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Analysis Report for AP-070

Analysis of Culebra and Magenta Hydraulic Tests Performed Between January 2005 and August 2008

AP-070: Analysis Plan for Non-Salado Hydraulic-Test Interpretations

Task Number 1.4.2.3

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1. Introduction

This report discusses the analyses of hydraulic tests performed in the Culebra Dolomite and Magenta Members of the Rustler Formation (Figure 1) at the Waste Isolation Pilot Plant (WIPP) site between January 2005 and August 2008. These analyses were performed in accordance with the Sandia National Laboratories (SNL) Analysis Plan for Non-Salado Hydraulic-Test Interpretations, AP-070, Revision 1 (Beauheim, 2004). The computer code used for analysis was nSIGHTS (n-dimensional Statistical Inverse Graphical Hydraulic Test Simulator), version 2.41. A detailed description of the approach followed in these analyses can be found in Beauheim et al. (1993, Appendix B) and Roberts et al. (1999, Chapter 6). The data analyzed for this report were collected at the following wells: SNL-6, IMC-461, C-2737, H-11b2, and H-15.

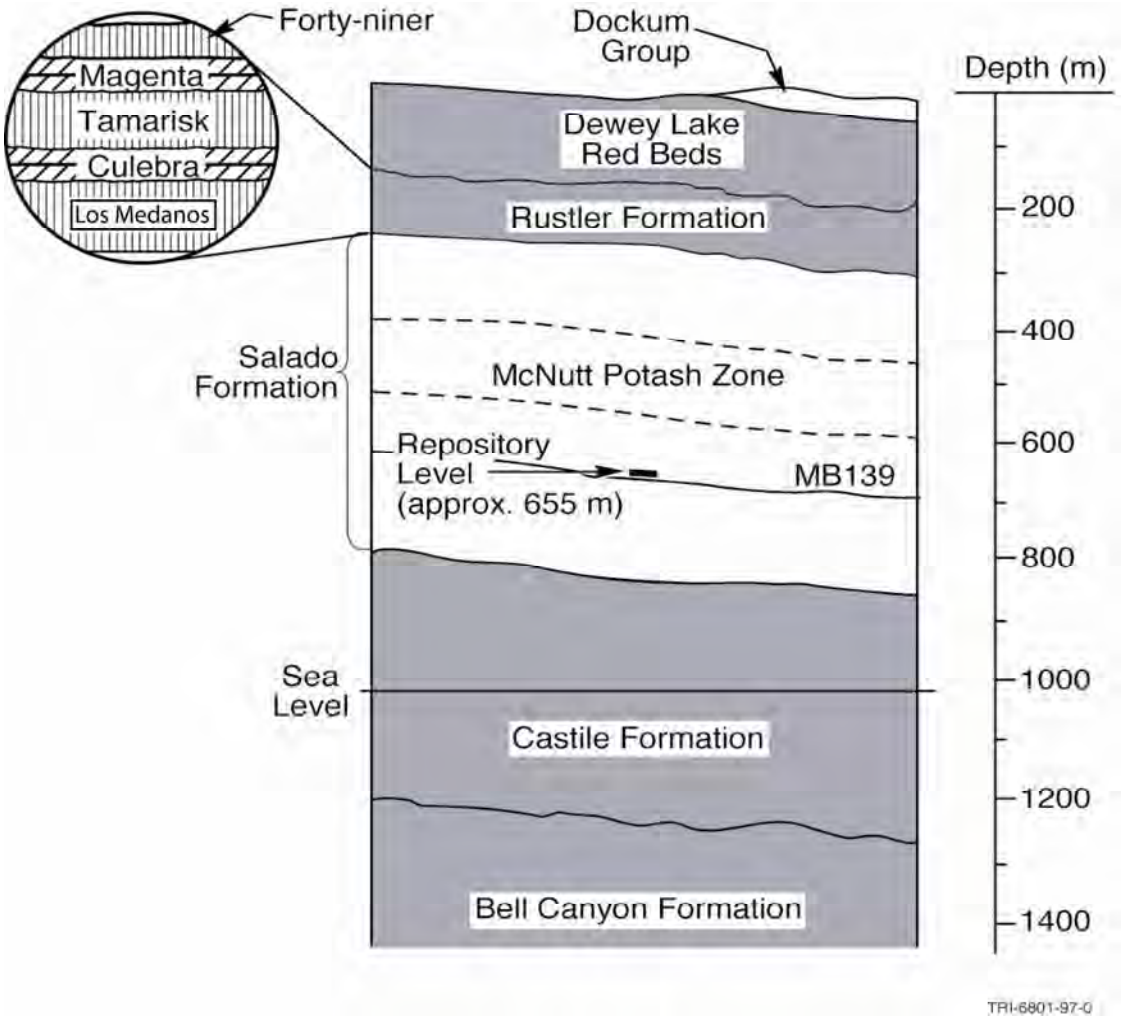


Figure 1. WIPP stratigraphy.

2. nSIGHTS Overview

The nSIGHTS code consists of two independent applications: nPre.exe and nPost.exe. The pre-processor and simulator, nPre, is used to process the field data prior to analysis, set up the mathematical model, and then run the model in inverse mode to estimate the hydraulic parameters of interest, e.g., transmissivity (T), flow dimension (n), etc. It also generates the data used to quantify the uncertainty associated with those hydraulic-parameter estimates. The post-processor, nPost, processes the results stored in the nPre output files, allowing graphical and statistical analysis of the simulation results.

All field data used in each analysis are entered or read into nPre and stored in a configuration file with an ***nPre*** extension. The field data include well radius, tubing-string radius, formation thickness, fluid density, and the transient pressure and flow-rate data. All input field data, including the reference ERMS numbers and field notebooks for each well, are listed in Appendix A.

The conceptual model chosen based on the characteristics of the test response determines the fitting parameters that will be estimated for each analysis. The model fitting parameters for each analysis are specified in the ***nPre*** configuration files named for each of the wells. Five hundred (500) sets of optimized fitting parameters were generated for each analysis in this report as part of the fitting-parameter uncertainty calculation. These 500 optimized parameter sets are stored in the nPre output file with an ***nOpt*** extension. The corresponding transient pressure simulations are stored in an nPre output file with an ***nXYsim*** extension. Both the ***nOpt*** and ***nXYsim*** files are read by nPost and all of the post-processing results are stored in a configuration file with an ***nPost*** extension.

The nSIGHTS input and output files for each tested well are stored in a directory structure like that shown in Figure 2.

Figure 2. Directory structure for Culebra nSIGHTS analyses.

The nPre configuration file is stored in the folder named for the tested well in a directory named for the strata tested (Figure 2). Transient pressure and flow-rate files are stored in the Data folder (Figure 3) and all nPre output files as well as the nPost configuration file are stored in the Post folder (Figure 4).

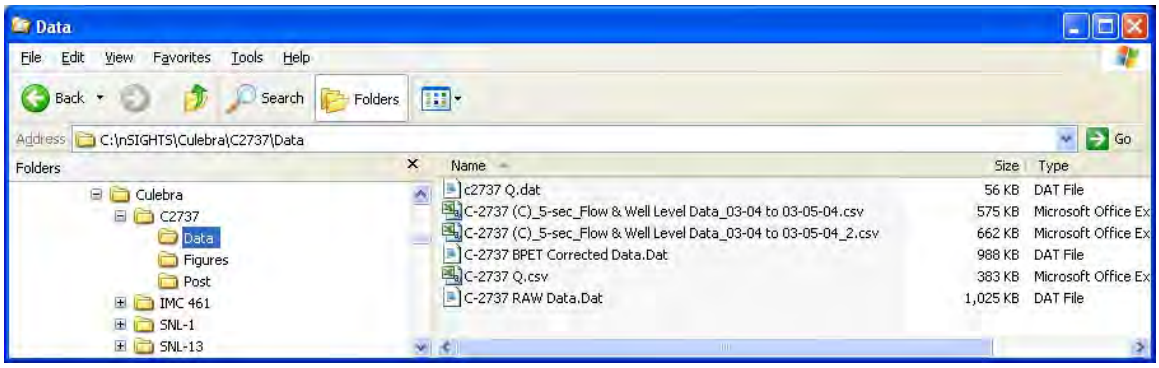


Figure 3. *Data* folder containing the pressure and flow-rate files for nPre input.

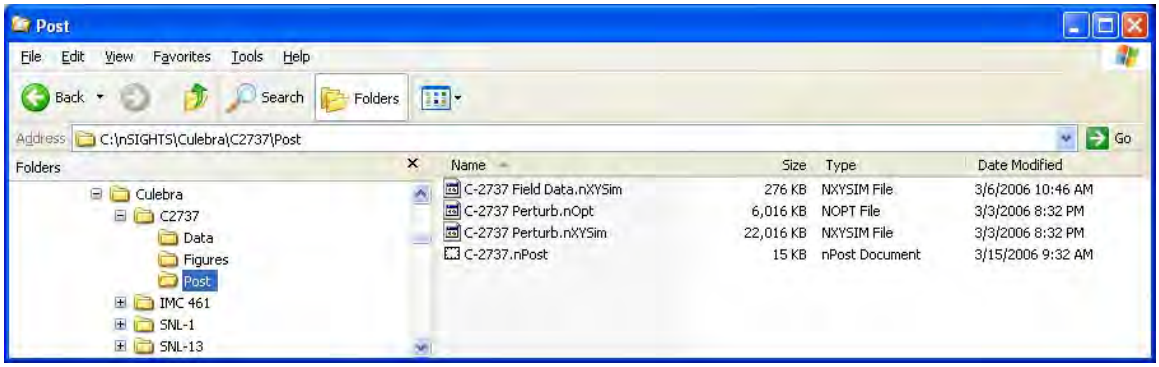


Figure 4. *Post* folder containing simulation output and post-processed data.

3. Test and Analysis Procedures

Slug tests were performed in wells SNL-6, IMC-461, and C-2737 (Figure 5). The SNL-6 slug test of the Culebra was superimposed on the ongoing slow recovery from drilling and completion of the well. The well was bailed for approximately 137 minutes to remove a slug of water, after which a Level TROLL® was installed for monitoring. Five slug tests were conducted on the Culebra in well IMC-461 using compressed nitrogen to depress water levels. After all pressures had stabilized, the pressurized nitrogen was released to initiate each slug test. The C-2737 slug tests of the Magenta used a straddle-packer tool with a downhole shut-in valve. The tool was lowered down hole with empty tubing and then the shut-in valve was opened to perform a slug-withdrawal test. After equilibration, water was added to perform a slug-injection test.

Pumping tests were performed on the Magenta in wells H-11b2 and H-15 (Figure 5). In H-11b2, the Magenta was pumped at a constant rate of approximately 0.2 gallons per minute (gpm) for 2.9 days. In H-15, the Magenta was pumped at a rate of approximately 1.0 gpm for 2.1 days, and then at approximately 1.5 gpm for an additional 0.2 days. Pressure recoveries were monitored in the two wells for periods of 27 and 12 days, respectively.

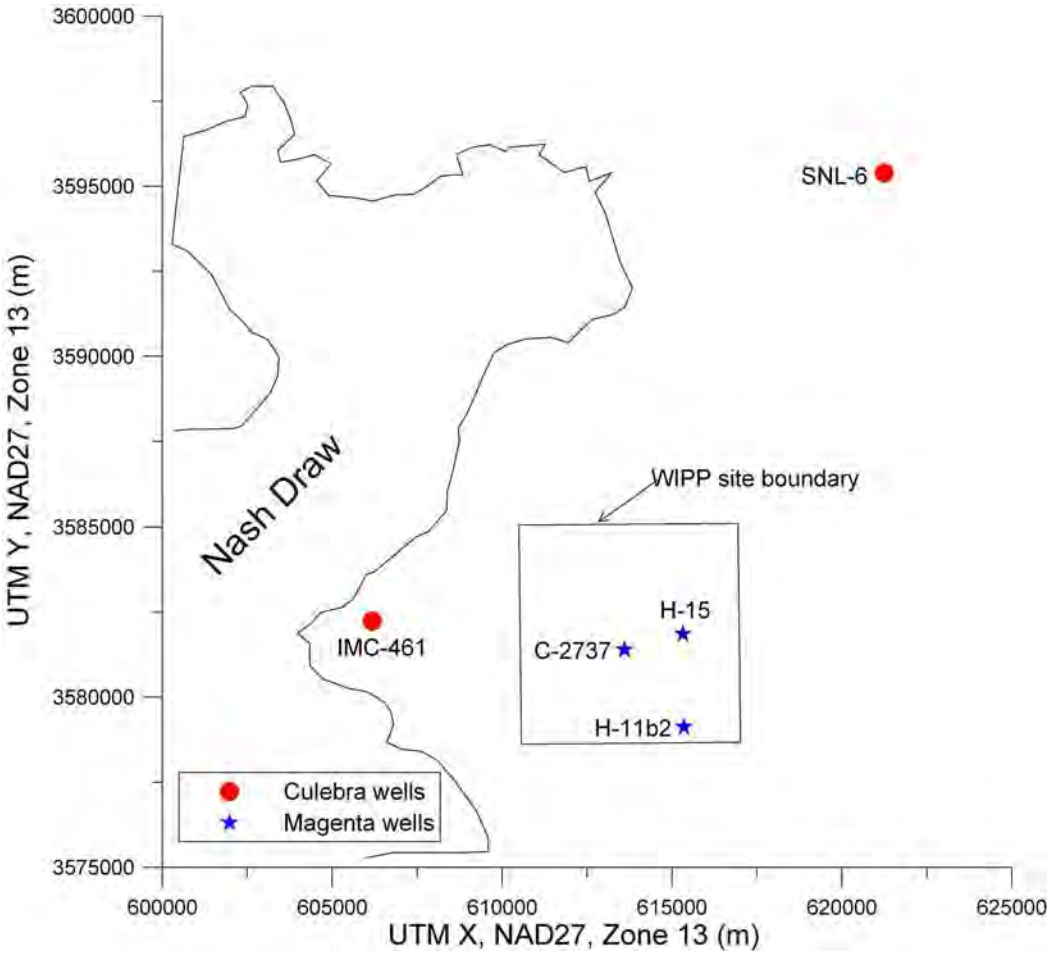


Figure 5. Locations of tested wells.

All the nSIGHTS test simulations incorporated pre-test pressure records of various durations as "history" periods where the associated pressures were simply specified in the simulations.

Test analysis involved finding the values of the fitting parameters that produced the best simulated matches to the pressure data collected during the slug or constant-rate test and subsequent recovery period. In addition to the formation properties of interest (principally transmissivity (*T*)), tubing string radius was also included as a fitting parameter in the pumping-test analyses so that nSIGHTS could exactly match the amount of wellbore storage observed during the test. The main objective of these analyses was to estimate *T* in the vicinity of each well for subsequent use in *T*-field generation and WIPP performance assessment calculations. Correlation between estimated *T* values and the other fitting parameters reported in Appendix B would be of interest if these correlations resulted in large uncertainty in the estimated *T* values. The uncertainty in the estimated *T* values, however, is relatively small, so any correlation between *T* and other fitting parameters is not of concern.

The uncertainty quantification method applied to the analyses in this report is a process referred to as *perturbation analysis*. In this process, preliminary analyses are performed in which a reasonable fit is obtained to the specified constraints defined in the nPre configuration file. The resulting values of the fitting parameters are the *baseline solution* set – a single value for each fitting parameter that provides a satisfactory fit to the data (*satisfactory* being a judgment call on the part of the analyst). Perturbation analysis begins by assigning a plus/minus range corresponding to the parameter space one wishes to investigate to each of the baseline fitting-parameter values. These plus/minus fitting-parameter ranges for each analysis are listed in Appendix B. Starting at the baseline value, the fitting parameters are randomly perturbed to fall somewhere within their assigned ranges and are then optimized from these random starting points. The objective of perturbation analysis is to sample the parameter space adequately and locate all of the minima within the parameter space. By definition, the parameter-space minimum that provides the best quantitative fit to the data, measured in terms of the smallest sum of squared errors (SSE), is the *global minimum* (assumed true solution), and the other minima are referred to as *local minima*. Local minima are effectively localized depressions in the parameter-space topography that trap the inverse regression algorithm during its attempt to find the global minimum – the smallest SSE.

Five hundred perturbation/optimization runs were performed for each of the analyses discussed in this report. From these perturbation results, only those solutions that provided a satisfactory fit (as determined by the analyst) to the data are presented in this report – effectively those solutions that fall within the global minimum. In some cases, the original baseline solution may not fall within the global minimum defined through perturbation analysis. The final number of satisfactory perturbation results for each test is reported in the Section 4 and 5 figure captions.

4. Culebra Analysis Results

Discussions of the Culebra test analyses for SNL-6 and IMC-461 are given below. A summary of the transmissivity estimates obtained from perturbation analysis of each test is shown in Table 1. The full range of *T* values from which the statistics in Table 1 are derived is presented as a scatter plot in each section below and a full listing is contained within the nPost configuration file for each analysis.

