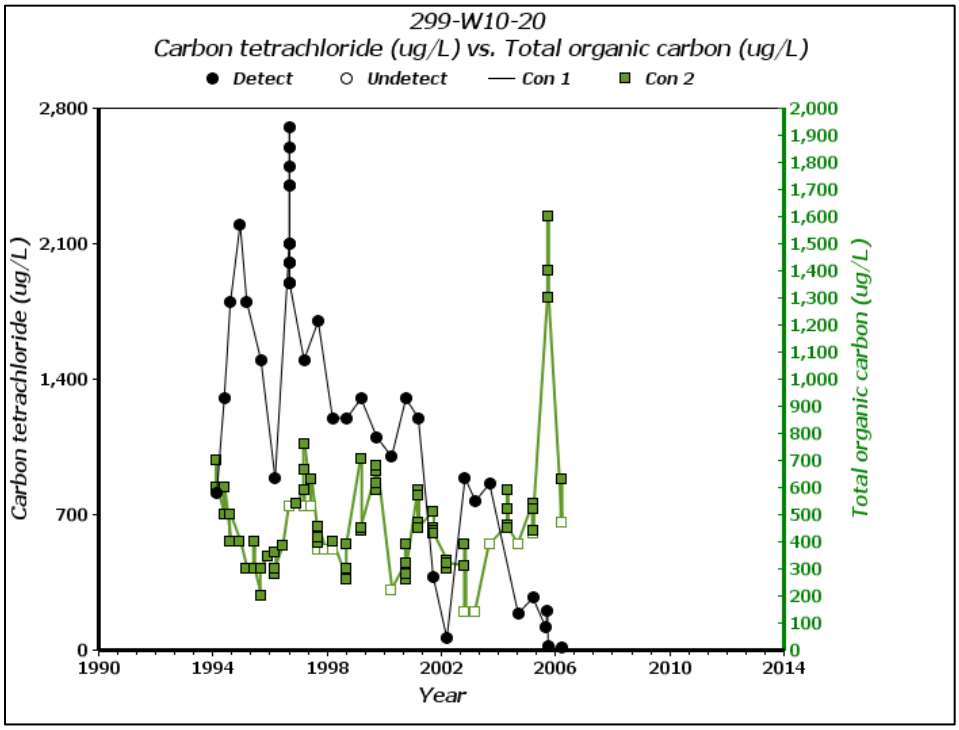


Figure D-7. Comparison of Carbon Tetrachloride to Total Organic Carbon

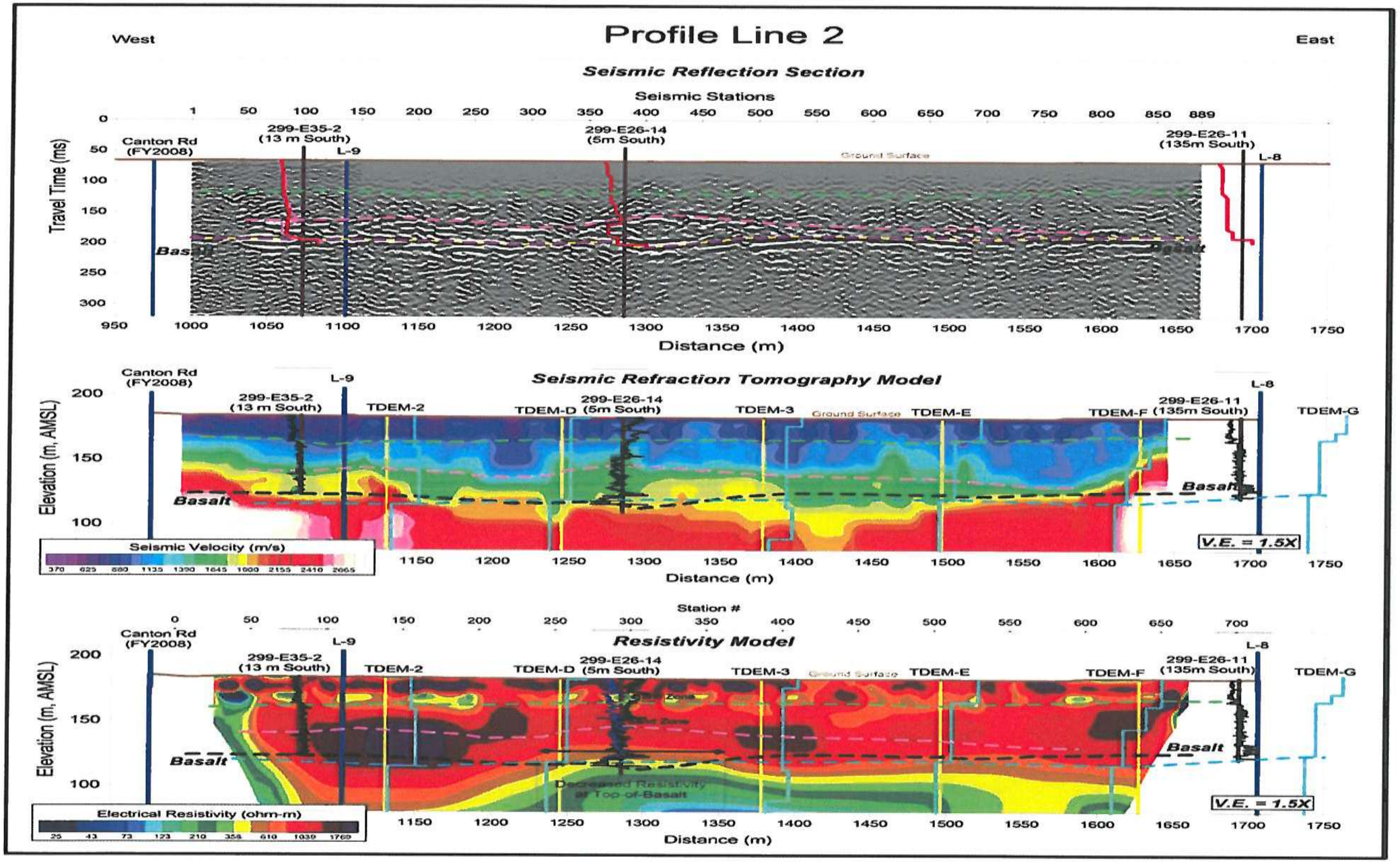


Figure D-8. Seismic Profile North of LERF extending from Well 299-E35-2 to Well 299-E26-11 and Including Well 299-E26-11

This page intentionally left blank.

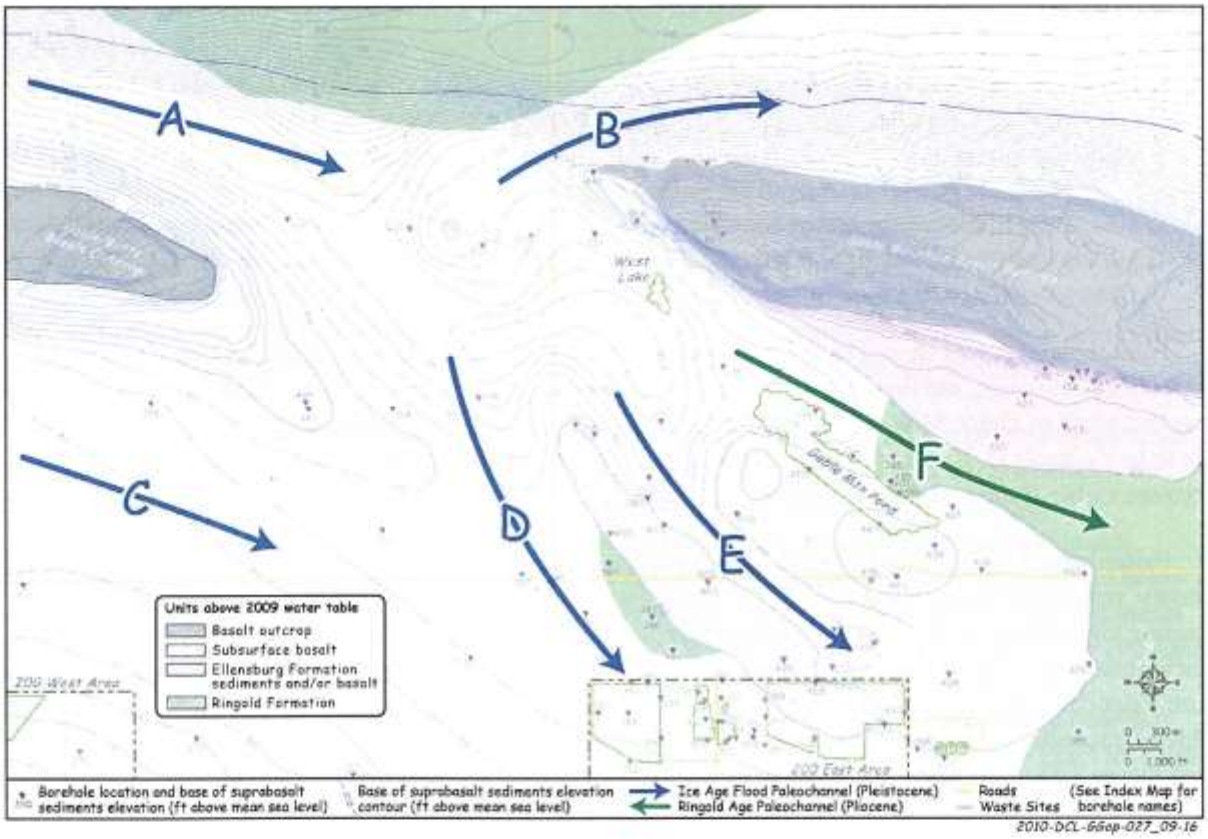


Figure D-9. Conceptual Model of Buried Paleochannels Extending Through Gable Gap

This page intentionally left blank.

