PNNL-17675

U.S. DEPARTMENT OF ENERGY

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

BP-5 Remedial Investigation Slug-Test Characterization Results for Well 699-52-55A

DR Newcomer

July 2008

Pacific Northwest
NATIONAL LABORATORY

DISCLAIMER

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

Printed in the United States of America

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

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

This document was printed on recycled paper.

PNNL-17675

BP-5 Remedial Investigation Slug-Test Characterization Results for Well 699-52-55A

DR Newcomer

July 2008

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

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

Pacific Northwest National Laboratory conducted slug-test characterization at the final, completed BP-5 Remedial Investigation well 699-52-55A near the 200-East Area at the Hanford Site on April 22, 2008. The slug-test characterization was in support of the BP-5 Remedial Investigation. The portion of the unconfined aquifer tested is composed of sediments of the lower Ringold Formation and the underlying Elephant Mountain basalt flowtop. The basalt flowtop unit was included as part of the effective test-interval length for the slug-test analysis because the flowtop unit is hydraulically communicative with the unconfined aquifer. Estimates of hydraulic conductivity for the effective test-interval length represent composite values for the lower Ringold Formation and the underlying Elephant Mountain basalt flow top.

The slug-test responses for the BP-5 Remedial Investigation well 699-52-55A indicated a heterogeneous formation pattern (i.e., radial variation of hydraulic properties with distance from the well) with moderately low-permeability test conditions. The low-stress slug-test analyses for the aquifer formation at well 699-52-55A provided the most reliable estimates of hydraulic conductivity because of stress-dependence delayed effects and a slightly non-linear test response associated with the high-stress test. Hydraulic-conductivity estimates for the aquifer-formation outer radial zone ranged from 0.15 m/d (0.49 ft/d) for the high-stress test to 0.23 m/d (0.75 ft/d) for the low-stress test by employing the standard type-curve analysis method. The Bouwer and Rice analysis method provided aquifer-formation estimates of hydraulic conductivity that are ~10% lower (i.e., 0.13 m/d [0.43 ft/d] and 0.20 m/d [0.66 ft/d], respectively) than estimates provided by the type-curve method. This is consistent with comparison of results between these slug-test analysis methods reported in Butler (1998). The Bouwer and Rice analysis estimates of hydraulic conductivity for the artificially created inner radial zone ranged from 1.4 m/d (4.6 ft/d) for the high-stress test to 1.7 m/d (5.6 ft/d) for the low-stress test. Moderately low permeability test conditions and a relatively thin test interval at well 699-52-55A indicate that the unconfined aquifer is not very transmissive at this well location compared to most other well locations in the general 200-East Area.

Acknowledgments

Those acknowledged include Rob Edrington of Fluor Hanford for coordinating the slug-testing activities and Olin Amos and Mike Weakley of Energy Solutions for providing field support and test equipment. Frank Spane of Pacific Northwest National laboratory (PNNL) provided technical peer review comments, Dave Lanigan of PNNL provided graphics support, and Wayne Cosby of PNNL provided editorial comments. Craig Swanson of Fluor Hanford and Jeff Serne of PNNL also provided technical review comments.

Contents

Figures

Tables

1.0 Introduction

Pacific Northwest National Laboratory conducted two different stress-level slug tests at well 699-52-55A, which is located north of the 200-East Area at the Hanford Site (Figure 1.1). The purpose of the slug tests was to provide hydraulic property information for the unconfined aquifer at the well 699-52-55A location. This type of areal characterization information is important for predicting/simulating contaminant migration (i.e., numerical flow/transport modeling) and designing proper monitor-well strategies within this area.

Section 2 describes the general hydrologic test system employed to perform the two slug tests. Section 3 discusses slug-test response and analysis methods. Section 4 presents pertinent information describing slug-testing activities and analysis results for the test/depth interval that was hydrologically characterized at this BP-5 well. Conclusions and references are provided in Sections 5 and 6, respectively. A well summary sheet is provided in Appendix A, a borehole lithologic log is presented in Appendix B, slug-test field notes are provided in Appendix C, and additional slug-test plots are shown in Appendix D.

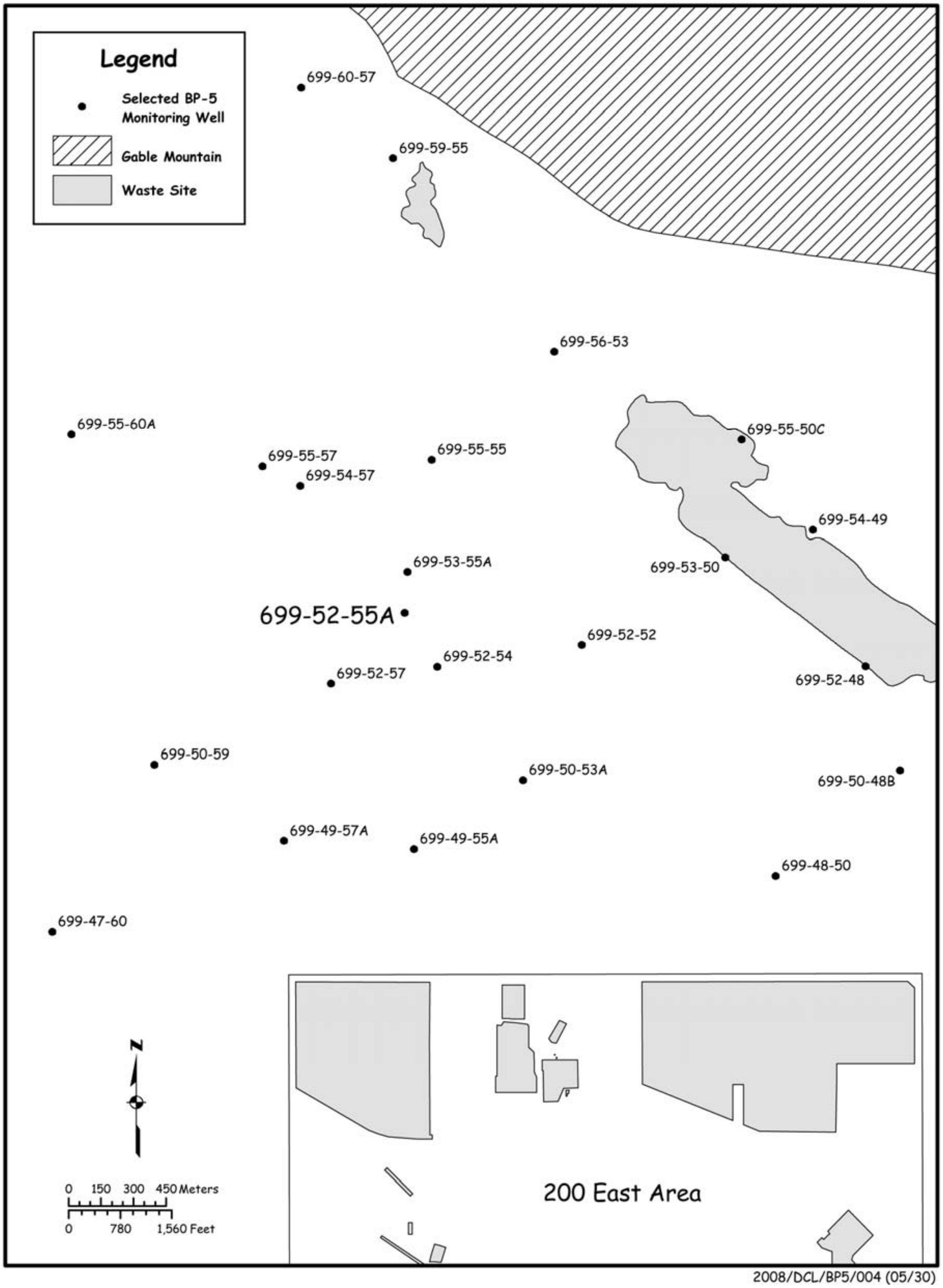


Figure 1.1. Map Showing Location of BP-5 Remedial Investigation Well 699-52-55A Tested

2.0 Hydrologic Test System Description

The following discussion of the general hydrologic test plan is taken primarily from similar slug-test characterization-program descriptions presented previously by Spane.[a] Hydrologic testing was implemented within the final well screen after the well was completed. Two different, stress-level slug withdrawal tests were conducted within the test-interval section. The reason for using a multi-stress-level approach was to determine whether the associated slug-test responses exhibited either a variable or stress-level dependence. As noted in Butler (1998) and Spane et al. (2003a), tests exhibiting either variable or stress-level dependence can provide valuable information pertaining to the presence of dynamic well skin or non-linear (i.e., turbulence) test-response conditions occurring within the test section. The slug tests were initiated using two slugging rods of different, known displacement volumes. The slugging rods were lowered slowly into the fluid column until the rods were completely submerged. Water-level pressures were allowed to reach full recovery before initiating the slug-withdrawal tests. Because the test-depth interval was composed of low-permeability Ringold Formation sediments resting on the Elephant Mountain Basalt, the recovery times of the slug-withdrawal tests were expected to be several minutes or longer.

Figure 2.1 shows the general slug-test configuration for well 699-52-55A. The test-system configuration within the well-screen section included a downhole pressure transducer, a slugging rod lowered by a drilling rig, and a surface data-logger system. The 20-slot (0.020-in.) well-screen section had a length of 3.0 m (10 ft) and an I.D. dimension of 0.102 m (4 in.). A Druck, Inc. pressure transducer strain-gauge, 0- to 34.5-kPa (0- to 5-psig) pressure transducer was installed below the fluid-column surface within the well-screen section to monitor the downhole test-interval response during slug testing. Pressure-transducer measurements were recorded with a Campbell Scientific, Inc. model CR-10X™ data logger and downloaded to a portable laptop computer. Details of the well construction are provided in the well summary sheet (Appendix A).

(a) FA Spane, Jr. *2003. Slug Test Characterization Results for Multi- Test/Depth Intervals Conducted During the Drilling of WMA-C Well 299-E27-22 (C4124).* Letter report to Jane Borghese (Fluor Hanford, Inc.), October 8, 2003.

FA Spane FA, Jr. 2005a. *Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of WMA-BX-BY Well 299-E33-49*. Letter report to Jane Borghese (Fluor-Hanford, ORP), January 10, 2005.

Spane FA, Jr. 2005b. *Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of CERCLA Operable Unit UP-1 Wells 299-W19-48, 699-30-66, and 699-36-70B.* Letter report to Mark Byrnes (Fluor-Hanford, ORP), September 13, 2005.

Spane FA, Jr. 2005c. *Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of CERCLA Operable Unit ZP-1 Wells 299-W11-43, 299-W15-50, and 299-W18-16*. Letter report to Mark Byrnes (Fluor-Hanford, ORP), September 13, 2005.