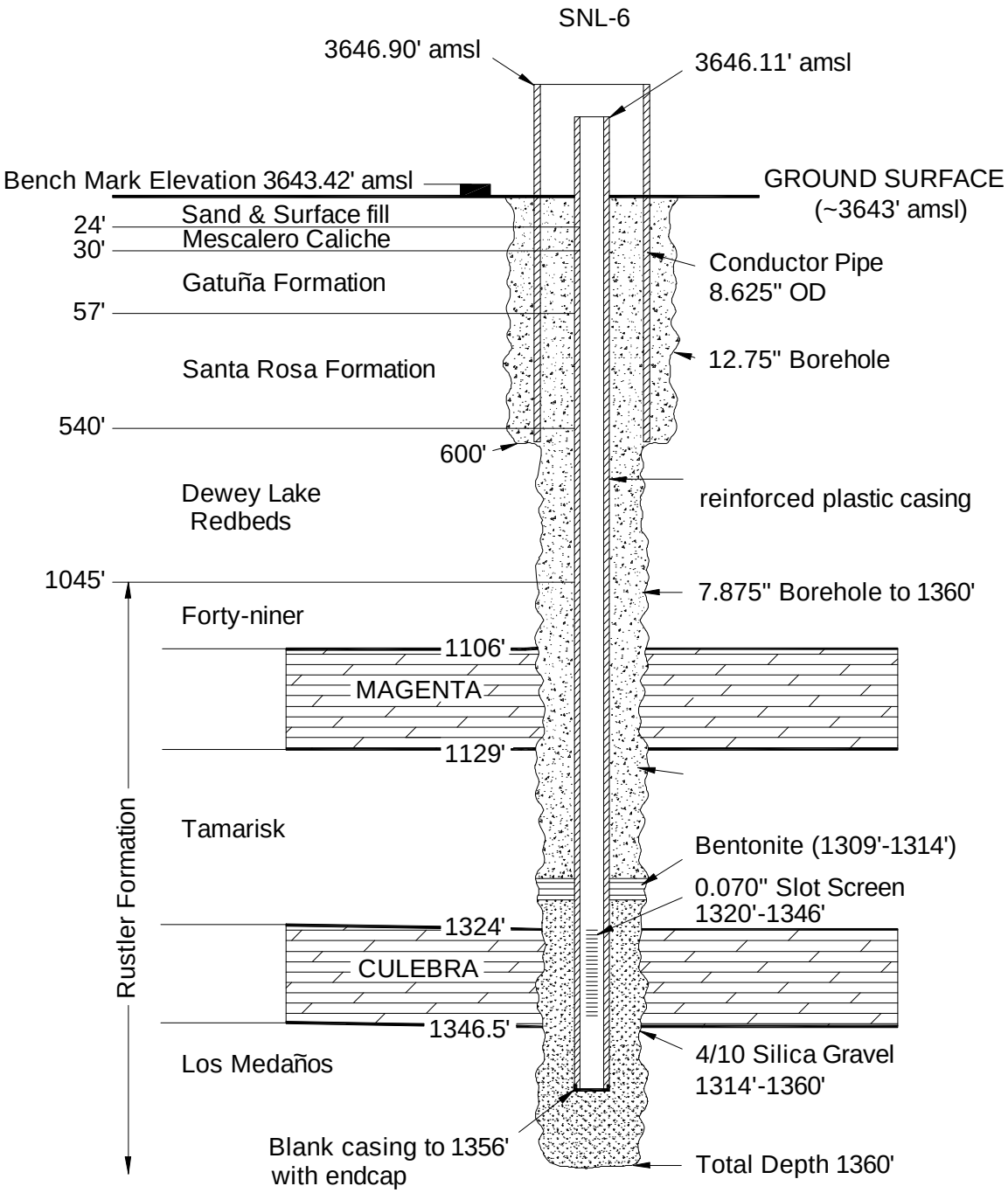
Table 1. Culebra Transmissivity Estimates.

Culebra Wells	Geometric Mean (m^2/s)	Log Geometric Mean (m^2/s)	Log Minimum (m^2/s)	Log Maximum (m^2/s)	Variance
SNL-6	8.72E-12	-11.059	-11.064	-11.048	9.77E-7
IMC-461*	1.92E-4	-3.72	-3.74	-3.68	4.47E-5
*Values are the geometric means of multiple tests described in Table 2.					

4.1 SNL-6

The Culebra interval of well SNL-6 was drilled on September 7, 2005, using compressed air with soap mist to remove cuttings (Powers, 2009). The well was completed on September 10, 2005, using 2.88-inch (7.32-cm) outside diameter (OD), 2.48-inch (6.30-cm) inside diameter (ID) fiberglass casing with a 26-ft (7.92-m) section of screen across the Culebra interval (Figure 6). All water was evacuated from the hole or well casing using compressed air on September 8, 10, 13, and 14, 2005.

The Culebra contains halite cements at SNL-6 (Powers et al., 2006), leading to an expectation of very low transmissivity. This expectation was supported by the very slow stabilization of the water level in the well observed since monitoring began with a Level TROLL® on November 18, 2005 (Figure 7). Because of this slow recovery, testing was planned to be superimposed on the existing trend rather than delayed until complete stabilization had occurred. On January 16, 2008, approximately 18 gallons (69 L) of water were bailed from the well over a period of approximately 137 minutes, amounting to an approximately 73-ft (22-m) slug removal. The Level TROLL® was reinstalled approximately 66 minutes later to monitor water-level (or pressure-head) recovery.



NOTE:

1. Depths in feet below ground surface unless otherwise noted.
2. Not to scale.
3. Well info ref. Powers (2009)

Figure 6. SNL-6 well configuration during testing.

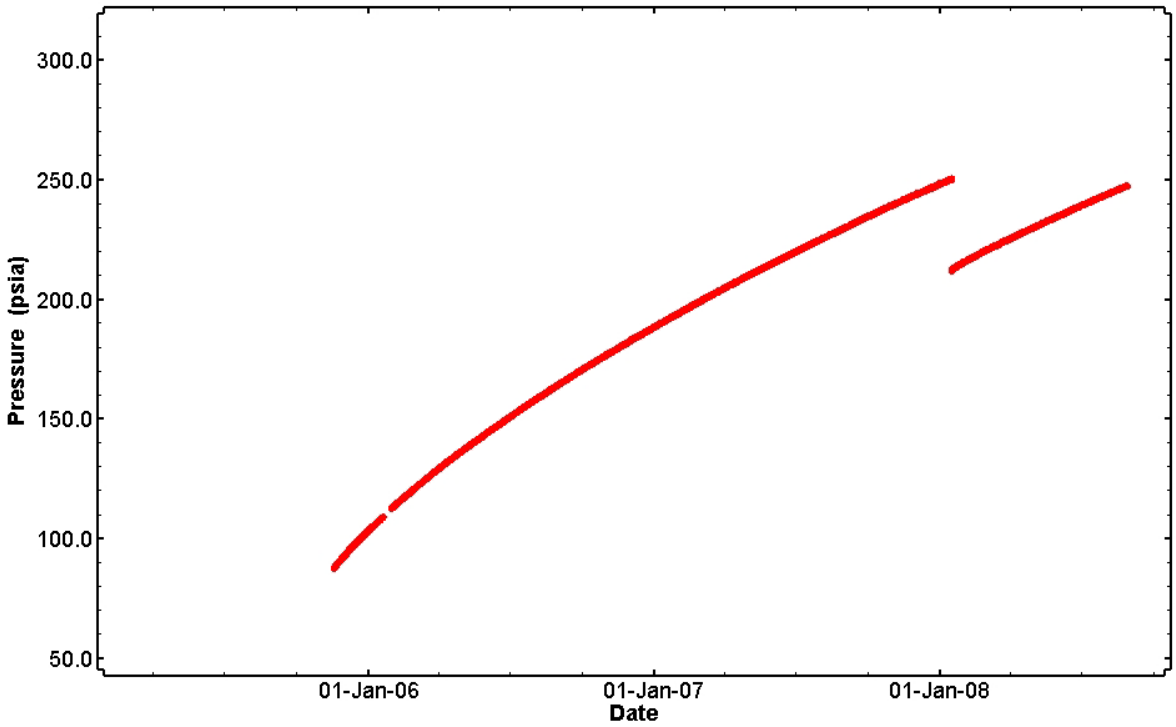


Figure 7. Pressure data from Culebra in SNL-6.

The nSIGHTS simulation of the SNL-6 test consisted of four sequences that included the entire history of the well from the time the Culebra was drilled on September 7, 2005 through August 27, 2008. A pressure-history sequence was constructed for the period between September 7 and November 18, 2005 from well-completion records (Powers, 2009) and is shown in Figure 8. The Culebra pressure response measured from November 18, 2005 to January 16, 2008 was simulated as a slug-type sequence. The period of slug removal on January 16, 2008 was treated as a pressure-history sequence, and the pressure recovery measured since the Level TROLL® was reinstalled was treated as a slug sequence. The details of each sequence, i.e., start/end time, pressure, etc., are specified in the SNL-6.nPre file and are listed in Appendix B.1. All of the data shown in Figure 7 were used in the SNL-6 regression analysis, i.e., both the initial pressure recovery following drilling and the 2008 slug-test response were simulated.

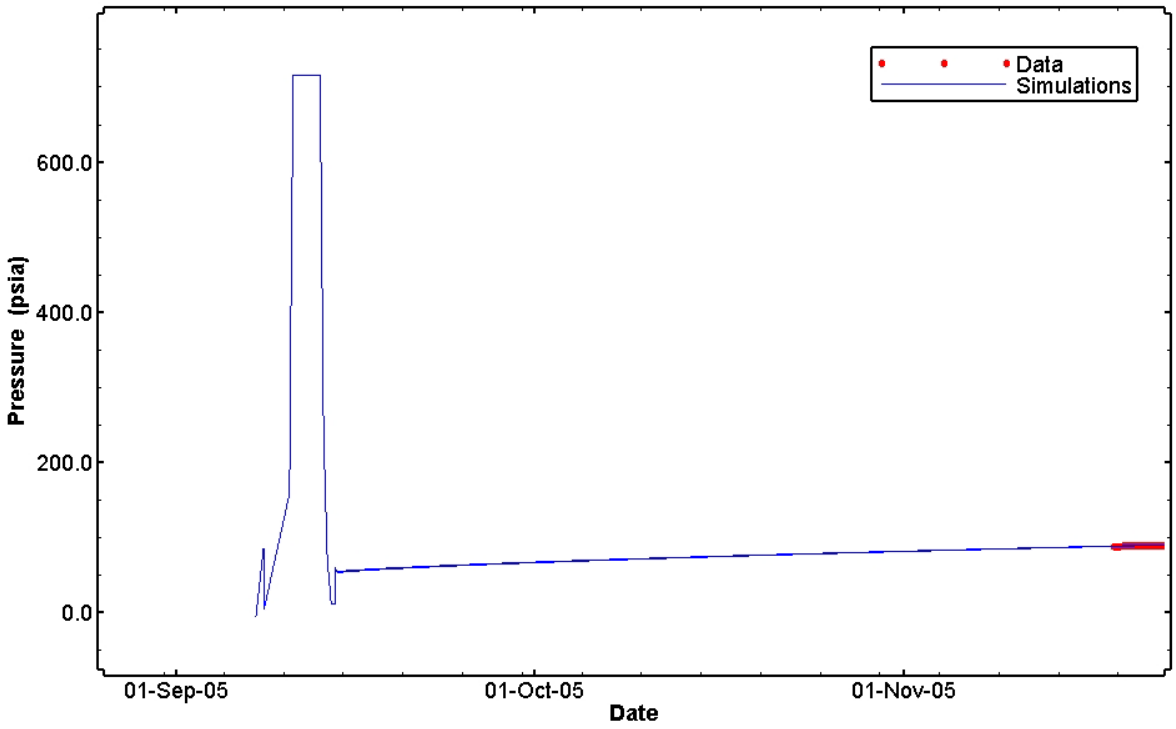


Figure 8. Simulated pressure-history for SNL-6 from well completion records.

The SNL-6 data were not suitable for creating a diagnostic plot to help determine the appropriate conceptual model, so the simplest model that was consistent with the geologic observations and produced a satisfactory fit to the data ("satisfactory" as determined by the analyst) was used: an infinite-acting radial system with wellbore storage. The objectives of the analysis included obtaining an estimate of the static formation pressure (P_f) of the Culebra at SNL-6 in addition to obtaining an estimate of transmissivity (T). The ranges of T and P_f values obtained from perturbation analysis are shown in Figures 9 and 10, respectively. The geometric mean T estimate derived from this analysis was 8.72E-12 m^2/s and the geometric mean P_f estimate was 591 psia (relative to the depth of the Level TROLL®). This P_f estimate corresponds to a freshwater head approximately 22 m above ground surface, or an elevation of approximately 1133 m above mean sea level (amsl). The simulated SNL-6 Cartesian responses corresponding to the 497 T and P_f values shown in Figures 9 and 10 are shown in Figure 11.

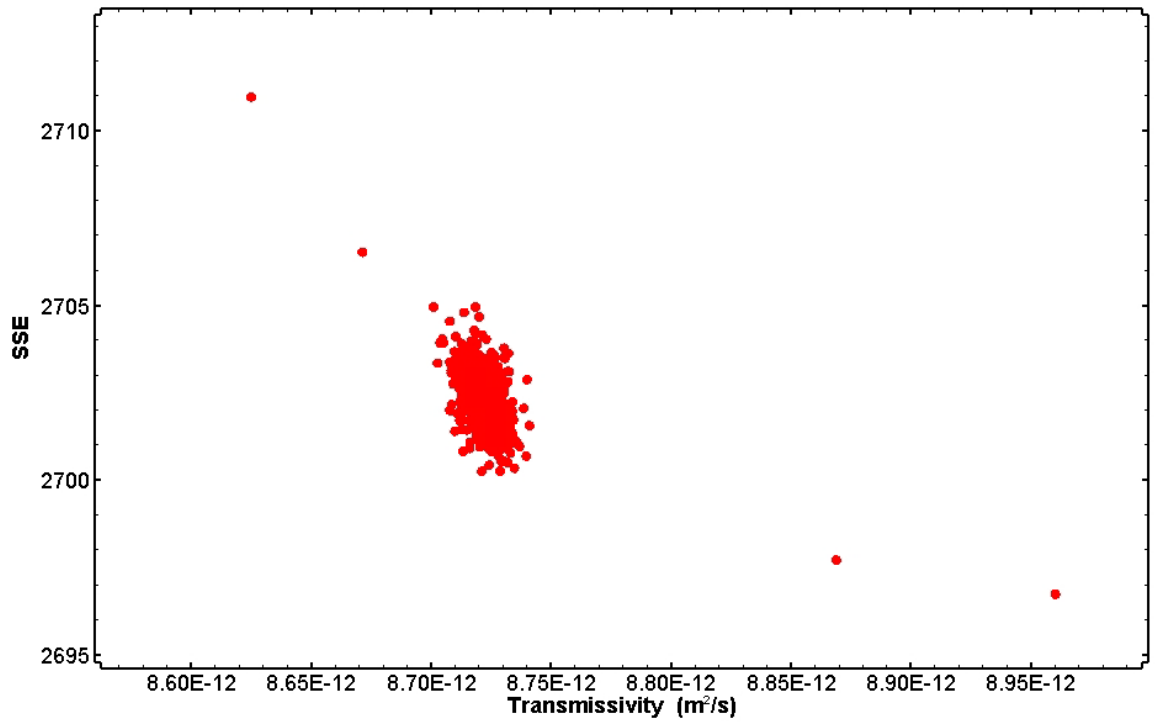


Figure 9. X-Y scatter plot showing 497 estimates of transmissivity derived from the SNL-6 perturbation analysis.

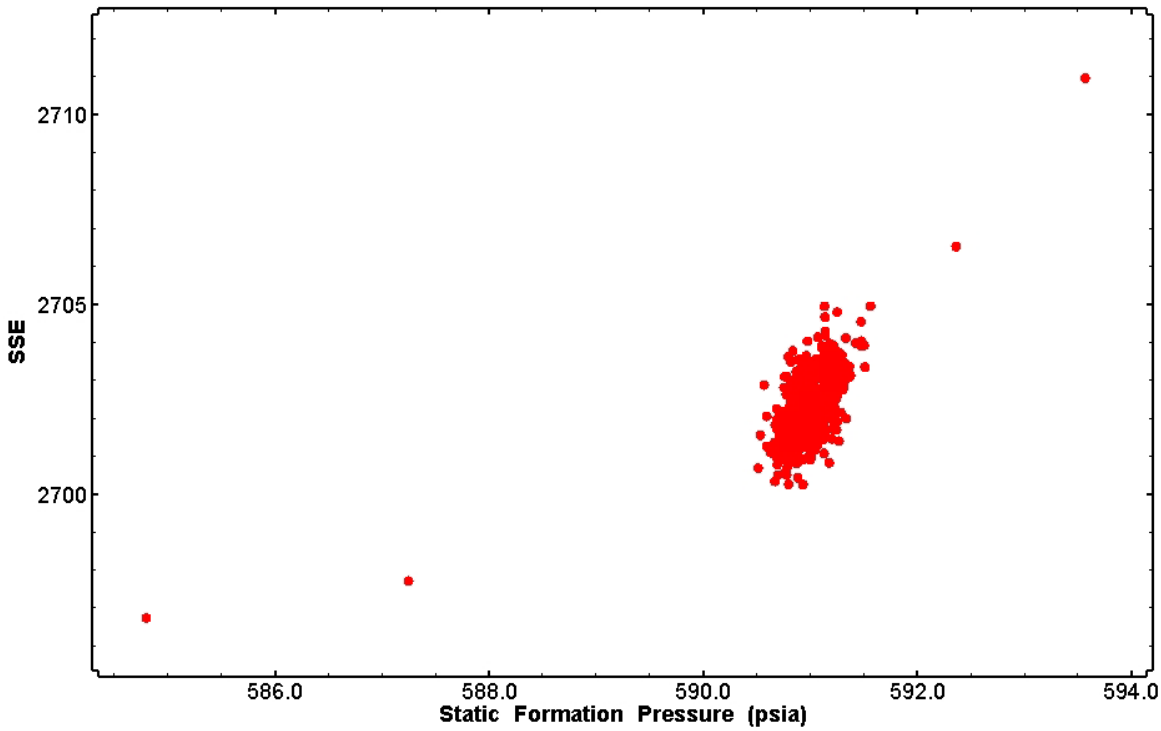


Figure 10. X-Y scatter plot showing 497 estimates of transmissivity derived from the SNL-6 perturbation analysis.