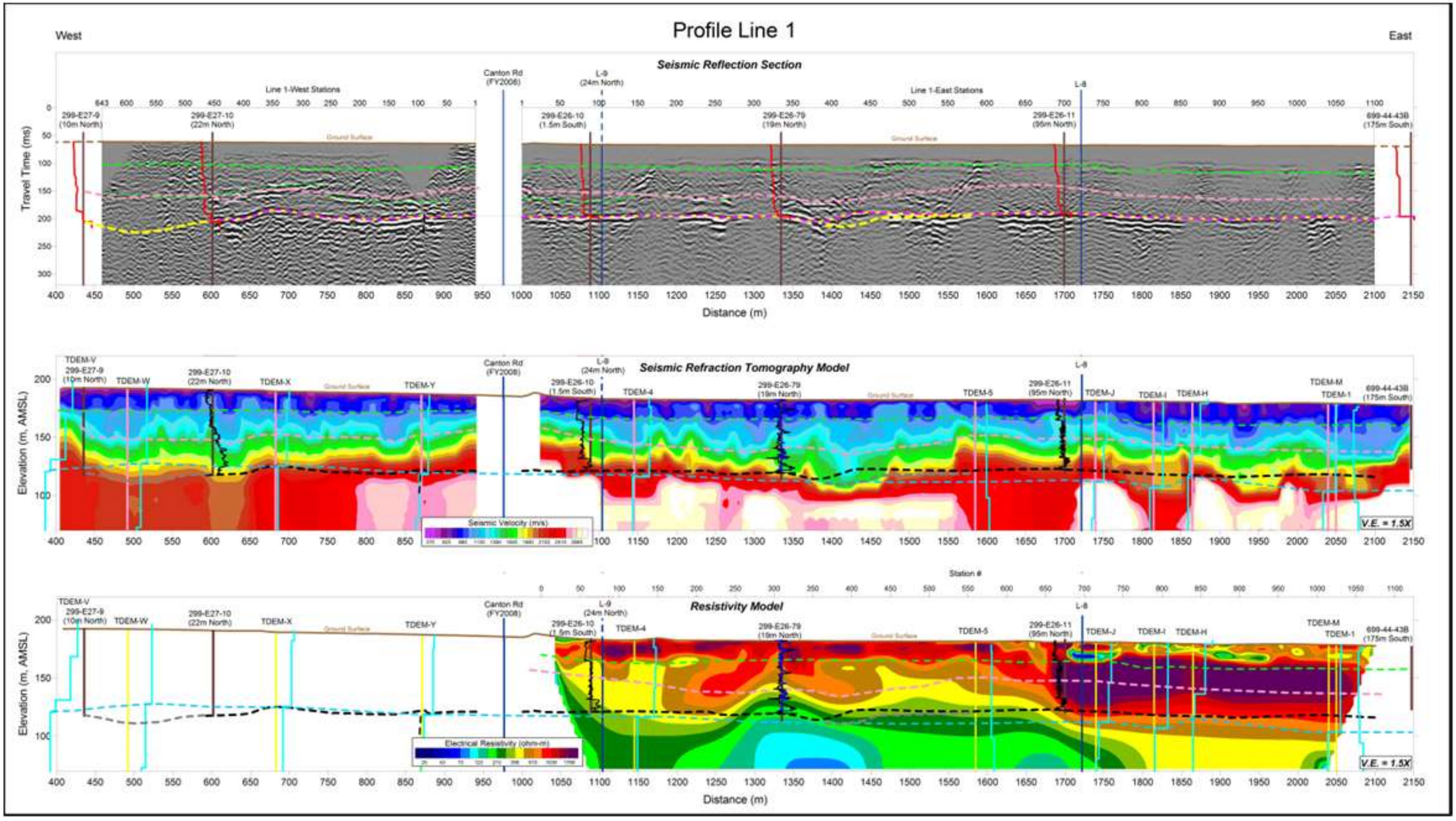
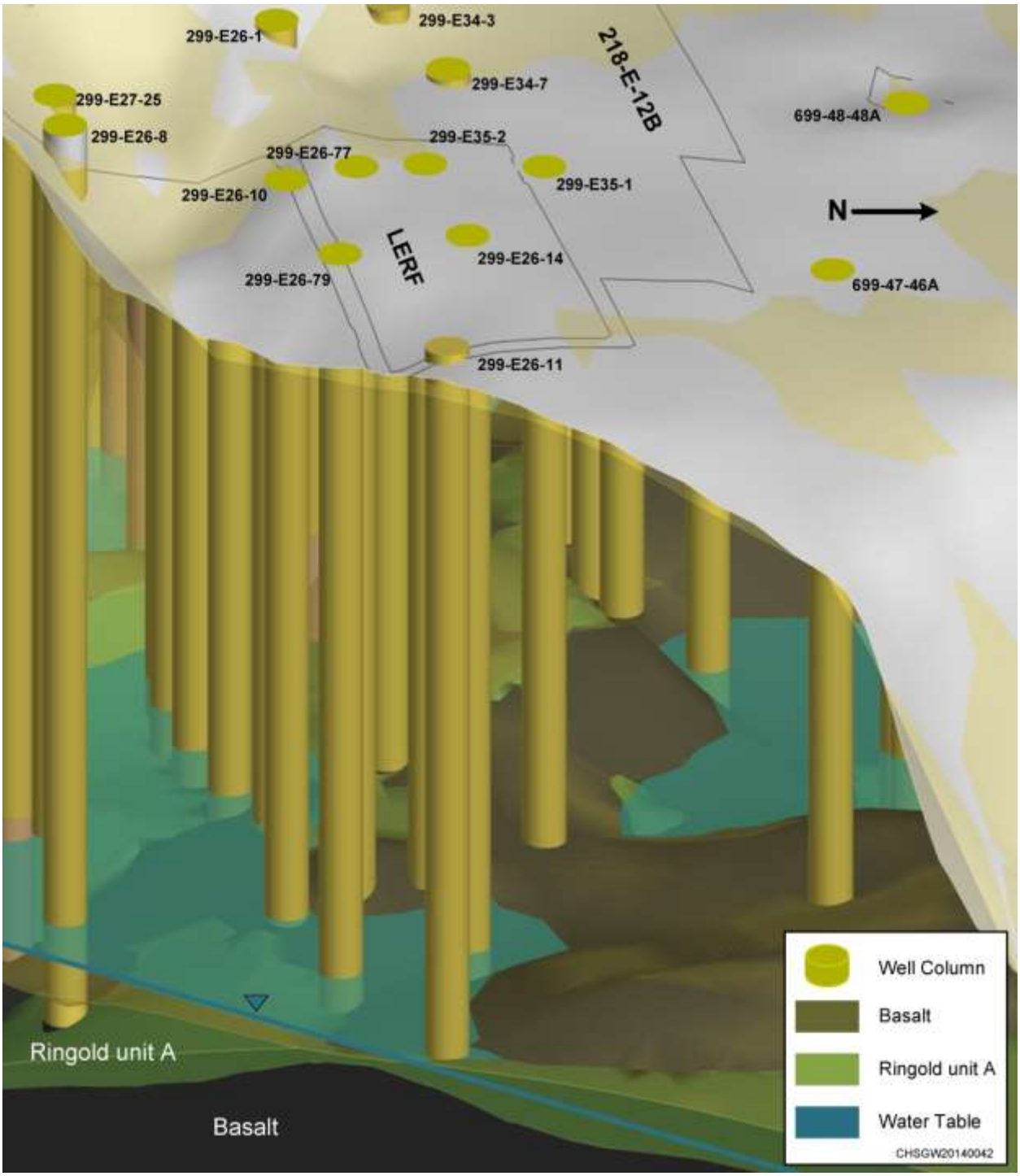


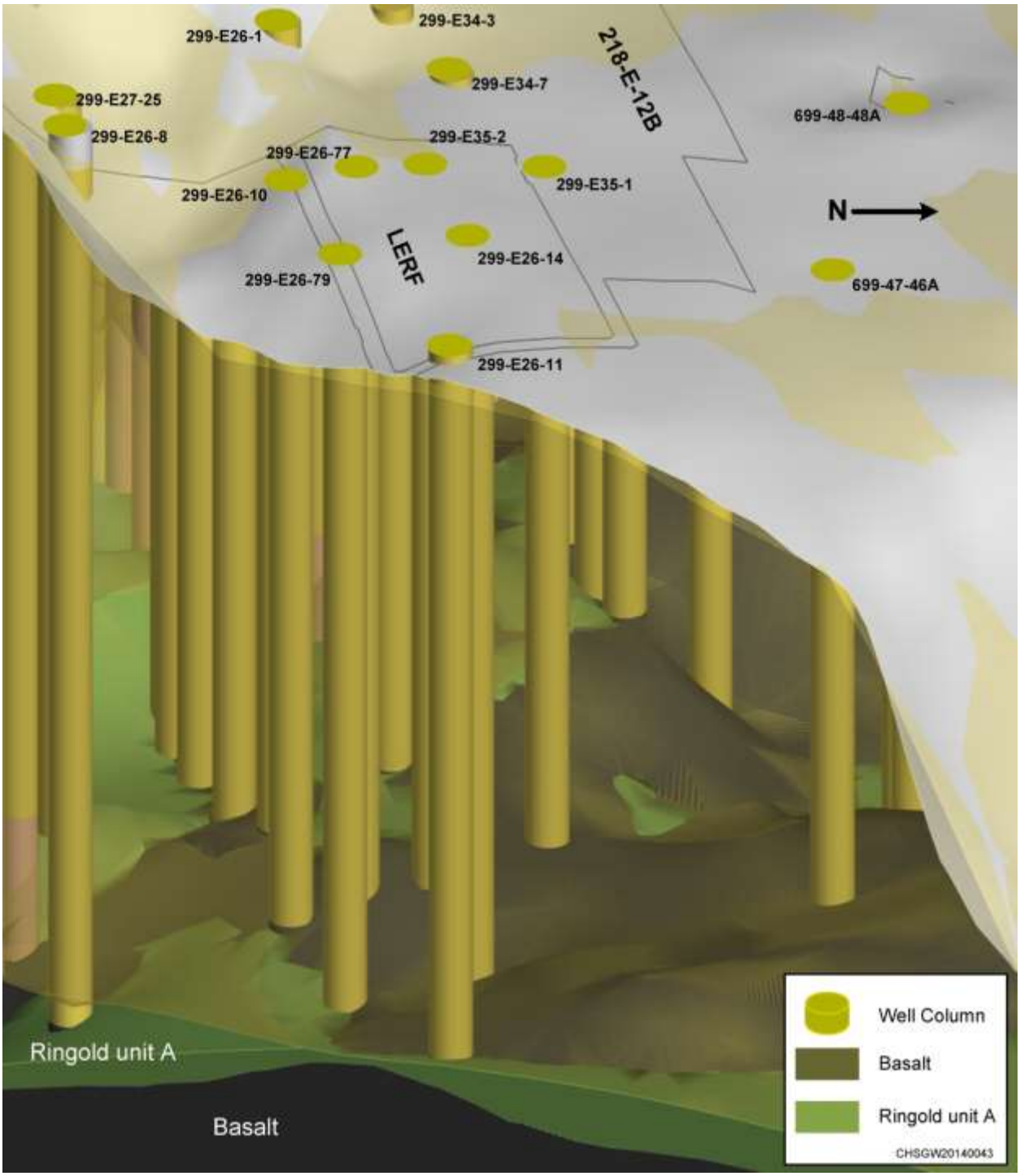
Figure D-10. Seismic Profile South of LERF with Focus on Area between Wells 299-E26-10 and 299-E26-11

This page intentionally left blank.