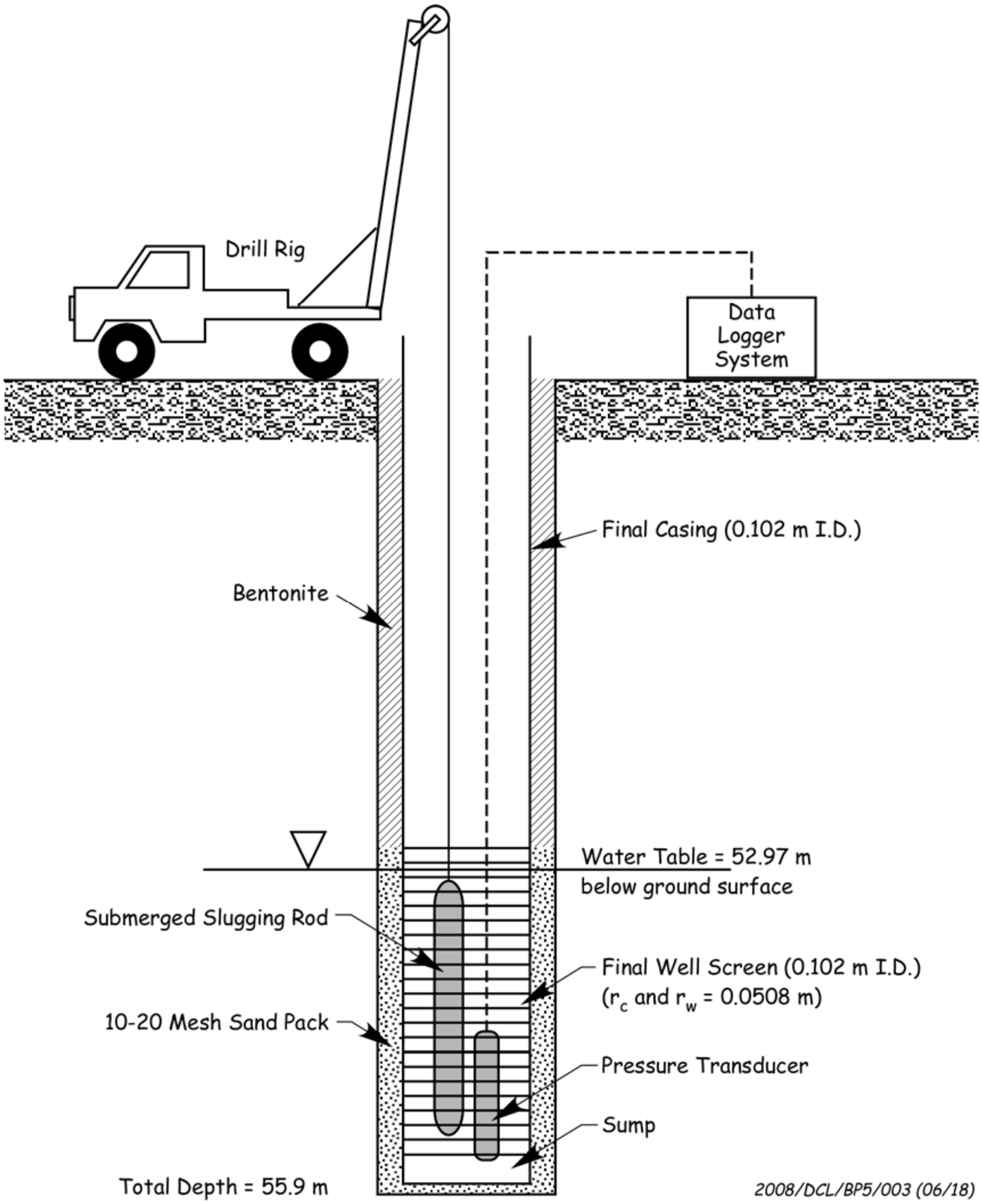


Figure 2.1. General Slug-Test Configuration within Well 699-52-55A

3.0 Slug-Test Response and Analysis

The following discussion pertaining to slug-test response and analysis is taken primarily from Spane.[c] As shown in Figure 3.1 and discussed in Butler (1998) and Spane et al. (2003a), water levels within a test well can respond in one of three ways to the instantaneously applied stress of a slug test. These response model patterns are 1) an over-damped response, where the water levels recover in an exponentially decreasing recovery pattern, 2) an under-damped response, where the slug-test response oscillates above and below the initial static, with decreasing peak amplitudes with time, and 3) a critically damped response, where the slug-test behavior exhibits characteristics that are transitional to the over- and under-damped response patterns. Factors that control the type of slug-test response model that is exhibited within a well include a number of aquifer properties (hydraulic conductivity) and well-dimension characteristics (well-screen length, well-casing radius, well-radius, aquifer thickness [b], fluid-column length) and can be expressed by the response-damping parameter, C_D, which Butler (1998) reports for unconfined aquifer tests as:

$$C_D = \sqrt{\frac{g}{L_e}} * \frac{r_c^2 \ln\left[R_e / r_w\right]}{2KL} \tag{3.1}$$

where g = acceleration due to gravity, m/s^2

L_e = effective well water-column length, m

r_c = well casing radius, m; i.e., radius of well water-column that is active during testing

R_e = effective test radius parameter, m; as defined by Bouwer and Rice (1976)

r_w = well radius of well-screen length, m

K = hydraulic conductivity of test interval length, m/sec

L = well-screen length, m.

(c) FA Spane, Jr. *2003. Slug Test Characterization Results for Multi- Test/Depth Intervals Conducted During the Drilling of WMA-C Well 299-E27-22 (C4124).* Letter report to Jane Borghese (Fluor Hanford, Inc.), October 8, 2003.

FA Spane FA, Jr. 2005a. *Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of WMA-BX-BY Well 299-E33-49*. Letter report to Jane Borghese (Fluor-Hanford, ORP), January 10, 2005.

Spane FA, Jr. 2005b. *Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of CERCLA Operable Unit UP-1 Wells 299-W19-48, 699-30-66, and 699-36-70B*. Letter report to Mark Byrnes (Fluor-Hanford, ORP), September 13, 2005.

Spane FA, Jr. 2005c. *Slug Test Characterization Results for Multi-Test/Depth Intervals Conducted During the Drilling of CERCLA Operable Unit ZP-1 Wells 299-W11-43, 299-W15-50, and 299-W18-16*. Letter report to Mark Byrnes (Fluor-Hanford, ORP), September 13, 2005.

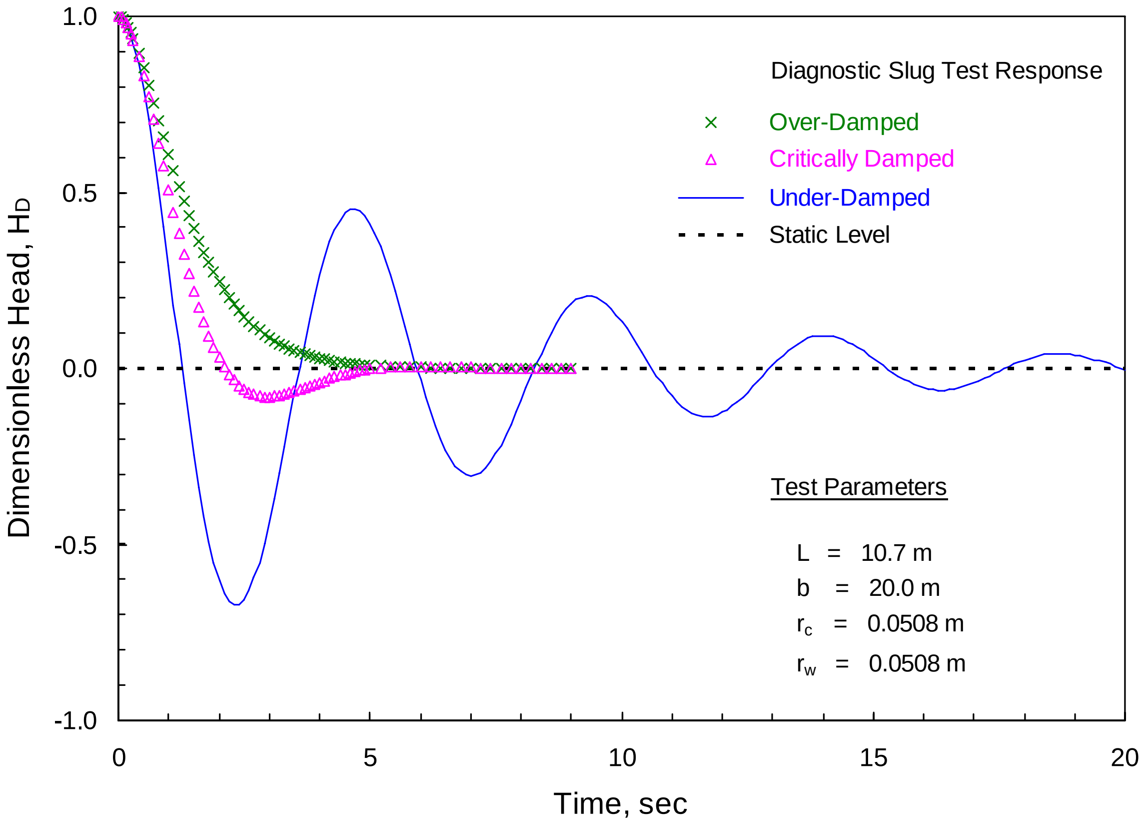


Figure 3.1. Diagnostic Slug-Test Response (taken from Spane and Newcomer 2008)

Given the multitude of possible combinations of aquifer properties, well-casing dimensions, and test-interval lengths, no universal C_D value ranges can be provided that describe slug-test response conditions. However, the following general guidelines on predicting slug-test responses are provided:

- C_D >3 = over-damped response
- C_D 1 - 3 = critically damped response
- C_D <1 = under-damped response.

An over-damped test response generally occurs within stress wells monitoring test formations of low to moderately high hydraulic conductivity (e.g., Ringold Formation) and are indicative of test conditions where frictional forces (i.e., resistance of groundwater flow from the test interval to the well) are predominant over test-system (i.e., Equation [3.1] parameters) inertial forces. Figure 3.2 shows predicted slug-test recovery as a function of hydraulic conductivity (K[d] range: 0.1 to 10 m/d [0.3 to 33 ft/d]; specific storage, S_s = 0.00001 m^{-1}; ratio of vertical to horizontal hydraulic conductivity, K_D = 1.0; and 1.0-m [3.3-ft] test interval length) for test interval lengths exhibiting over-damped response characteristics and general test conditions at well 699-52-55A. As indicated in the figure, test interval lengths having hydraulic conductivity values of approximately 10 m/d (33 ft/d) or less should be readily resolved for tests exhibiting over-damped slug-test behavior. For over-damped slug tests, two different methods can be used for the slug-test analysis: the semi-empirical, straight-line analysis method described in Bouwer

(d) K refers to radial (i.e., horizontal) hydraulic conductivity throughout this report and Rice (1976) and Bouwer (1989) and the type-curve-matching method for unconfined aquifers presented in Butler (1998). For over-damped slug tests, hydraulic-conductivity estimates obtained with the Bouwer and Rice analytical method are generally less reliable than corresponding estimates obtained with the type-curve-matching method, particularly for aquifer formations that behave elastically (Hyder and Butler 1995; Butler 1998). However, results of the Bouwer and Rice method are generally consistent with type-curve analysis results if the aquifer formation is thin, and therefore behaves inelastically, as is the case at the 699-52-55A well location. A detailed description of over-damped, slug-test-analysis methods is presented in Spane and Newcomer (2004).