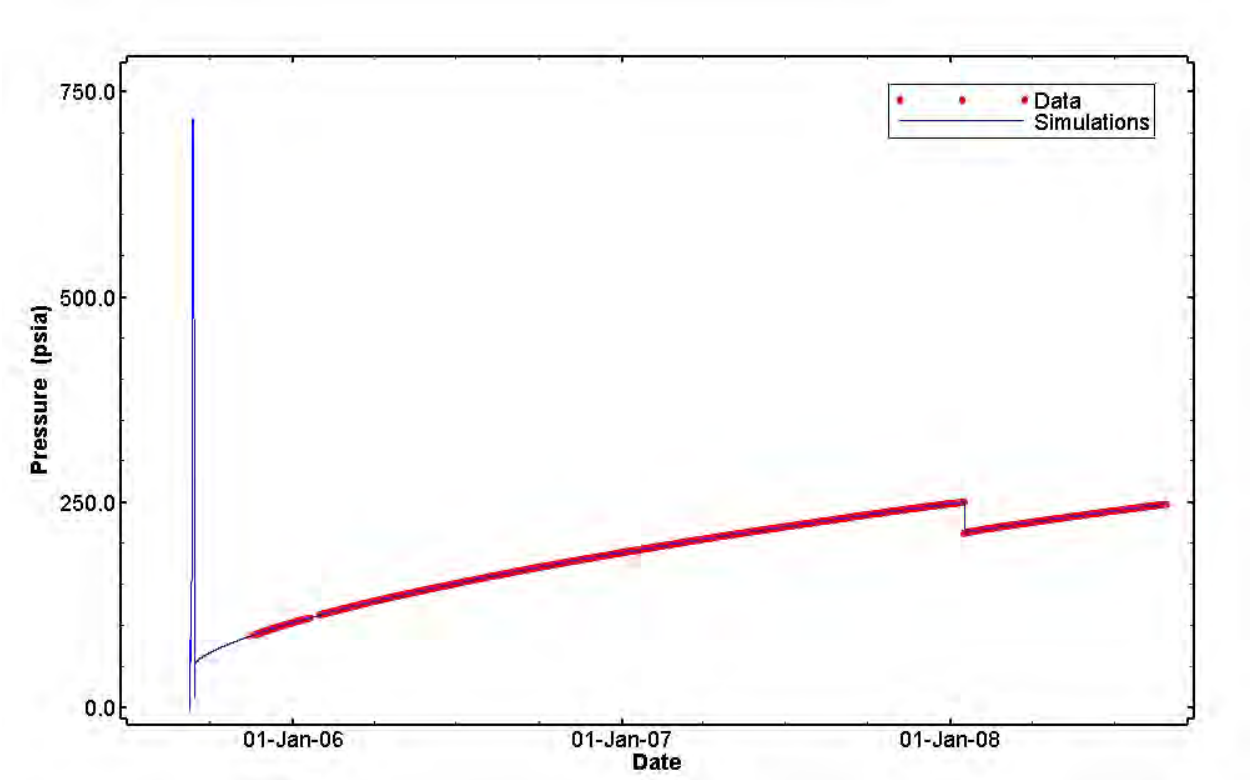
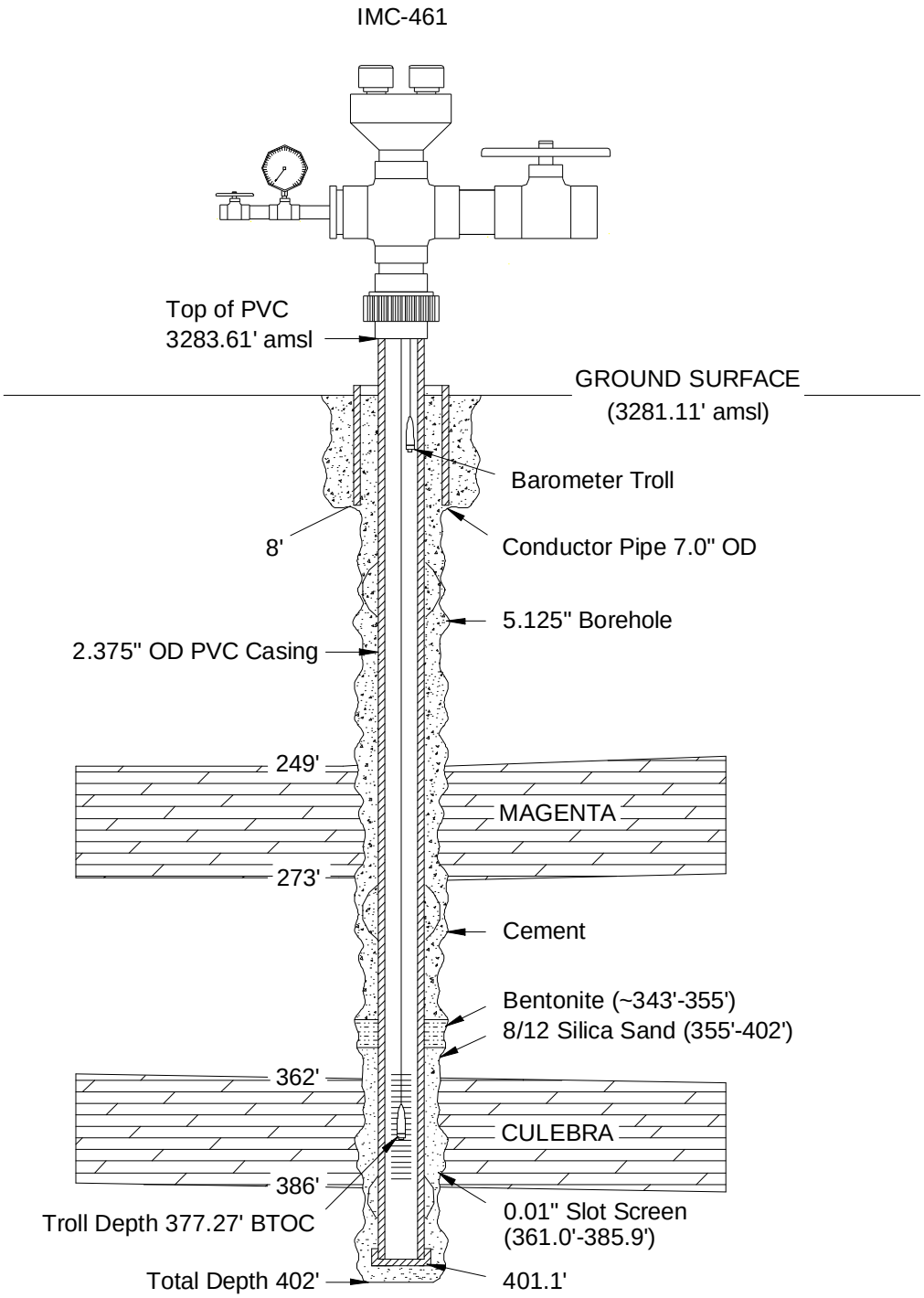


Figure 11. Linear plot showing 497 simulations of the SNL-6 pressure response.

4.2 IMC-461

The configuration of well IMC-461 is shown in Figure 12. A pressure-manifold system was attached to the IMC-461 wellhead on January 25, 2005. With this system, the 2-inch PVC well casing could be pressurized with compressed nitrogen to depress the water level in the well. After the water level was lowered to the desired depth and all pressures had stabilized, the nitrogen was rapidly vented from the well to initiate a slug test. Three such slug tests were performed on January 25, 2005, and two were conducted on January 26, 2005. The slug magnitudes for the first three tests were nominally 40 psi, 40 psi, and 20 psi. The slug magnitudes for the last two tests were nominally 30 and 50 psi.

Figure 13 shows the pressure records from the IMC-461 tests used in this analysis. Pressures prior to and between the slug tests on each day were included in the nSIGHTS simulations as pressure histories; the data from January 25 were not included as histories for the tests conducted on January 26. Each slug test was fit separately using the same model. The details of each sequence, i.e., start/end time, etc., are specified in the IMC-461.nPre files and are listed in Appendix B.2.



NOTE:

1. Depths in feet below ground surface unless otherwise noted.
2. Not to scale.
3. Well info ref. Beauheim (2005)

Figure 12. IMC-461 well configuration during testing.

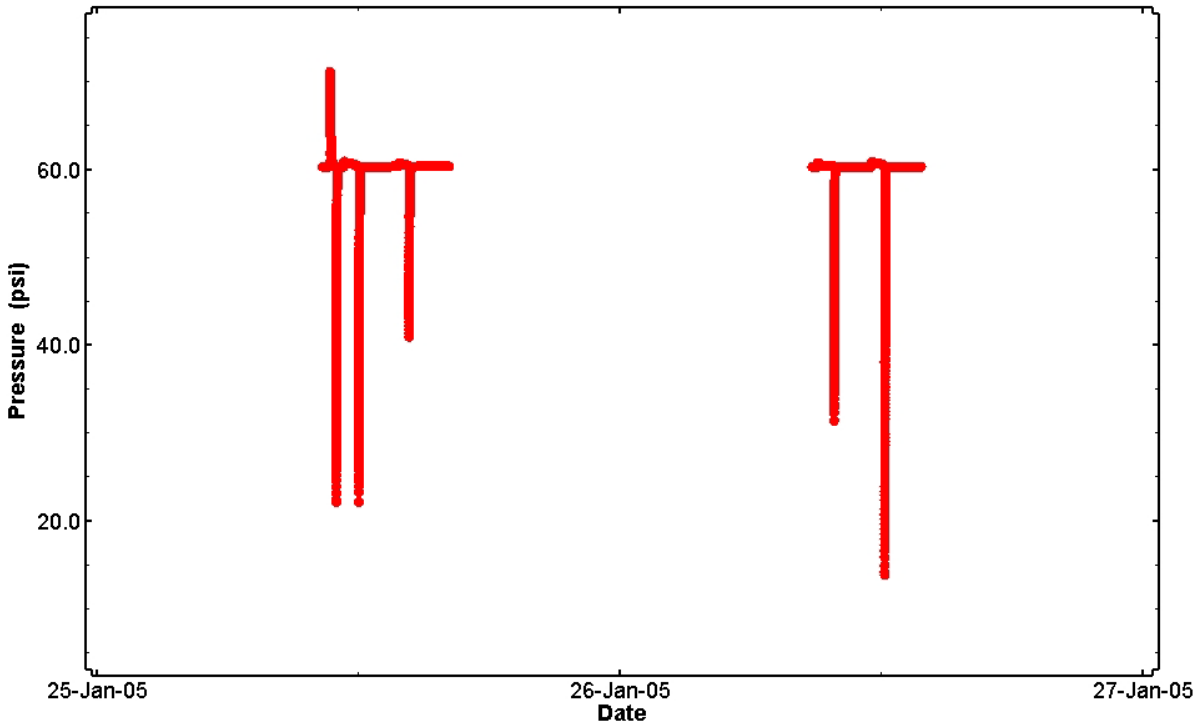


Figure 13. Pressure data from slug tests of the Culebra in IMC-461.

The IMC-461 conceptual model was an infinite-acting, homogeneous, radial system with wellbore storage and a pressure-dependent skin. The pressure-dependent skin was applied allowing for three zones based on pressure points of 40, 56, and 63 psi to influence skin hydraulic conductivity. This approach was adopted because the small slots in the IMC-461 well screen were believed to be restricting the flow of water at high pressure gradients/velocities. The geometric mean skin hydraulic conductivity (K_s) estimates at each pressure point are given in Table 2 for each slug test. Linear interpolation was used to estimate K_s values between the three pressure points. The model provided satisfactory fits to each slug test, but required slightly different parameter values for each, as listed in Table 2.

Table 2 also lists how many of the 500 perturbation runs for each test had low SSE values near the global minimum and produced acceptable fits. The T value for each of those fits is plotted against SSE in Figure 14. The geometric mean T calculated for each test from those fits is given in Table 2. The geometric mean T of the mean T values from each test is 1.92E-4 m^2/s. The semilog Ramey A (Ramey et al., 1975) and log-log Ramey B simulations corresponding to the T values shown in Figure 14 are shown in Figures 15 through 24.

Table 2. Parameter Estimates Per Slug Test Derived from the IMC-461 Perturbation Analysis.

IMC-461 Slug Test Estimates	Test 1	Test 2	Test 3	Test 4	Test 5
Skin Pressure Zone mean *K* (m/s) @40 psi	4.05E-7	5.29E-7	1.06E-7	4.58E-7	3.57E-7
Skin Pressure Zone mean *K* (m/s) @56 psi	4.72E-7	1.01E-6	1.20E-6	1.21E-6	6.76E-7
Skin Pressure Zone mean *K* (m/s) @63 psi	3.74E-6	1.44E-5	9.04E-6	8.43E-6	4.94E-6
Mean Formation *K* Estimate (m/s)	2.41E-5	2.11E-5	2.64E-5	2.99E-5	3.06E-5
Mean Formation *T* Estimate (m^2/s)	1.76E-4	1.55E-4	1.93E-4	2.19E-4	2.24E-4
Log Mean *T* (m^2/s)	-3.753	-3.81	-3.71	-3.660	-3.65
Log Minimum *T* (m^2/s)	-3.824	-3.85	-3.73	-3.672	-3.70
Log Maximum *T* (m^2/s)	-3.748	-3.80	-3.70	-3.656	-3.54
T Variance	1.20E-4	4.56E-5	1.23E-4	3.76E-6	7.06E-5
Perturbation Runs Accepted	187	242	96	203	211

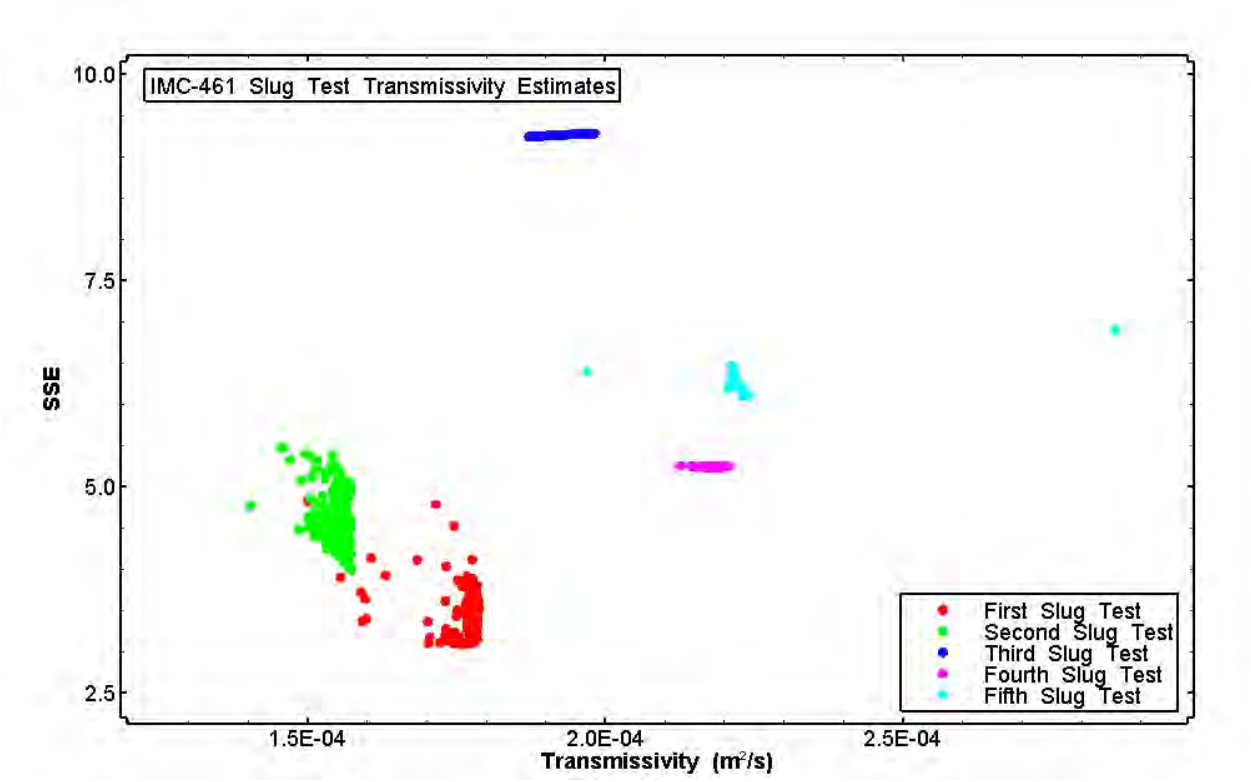


Figure 14. Formation transmissivity comparison from IMC-461 slug tests.

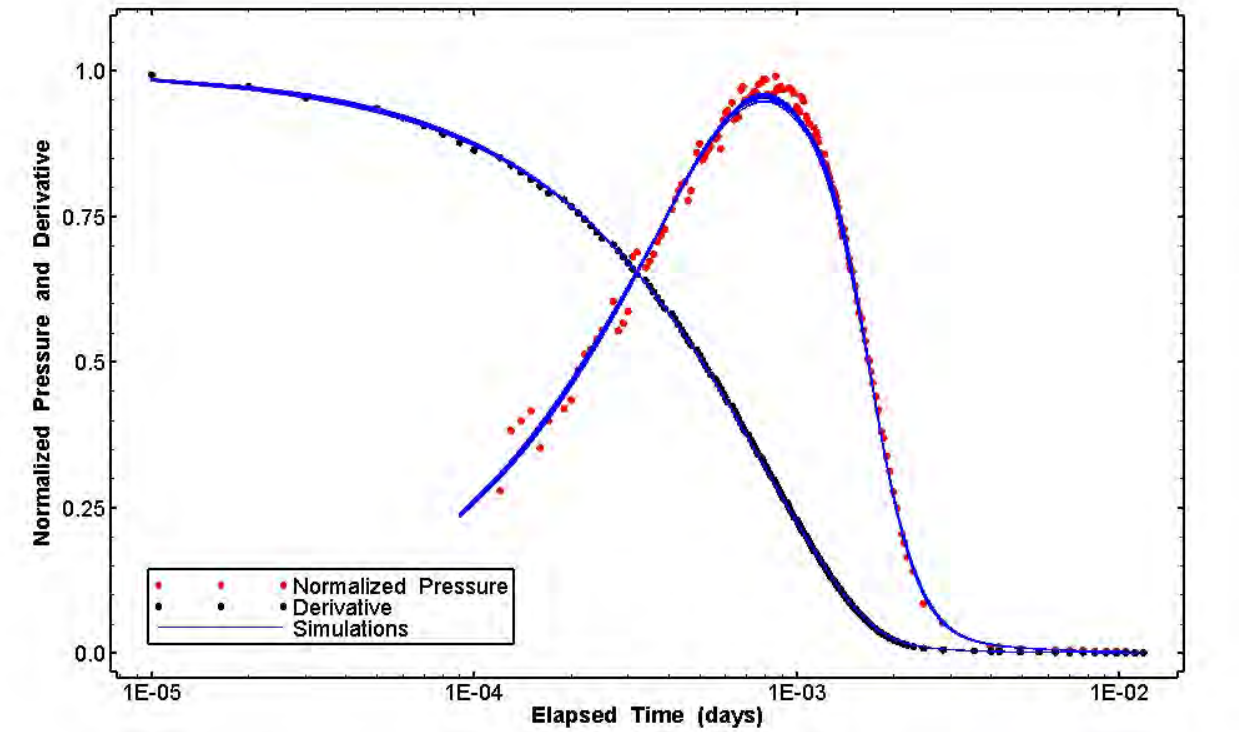


Figure 15. Semilog Ramey A plot showing 187 simulations of the IMC-461 response for slug test 1.