Note: The Hanford sediments have been removed to portray the basalt surface, remnant Ringold Formation, and groundwater elevation.

Figure D-11. Three Dimensional View from East of LERF Looking West-Northwest into the Soil Column



Note: The Hanford sediments and groundwater have been removed to portray the basalt surface and remnant Ringold Formation sediments.

Figure D-12. Three Dimensional View from East of LERF Looking West-Northwest into the Soil Column

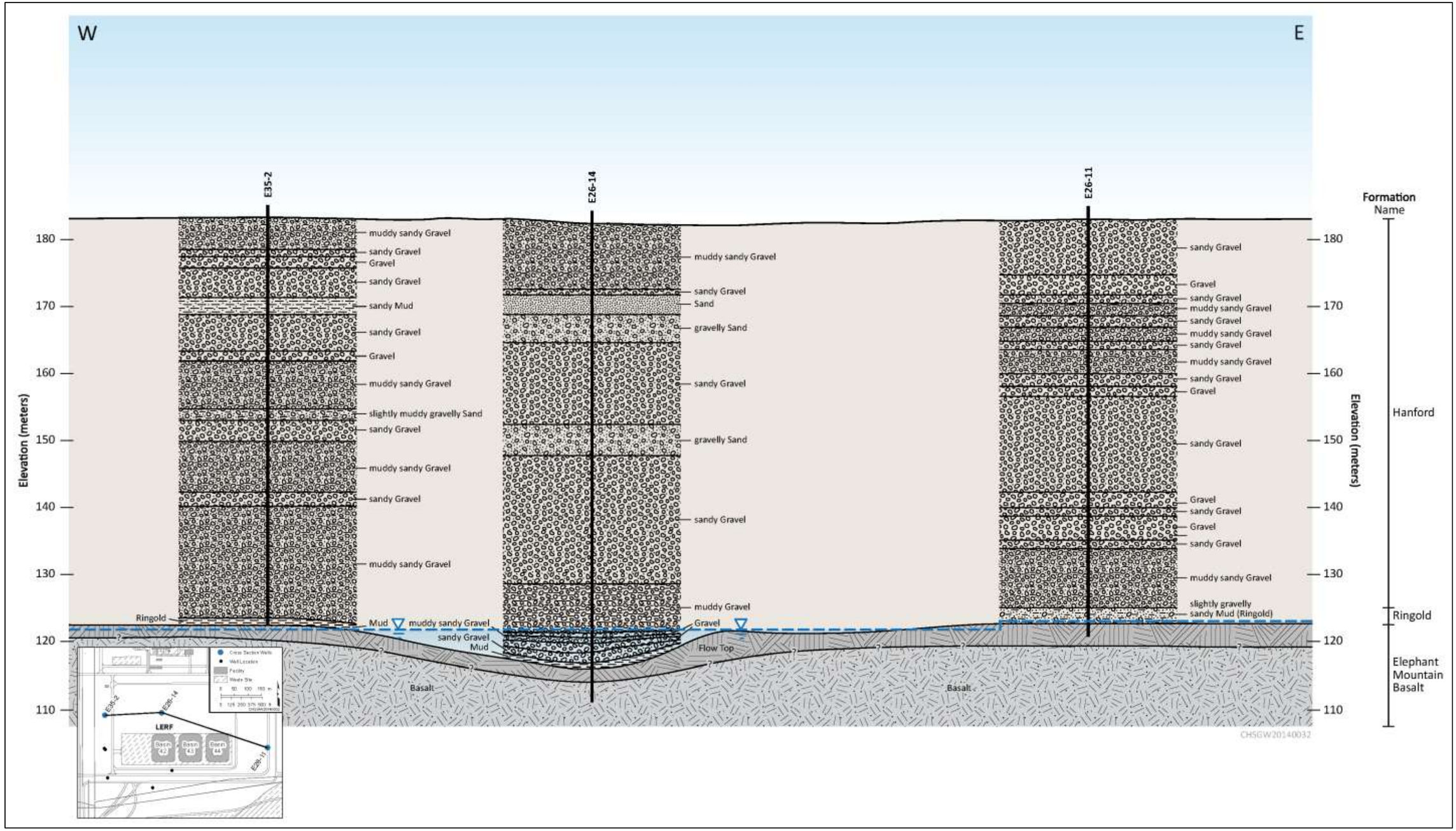


Figure D-13. West to East Geologic Cross Section Just North of LERF

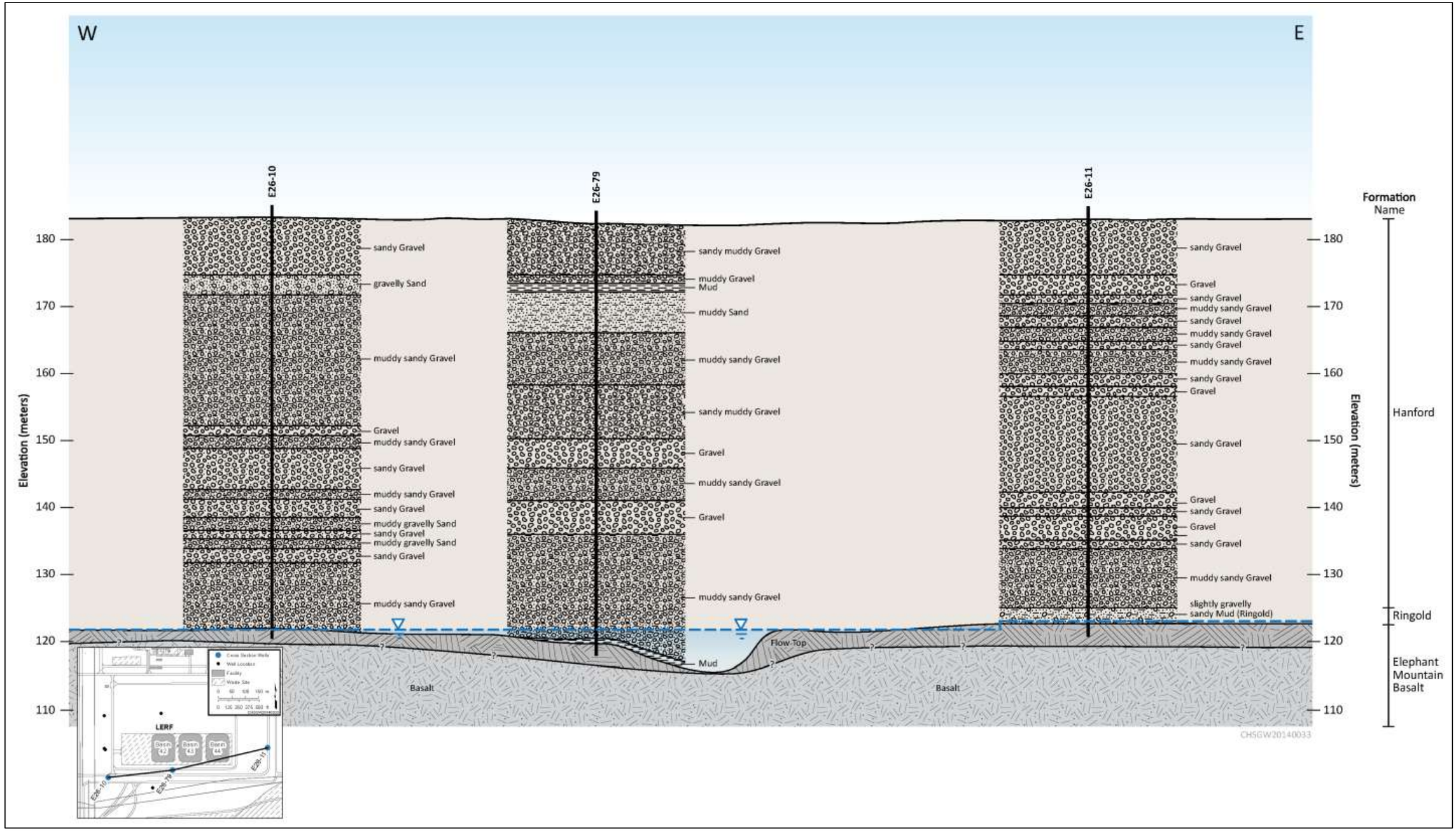
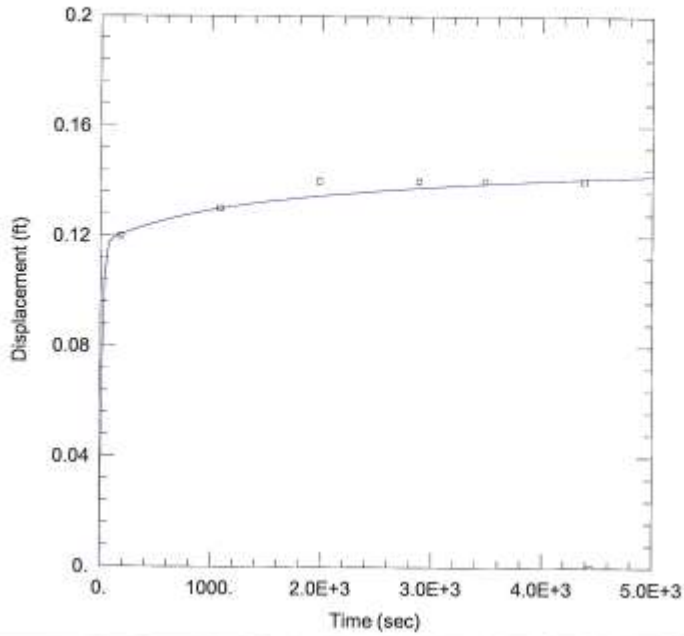