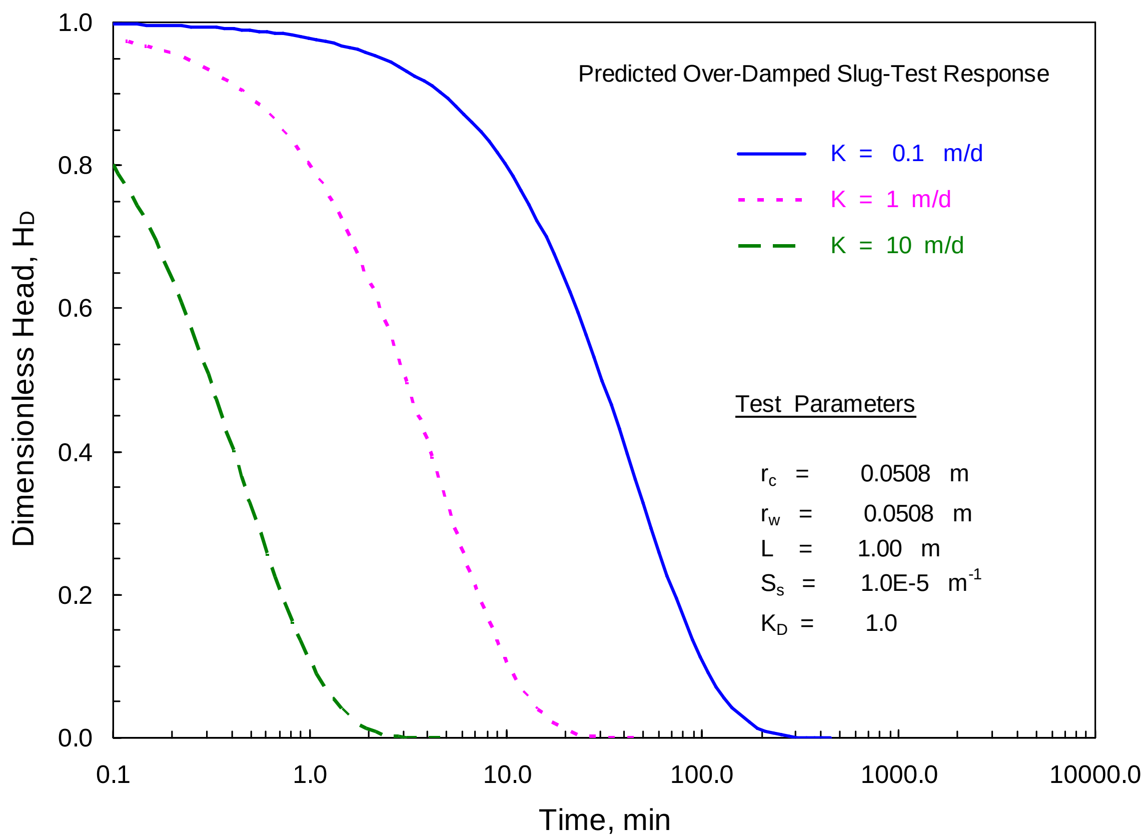


Figure 3.2. Over-Damped Slug-Test Response as a Function of Test-Interval Hydraulic Conductivity

Under-damped test-response patterns are exhibited within stress wells where inertial forces are predominant over formational frictional forces. This commonly occurs in wells with extremely long fluid columns (i.e., large water mass within the well column) and/or that penetrate highly permeable aquifers (e.g., Hanford formation). Tests exhibiting under-damped behavior should be conducted with very small stress-level applications. The slug-test response at well 699-52-55A did not exhibit an under-damped test-response pattern.

As mentioned previously, critically damped test responses are indicated by stress well water-level responses that are transitional between the over- and under-damped test conditions, as shown in Figure 3.1. They typically occur in wells that monitor test formations exhibiting intermediate to high hydraulic conductivity. As noted in Butler (1998), distinguishing between slug-test responses that are over damped and critically damped may be difficult in some cases (i.e., due to test signal noise) when examined on arithmetic plots. Proper model identification may be enhanced when semi-log plots are used, i.e., log head versus time (e.g., Bouwer and Rice plot). Critically damped slug tests exhibit a diagnostic concave-downward pattern when plotted in this semi-log plot format. This is in contrast to over-damped response behavior, which displays either a linear or concave upward (elastic) pattern. Critically damped slug-test responses are influenced by processes (e.g., inertial) that are not accounted for in the previously discussed slug-test analytical methods (i.e., for over-damped tests). Because of this, slug tests exhibiting these response characteristics cannot be analyzed quantitatively with the Bouwer and Rice or standard type-curve methods. High-K analysis methods that can be employed for analyzing unconfined aquifer tests exhibiting response behavior that is either critically damped or under damped include those described in Springer and Gelhar (1991), Butler (1998), McElwee and Zenner (1998), McElwee (2001), Butler and Garnett (2000), and Zurbuchen et al. (2002). Because of the ease provided by a spreadsheet-based approach, the test-analysis method presented in Butler and Garnett (2000) is preferred for analyzing tests exhibiting critically damped behavior. A detailed discussion of this analytical procedure and method is presented in Spane and Newcomer (2004). The slug-test response at well 699-52-55A did not exhibit a critically damped test-response pattern.

Well 699-52-55A is screened across the water table, and the well-screen sand filter pack has a relatively high permeability compared to the permeability of the aquifer formation. Because of this test condition, the actual stress level imposed by the slugging rods on the test formation was lower than the theoretical stress level. This is due to the added pore volume of the sand filter pack at the time of slug-test initiation. For this test situation, the actual slug-test stress level is determined by projecting the observed early test response using linear regression back to the time of test initiation on a semi-log plot. For this case where the observed or projected slug-test stress level, H_p, is less than the theoretical stress level, H_o, an equivalent well radius, r_{eq}, must be used instead of the actual well casing radius, r_c, in the analytical methods. The r_{eq} value can be calculated by using the following relationship presented in Butler (1998):

$$r_{eq} = r_c \left(H_o / H_p \right)^{1/2}$$

4.0 Slug-Test Results

The following discussion presents pertinent information describing slug-testing activities and analysis results for the final, completed BP-5 Remedial Investigation well 699-52-55A. Table 4.1 presents slug-test information for the test/depth interval, while Table 4.2 summarizes the slug-test-analysis results. A geologic borehole log summary is provided in Appendix B, which can be referred to for a geologic description of the respective test/depth interval. The slug-test field notes for this well are provided in Appendix C. Additional slug-test plots are shown in Appendix D. The slug-test data are not included in this report due to the large volume of spreadsheet file data, but can be found in the project files.

Table 4.1. Slug-Test Characteristics for the Test/Depth Interval at BP-5 Remedial Investigation Well 699-52-55A

Test Well Number	Test Date	Test Parameters			Diagnostic Slug-Test Response Model	Hydrogeologic Unit Tested[a]
		Number of Slug Tests	Depth to Water (m bgs)	Depth/Test Interval (m bgs)		
699-52-55A	4/22/08	2	52.97	52.97 - 54.80 (1.83)	Heterogeneous Formation/Exponential-Decay (over-damped)	Lower Ringold Formation/Elephant Mountain Flow Top

(a) Assumed to be uniform within the well-screen section.

Table 4.2. Slug-Test Analysis Results for BP-5 Remedial Investigation Well 699-52-55A

Test Well Number	Test Number	Test Zone	Type-Curve Analysis Method		Bouwer and Rice Analysis Method
			Hydraulic Conductivity, K,[a] (m/d)	Specific Storage, S_s (m^{-1})	Hydraulic Conductivity, K,[a] (m/d)
699-52-55A	SW #1	Outer Zone Formation	0.23	1.00E-05	0.20
	SW #1	Artificially Created Inner Zone	NA	NA	1.7
	SW #2	Outer Zone Formation	0.15	1.00E-05	0.13
	SW #2	Artificially Created Inner Zone	NA	NA	1.4

(a) Assumed to be uniform within the well-screen section.
NA = Not analyzed

4.1 Well 699-52-55A

The borehole geology log (Appendix B) indicates that the test-interval section lies within sediments of the lower Ringold Formation and the underlying Elephant Mountain basalt flowtop. The lower Ringold Formation consists of gravelly sand (80% sand and 20% gravel) within the upper 0.37 m (1.2 ft) of the test-depth interval and silty gravelly sand (80% sand, 15% gravel, and 5% silt) within the underlying 0.67 m (2.2 ft) of the test-depth interval. The Elephant Mountain basalt flowtop consists of basalt containing 20 to 25% sand within the bottom 0.79 m (2.6 ft) of the test-depth interval. The basalt flowtop unit was included as part of the effective test-interval length for the analysis because the flowtop unit is hydraulically communicative (i.e., pressure responses act dynamically to barometric pressure fluctuations and water-level response trends) with the unconfined aquifer (Spane and Newcomer 2004). This is consistent with the testing approach for characterization of Hanford formation sediments overlying the basalt flowtop at the nearby Liquid Effluent Retention Facility in the 200-East Area (Spane and Newcomer 2004).

Two slug withdrawal tests (one low-stress and one high-stress test) were conducted between 1036 hours and 1400 hours (Pacific Daylight Time [PDT]), April 22, 2008, after the well was constructed and developed in January 2008. The slug tests were conducted with two different sized slugging rods that were fully submerged in the water column; one with a fully submerged volume of 0.0035 m^3 (0.125 ft^3) and a larger one with a fully submerged volume of 0.0092 m^3 (0.326 ft^3) (see Appendix C for slugging rod dimensions). These fully submerged slug-rod volumes imparted a theoretical applied stress level of 0.44 m (1.4 ft) for the low-stress test and 1.14 m (3.7 ft) for the high-stress test within the 0.1016-m (4-in.) I.D. well screen. Downhole test-interval response pressures during testing were monitored with a 0- to 34.5-Pa (0- to 5-psig) pressure transducer set at a depth of ~56-m (~184-ft) bgs. The static depth-to-water for the test interval measured before testing was 52.97 m (173.79 ft) bgs.

A diagnostic analysis of slug tests conducted for this test/depth interval indicates a heterogeneous formation response condition (i.e., radial variation of hydraulic properties with distance from the well), as shown by a selected derivative plot in Figure 4.1. This test pattern exhibits an inner, radial-zone response during the initial fast-recovery portion of the test (i.e., higher permeability) that transitions to a slower test response (i.e., lower permeability) for the surrounding outer, radial-zone formation (Bouwer 1989). The presence of a high-permeability inner-zone reflects an artificially induced condition that was likely attributed to a sand filter pack with higher permeability. The thickness of the filter pack surrounding the well screen is 0.051 m (2 in.). Because of this artificially induced condition, only the outer-zone analysis results should be used for aquifer formation characterization at this well location.

Slug tests showing linear response characteristics for heterogeneous formation tests can be analyzed using the homogeneous formation analysis approaches described in Section 3.0 (Spane and Newcomer 2008). A comparison of the normalized, low- and high-stress, slug-test responses indicated stress dependence, with the higher stress test exhibiting a delayed test recovery (Figure 4.2). This delayed test-recovery response is attributed to a change in the effective length of the screen through which water flows into the well during the test. The observed H_o value for the high-stress test was ~60% of the effective screen length, which is too large for analyzing slug tests conducted in wells screened across the water table, particularly in thin aquifers such as the case at well 699-52-55A, using approaches for homogeneous formation analyses (Butler 1998). The high-stress test results indicate a test response approaching a non-linear test condition, as shown by the slightly concave downward plot in Figure D.3. For this reason, the low-stress slug-test results (observed H_o value ~25% of effective screen length), analyzed quantitatively using the approach for homogeneous formation analysis described in Butler (1998), provide a more reliable estimate of K than for the K estimate provided by the high-stress test analysis results.

For the homogeneous formation analysis, the standard type-curve method provided aquifer formation K estimates ranging from 0.15 m/d (0.49 ft/d) for the high-stress test to 0.23 m/d (0.75 ft/d) for the low-stress test. A selected example of the test-analysis plots for this well is shown in Figure 4.3. For the Bouwer and Rice method, estimates of K for the outer-zone ranged between 0.13 m/d (0.43 ft/d) for the high-stress test and 0.20 m/d (0.66 ft/d) for the low-stress test, ~10% lower than estimates obtained for the type-curve method. A selected example of the Bouwer and Rice analysis plot for this well is shown in Figure 4.4. The reason for the close correspondence between the estimates is that the test interval is relatively thin, and therefore the aquifer behaves as an inelastic formation. This is consistent with previous comparisons between estimates using these slug-test analysis methods, as reported in Butler (1998). The estimates of hydraulic conductivity for the effective test-interval length at well 699-52-55A represent composite values for the lower Ringold Formation and the underlying Elephant Mountain basalt flow top. These moderately low estimates of hydraulic conductivity and a relatively thin test interval at well 699-52-55A indicate that the unconfined aquifer is not very transmissive at this well location compared to most other well locations in the general 200-East Area, such as reported in Spane et al. (2001), Spane et al. (2003b), and Spane and Newcomer (2004). As noted previously, the low-stress, outer-zone test results are considered to be more representative estimates of K for the aquifer formation.