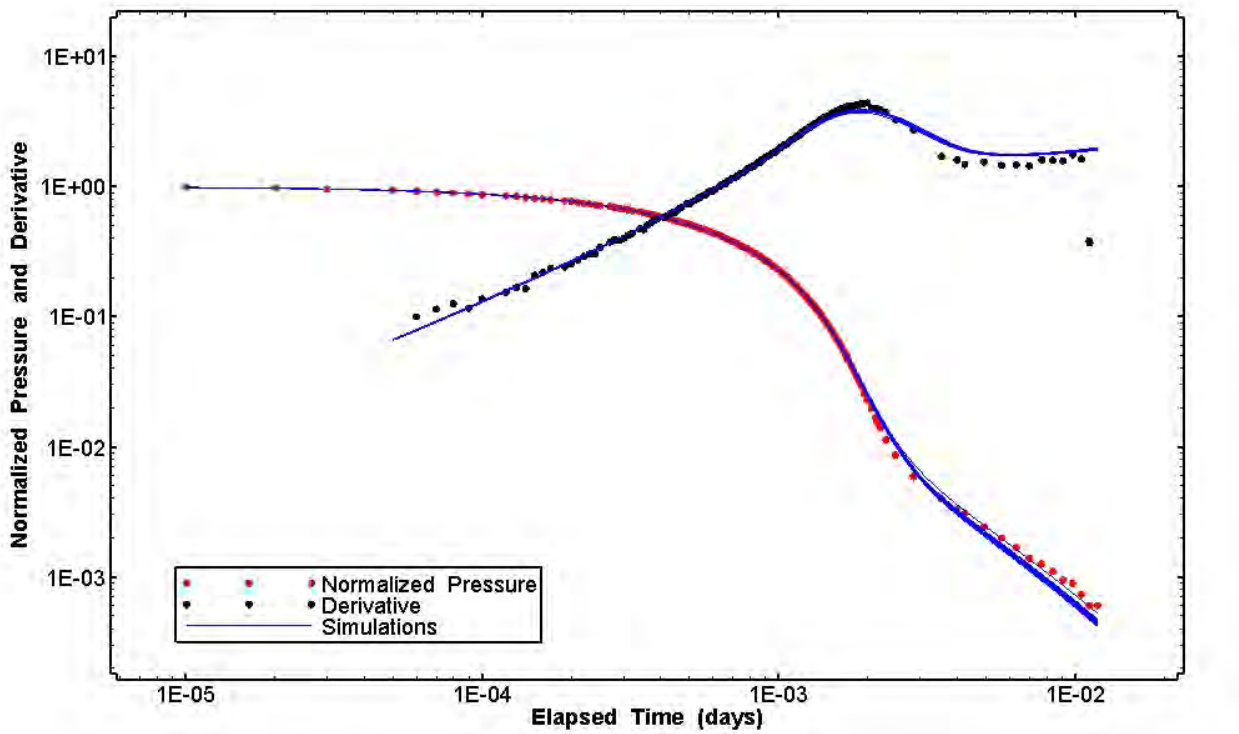


Figure 16. Log-log Ramey B plot showing 187 simulations of the IMC-461 response for slug test 1.

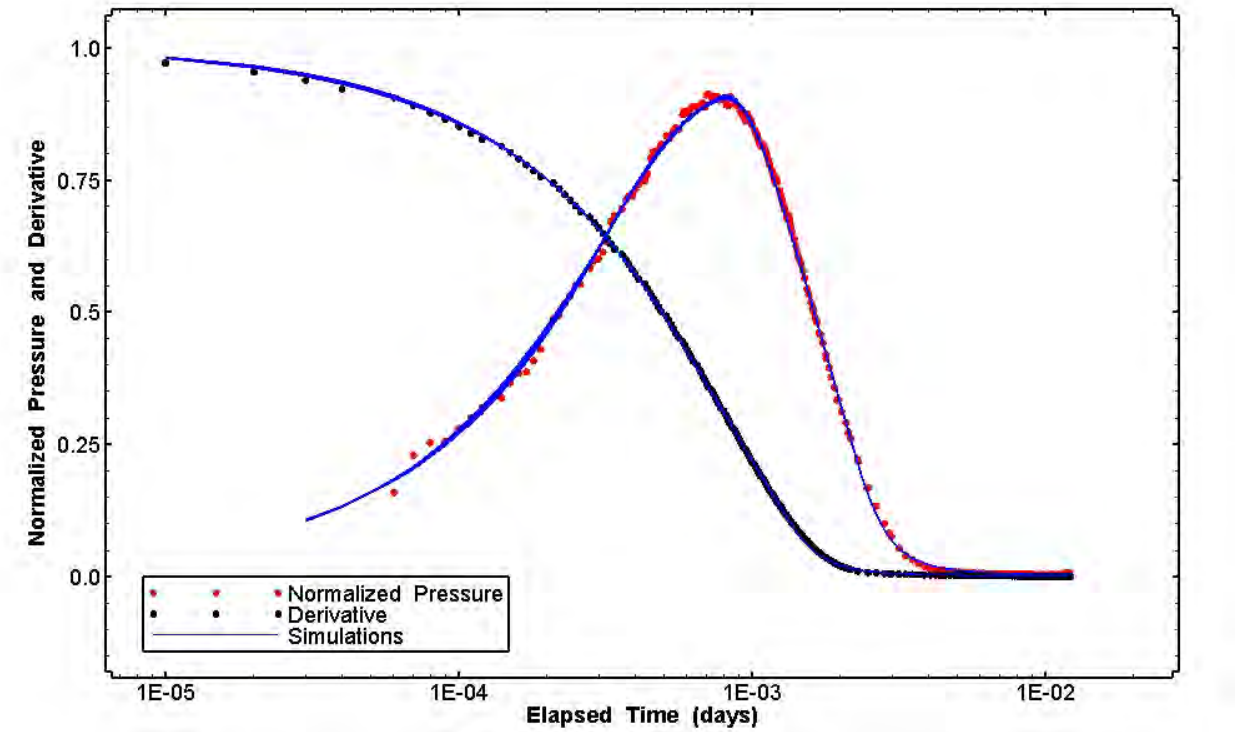


Figure 17. Semilog Ramey A plot showing 242 simulations of the IMC-461 response for slug test 2.

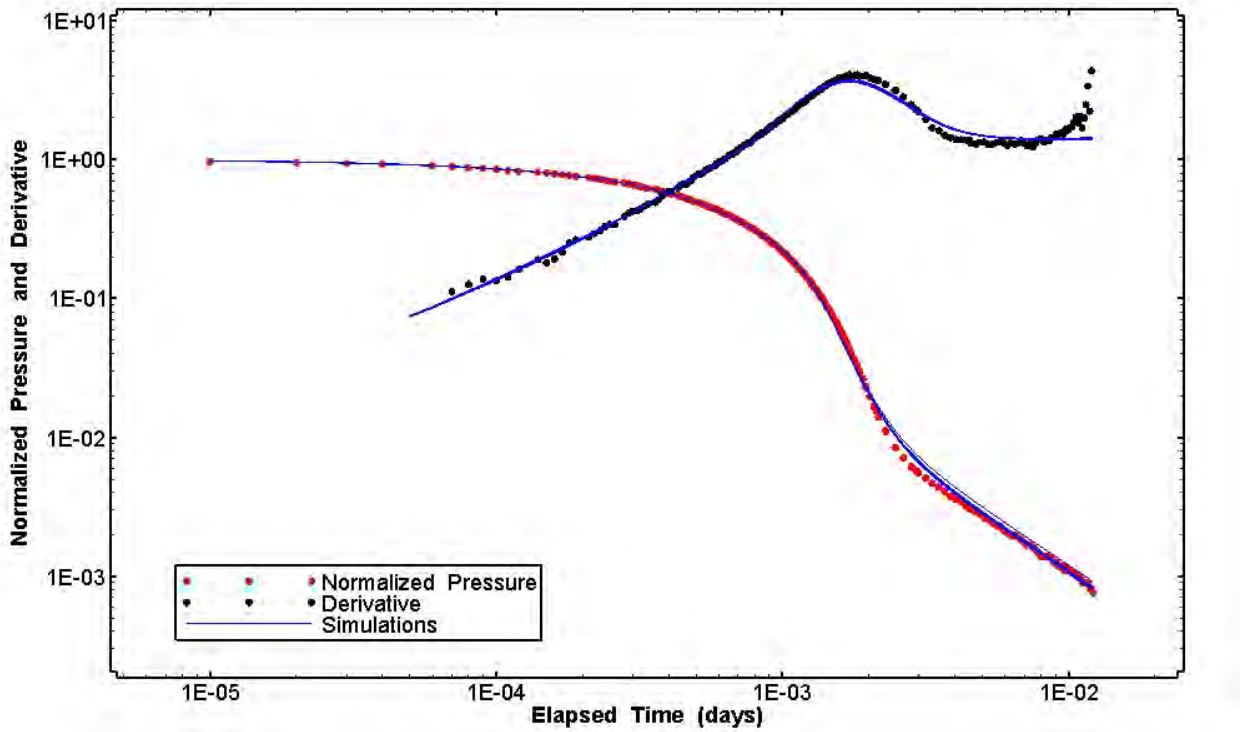


Figure 18. Log-log Ramey B plot showing 242 simulations of the IMC-461 response for slug test 2.

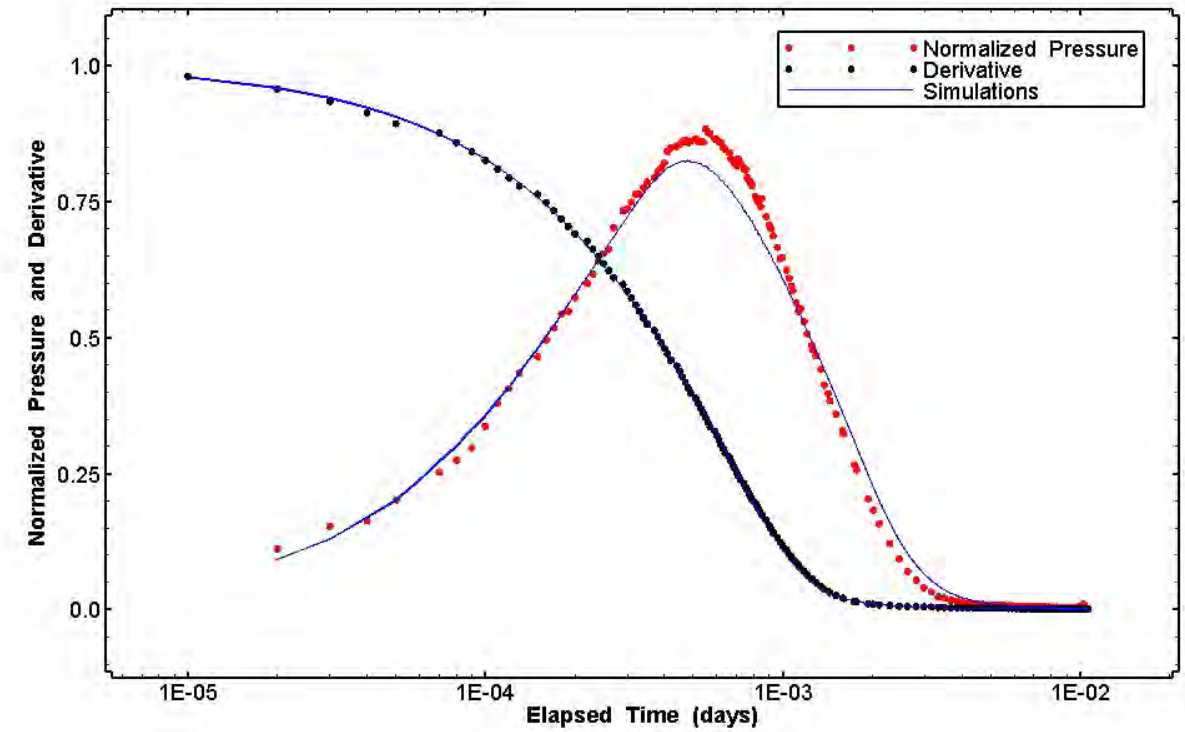


Figure 19. Semilog Ramey A plot showing 96 simulations of the IMC-461 response for slug test 3.

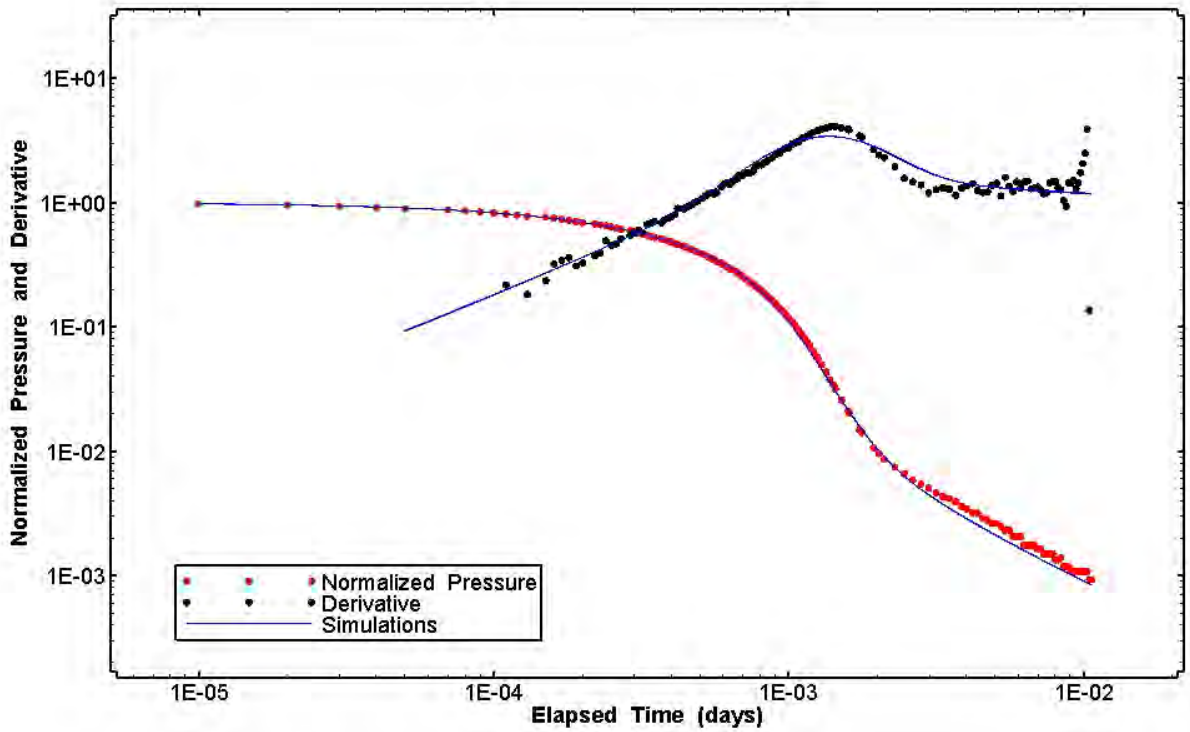


Figure 20. Log-log Ramey B plot showing 96 simulations of the IMC-461 response for slug test 3.

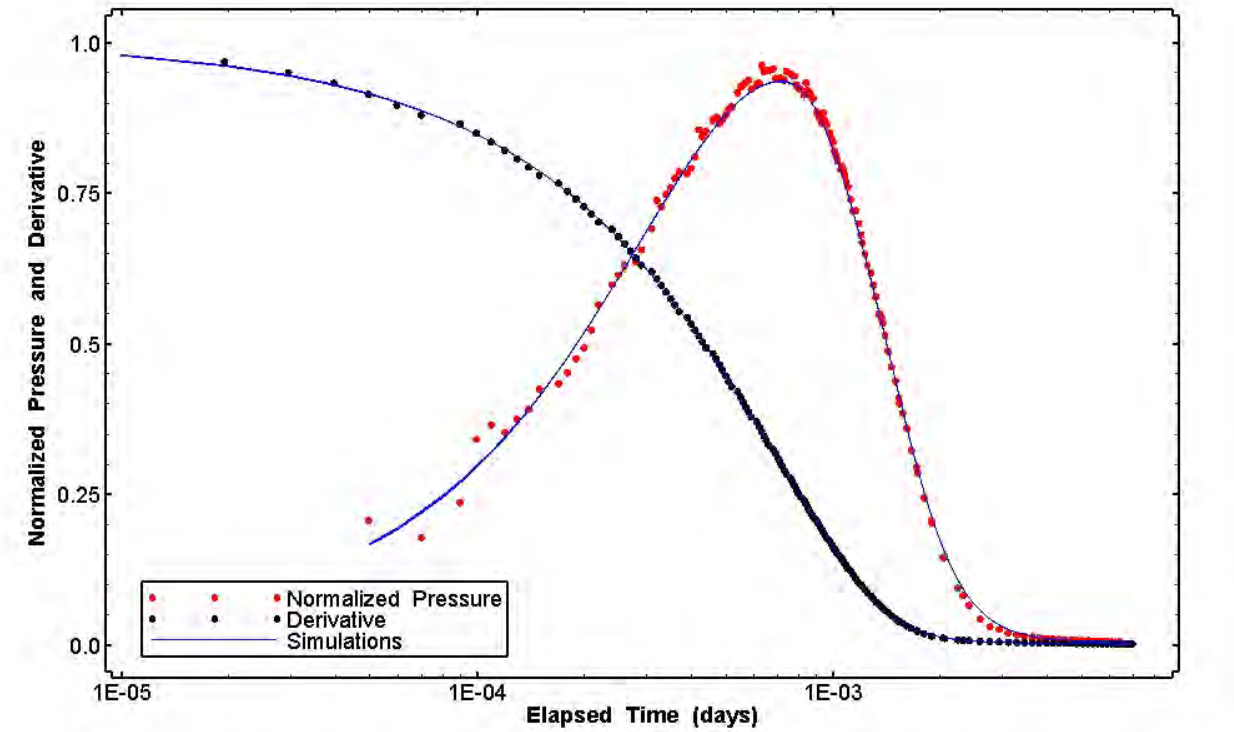


Figure 21. Semilog Ramey A plot showing 203 simulations of the IMC-461 response for slug test 4.