Figure D-14. West to East Geologic Cross Section Just South of LERF



WELL TEST ANALYSIS

Data Set: C:\Documents and Settings\h0091818\My Documents\E26-79\E26-79-2\E26-14.aqt
Date: 07/26/13 Time: 20:03:41

PROJECT INFORMATION

Company: CH2MHill
Client: DOE
Location: LERF
Test Well: 299-E26-14
Test Date: 9-27-2011

AQUIFER DATA

Saturated Thickness: 18. ft Anisotropy Ratio (Kz/Kr): 1.189E+4

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
299-E26-14	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ 299-E26-14	0	0

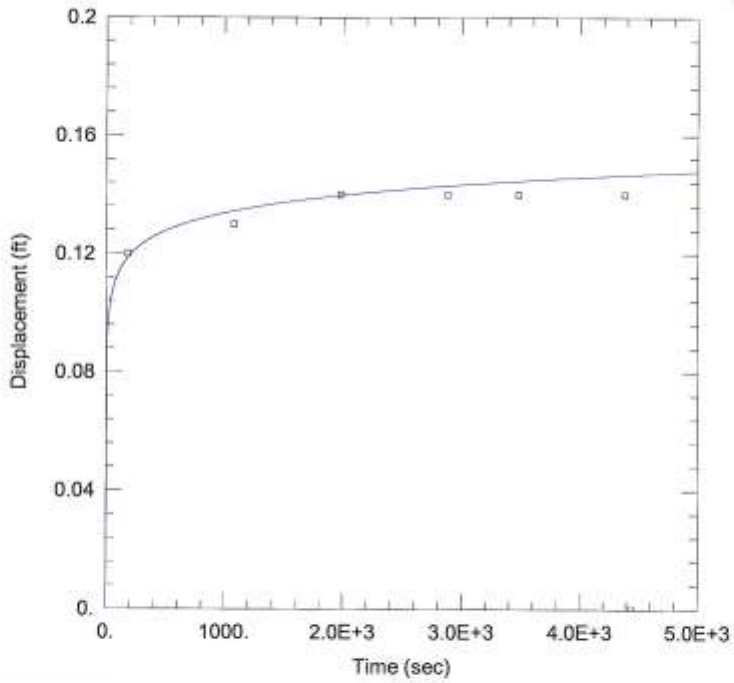
SOLUTION

Aquifer Model: Unconfined Solution Method: Moench

T = 56.97 cm^2/sec S = 1.109E-10
Sy = 0.001 ß = 1.023
Sw = 0.6 r(w) = 0.167 ft
r(c) = 0.5043 ft alpha = 0.002512 sec^{-1}

α = empirical constant (fitting parameter, early part of curve matching) for noninstantaneous drainage
β = empirical constant (fitting parameter, late part of curve matching)
Kz = vertical hydraulic conductivity Kr = horizontal hydraulic conductivity
T = transmissivity S = storativity
Sy = specific conductance Sw = wellbore skin factor
r(c) = casing radius r(w) = well radius

Figure D-15. AQTESOLV Moench Unconfined Aquifer Pumping/Recovery Test for Type-Curve Match to Well 299-E26-14 with Wellbore Skin Affects and Delayed Gravity Response



WELL TEST ANALYSIS

Data Set: C:\Documents and Settings\h0091818\My Documents\E26-79\E26-79-2\E26-14.aqt
Date: 07/26/13 Time: 22:12:52

PROJECT INFORMATION

Company: CH2MHill
Client: DOE
Location: LERF
Test Well: 299-E26-14
Test Date: 9-27-2011

AQUIFER DATA

Saturated Thickness: 18. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
299-E26-14	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ 299-E26-14	0	0

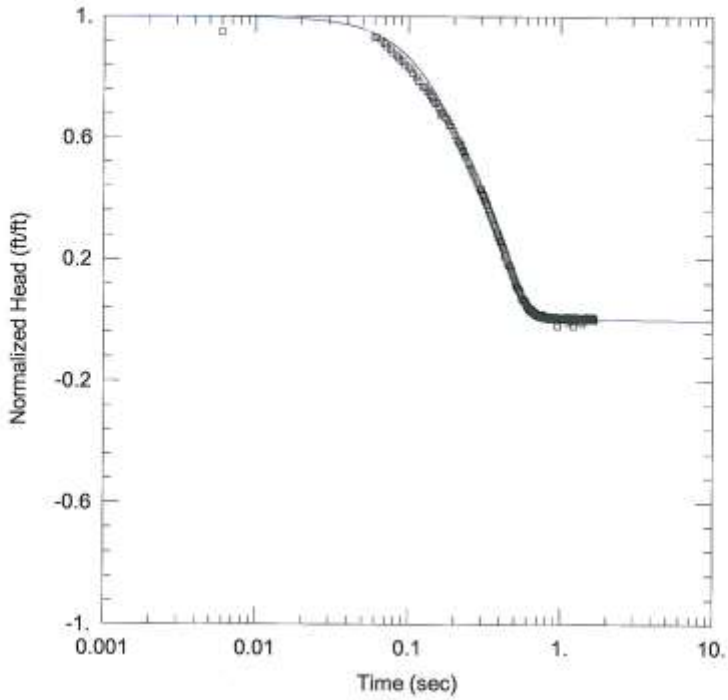
SOLUTION

Aquifer Model: Unconfined
Solution Method: Neuman

T = 50.78 cm^2/sec
S = 1.109E-10
Sy = 0.001
ß = 1.023

T = transmissivity
S = storativity
β = empirical constant (fitting parameter, late part of curve matching)
Sy = specific conductance

Figure D-16. AQTESOLV Neuman Unconfined Aquifer Pumping/Recovery Test for Type-Curve Match to Well 299-E26-14 with Delayed Gravity Response



WELL TEST ANALYSIS

Data Set:
Date: 07/26/13 Time: 11:38:17

PROJECT INFORMATION

Company: CH2MHill
Client: DOE
Location: LERF
Test Well: 299-E26-77
Test Date: 11-18-2008

AQUIFER DATA

Saturated Thickness: 24.15 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (299-E26-77-2)

Initial Displacement: 3.347 ft
Total Well Penetration Depth: 24.15 ft
Casing Radius: 0.167 ft
Static Water Column Height: 24.15 ft
Screen Length: 24.15 ft
Well Radius: 0.833 ft

SOLUTION

Aquifer Model: Unconfined
K = 0.1549 cm/sec
Solution Method: Springer-Gelhar
Le = 0.8248 ft

K = Hydraulic conductivity
Le = Effective water column length

Figure D-17. AQTESOLV Springer-Gelhar Critically Dampened Type-Curve Match to Well 299-E26-77 Second Slug Withdraw Test November 18, 2008

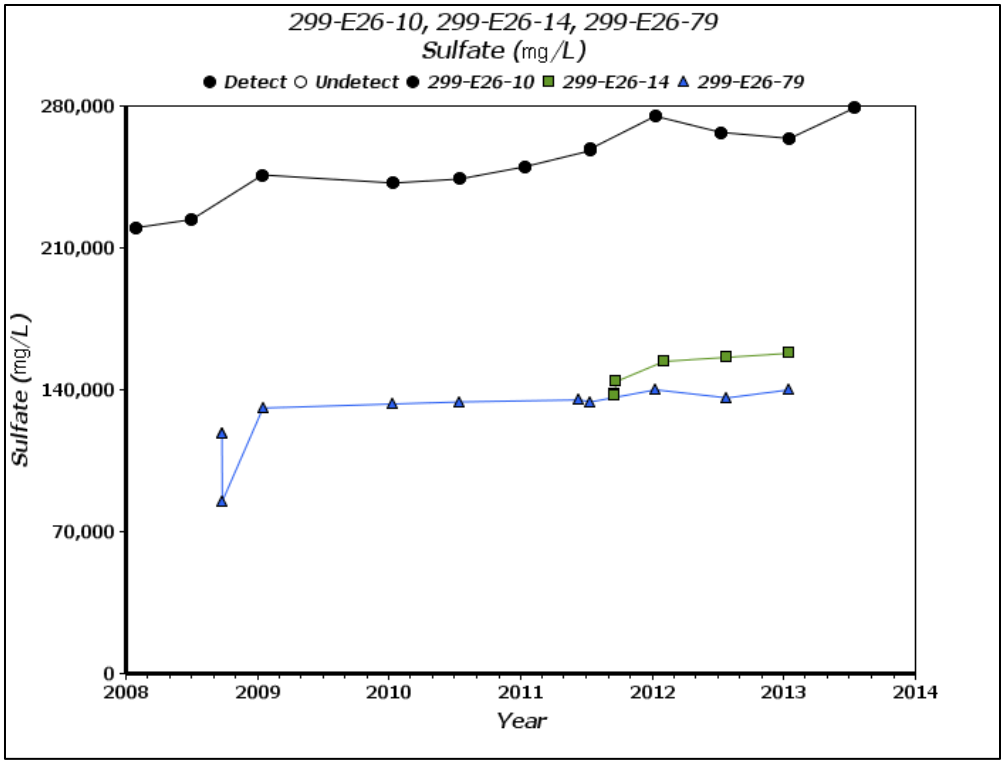


Figure D-18. Comparison of Sulfate Concentration Results in Wells 299-E26-10, 299-E26-14, and 299-E26-79