Estimates of K for the inner-zone ranged from 1.4 to 1.7 m/d (4.6 to 5.6 ft/d) for the high- and low-stress tests, respectively. A selected example of the Bouwer and Rice analysis plots for the inner zone is shown in Figure 4.5. This high-permeable inner radial zone reflects an artificially induced condition that was attributed to a sand filter pack with higher permeability than the outer-zone formation. The plots for the high-stress test analysis for this well are provided in Appendix D.

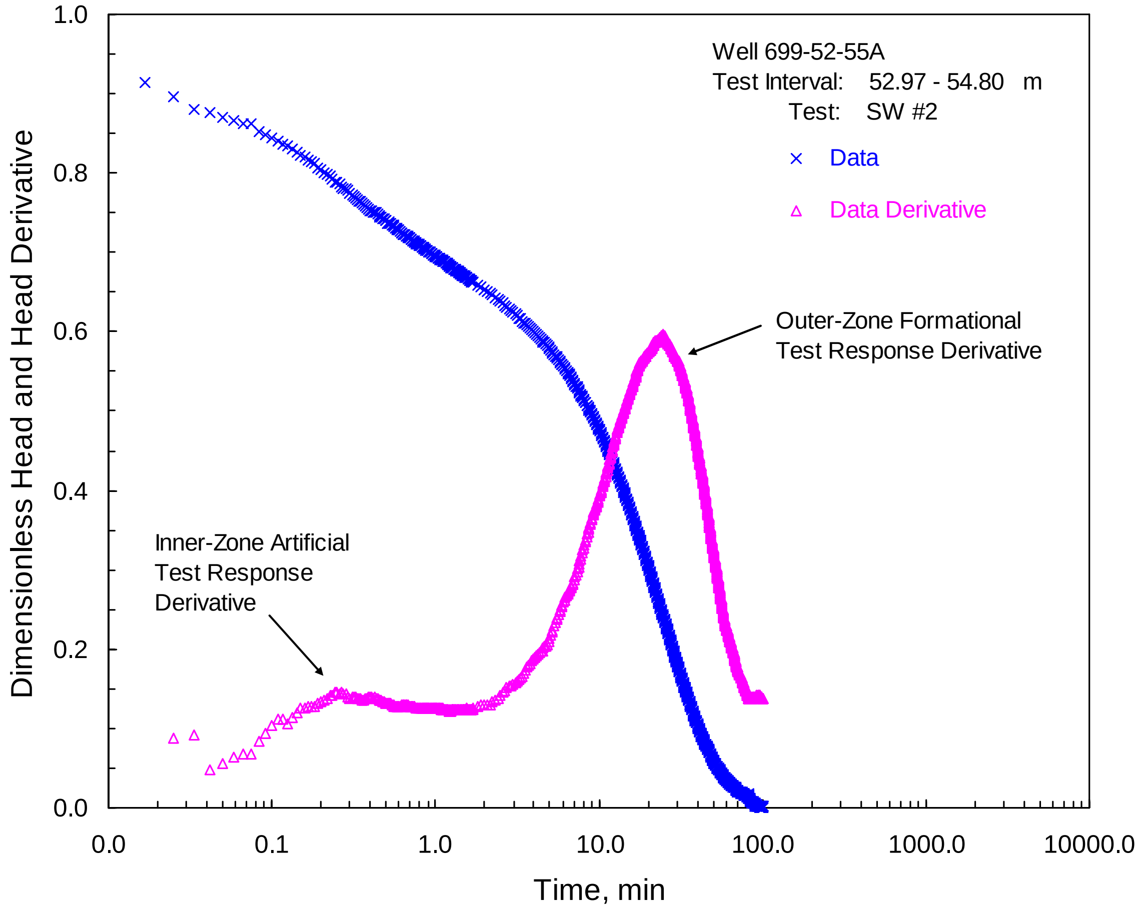


Figure 4.1. Diagnostic Analysis Plot for Well 699-52-55A

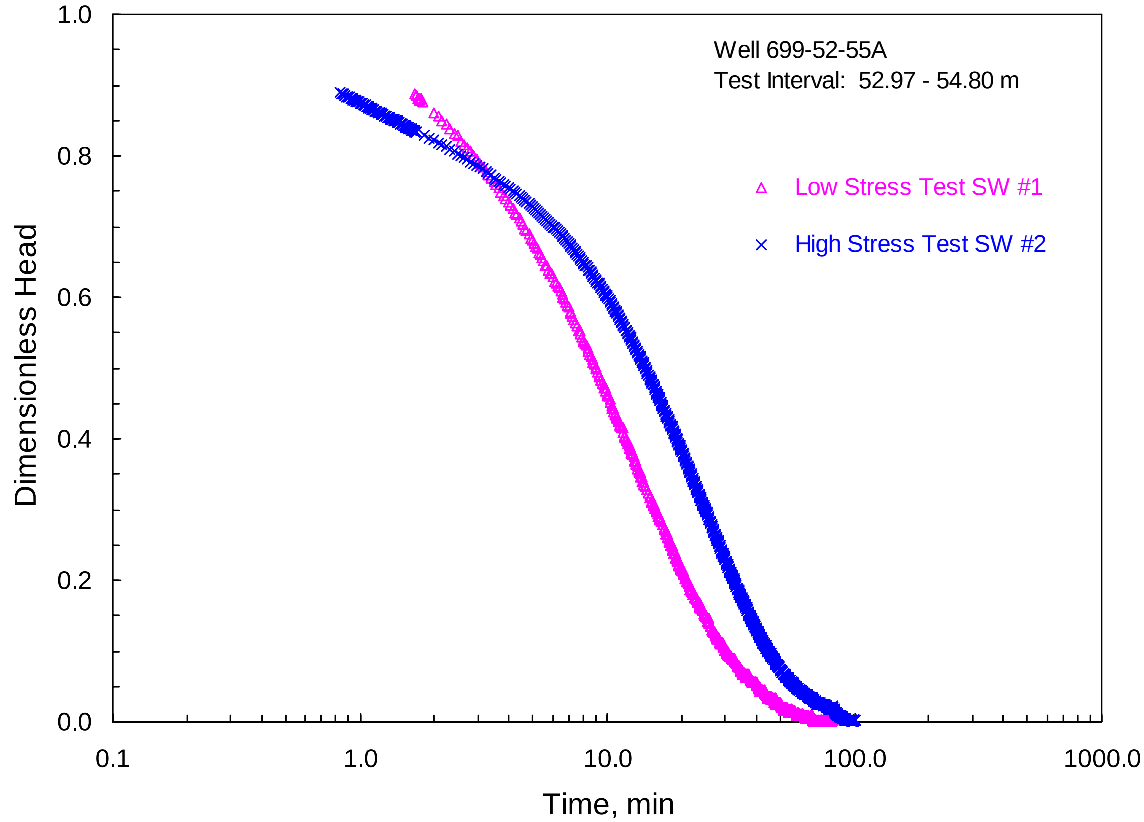


Figure 4.2. Comparison of Low-Stress and High-Stress Slug-Test Responses for Well 699-52-55A