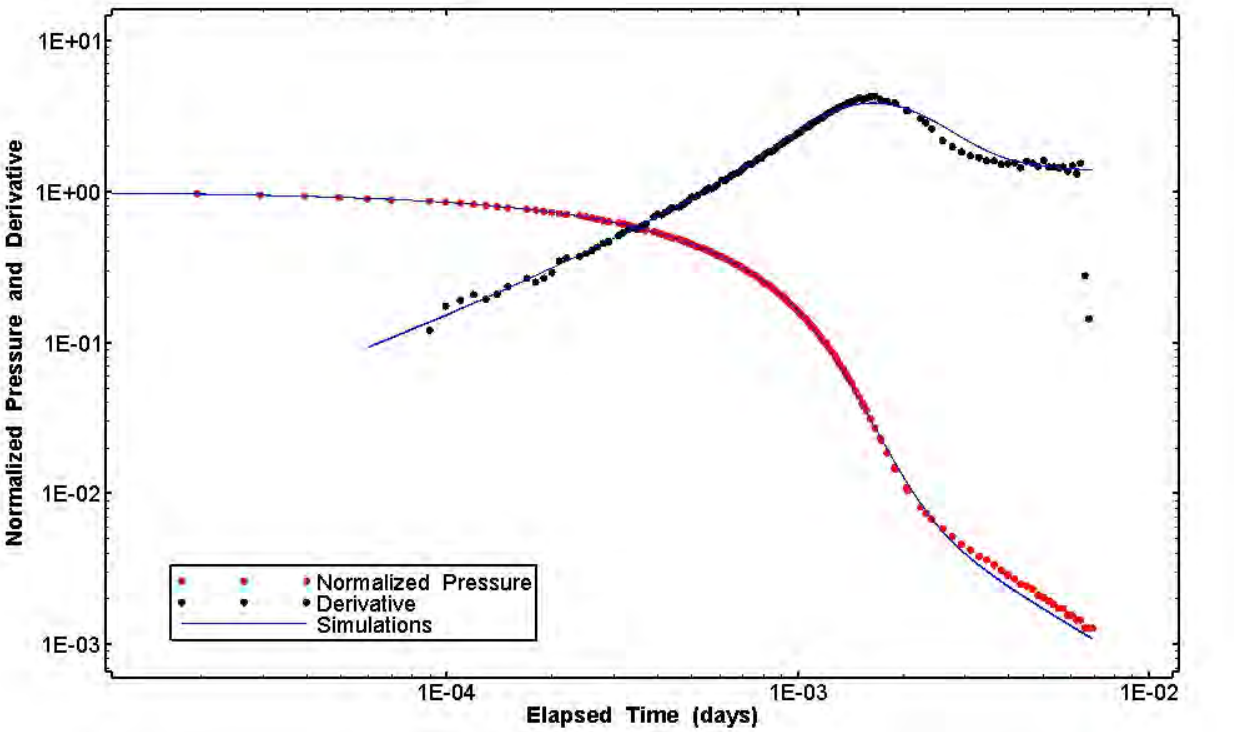


Figure 22. Log-log Ramey B plot showing 203 simulations of the IMC-461 response for slug test 4.

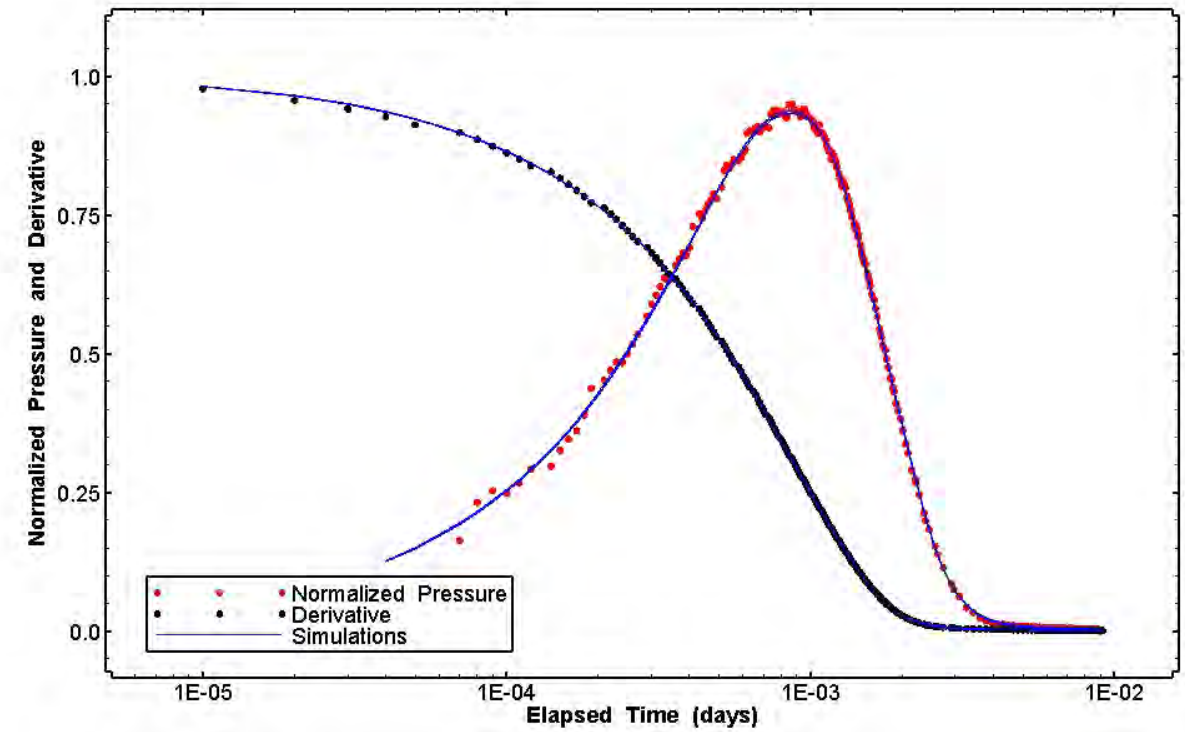


Figure 23. Semilog Ramey A plot showing 211 simulations of the IMC-461 response for slug test 5.

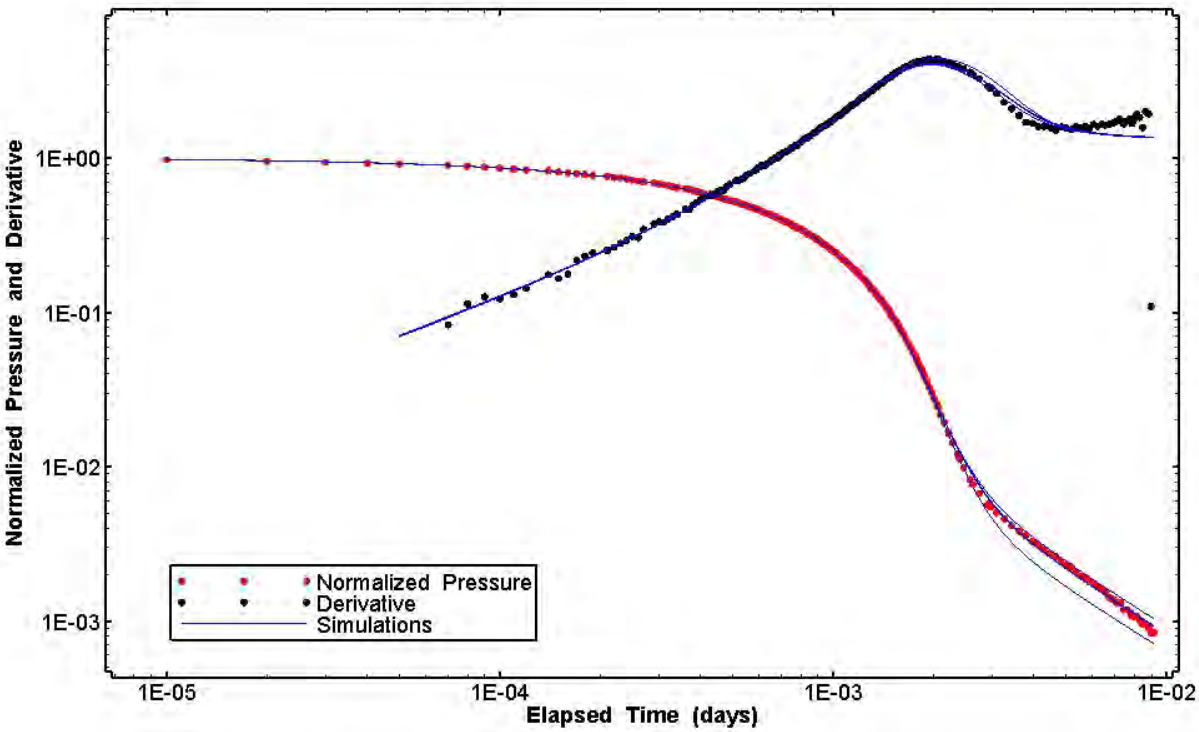


Figure 24. Log-log Ramey B plot showing 211 simulations of the IMC-461 response for slug test 5.

5. Magenta Analysis Results

Discussions of the Magenta test analyses for C-2737 (withdrawal – W and injection – I), H-11b2, and H-15 are given below. A summary of the transmissivity estimates obtained from perturbation analysis of each test is shown in Table 3. The full range of *T* values from which the statistics in Table 3 are derived is presented as a scatter plot in each section below and a full listing is contained within the nPost configuration file for each analysis.

Table 3. Magenta Transmissivity Estimates.

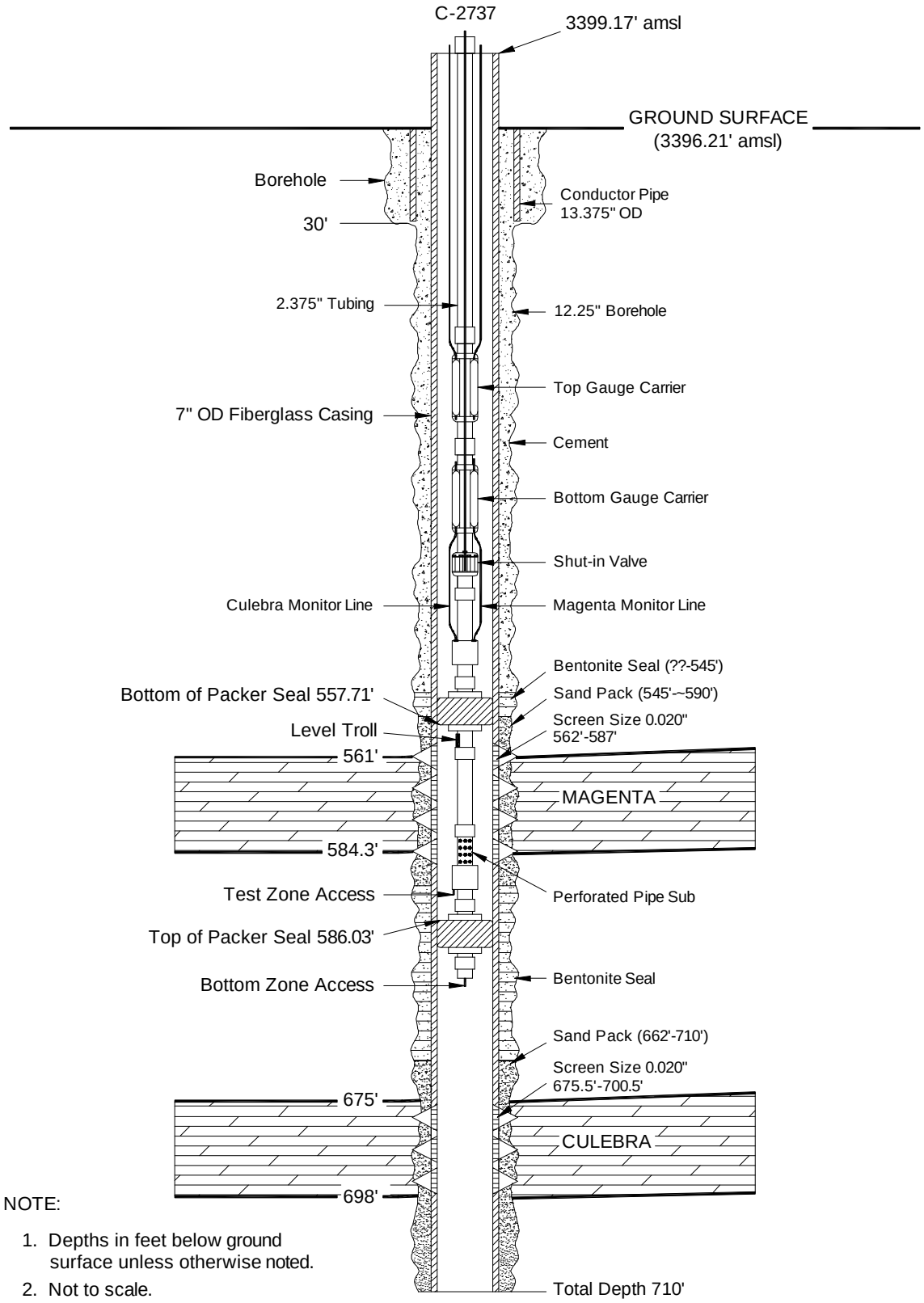
Magenta Wells	Geometric Mean (m^2/s)	Log Geometric Mean (m^2/s)	Log Minimum (m^2/s)	Log Maximum (m^2/s)	Variance
C-2737 – W	1.11E-7	-6.96	-7.12	-6.91	1.88E-3
C-2737 – I	1.99E-7	-6.70	-6.71	-6.69	5.35E-6
H-11b2	1.56E-7	-6.81	-6.82	-6.80	6.40E-6
H-15	9.50E-7	-6.0222	-6.0223	-6.0219	3.62E-9

5.1 C-2737

Hydraulic testing of the Magenta Member of the Rustler Formation in C-2737 occurred between January 10 and 17, 2007, and consisted of a slug-withdrawal test followed by a slug-injection test. All testing was performed using a straddle-packer tool set across the Magenta (Figure 25). The straddle-packer tool was equipped with a downhole shut-in valve configured to be in a closed position except when power was applied to it.

The straddle-packer tool string was installed into C-2737 on January 9, 2007 with the tubing empty of water. On January 10, 2007, the shut-in valve was opened to initiate the slug-withdrawal test. The test proceeded normally until it was terminated on January 15, 2007 by closing the shut-in valve. Approximately 15 gallons (57 L) of fresh water were then added to the tubing above the valve, after which the valve was opened to initiate a slug-injection test. This test continued until January 16, 2007.

Figure 26 shows the pressure record from C-2737 used in this analysis. The pressures measured prior to opening of the shut-in valve on January 10, 2007, were included in a pressure-history period for simulation of the slug-withdrawal test. For simulation of the slug-injection test, all pressures measured prior to opening the shut-in valve on January 15, 2007 (including the slug-withdrawal test), were included in a pressure-history period. The details of each sequence, i.e., start/end time, etc., are specified in the C-2737_first.nPre and C-2737_second.nPre files and are listed in Appendix B.3.



NOTE:

1. Depths in feet below ground surface unless otherwise noted.
2. Not to scale.
3. Well info ref. Powers (2002)

Figure 25. Configuration of well C-2737 during testing.

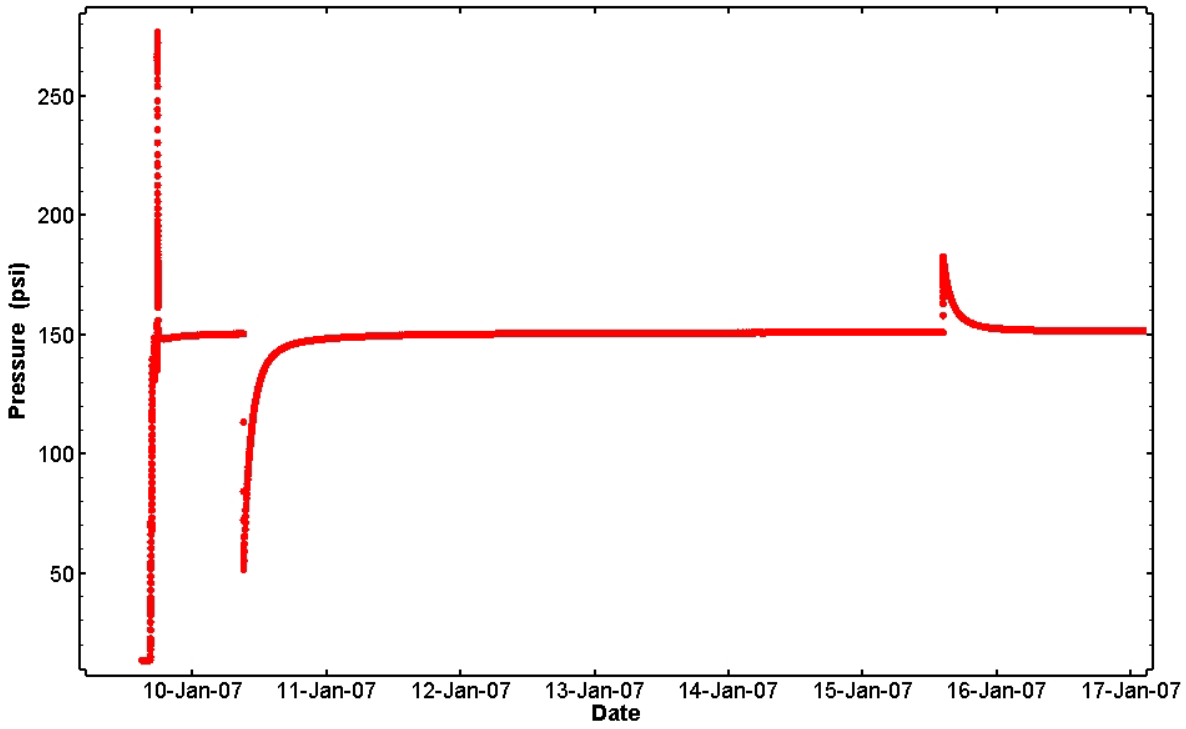


Figure 26. Pressure data from slug tests of the Magenta in C-2737.

The specified C-2737 conceptual model was an infinite-acting, homogeneous, radial system with wellbore storage and skin. Due to an inability to fit the slug-withdrawal and slug-injection tests with identical parameters, each test was fit with separate simulations. Of the 500 perturbation/optimization runs performed for the slug-withdrawal test, 43 provided satisfactory fits to the data. The range of transmissivity (*T*) values estimated from these 43 runs is shown in Figure 27. The geometric mean *T* value was 1.11E-7 m^2/s. The Cartesian (linear), semilog Ramey A, and log-log Ramey B simulations corresponding to the 43 *T* values are shown in Figures 28, 29, and 30, respectively. Of the 500 perturbation/optimization runs performed for the slug-injection test, only 59 provided satisfactory fits to the data. The range of transmissivity (*T*) values estimated from these 59 runs is shown in Figure 31. The geometric mean *T* value was 1.99E-7 m^2/s. The Cartesian (linear), semilog Ramey A, and log-log Ramey B simulations corresponding to the 59 *T* values are shown in Figures 32, 33, and 34, respectively.