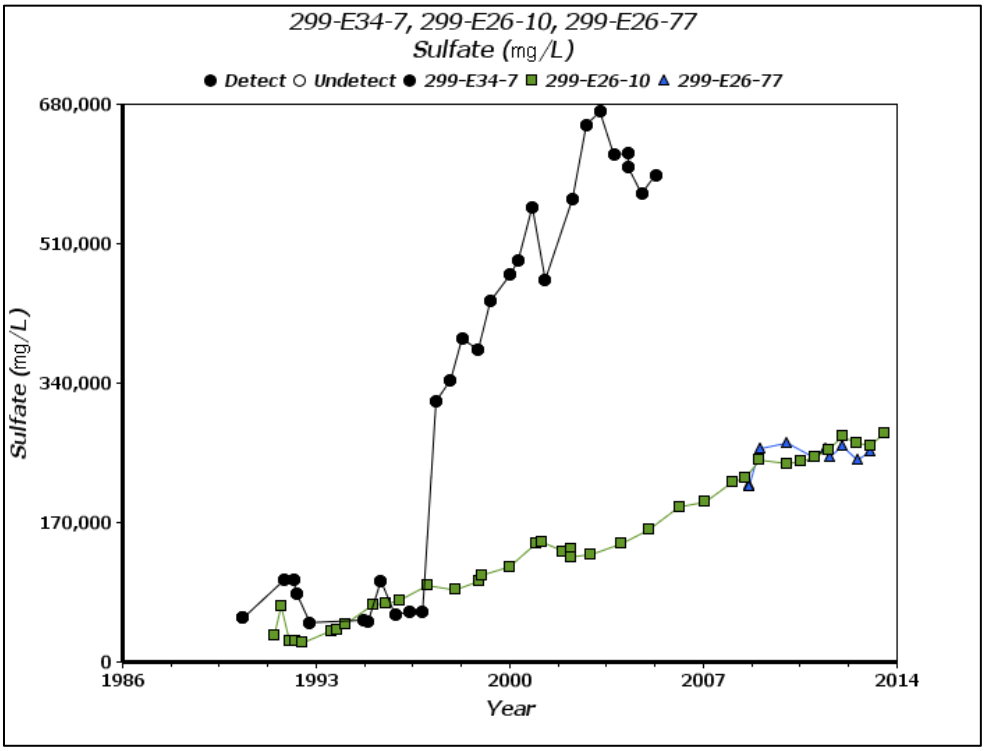


Figure D-19. History of Sulfate Increases in Wells 299-E26-10, 299-E26-77, and 299-E34-7

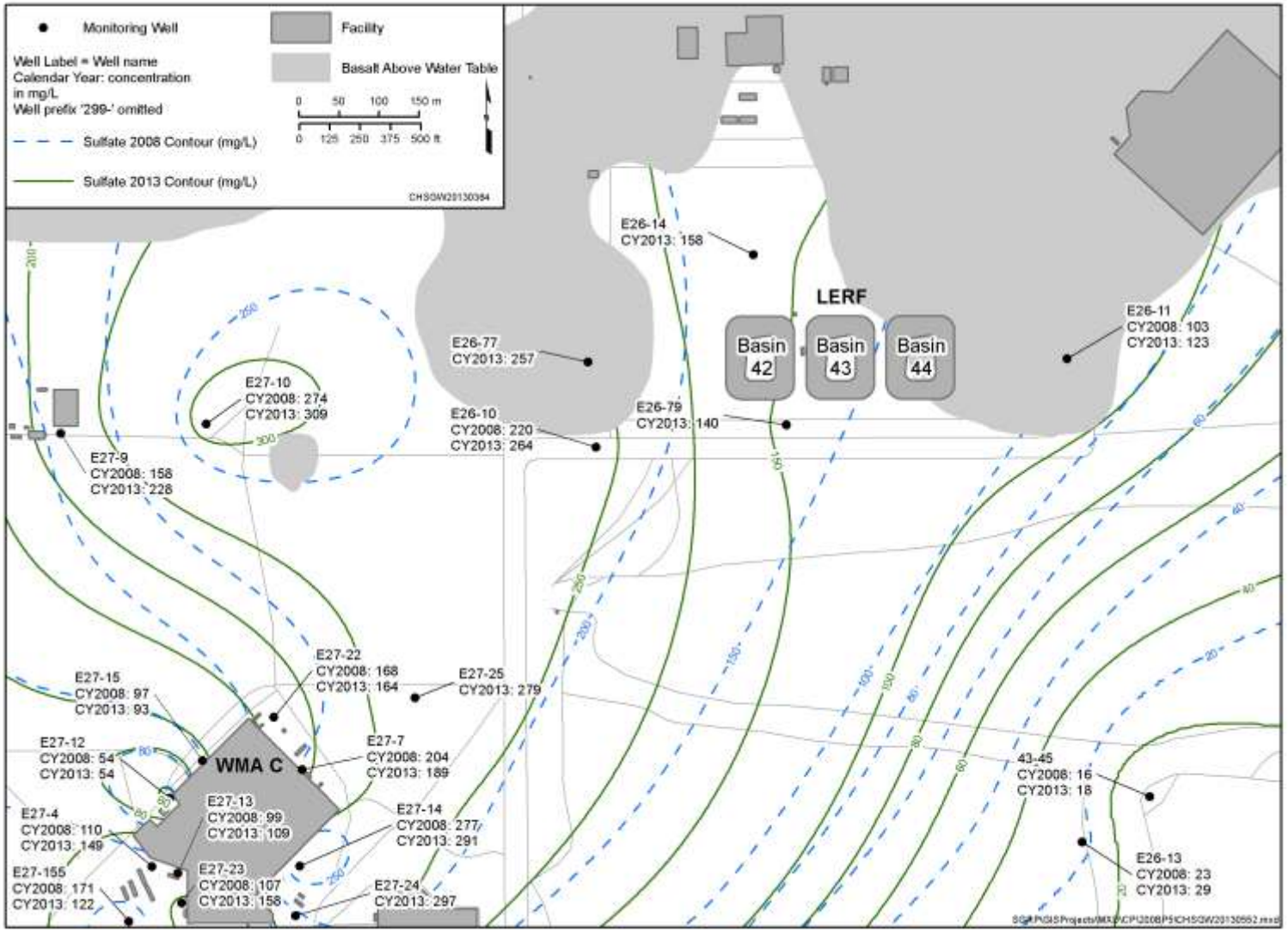


Figure D-20. 2008 and 2013 Regional Sulfate Plume

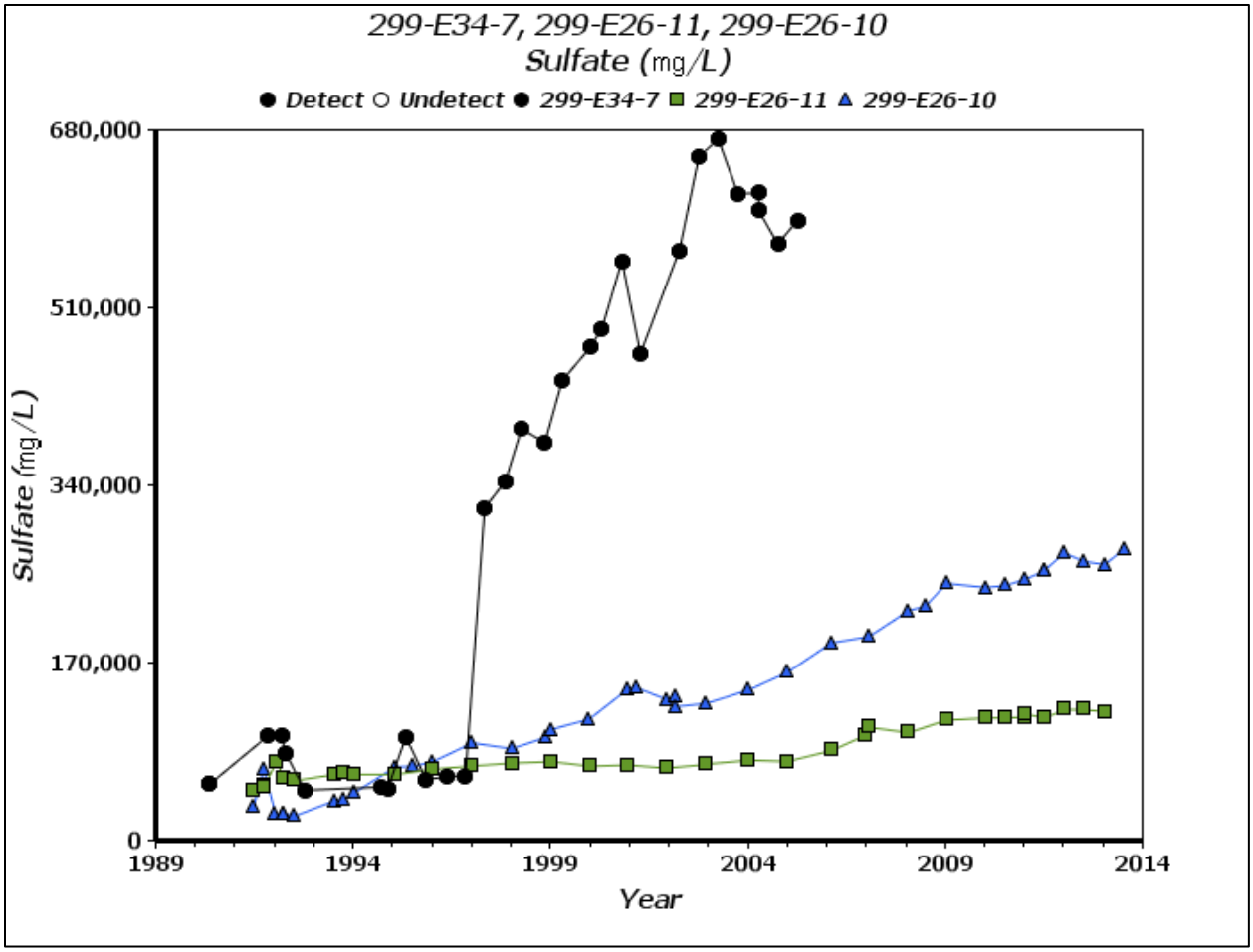


Figure D-21. Comparison of Sulfate Increases in Wells 299-E26-10, 299-E26-11, and 299-E34-7