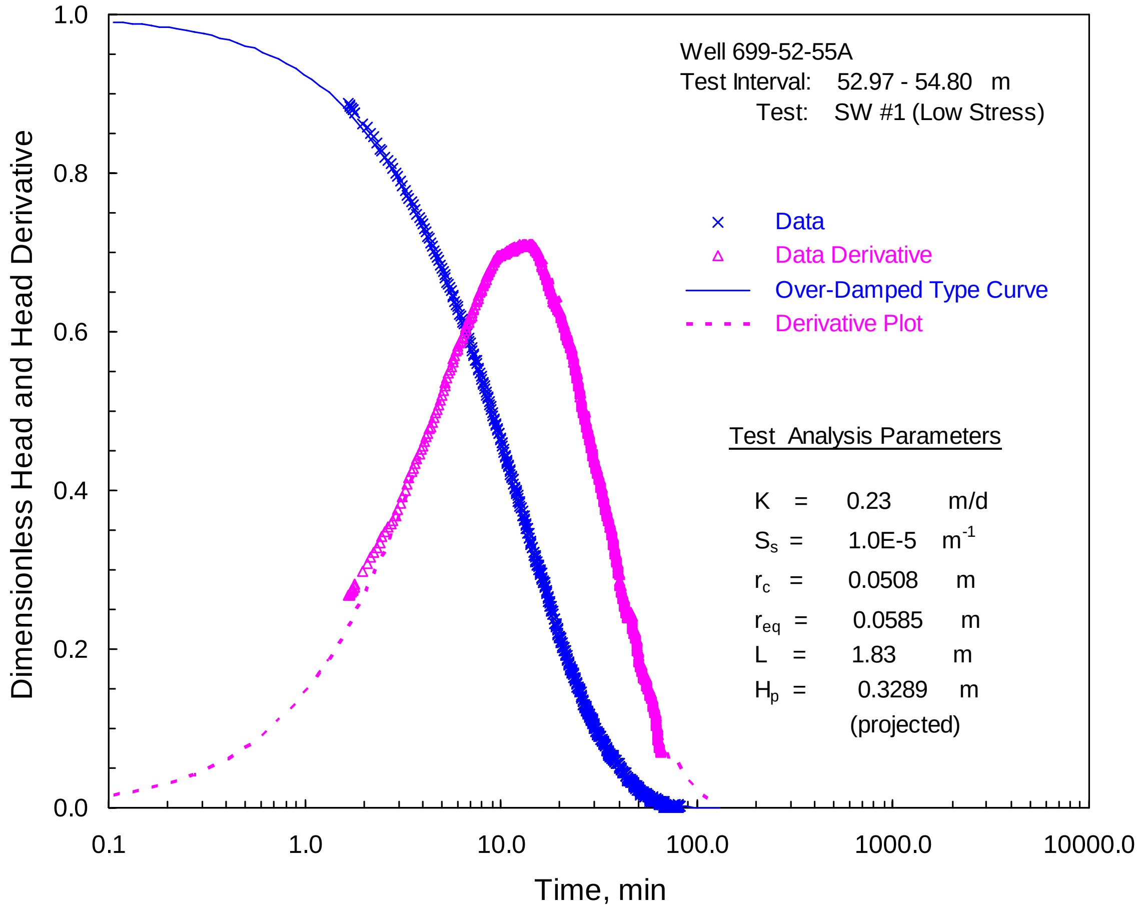


Figure 4.3. Selected Type-Curve Analysis Plot for Well 699-52-55A

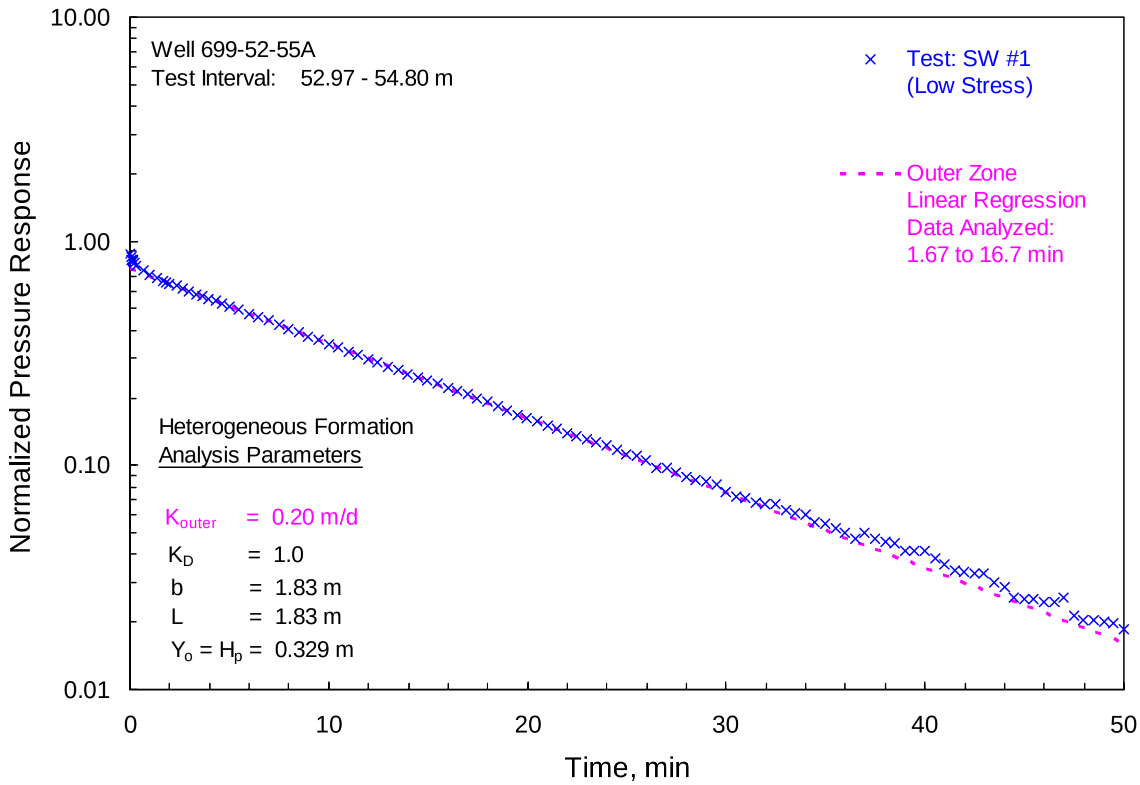


Figure 4.4. Selected Bouwer and Rice Analysis Plot for Outer Zone, Well 699-52-55A

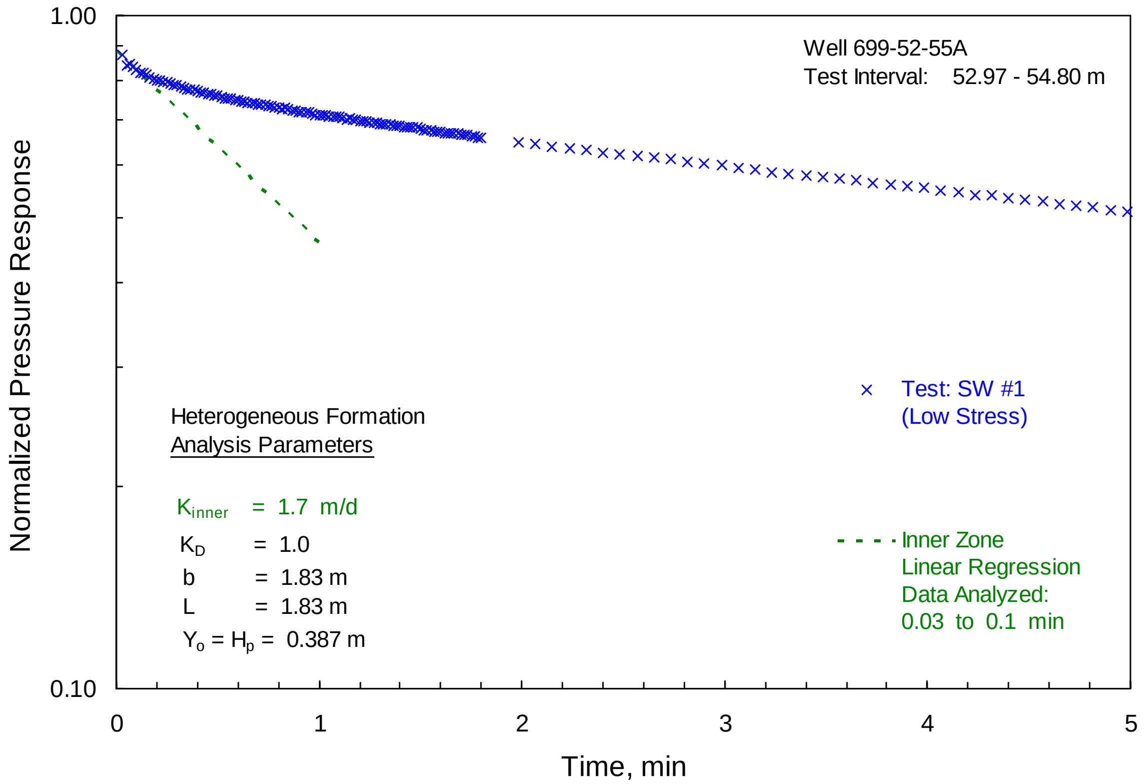


Figure 4.5. Selected Bouwer and Rice Analysis Plot for Inner Zone, Well 699-52-55A

5.0 Conclusions

Two slug-withdrawal tests using two different sized slug rods were conducted within a test/depth interval in the final, completed BP-5 well 699-52-55A. The test/depth interval represents the upper 1.83 m (6.0 ft) of the unconfined aquifer that is composed of sediments of the lower Ringold Formation within the upper 1.04 m (3.4 ft) and the Elephant Mountain basalt flowtop within the lower 0.79 m (2.6 ft). The basalt flowtop unit was included as part of the effective test-interval length for the analysis because the flowtop unit is hydraulically communicative with the unconfined aquifer. Estimates of hydraulic conductivity for this effective test-interval length represent composite values for the lower Ringold Formation and underlying basalt flowtop unit.

The slug-test analyses indicated a heterogeneous formation, exponential decay (over-damped) response pattern with moderately low permeability test conditions. The low-stress slug-test analyses provided the most reliable estimates of hydraulic conductivity because of stress-dependence delayed effects and a slightly non-linear test response associated with the high-stress test. This non-linear test condition was attributed to an observed initial displacement that was too high a percentage of the effective screen length for a well screen completed across the water table in a thin aquifer. For the results of the low-stress test analysis, a hydraulic conductivity value of 0.23 m/d (0.75 ft/d) for the aquifer formation was estimated by the method of type-curve-matching analysis, and a value of 0.20 m/d (0.66 ft/d) was estimated by the Bouwer and Rice analysis method. Hydraulic-conductivity estimates obtained with the Bouwer and Rice analytical method correspond within 10% of the estimates obtained with the type-curve method due to a relatively thin, inelastic test interval. These moderately low estimates of hydraulic conductivity and a relatively thin test interval at well 699-52-55A indicate that the unconfined aquifer is not very transmissive at this well location compared to most other well locations in the general 200-East Area. An estimate for low-stress, slug-test hydraulic conductivity for the inner zone, attributed to a higher-permeability sand filter pack, was 1.7 m/d (5.6 ft/d) using the Bouwer and Rice analysis method.

6.0 References

Bouwer H. 1989. "The Bouwer and Rice slug test – an update." *Ground Water* 27(3):304-309.

Bouwer H, and RC 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.

Butler JJ, Jr. 1998. *The Design, Performance, and Analysis of Slug Tests*. Lewis Publishers, CRC Press, Boca Raton, Florida.

Butler JJ, Jr. and EJ Garnett. 2000. *Simple procedures for analysis of slug tests in formations of high hydraulic conductivity using spreadsheet and Scientific Graphics Software*. Open-file Report 2000-40, Kansas Geological Survey, Lawrence, Kansas.

Hyder Z and JJ Butler, Jr. 1995. "Slug tests in unconfined formations: An assessment of the Bouwer and Rice technique." *Ground Water* 33(1):16-22.

McElwee CD. 2001. "Application of a nonlinear slug test model." *Ground Water* 39(5):737-744.

McElwee CD and MA Zenner. 1998. "A nonlinear model for analysis of slug-test data." *Water Resources Research* 34(1):55-66.

Spane FA, Jr., PD Thorne, and DR Newcomer. 2001. *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2000*. PNNL-13514, Pacific Northwest National Laboratory, Richland, Washington.

Spane FA, Jr., JJ Butler, MD White, and TJ Gilmore. 2003a. *Improving Pulse/Slug interference tests for contaminated site hydraulic property characterization*. SERDP Fiscal Year 2004 Research Proposal, submitted February 25, 2003.

Spane FA, Jr., DR Newcomer, and PD Thorne. 2003b. *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2002*. PNNL-14186, Pacific Northwest National Laboratory, Richland, Washington.

Spane FA, Jr., and DR Newcomer. 2004. *Results of Detailed Hydrologic Characterization Tests – Fiscal Year 2003*. PNNL-14804, Pacific Northwest National Laboratory, Richland, Washington.

Spane FA, Jr., and DR Newcomer. 2008. *Results of Detailed Hydrologic Characterization Tests – Fiscal and Calendar Year 2005*. PNNL-17348, Pacific Northwest National Laboratory, Richland, Washington.

Springer RK and LW Gelhar. 1991. "Characterization of large-scale aquifer heterogeneity in glacial outwash by analysis of slug tests with oscillatory response, Cape Cod, Massachusetts." In: *U.S. Geological Survey Water Resources Investigations*. Report 91-4034:36-40.

Zurbuchen BR, VA Zlotnik, and JJ Butler, Jr. 2002. "Dynamic interpretation of slug tests in highly permeable aquifers." *Water Resources Research*, 38(3):10.1029/2001WR000354.

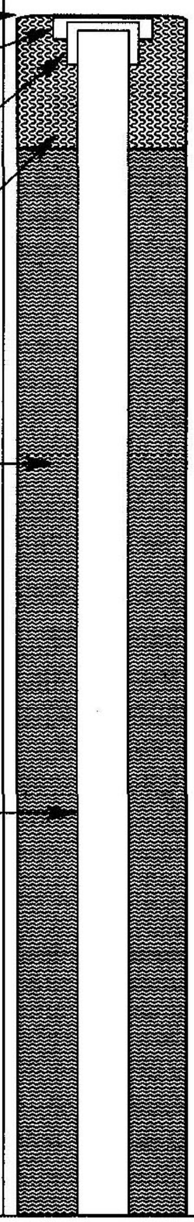
Appendix A

Well Summary Sheet for Well 699-52-55A

Appendix A: Well Summary Sheet for Well 699-52-55A

WELL SUMMARY SHEET		Start Date: 11/20/07 Finish Date: 1/22/08	Page 1 of 3
Well ID: C5861		Well Name: 699-52-55A	
Location: 600 Area N. of R.R., S. of 699-53-55A		Project: 200-BP-5 RI/FS	
Prepared By: Jeff Fetters/G Kasza	Date: 1/9/08	Reviewed By: L. D. Walker	Date: 1-30-08
Signature: Greg Kasza		Signature: Geologist - LW 1-30-08 L D Walker	

CONSTRUCTION DATA

Description	Diagram
12-in Flush Mount Well Wead 12-in Protective Casing: 0-1.5 ft bgs 6-in I.D. Type 304/304L Stainless Steel Protective Casing: 0.5-3.5 ft bgs with locking well cap Portland Cement Type I/II: 0 - 9.8 ft bgs Granular Bentonite Crumbles: 9.8 - 156.1 ft bgs 4-in I.D. Type Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: -1.1 - ~~183.1~~ ft bgs 169.8' LW 1-30-08 All depths are in feet below ground surface. Borehole drilled with 11 3/4-in threaded casing 0.0-74.0 ft and 8-in threaded casing 74.0-176.8 ft All temporary drill casing was removed from the ground.	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
0		0-3 Eolian deposits (Sand)
		3-10 Gravel G
10		10-19 Silty Sandy Gravel msG
		19-30 Sand S
20		
30		30-33 Gravelly Sand gS
		33-40 Sandy Gravel sG
40		40-45 Gravel G
		45-50 Silty Sandy Gravel msG
50		50-55 Silty Gravel mG
		55-65 Silty Sandy Gravel msG
60		
		65-79 Gravel G
70		
80		79-90 Sandy Gravel sG

WELL SUMMARY SHEET

WELL SUMMARY SHEET	Start Date: 11/20/07 Finish Date: 1/22/08	Page 2 of 3

Well ID: C5861	Well Name: 699-52-55A
Location: 600 Area N. of R.R., S. of 699-53-55A	Project: 200-BP-5 RI/FS
Prepared By: Jeff Fetters / GKAS2A Date: 1/9/08	Reviewed By: L.D. Walker Date: 1/30/08
Signature: [signature]	Signature: [signature]

CONSTRUCTION DATA

Description

All depths are in feet below ground surface.