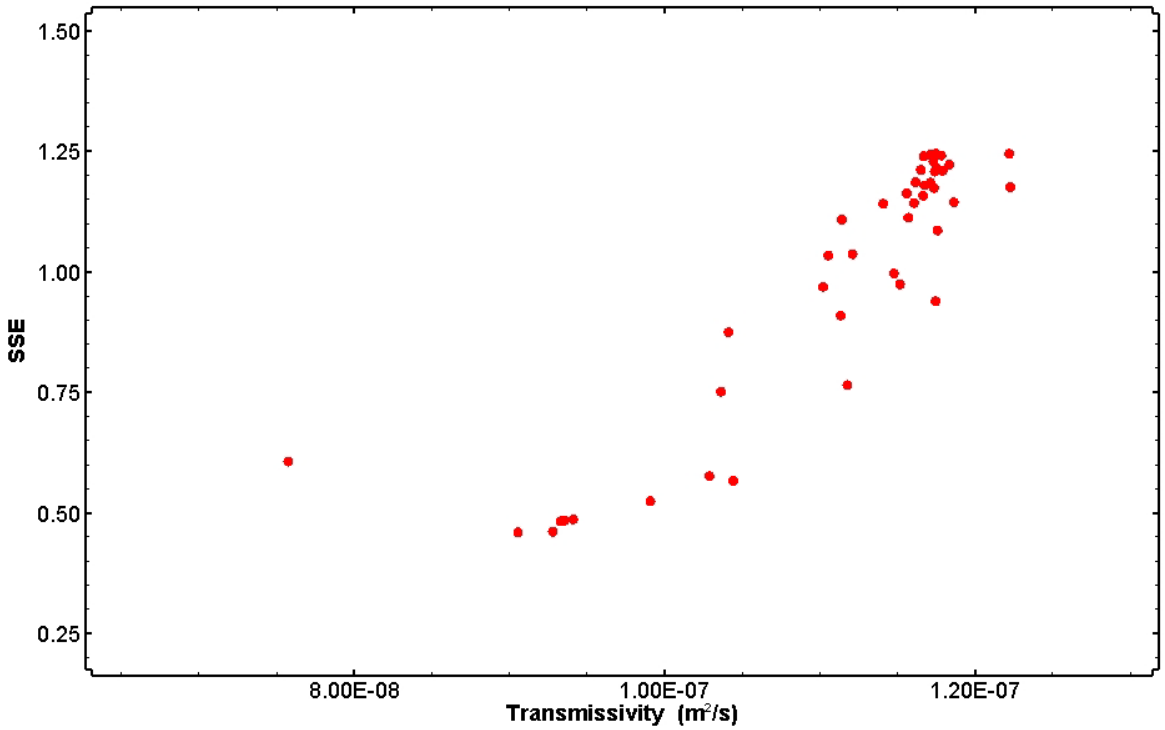


Figure 27. XY-scatter plot showing 43 estimates of transmissivity derived from the C-2737 slug-withdrawal test perturbation analysis.

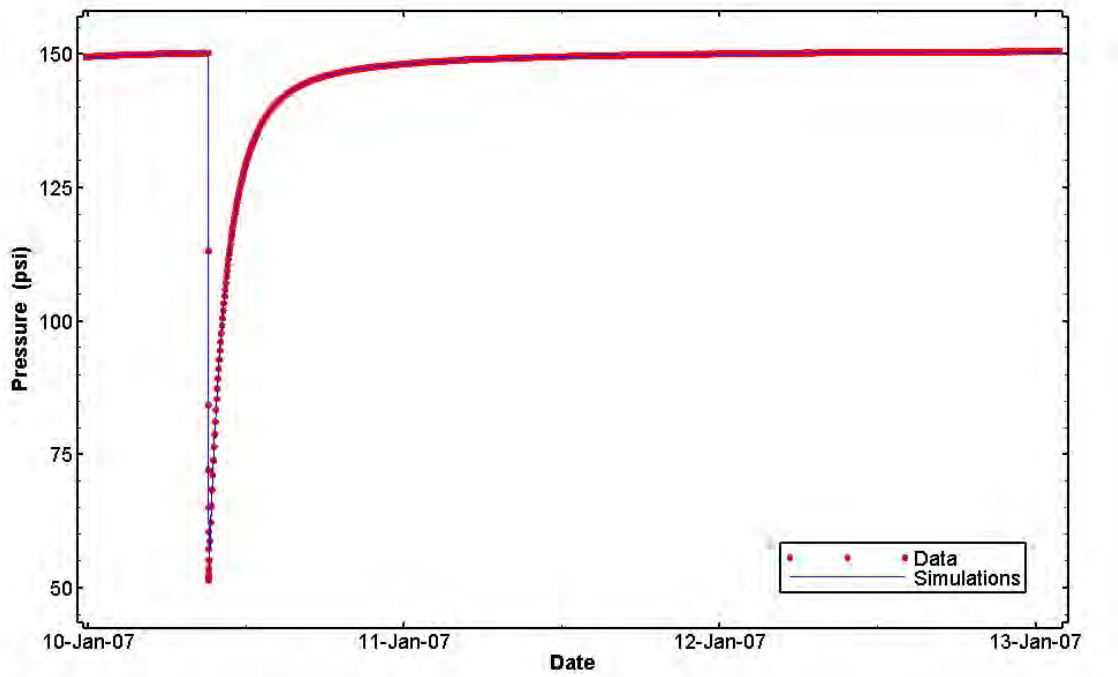


Figure 28. Linear plot showing 43 simulations of the C-2737 slug-withdrawal test.

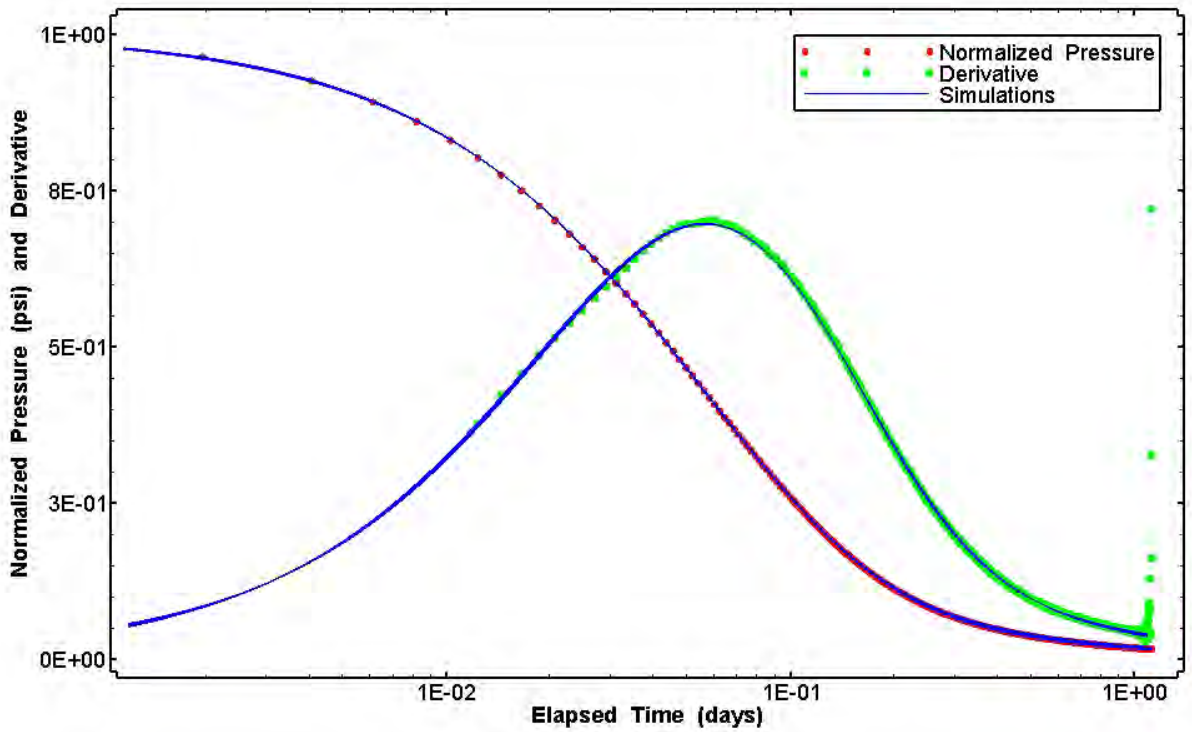


Figure 29. Semilog plot showing 43 simulations of the C-2737 slug-withdrawal test Ramey A and derivative response.

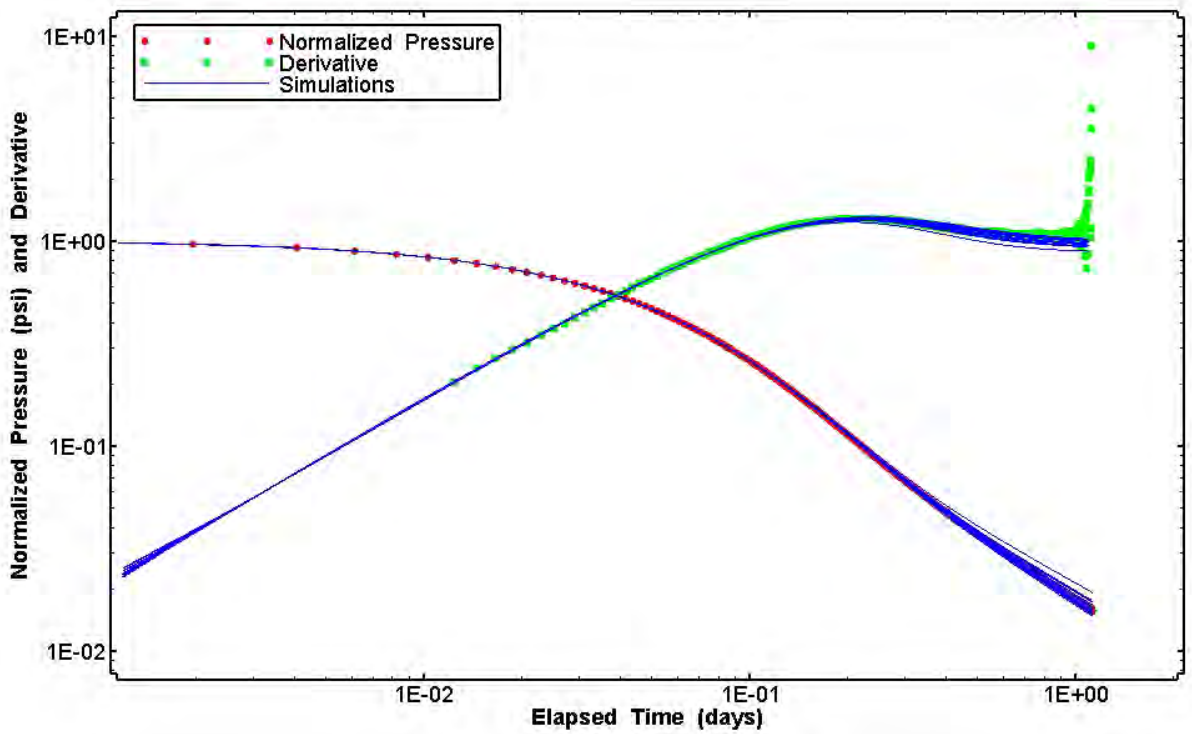


Figure 30. Log-log plot showing 43 simulations of the C-2737 slug-withdrawal test Ramey B and derivative response.

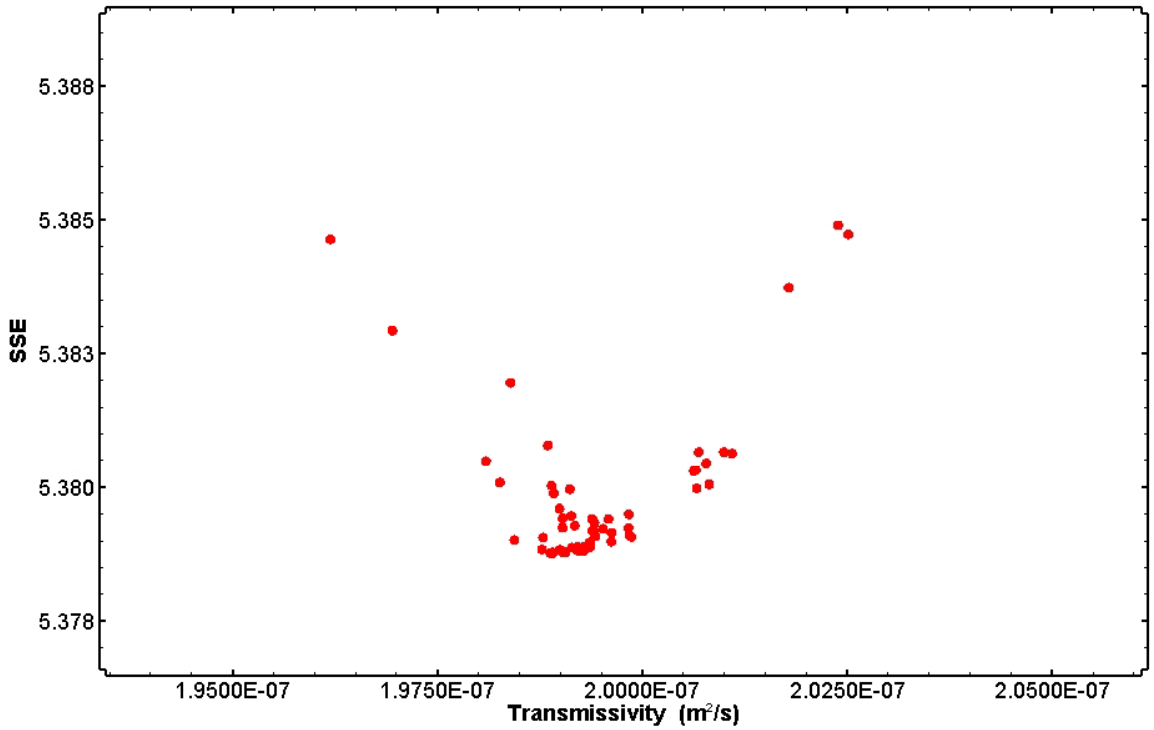


Figure 31. XY-scatter plot showing 59 estimates of transmissivity derived from the C-2737 slug-injection test perturbation analysis.

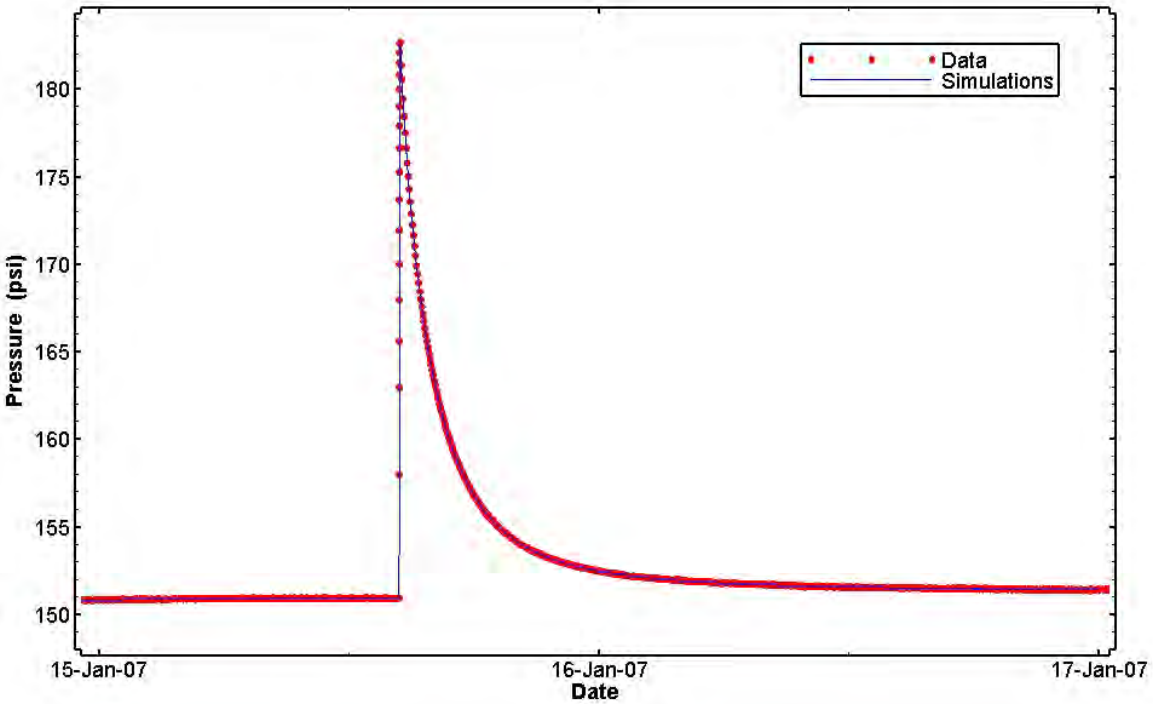


Figure 32. Linear plot showing 59 simulations of the C-2737 slug-injection test response.

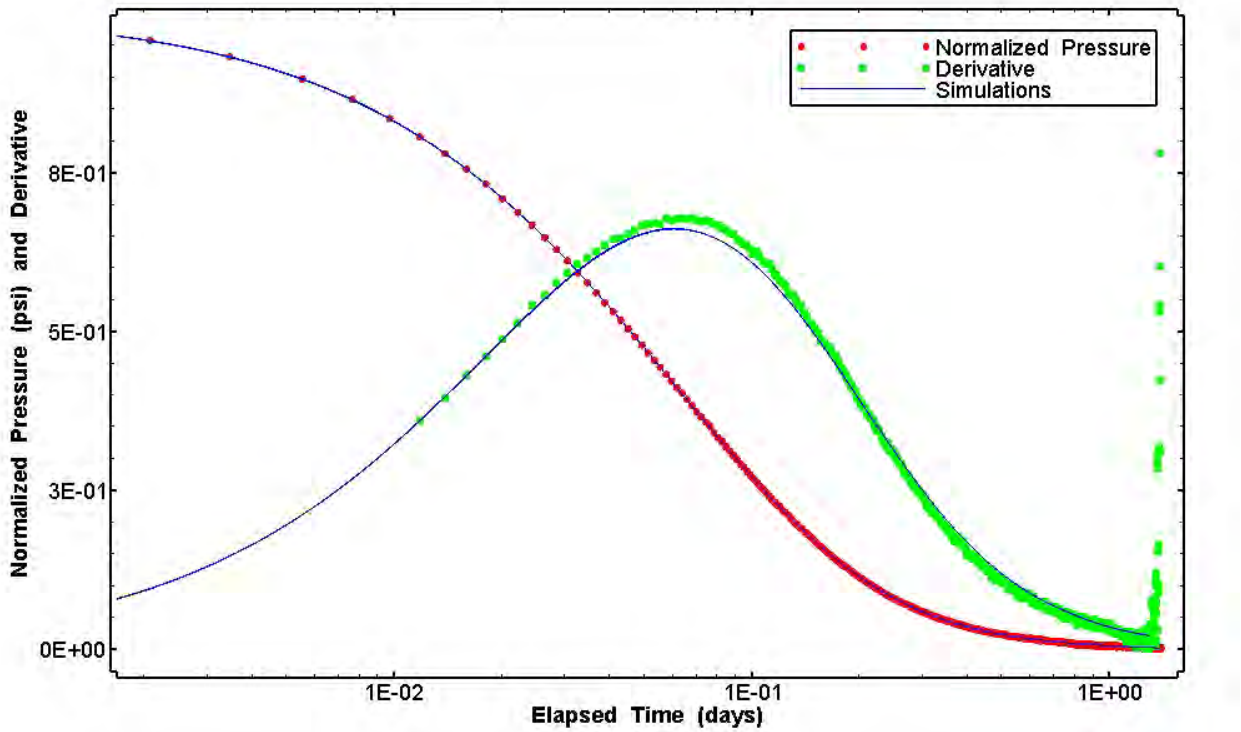


Figure 33. Log-log plot showing 59 simulations of the C-2737 slug-injection test Ramey A and derivative response.