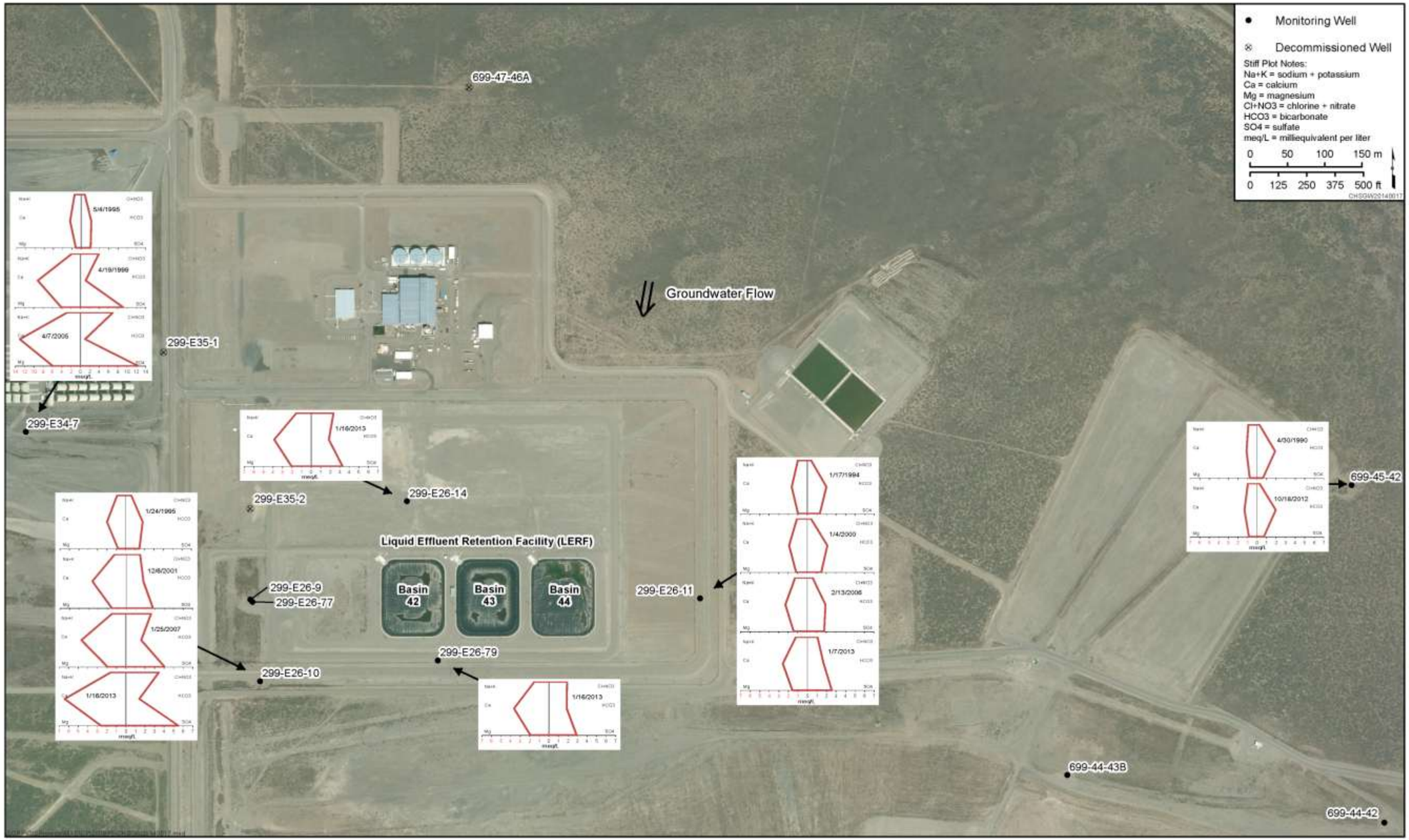


Figure D-22. Historical View of Changing Groundwater Conditions Beneath the Vicinity of LERF

This page intentionally left blank.

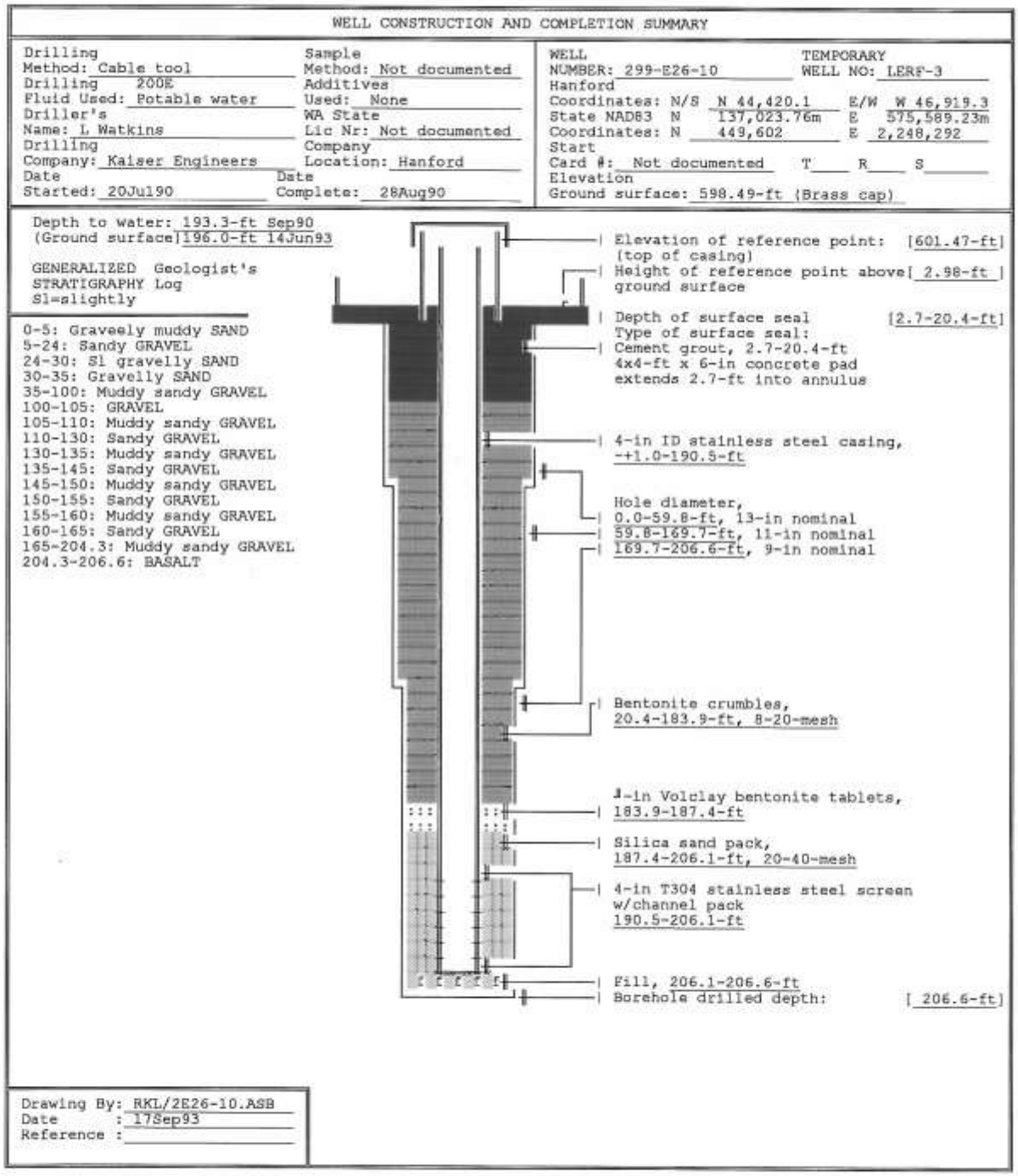


Figure D-23. Well Construction Diagram for Well 299-E26-10 in LERF Groundwater Monitoring Network

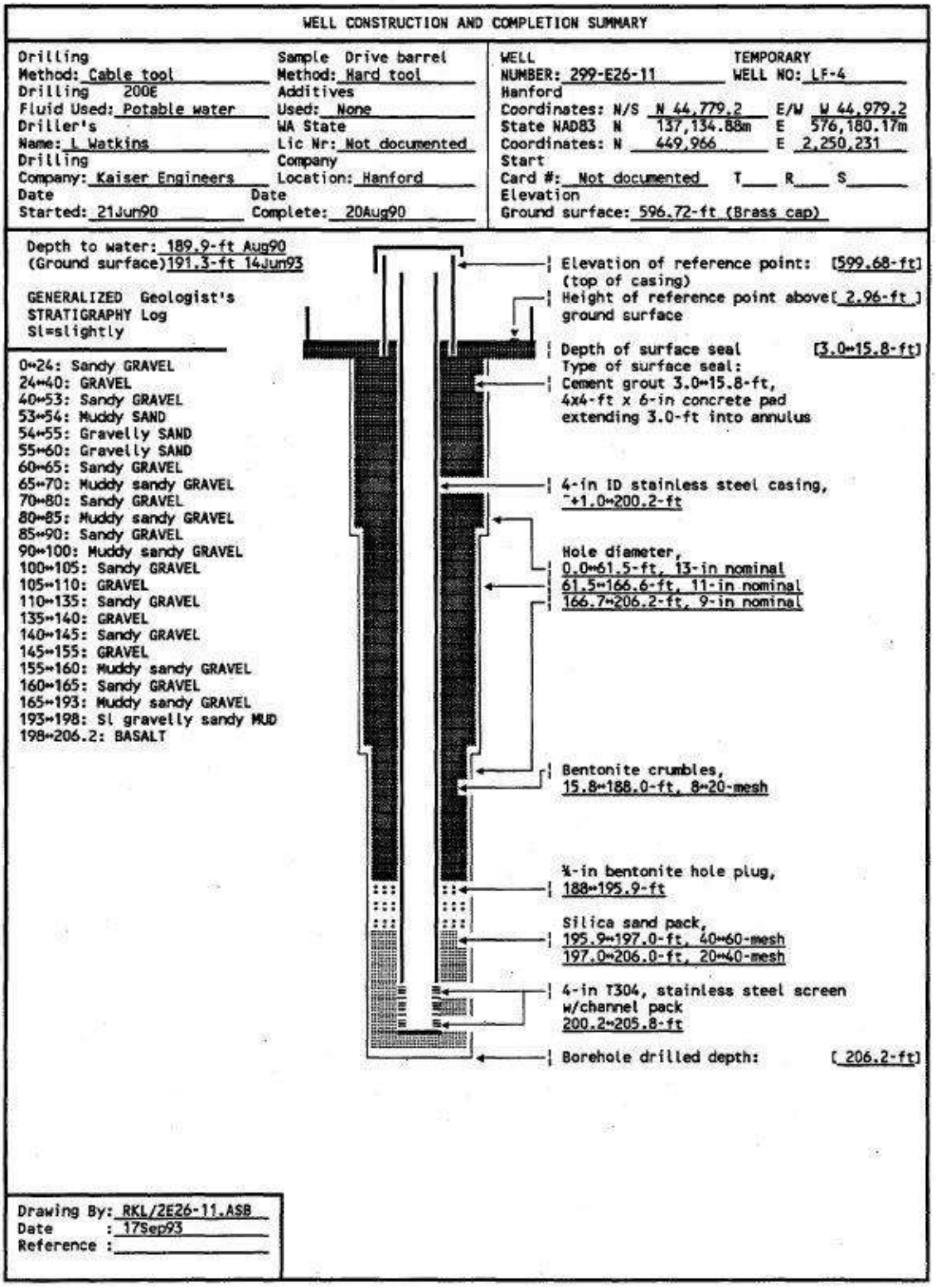


Figure D-24. Well Construction Diagram for Well 299-E26-11 in the Past LERF Groundwater Monitoring Network