Borehole drilled with 11 3/4-in threaded casing 0.0-74.0 ft and 8-in threaded casing 74.0-176.8 ft

All temporary drill casing was removed from the ground.

Granular Bentonite Crumbles: 9.8 - 156.1 ft

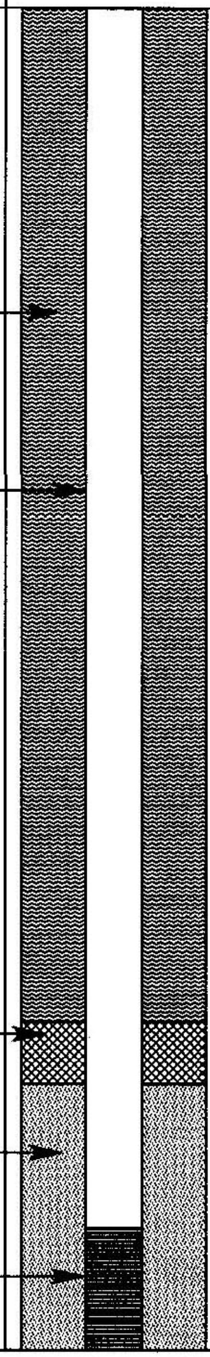
4-in I.D. Type Stainless Steel Type 304/304L, Schedule 10 Permanent Casing: -1.1 - ~~183.1 ft~~ 169.8' LW 1-30-08

3/8-in Bentonite Pellets: 156.1 - 160.1 ft bgs

Primary Filter pack 10-20 Mesh Colorado Silica Sand: 160.1 - 183.1 ft bgs

4-in I.D. Stainless Steel, Type 304, 20 Slot Screen (.020-in): 169.8 - 179.8 ft bgs

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 90, 100, 110, 120, 130, 140, 150, 160, 170

Graphic Log

Lithologic Description/Groundwater Sample Depths (ft bgs)

90-105 Silty Sandy Gravel msG

105-110 Sandy Gravel sG

110-115 Gravel G

115-123 Silty Sandy Gravel msG

123-130 Gravelly silt gM

130-135 Gravelly Sand gS

135-139 Gravel Silty Sand gmS

139-145 Silty Gravel Sand mgS

145-147 Gravelly Silt gM

147-155 Silt M

155-157 Sandy Silty sM

157-158 Sand S

158-170 Silty Sand mS

170-175 Gravelly Sand gS

175-177.2 Silty Gravely Sand mgS

177.2-183.2 Basalt

WELL SUMMARY SHEET		Start Date: 11/20/07 Finish Date: 1/22/08	Page 3 of 3
Well ID: C5861		Well Name: 699-52-55A	
Location: 600 Area N. of R.R., S. of 699-53-55A		Project: 200-BP-5 RI/FS	
Prepared By: Jeff Fetters / G KASZA	Date: 1/9/08	Reviewed By: L. D. Walker	Date: 1/30/08
Signature: Greg Kasza		Signature: [signature]	

CONSTRUCTION DATA

Description	Diagram
4-in I.D. Stainless Steel, Type 304, 20 Slot Screen (.020-in): 169.8 - 179.8 ft bgs Primary Filter pack 10-20 Mesh Colorado Silica Sand: 160.1 - 183.1 ft bgs 4-in I.D. Stainless Steel Sump: 179.8-183.1 ft bgs Natural Fill 183.1' → 183.3'	

All depths are in feet below ground surface.

Borehole drilled with 11 3/4-in threaded casing 0.0-74 ft and 8-in threaded casing 74-176.8 ft

All temporary drill casing was removed from the ground.

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description/Groundwater Sample Depths (ft bgs)
180		177.2-~~183.2~~ 183.3' Basalt LW 1-30-08
190		TD = 183.3' bgs
200		
210		
220		
230		
240		
250		
260		

Appendix B

Borehole Log for Well 699-52-55A

Appendix B: Borehole Log for Well 699-52-55A

BOREHOLE LOG — Page 1 of 5 — Date: 11/20/07

Well ID: C5861	Well Name: 699-52-55A
Location: 600 Area N of RR, S. of 699-53-55A	
Project: 200-BP-5 RI/FS	Reference Measuring Point: ground surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description (Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level)
5	grab			0-3' - wind blown Deposits (Eolian) 5' - Gravel (G) 90% gvl, 5% silt, 5% snd; gvl: 70% basalt 30% qtz/others, 10cm-2mm (sc-VFP), R, Predom VCP; snd: M-VF, R-SR, 70% basalt 30% qzt; Silt: Dry, no Rxn HCl, 10YR 4/3 brown	Cable Tool, 11 3/4" OD threaded casing
10	grab			10' - Silty Sandy Gravel (msG) 60% gvl 10% snd, 30% silt; gvl: 6cm-2mm (VCP-VFP) R-SR 80% basalt, 20% qzt; snd: VC-VF, A, 60% basalt 40% qzt/others; silt: Dry 10YR 4/1 Dk gray, Mod Rxn HCl	10' Suspect larger gvls. 12' 20cm basalt boulder
15	grab			15' - Silty Sandy Gravel, same lithology as above	Drilling rate ↓
20	grab			19' - Sand (S) 90% snd 10% gvl; gvl: 9cm-2mm (Sc-VFP), 90% basalt 10% qtz/others, R; snd: VC-M, 90% basalt 10% qtz/others, SR-SA, Dry, no Rxn HCl, gley 1 2.5/10y greenish black	19' Dr ↑.
25	grab			25' - Sand (S) same lithology as above, 100% basalt gvls.	
30	grab			30' - gravelly Sand (gS) lithology same as above w/ gvls to 20% gvl are 80% basalt 10% qtz/others	
33	grab			33' Sandy gravel (sG) 40% gvl 60% snd; gvl: 9cm-2mm (Sc-VFP), R, 70% basalt, 30% qtz; snd: VC-F, 70% basalt 30% qtz, SR, SA, VWk Rxn HCl, Dry, 10YR 3/2 VDk grayish brown, Trace of Clay	
35				35' sandy gravel (sG) 75% gvl 25% snd; gvl: 90% basalt 10% qtz 6cm-2mm (VCP-VFP), R; snd: VC-VF, 60% basalt 40% qtz, Dry, 10YR 3/2 VDk grayish brown VWk Rxn HCl	35' snd predom M grained
40	grab			40' gravel (G) 80% gvl 20% snd; gvl 90% basalt, 10% qzt, R, 7cm-2mm (VCP-VFP); snd: 70% basalt 30% qzt, SA-SR, VC-M, Dry, 10YR 3/2 no Rxn HCl	41' increase in "pea" sized gvls. & silt. 43' casing driving very hard.

Reported By: J Fetters	Reviewed By: L. D. Walker
Title: geologist	Title: Geologist
Signature: [signature] Date: 11/27/07	Signature: [signature] Date: 2/1/08

A-6003-642 (03/03)

BOREHOLE LOG

Date: 11/27/07

Well ID: C5861	Well Name: 699-52-55A
Location: 600 area N of RR, S. of 699-53-55A	
Project: 200-BP-5 Ri/Fs	Reference Measuring Point: Ground

Depth (Ft.)	Sample Type No.	Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
45	grab			45' Silty Sandy Gravel (msG) 70% gvl 15% snd 15% silt; Gvl: 10cm-2mm (SC-VFP) 70% basalt 30% qtz, R; Snd: 60% qtz 40% basalt, VC-VF Predom M-VF, SA-SR; Silt: Dry, mod Rxn HCl 2.5Y 3/2 VDK gray brown	Cable Tool 11 3/4" Casing 46' ↑ silt content
50	grab			50' - Silty Gravel (mG) 70% gvl 5% snd 25% silt; Gvl: 70% basalt 30% qtz, R, >12cm-2mm (LC-VFP); Silt: Moist, 10YR 3/2, wk Rxn HCl; Snd: lithology same as above	53' DR ↓, Casing driving hard.
55	grab			55' - Silty Sandy gravel (msG); 60% gvl 20% snd 20% silt; Gvl: 40% qtz 60% basalt, R, 2cm-2mm (SC-VFP); Snd: 70% qtz 40% basalt, VC-VF (Predom M-F) SA-A; Silt: Slightly Moist, 2.5Y 4/2 DK grayish brown, Vwk Rxn HCl	
58	grab			58' - Silty Sandy Gravel (msG); 50% snd 40% gvl 10% silt; gvl: 60% basalt 40% qtz, 5cm-2mm, R; Snd: 50% basalt 50% qtz, A, SA, VC-VF (Predom M-F); Silt: Dry, 7.5Y 4/2, brown Vwk Rxn HCl	
60	grab			60' - lithology same as above	64' DR ↑
65	grab			65' - Gravel (G) 80% gvl 10% snd 10% silt: gvl: 50% basalt 50% qtz, 11cm-2mm, R; Snd: VC-VF Predom VC-C) 50% basalt 50% qtz, SA-A; Silt: Slightly moist: 10YR 4/2 DK grayish brown Vwk to mod Rxn HCl	65' moisture ↑ 67' DR ↓ 68: noticable amount of vesicular basalt Cobbles
70	grab			70' - lithology same as above	74' Casing reduced from 11 3/4"- 8"
75	grab			75' - lithology same as above	
80	grab			79' - Sandy Gravel (sG); 70% gvl 30% snd; gvl: 60% basalt 40% others, R, 12cm-2mm (SC-VFP); Snd: VC-VF Predom F-VF, 90% qtz 10% basalt, A-SA, Dry, Vwk Rxn HCl, 2.5Y 4/2 Dk grayish brown	79' suspect gvl > 20 cm due to high amounts of Fresh broken Clasts.