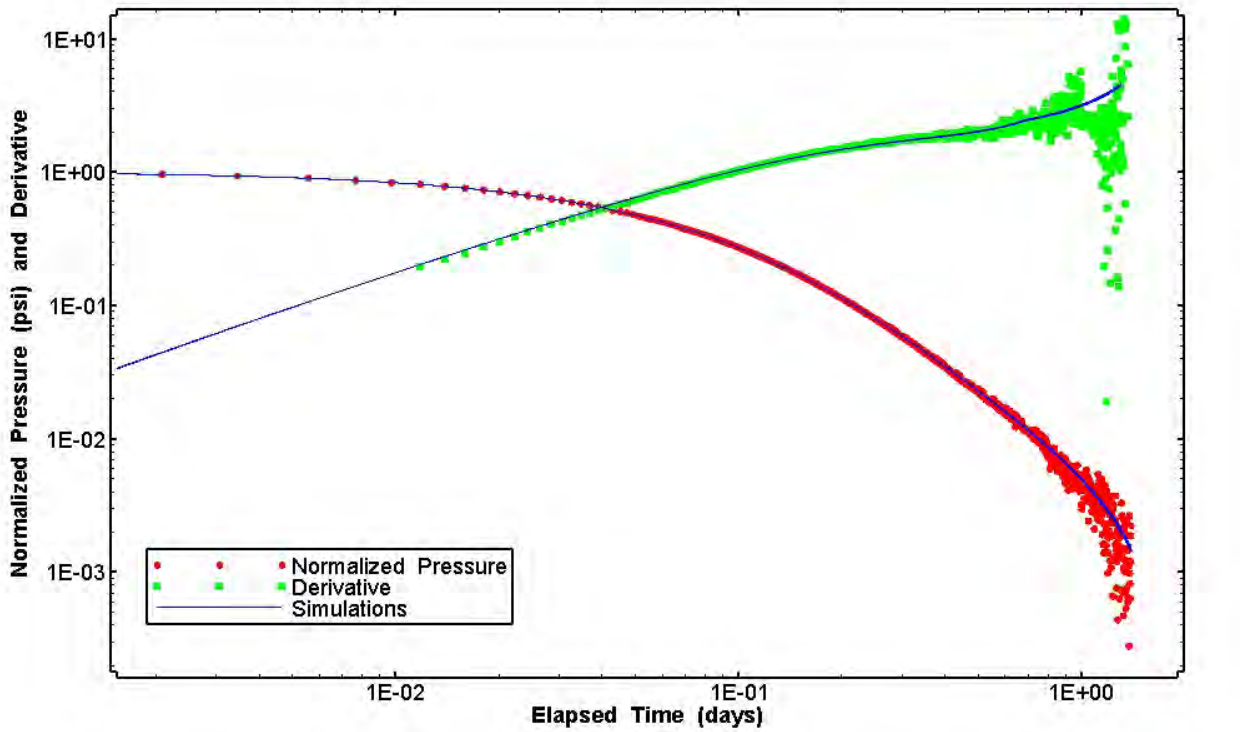


Figure 34. Log-log plot showing 59 simulations of the C-2737 slug-injection test Ramey B and derivative response.

5.2 H-11b2

A pumping test was conducted in well H-11b2 to evaluate the hydraulic properties of the Magenta. The configuration of H-11b2 during the test is shown in Figure 35. Pumping was initiated on April 21, 2008, and continued for approximately 3 days at a nominal rate of 0.2 gpm (1.3E-2 L/s). Pressure recovery was then monitored for the next 27 days. Figure 36 shows the pressure record from H-11b2 used in this analysis, and Figure 37 shows the flow-rate record. The pressures shown in Figure 36 were separated into four nSIGHTS sequences for this analysis. The first 8 hours and final 24 hours of the pumping period were included in the nSIGHTS simulation as pressure-history sequences due to minor irregularities in the pumping rate. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the H-11b2.nPre file and are listed in Appendix B.4.

The specified H-11b2 conceptual model, based on the characteristics of the buildup-period diagnostic plot, was an infinite-acting, homogeneous, radial system with wellbore storage and skin. Of the 500 perturbation/optimization runs performed, 97 provided satisfactory fits to the data. The range of Magenta T values estimated from these 97 runs is shown in Figure 38. The geometric mean T value was 1.56E-7 m^2/s. The Cartesian and log-log pressure-buildup diagnostic simulations corresponding to these 97 T values are shown in Figures 39 and 40, respectively.

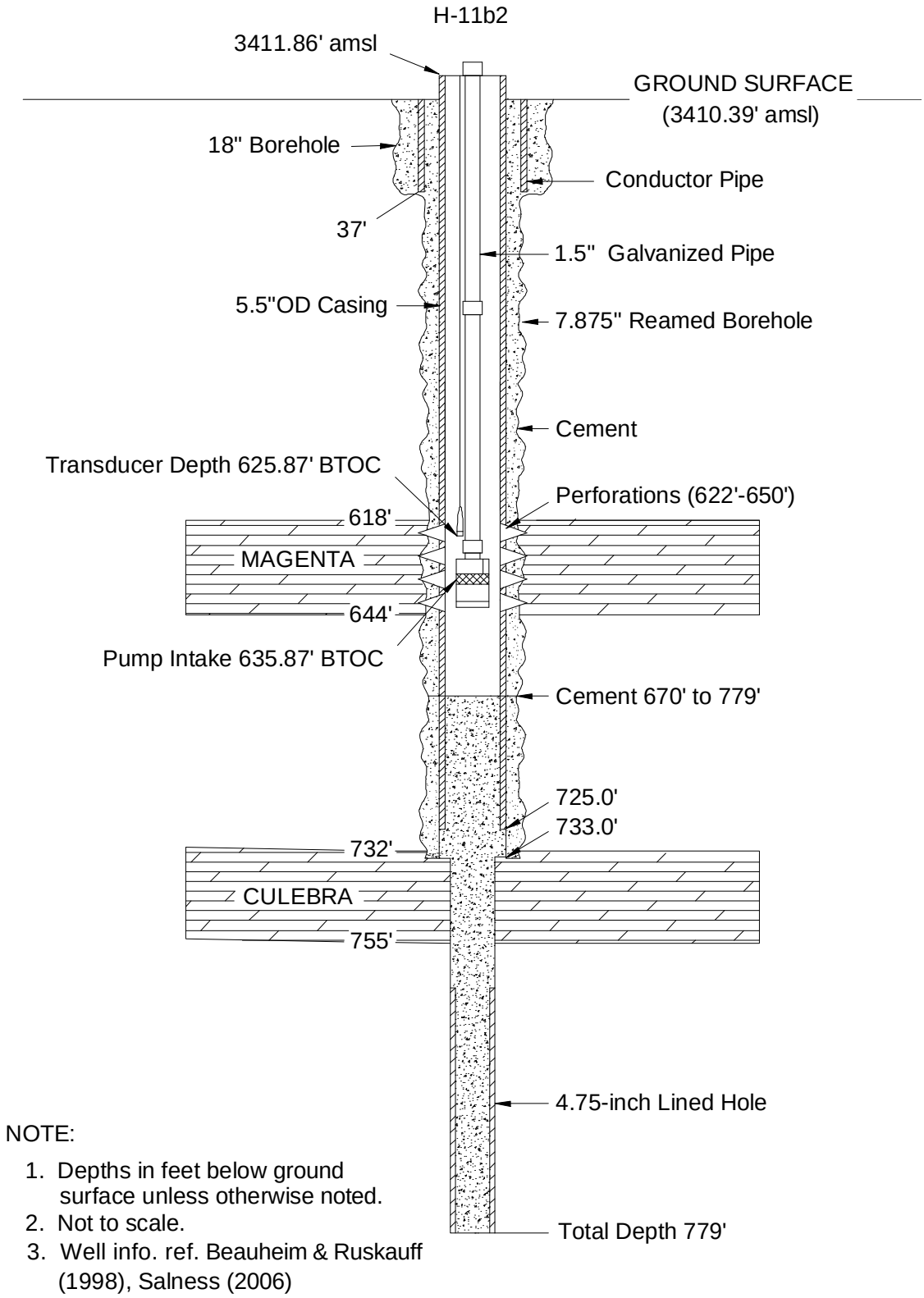


Figure 35. Configuration of well H-11b2 during testing.

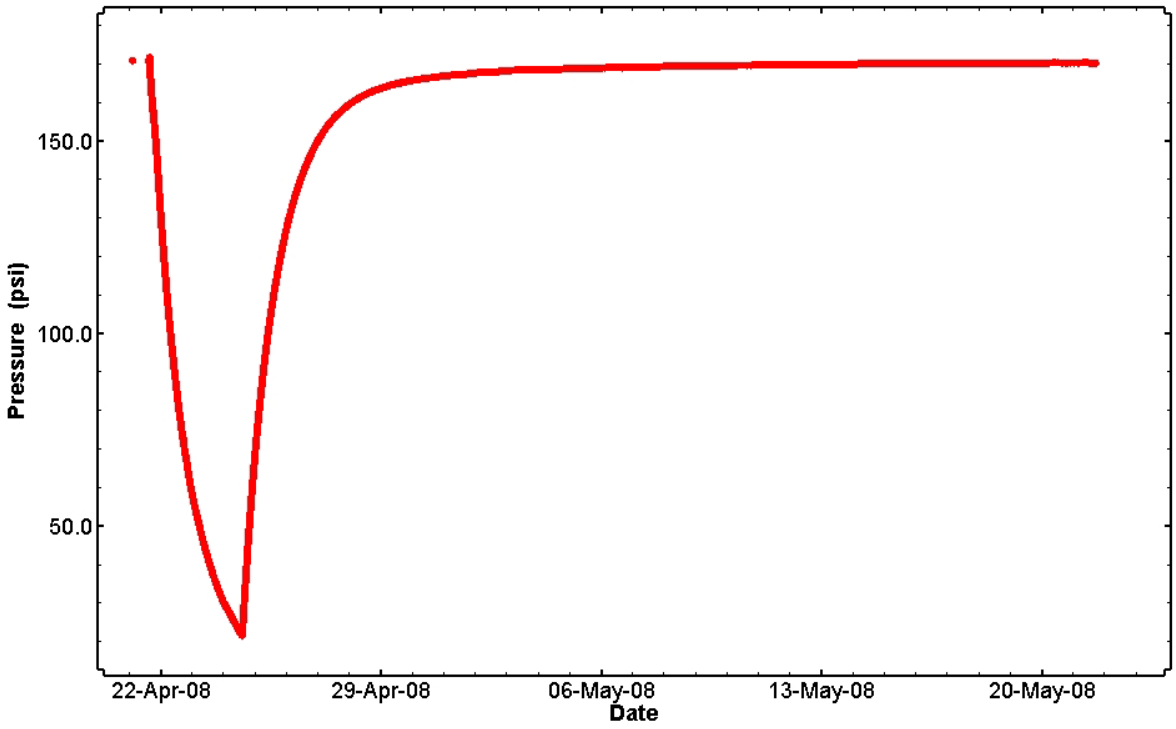


Figure 36. Pressure data from the Magenta pumping test in H-11b2.

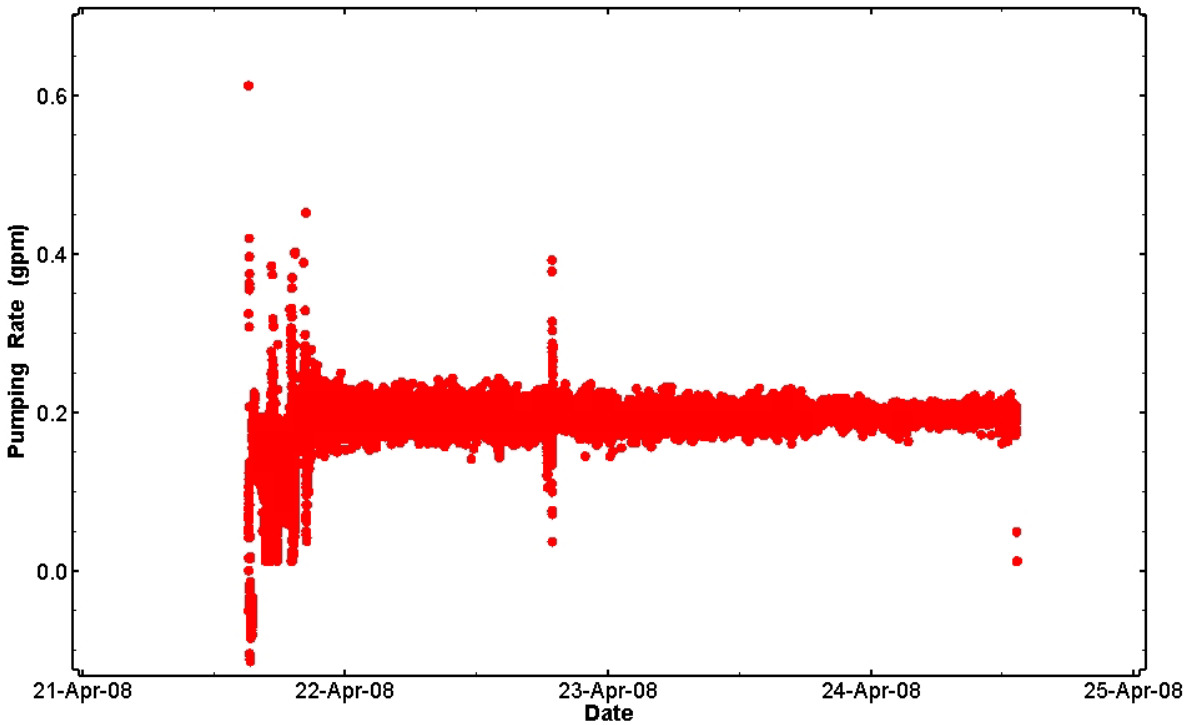


Figure 37. Flow-rate data from the Magenta pumping test in H-11b2.

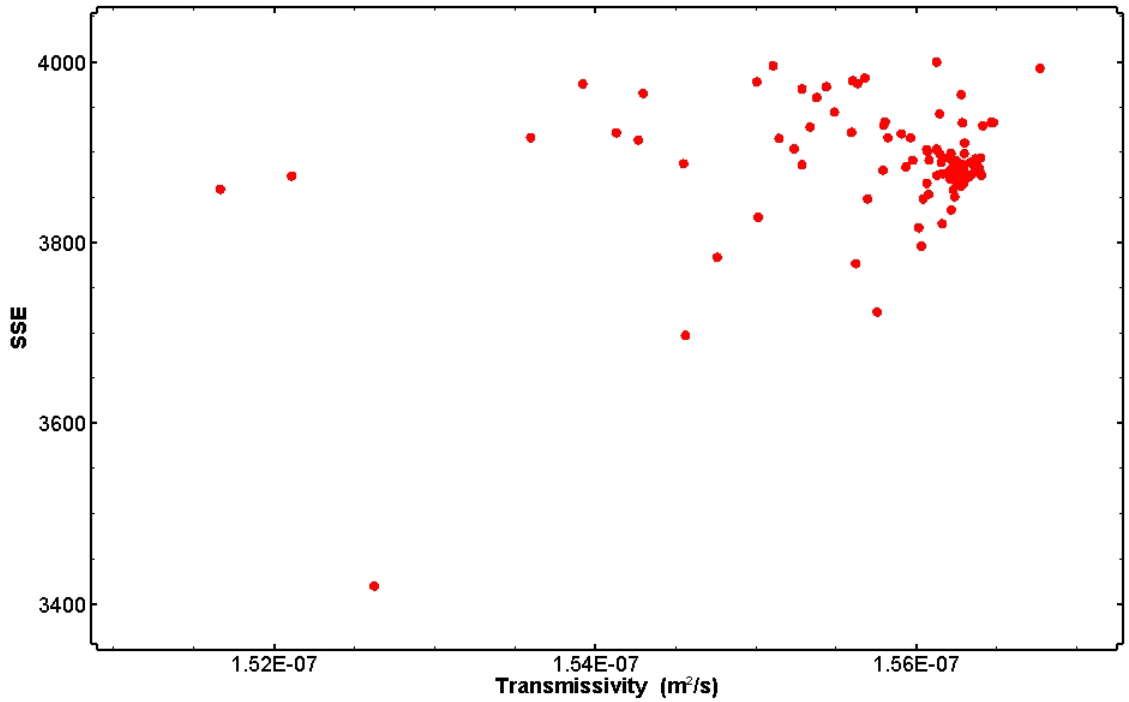


Figure 38. XY-scatter plot showing 97 estimates of transmissivity derived from the H-11b2 perturbation analysis.