WELL SUMMARY SHEET		Start Date: 9/8/11 Finish Date: 9/27/11	Page 1 of 2
Well ID: C8204		Well Name: 299-E26-14	
Location: 250 meters south of LERF Facility		Project: 2 M-24 RCRA Groundwater Wells	
Prepared By: Patrick Cabbage	Date: 10/20/11	Reviewed By: DC Weekes	Date: 10/24/11
Signature: Patrick Cabbage		Signature: DC Weekes	

CONSTRUCTION DATA

Description

Stainless Steel Protective Casing: 2.88 ft above ground surface

Type I/II Portland Cement Grout: 0 - 9.2 ft bgs

#8 Granular Bentonite Crumbles: 9.2 - 187.3 ft bgs

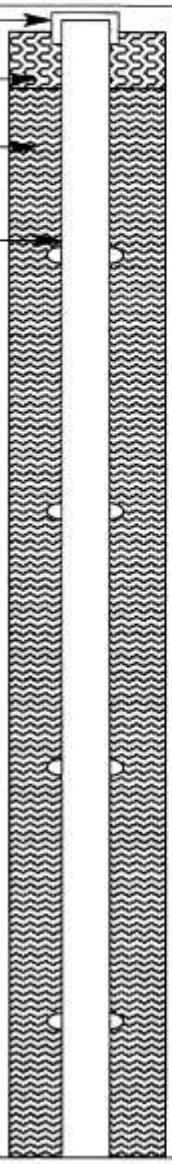
4-in I.D., Schedule 10, Type 304, Stainless Steel Permanent Casing: 1.79 ft ags - 195.90 ft bgs

All temporary drill casing was removed from the ground.

All depths are in feet below ground surface.

The borehole was drilled with 10 ¾-inch O.D. casing from 0.0 - 100.6 ft bgs, with 8 ¾-inch O.D. casing from 100.6 - 220.7 ft bgs, and with open hole from 220.7 to 240.6 ft bgs.

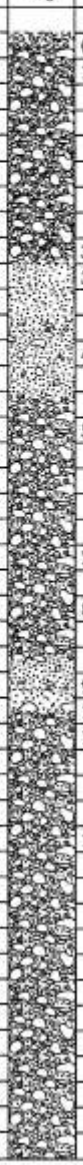
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 20, 40, 60, 80, 100, 120, 140, 160

Graphic Log



Lithologic Description/Groundwater Sample Depths (ft bgs)

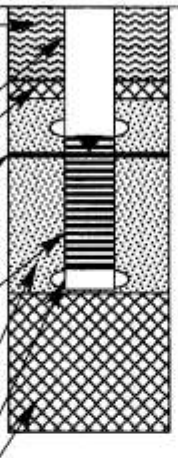
0-1 Gravel Drill Pad (G)
1-34 Silty Sandy Gravel (msG)
34-36 Sandy Gravel (sG)
36-45 Sand (S)
45-57 Gravelly Sand (gS)
57-77 Sandy Gravel (sG)
77-83 Sandy Gravel (sG)
83-98 Sandy Gravel (sG)
98-103 Gravelly Sand (gS)
103-106 Gravelly Sand (gS)
106-122 Sandy Gravel (sG)
122-177 Sandy Gravel (sG)

Figure D-25. Well Construction Diagram for Well 299-E26-14 in LERF Groundwater Monitoring Network

WELL SUMMARY SHEET		Start Date: 9/8/11 Finish Date: 9/27/11	Page 2 of 2
Well ID: C8204		Well Name: 299-E26-14	
Location: 250 meters south of LERF Facility		Project: 2 M-24 RCRA Groundwater Wells	
Prepared By: Patrick Cabbage	Date: 10/21/11	Reviewed By: DC Weekes	Date: 10/24/11
Signature: Patrick Cabbage		Signature: DC Weekes	

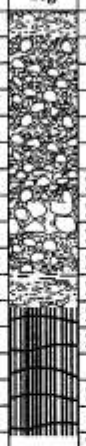
CONSTRUCTION DATA

Description	Diagram
#8 Granular Bentonite Crumbles: 9.2 - 187.3 ft bgs	
4-in I.D., Schedule 10, Type 304, Stainless Steel Permanent Casing: 1.79 ft ags - 195.90 ft bgs	
3/8-in Bentonite Pellets: 187.3 - 190.0 ft bgs	
Static Water Level: 198.4 ft bgs (9/27/11)	
4-in I.D., Schedule 10, Type 304, Stainless Steel 20-slot Screen: 195.90 - 215.90 ft bgs	
Primary Filter Pack 10-20 Mesh Colorado Silica Sand: 190.0 - 219.6 ft bgs	
4-in I.D., Schedule 10, Type 304, Stainless Steel Sump: 215.90 - 218.90 ft bgs	
3/8-in Bentonite Pellets: 219.6 - 240.6 ft bgs	



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
180		177-180 Silty Gravel (mG)
		180-200 Silty Sandy Gravel (msG)
200		200-202.5 Gravel (G)
		202.5-205 Silty Sandy Gravel (msG)
		205-210 Gravel (G)
		210-215.5 Sandy Gravel (sG)
		215.5-217 Silt (M)
220		217-220 Gravelly Silt (gM)
		220-221 Silty Gravel (mG)
		221-240.6 Basalt
240		**TD = 240.6 ft bgs (09-21-2011)**
260		



All temporary drill casing was removed from the ground.

All depths are in feet below ground surface.

The borehole was drilled with 10 ¾-inch O.D. casing from 0.0 - 100.6 ft bgs, with 8 ¾-inch O.D. casing from 100.6 - 220.7 ft bgs, and with open hole from 220.7 to 240.6 ft bgs.

Figure D-25. Well Summary Sheet for Well 299-E26-14 in the LERF Groundwater Monitoring Network (Cont.)

WELL SUMMARY SHEET

Start Date: 08/12/2008
Finish Date: 02/05/2008
Page 1 of 2

Well ID: C16455
Well Name: 299-E26-77
Location: Inside fence, LERF 200 E
Project: M-24 RCRA Wells (LERF)
Prepared By: S. Sexton
Date: 9/08/08
Reviewed By: L. D. Walker
Date: 10/13/08
Signature:
Signature:

CONSTRUCTION DATA

Description:

6" x 4' x 4' concrete pad
6" stainless steel protective monument:

4" ID Sch. 10 stainless steel casing: 1.96 ft ags to 200.85 ft bgs
4" stainless steel wire wrap screen, 0.020": 200.85 to 225.6 ft bgs
4" Sch. 10 stainless steel sump: 225.6 to 228.6 ft bgs

Portland cement grout: 0 to 11.05 ft bgs
Bentonite granules: 11.05 to 189.0 ft bgs
Bentonite pellets: 189.0 to 194.6 ft bgs
10-20 silica sand: 194.6 to 232.8 ft bgs

casing joint

Diagram

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 20, 40, 60, 80, 100

Graphic Log

Lithologic Description:

0-0.5: gravel drill pad
0.5-5: gravelly Silt (gM)
5-34: silty Gravel (mG)
34-38: gravelly silty Sand (gmS)
38-43: silty sandy Gravel (msG)
43-45.5: gravelly Sand (gS)
45.5-52: silty Sand (mS)
52-75: silty sandy Gravel (msG)
75-123: sandy silty Gravel (smG)

A-6003-643 (03/03)

Figure D-26. Well Summary Sheet for Well 299-E26-77 in LERF Groundwater Monitoring Network