Reported By: J Fetters	Reviewed By: L.D. Walker
Title: geologist	Title: Geologist
Signature: [signature] Date: 11/30/07	Signature: [signature] Date: 2/1/08

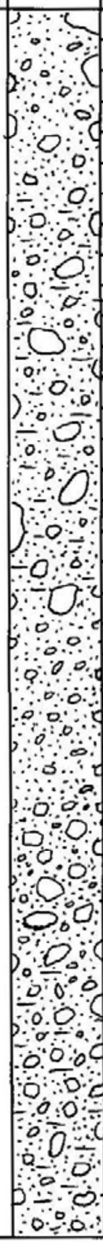
A-6003-642 (03/03)

BOREHOLE LOG

Page 3 of 5
Date: 12/4/07

Well ID: C5861 | Well Name: 699-52-55A | Location: 600 area N of RR, S. of 699-53-55A

Project: 200-BP-5 Ri/Fs | Reference Measuring Point: ground

Depth (Ft.)	Sample: Type No.	Sample: Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
85	grab			85'- Sandy gravel, lithology Same as above	Cable Tool, 8" casing 85' noticable ~~ammounts~~ amounts of vesicular basalt cobbles
90	grab			90'- Silty Sandy Gravel (msG) 60% gvl 30% snd 10% silt; gvl: 50% basalt 50% qtz, 12cm-2mm (SC-VFP) R; Snd: 90% qtz 10% basalt, VC-VF (Predom F-VF) A-SA; Silt: Moist, 10YR 4/3 Brown, VWk Rxn HCl	90'- Suspect larger gvls >20 cm, ↑ moisture clasts coated w/ moist Silt 91' ↓ moisture
95	grab			95'- lithology same as above, silt is Dry	
100	grab			100'- lithology same as above	
105	grab			105'- Sandy gravel (sG) 70% gvl 30% snd; gvl: 6cm-2mm (VCC-VFP) 60% qtz 40% basalt, R; Snd: 90% qtz 10% basalt, VC-VF (Predom F-VF) Dry, 7.5Y 4/2 brown, VWk Rxn HCl	105' suspect larger gvls due to amount of Freshly broken Angular Clasts
110	grab			110'- gravel (g) 90% gvl 10% snd; gvl: 10cm-2mm (SC-VFP) 50% basalt 50% qtz, R, (suspect larger gvls >10cm); Snd: VC-VF 80% qtz 20% basalt, A-SA, Dry, 7.5Y 4/2 brown, VWk Rxn HCl, Slight (weak) cementation	111' DR ↓
115	grab			115'- Silty Sandy Gravel (msG) 80% gvl 10% snd 10% silt gvl: 50% basalt 50% qtz, R, 10cm-2mm; snd: 50% b, 50% qtz, M-VF, A; Silt: Dry, 5Y 4/1 Dk gray, VWk Rxn HCl	
120	grab			120'- lithology same as above	
123	grab			123'- gravelly silty sand (gmS) 60% snd, 30% gvl, 10% silt; gvl: 50% basalt 50% qtz, R, 4cm-2mm (VCP-VFP); snd: 60% qtz 40% basalt; VC-VF, A-SA; Silt Dry, 10YR 4/2 Dk grayish brown, Mod Rxn HCl, mod cementation	123' gravels size ↓,

Reported By: J Fetters | Reviewed By: L. D. Walker

Title: geologist | Title: Geologist

Signature: [signature] Date: 1/24/08 | Signature: [signature] Date: 2/1/08

A-6003-642 (03/03)

BOREHOLE LOG

Page 4 of 5
Date: 12/6/07

Well ID: C5861	Well Name: 699-52-55A	Location: 600 Area N. of RR, S. of 699-53-55A
Project: 200-BP-5 RI/FS		Reference Measuring Point: ground

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
125	grab			125' - lithology same as above, color	Cable Tool 8" casing
				to 7.5y 4/2 Brown	
130	grab			130' - gravelly sand (gS) 70% snd 30% gvl:	
				gvl: 50% basalt 50% qtz, R, 4cm-2mm (VCP-VFP)	
				Snd: 60% qtz 40% basalt, A-SA, Dry, 5y 4/2	
				olive gray, wk Rxn HCl	
135	grab			135' - gravelly silty sand (gmS) 70% snd 20%	
				gvl 10% silt: 80% qtz 20% basalt, A-SA, VC-VF (Predom	135' basalt snd grains
				M-VF); gvl: 50% basalt 50% qtz, R-SR, 5cm-2mm	larger than qtz/others
				(VCC-VFP); Silt: Dry, 5y 5/2 olive gray, mod Rxn	
				HCl	139' ↑ sand size &
140	grab			139': silty gravelly sand (msG); 40% gvl 40% snd	gvl: %
				20% silt; gvl: 50% basalt 50% qtz, R, 5cm-2mm	141' - cuttings not staying
				(VCC-VFP); snd: 80% qtz 20% basalt, A-SA M-	in Drive barrel ↑
				VF; Dry 10YR 5/2 grayish brown, mod	gvl size
				Rxn HCl	144 ↑ silt content
				142' - lithology same as above w/ wk	
145	grab			cementation, strong Rxn HCl	145' - grab sample,
				145' - gravelly silt (gM) 80% silt 10% gvl; gvl: 50% basalt	snd predom F-VF
148	grab			50% qtz, R, 6cm-2mm; snd: VC-VF, 80% qtz 20% basalt,	148' grab sample
149	grab			A-SA; Silt: Dry, 10YR 6/2 lt. brownish gray, mod	149' grab sample
150	grab			Rxn HCl	
				147-147.5 silt (M) slightly moist, wk-mod Rxn	
152	grab			HCl. 10YR 4/2 dk grayish brown	152' - grab sample
				148' lithology same as above	
				151' - silt (M): slightly moist, 5y 5/3, olive, wk	
155	grab			Rxn HCl, Rust Red mottling present	155' grab sample, Red-
				153' - lithology same as above	orange mottling
				155' - sandy silt (sM) 50% snd 50% silt; snd: VF, 80% qtz,	157' - grab sample
157	grab			20% basalt, A-SA; silt: slightly moist, 5y 4/3 olive	158' - Predom M-VF snd.
				wk Rxn HCl	
				157': sand (S): VF, slightly moist, 5Y 5/3 olive, mod Rxn	160' grab sample
160	grab			HCl, A-SA, no mottling present	
				158' - silty sand (mS) 80% snd 15% silt 5% gvl: gvl 2cm-2mm, R, 50%	
163	grab			basalt 50% qtz; snd: VC-VF, A-SA, 80% qtz 20% basalt; Silt	163 grab sample
				Dry 2.5Y 5/2 grayish brown, wk Rxn HCl	

Reported By: J Fetters		Reviewed By: L. D. Walker
Title: geologist		Title: Geologist
Signature: J Fetters	Date: 12/10/07	Signature: LD Walker — Date: 2/1/08

A-6003-642 (03/03)

BOREHOLE LOG

Date: 12/10/07

Well ID: C5861	Well Name: 699-52-55A	Location: 600 area N of RR S. of 699-53-55A
Project: 200-BP-5 RI/FS		Reference Measuring Point: ground

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
165	grab			165- lithology same as above, w/ mod rxn HCl	Cable Tool 8" casing 165' grab sample
167.5	grab				
170	grab			170'-gravelly sand (gS): 80% snd 20% gvl: 50% basalt, 50% qtz, SA-SR, 2cm-2mm (CP-UFP); Snd: VC-UF (Predom M-F) 70% basalt, 30% qtz, A, Dry, 10YR 4/2 Dk grayish brown, wk rxn HCl, Basalt = larger grain size	170' grab sample
173.5	grab			173.5 - lithology same as above, gvl. ↑ to 3cm.	173.5' grab sample
175	grab	SS 174-176.5 75%		175'- Silty gravelly sand (mgS) 80% snd 15% gvl, 5% silt; Gvl: 60% basalt 40% qtz, R, 2cm-2mm (CP-VFP), Snd: VC-VF (Predom C-VC) 60% basalt 40% qtz, A; Silt: wet, no Rxn HCl 10YR 3/2 VDK grayish brown	175' grab sample S.S. 174-176.5 - S.S. Encountered large cobble, shoe damaged could not be removed, contents dumped into bowl.
180				177.2 - Basalt; present as chips + fines in drill cuttings; non-vesicular basalt; very dark gray to black in color; 20-25% (by mass) sand, same lithology as sand above.	
185					183.32' = T.D. (1/4/08) Static WL. = 173.5 (12/11/07)
190					

Reported By: J Fetters	Reviewed By: L. D. Walker
Title: geologist	Title: Geologist
Signature: J Fetters Date: 1/28/08	Signature: LD Walker Date: 2/1/08

A-6003-642 (03/03)

Appendix C

Slug-Test Field Notes for Well 699-52-55A

Appendix C: Slug-Test Field Notes for Well 699-52-55A

PNNL SLUG TEST FIELD MEASUREMENTS - FINAL, COMPLETED WELL

Test Date/Time: 4-22-08

Well ID: 699-52-55A

Test/Depth Interval: 173.79-179.8 ft (52.97-54.80m)

Reference Pt. for Depth-to-Water: top of 12-in. Flush mount

Pre-Test Depth-to-Water: 173.79 ft bgs

Transducer S/N: 2162639

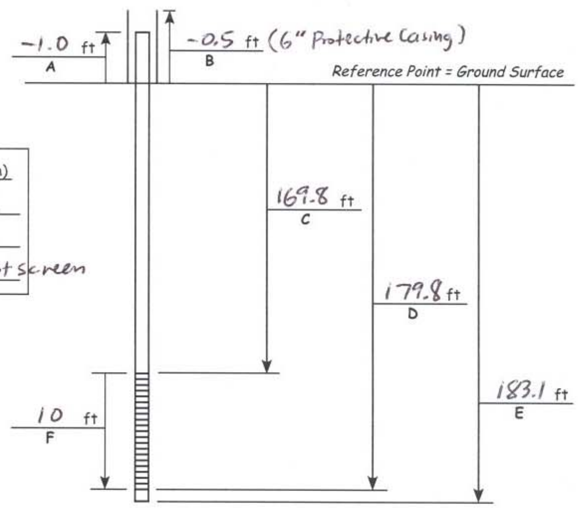
Post-Test Depth-to-Water: 173.79 ft bgs

Multiplier: 2.3400 ft/(mV/V)

Logger S/N: X16271

Measured Test Lengths

A = Reference Pt (RP) to Top of Inner Well Casing
B = RP to Top of Outer Protective Casing
C = RP to Top of Screen
D = RP to Bottom of Screen
E = RP to Bottom of Well
F = Screen Length



Test Stress Information

Test #	Stress Applied
1	0.1251 ft³ (2" O.D.)
2	0.3256 ft³ (3" O.D.)

Well Diameter (inch)
well-screen 4
well casing 4
borehole 8" at screen

Prepared by: Darrell Newcomer (sign) Darrell Newcomer (print) Date: 4-22-08

Reviewed by: [signature] (sign) Rob D. Mackley (print) Date: 4/30/08

Time:	Field Notes:
	D/W = 173.79' bgs (measured by Olin Amos of Energy Solutions)
	D/B = 183.56' bgs " " "
	Olin Amos of Energy Solutions provided drill rig and slug rods to support slug testing.
0845 (PDT)	Set small 2" O.D. slug rod on bottom of well and raised it up 3'. Make
	mark (submerged level) and then raise it 6' and mark cable again. These
	marks are the submerged and unsubmerged marks.
	183.56 - 173.79 = 9.77' of water column.
0858	Synchronized logger clock with watch to PDT
0903	Install 5 psig transducer SN 2162639 to bottom of well
	Reading is 9.6416' logger SN X16271 Multiplier = 2.3400
0905	Collecting base line data

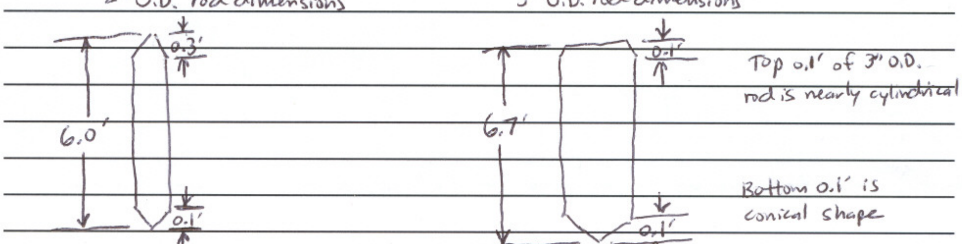
2008/DCL/SlugTest/001 (04/23)

PNNL SLUG TEST FIELD MEASUREMENTS - FINAL, COMPLETED WELL (continuation sheet)

Test Date/Time: 4-22-08 — Well ID: 699-52-55A

Test/Depth Interval: 173.79 - 179.8 ft bgs

Time:	Field Notes:
0920	Lower 2" O.D. slug rod into water column slowly to upper mark. Upper mark is even with ground surface – well is flush-mounted. Rod is fully submerged Δt = 5 sec.
	Recovery is very slow
	4" ID casing is 1.0' below ground surface. 6" casing is 0.5' below ground surface.
1025	Water level has recovered to 9.76'
1033	9.7505'
1036	Initiate slug withdrawal test #1; 2" O.D. rod raised completely out of water column. Lower mark at least a foot above ground surface.
~1039	Changed Δt from 1 sec to 5 sec.
1155	Remove 2" O.D. rod from well and replace it with 3" O.D. rod.
1158	Lower 3" O.D. rod into water column to upper mark. Rod is completely submerged. Lower mark was moved down 0.7' because 3" O.D. rod is 6.7' long. (2" O.D. rod is 6.0' long)
1400	Initiate slug withdrawal test #2 using 3" O.D. rod. Rod was fully submerged; Δt = 0.5 sec
1402	Change Δt to 5 sec. Slow recovery
1522	Took well cap off and it disturbed water level readings a bit.
1557	D/W = 52.971 m bgs = 173.79' bgs Etape # WL3099
1602	Turn logger off. Data downloaded to file name CR10X_X16621_6-52-55A_S1-2.dat and backed it up on jump drive.



Prepared by: Darrell Newcomer (sign) D. Newcomer (print) Date: 4-22-08 Reviewed by: [signature] (sign) Rob D. Mackley (print) Date: 4/30/08

2008/DCL/SlugTest/002 (04/23)

Appendix D

Slug-Test SW #2 Plots for Well 699-52-55A

Appendix D: Slug-Test SW #2 Plots for Well 699-52-55A

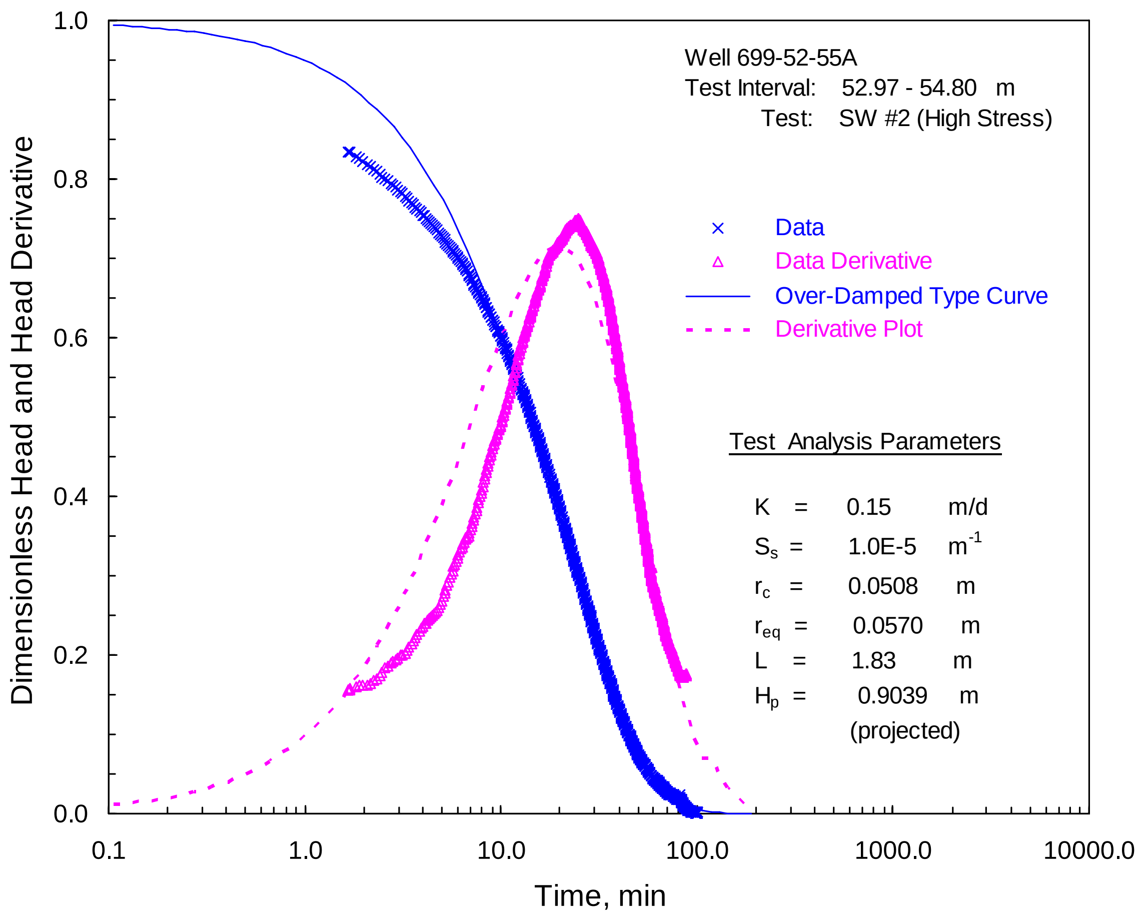


Figure D1. Type-Curve Analysis Plot for Test SW #2, Well 699-52-55A

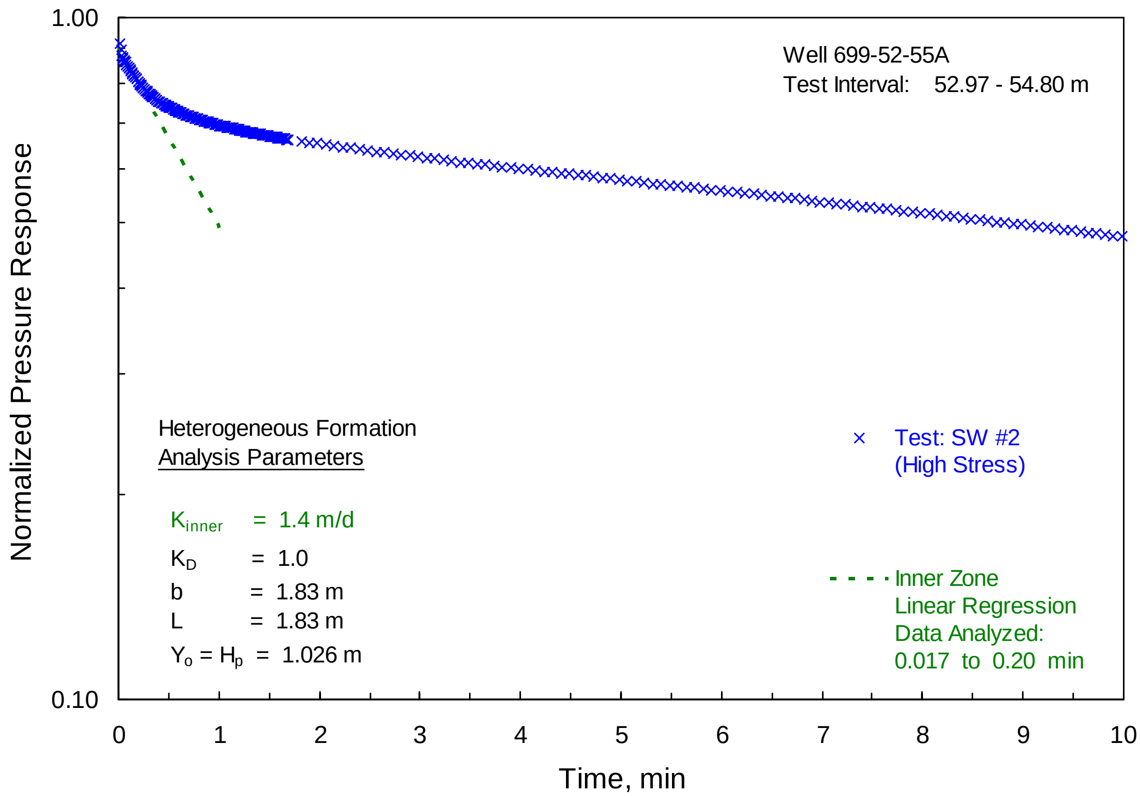


Figure D2. Bouwer and Rice Analysis Plot for Inner Zone, Test SW #2, Well 699-52-55A

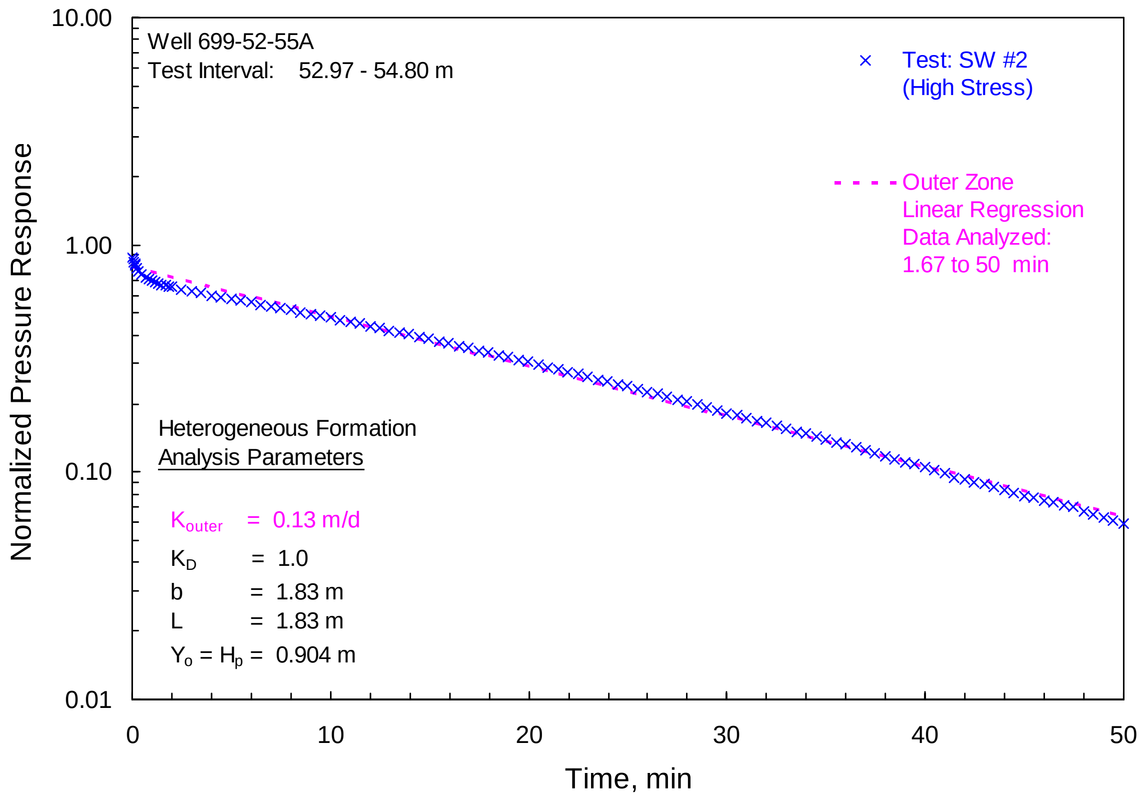


Figure D3. Bouwer and Rice Analysis Plot for Outer Zone, Test SW #2, Well 699-52-55A

Distribution

No. of
Copies

ONSITE

8	Pacific Northwest National Laboratory	
	D. R. Newcomer (5)	K6-96
	F. A. Spane	K6-96
	Hanford Technical Library (2)	P8-55
8	Fluor Hanford, Inc.	
	R. S. Edrington	E6-35
	D. S. Miller	E6-44
	S. M. Narbutovskih	E6-44
	L. C. Swanson	E6-35
	G. S. Thomas (2)	E6-44
	B. A. Williams	E6-44
	C. S. Wright	E6-35