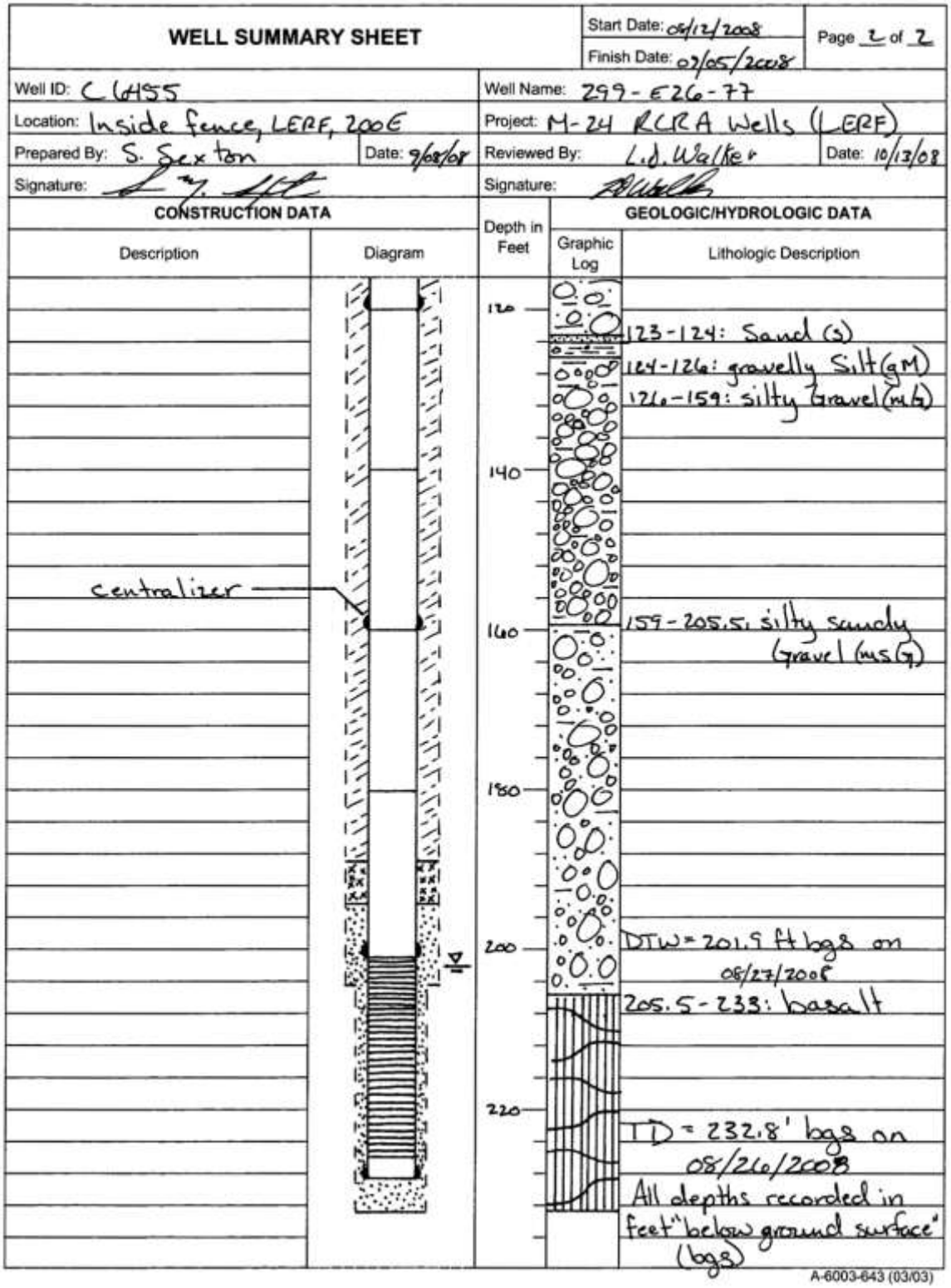


Figure D-26. Well Summary Sheet for Well 299-E26-77 in LERF Groundwater Monitoring Network (Cont.)

WELL SUMMARY SHEET

Start Date: 09/09/2008
Finish Date: 10/02/2008
Page 1 of 2

Well ID: C6826
Well Name: 299-E26-79
Location: Inside fence, LERF, 200E
Project: M-24 RCRA Wells (LERF)
Prepared By: S. Sexton
Date: 10/4/08
Reviewed By: L.D. Walker
Date: 10/13/08
Signature:
Signature:

CONSTRUCTION DATA

Description:

6" x 4' x 4' concrete pad
6" stainless steel protective monument: 3.0' bgs to 3.1' ags

4" stainless steel Sch. 10 casing: 2.3 ft ags to 195.2 ft bgs
4" stainless steel wire wrap screen, 0.020": 195.2 to 220.2' bgs
4" stainless steel Sch. 10 sump: 220.2 to 223.2 ft bgs

Portland cement grout: 0 to 10.3 ft bgs
Bentonite granules: 10.3 to 183.0 ft bgs
Bentonite pellets: 183.0 to 187.8 ft. bgs
10-20 silica sand: 187.8 to 224.76 ft bgs

Casing joint

Diagram

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 20, 40, 60, 80, 100

Graphic Log

Lithologic Description:

0-1: gravel drill pad
1-27: sandy silty Gravel (sm G)
27-27.5: sandy Silt (sM)
27.5-29: silty Gravel (m G)
29-32: sandy Silt (sM)
32-54: silty Sand (m S)
54-79: silty sandy Gravel (msG)
79-119: sandy silty Gravel (smG)

A-6003-643 (03/03)

1 **Figure D-27. Well Summary Sheet for Well 299-E26-79 in LERF Groundwater Monitoring Network**

2

WELL SUMMARY SHEET

Start Date: 09/09/2008
Finish Date: 10/02/2008
Page 2 of 2

Well ID: C68826
Well Name: 299-E26-79
Location: Inside fence, LERF, 200E
Project: M-24 RCRA Wells (LERF)
Prepared By: S. Sexton Date: 10/6/08
Reviewed By: L. D. Walker Date: 10/13/08
Signature:
Signature:

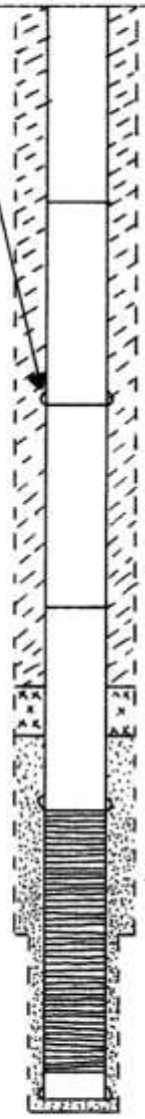
CONSTRUCTION DATA

Description

centralizer

All temporary casing removed from borehole

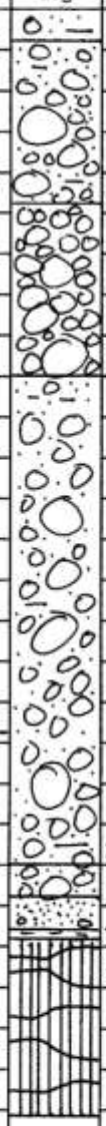
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 120, 140, 160, 180, 200, 220

Graphic Log



Lithologic Description

119-135: silty sandy Gravel (msG)
135-152: Gravel (G)
152-200: silty sandy Gravel
DTW = 201.7 ft bgs on 09/22/2008
200-203: sandy Gravel (sG)
203-206: gravelly Sand (gS)
206-207: modified clay
207-224.76: basalt
TD = 224.76 ft bgs on 09/23/2008
All depths recorded in feet "below ground surface" (bgs)

A-6003-643 (03/03)

Figure D-27. Well Summary Sheet for Well 299-E26-79 in LERF Groundwater Monitoring Network (Cont.)

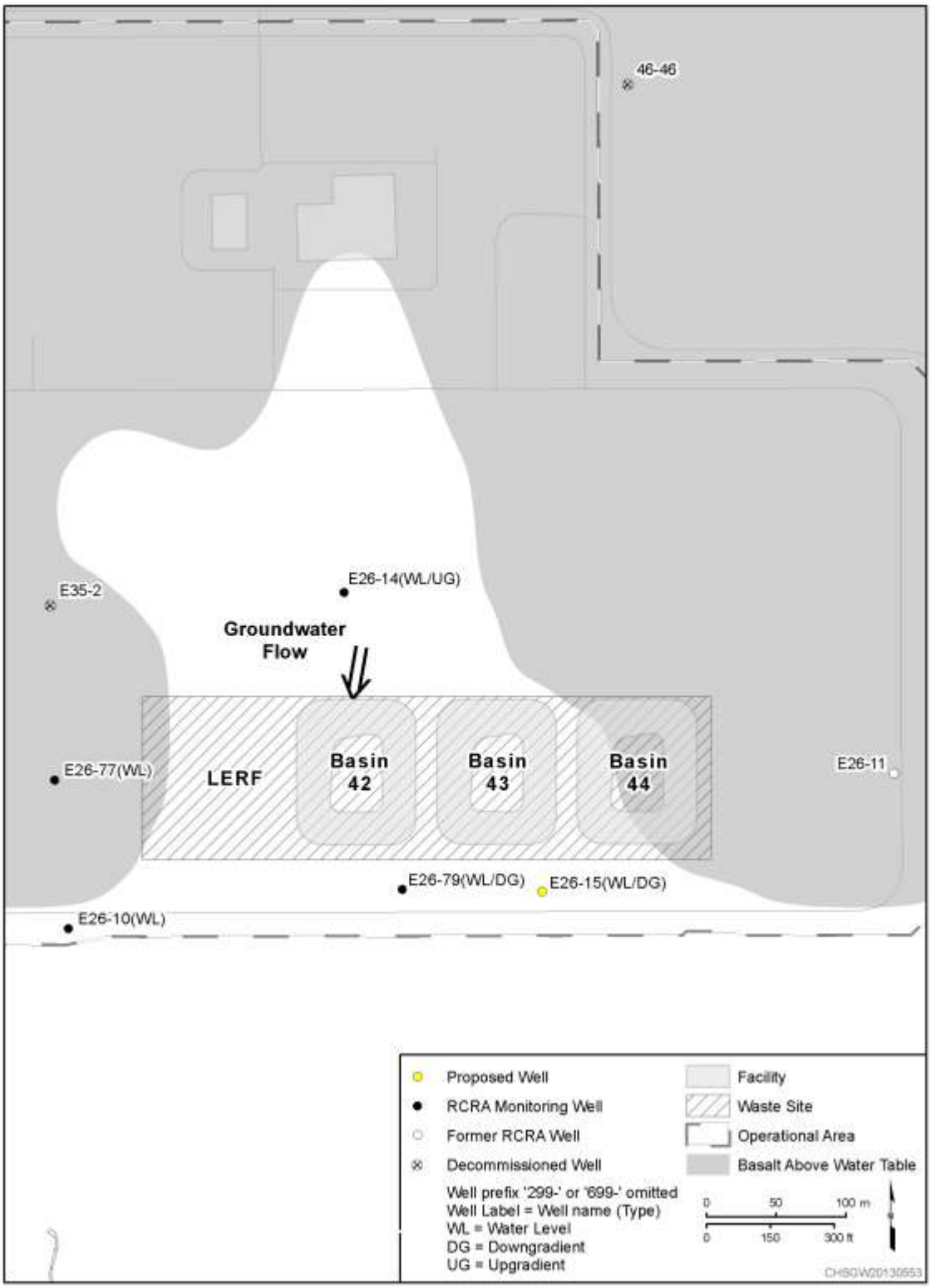


Figure D-28. Proposed LERF Well and Facility Description Map

This page intentionally left blank.