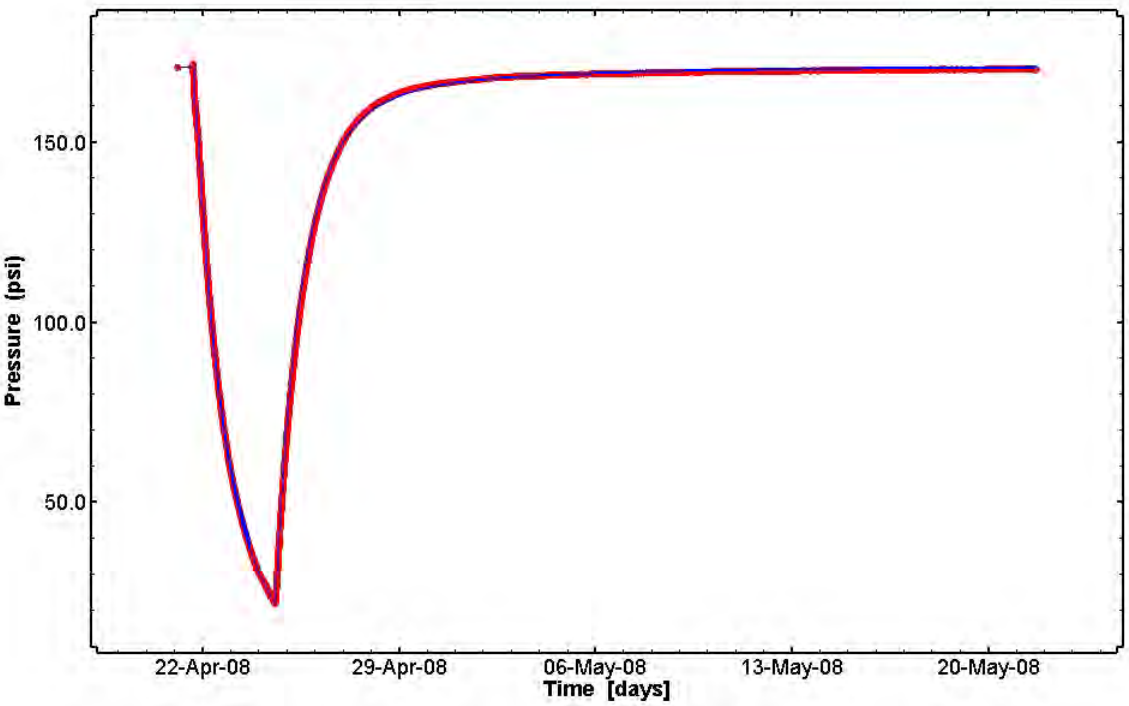


Figure 39. Linear plot showing 97 simulations of the H-11b2 pressure response.

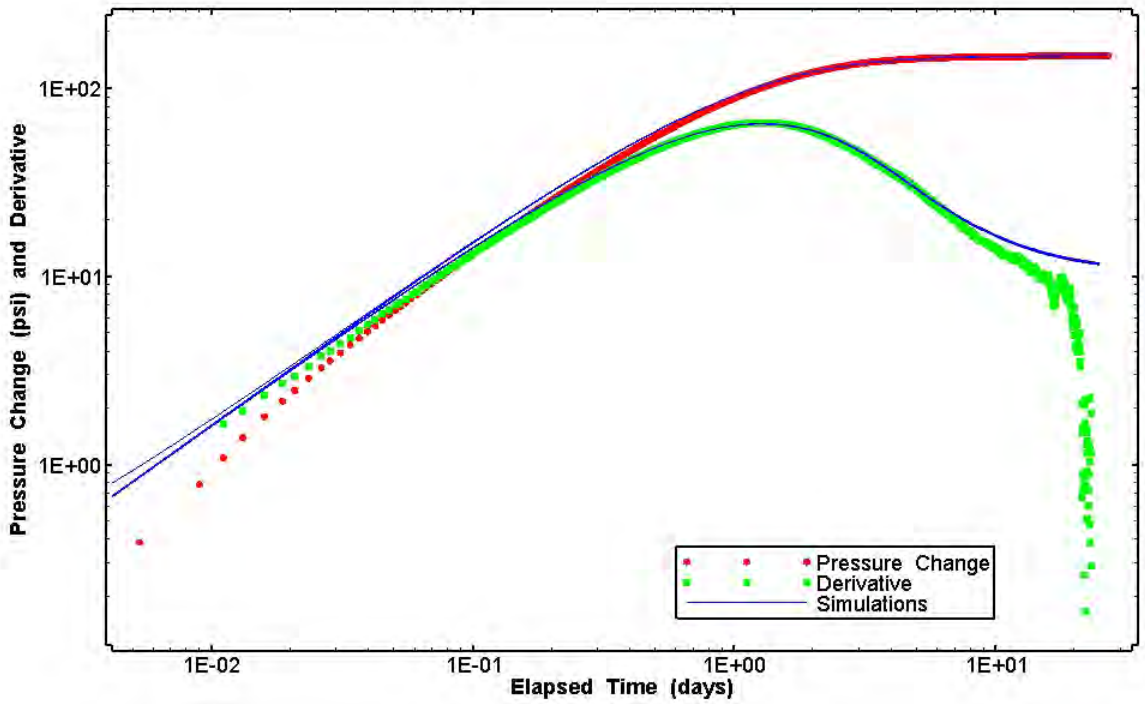
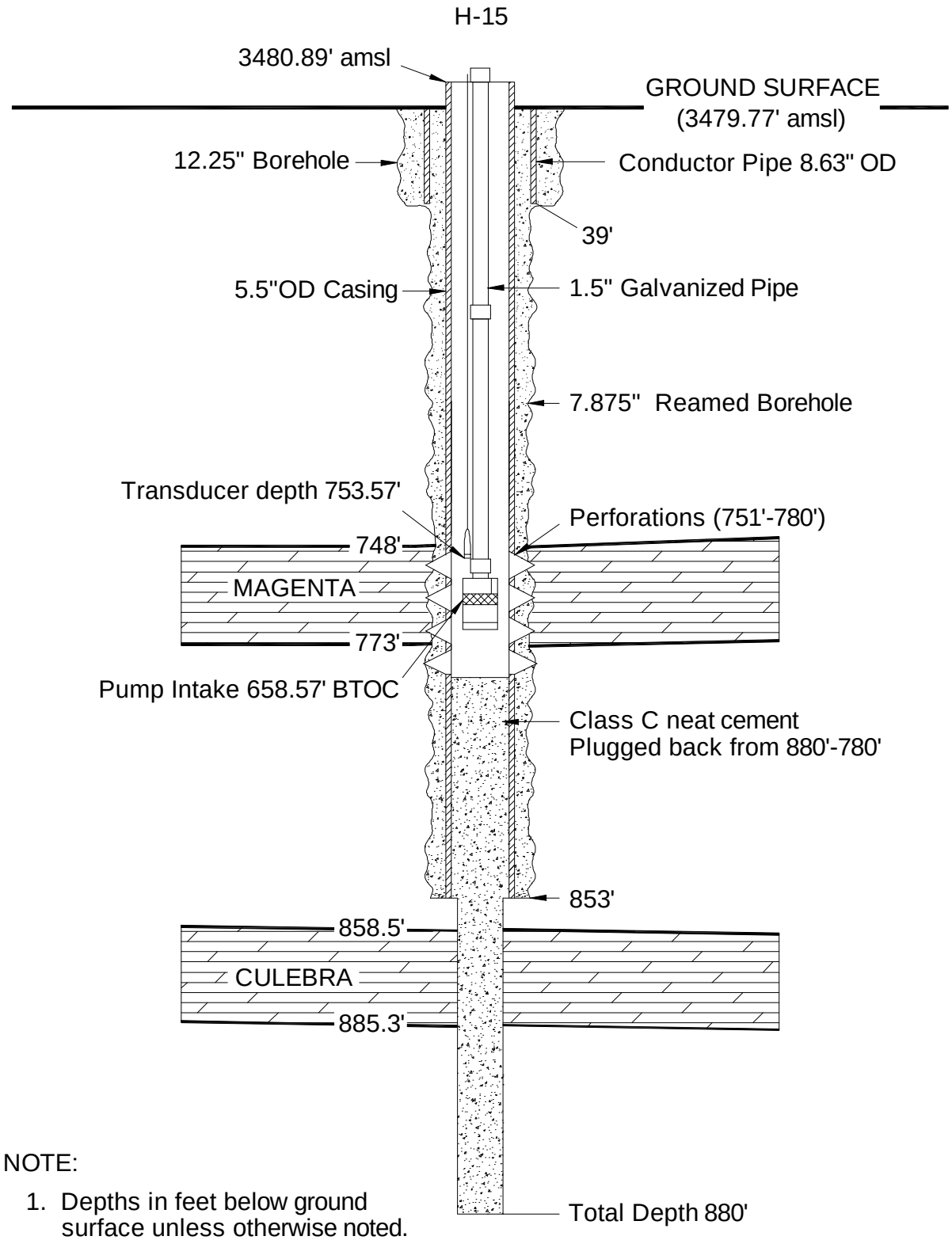


Figure 40. Log-log plot showing 97 simulations of pressure change and derivative during the H-11b2 pressure-buildup test.

5.3 H-15

A dual-rate (6.3E-2 and 9.5E-2 L/s [1.0 and 1.5 gpm]) pumping test was initiated in the Magenta in H-15 on March 17, 2008 and continued for approximately 2.3 days, followed by a ~12-day recovery period. The configuration of the well during the test is shown in Figure 41. Figure 42 shows the pressure record from H-15 used in this analysis, and Figure 43 shows the flow-rate record. The pressures shown in Figure 42 were separated into four nSIGHTS sequences for this analysis. The pre-test pressures beginning on March 17, 2008 were included in the nSIGHTS simulation as a pressure history. The pressures measured at the brief transition between the two pumping rates were also included in the nSIGHTS simulation as a pressure history to account for the stabilization of the second pumping rate. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the H-15(M).nPre file and are listed in Appendix B.5.

The specified H-15 conceptual model, based on the characteristics of the Bourdet diagnostic plot (Bourdet et al., 1989) of the recovery period shown in Figure 44, was an infinite-acting, homogeneous, radial system with wellbore storage and skin. The pressure derivative begins to stabilize around an elapsed time of 7 days (Figure 44). Of the 500 perturbation/optimization runs performed, the 96 with the lowest SSE values were selected as providing the best fits to the data. Figure 45 shows that these 96 runs encompassed a very small range of *T* values. The geometric mean *T* value was 9.50E-7 m^2/s. The Cartesian, log-log pressure-drawdown, and log-log pressure-buildup diagnostic simulations corresponding to these 96 *T* values are shown in Figures 46, 47, and 48, respectively.



NOTE:

1. Depths in feet below ground surface unless otherwise noted.
2. Not to scale.
3. Well info ref. Mercer & Snyder (1990)

Figure 41. Configuration of well H-15 during testing.

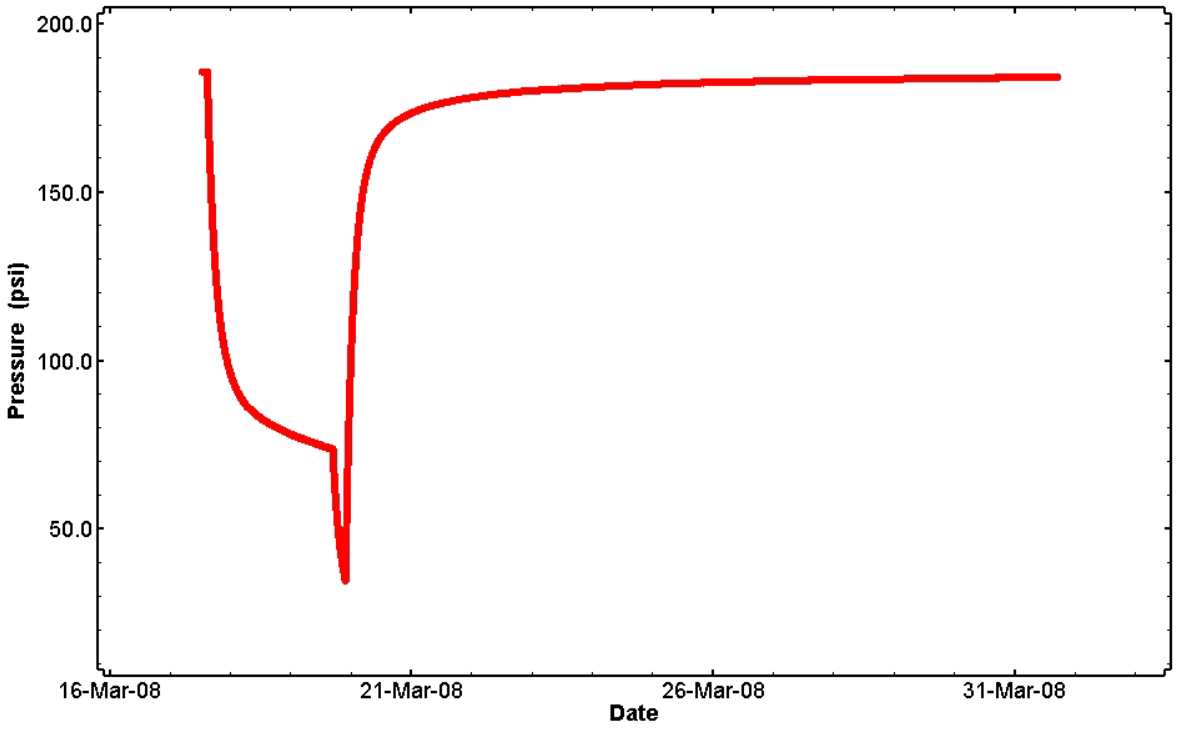


Figure 42. Pressure data from the Magenta pumping test in H-15.

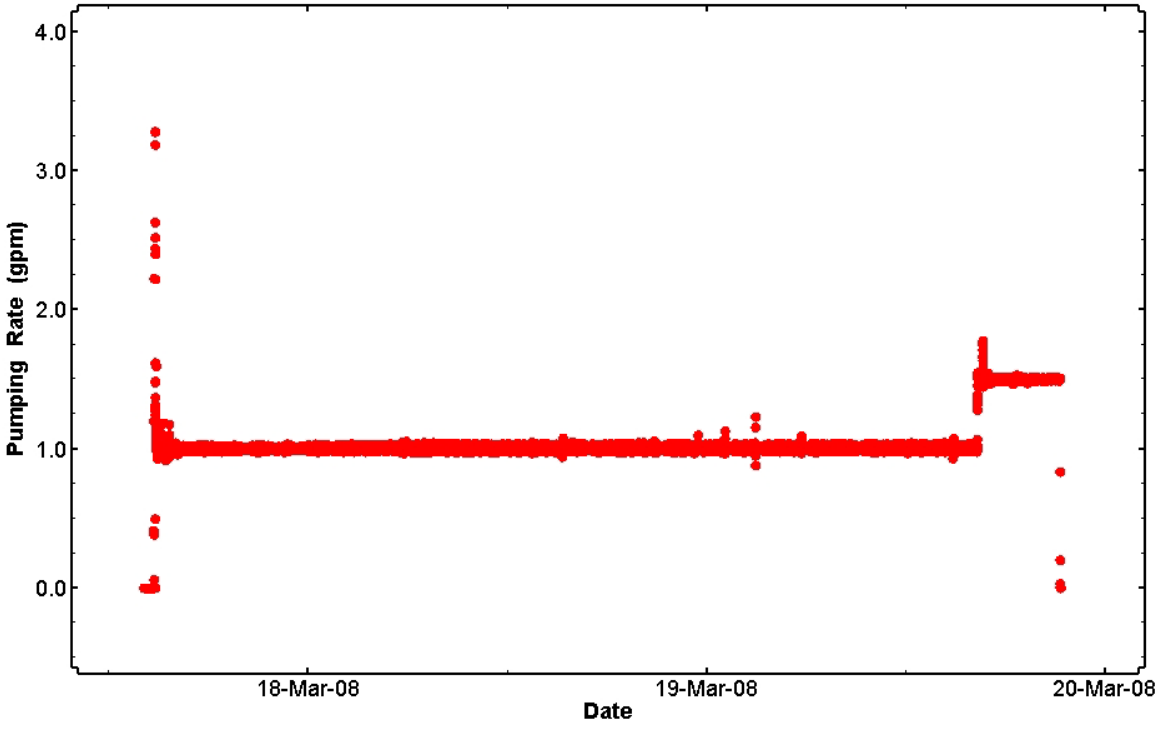


Figure 43. Flow-rate data from the Magenta pumping test in H-15.

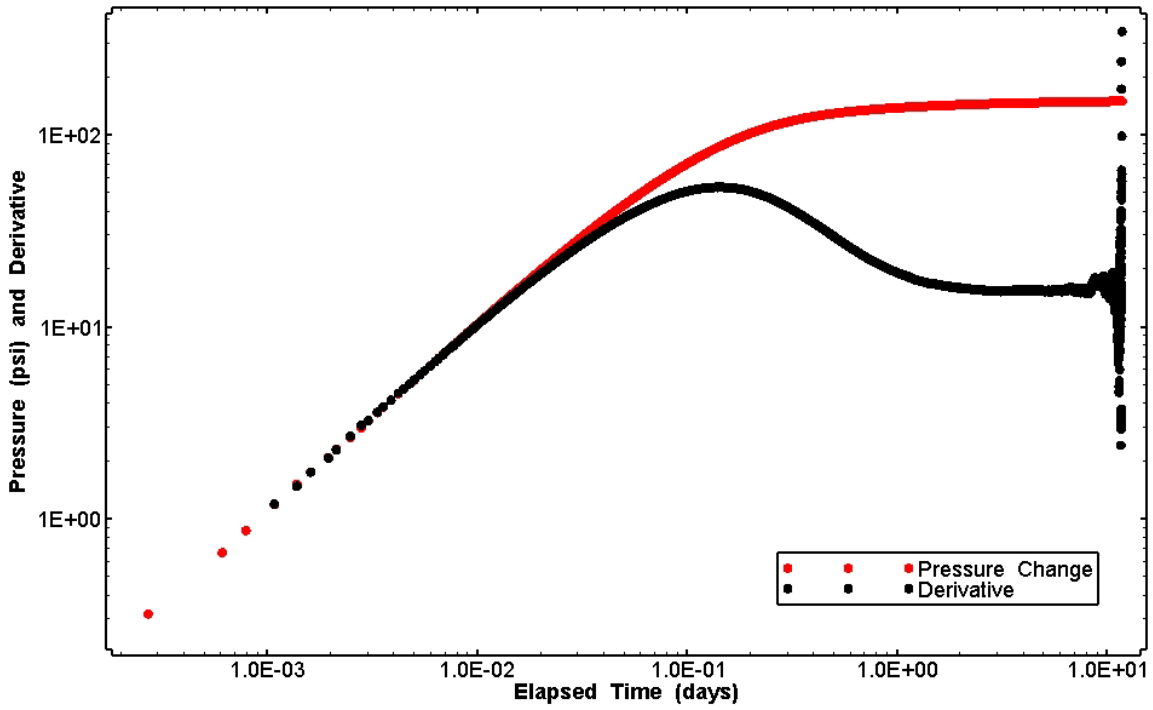


Figure 44. Log-log diagnostic plot of the H-15 pressure-buildup test.

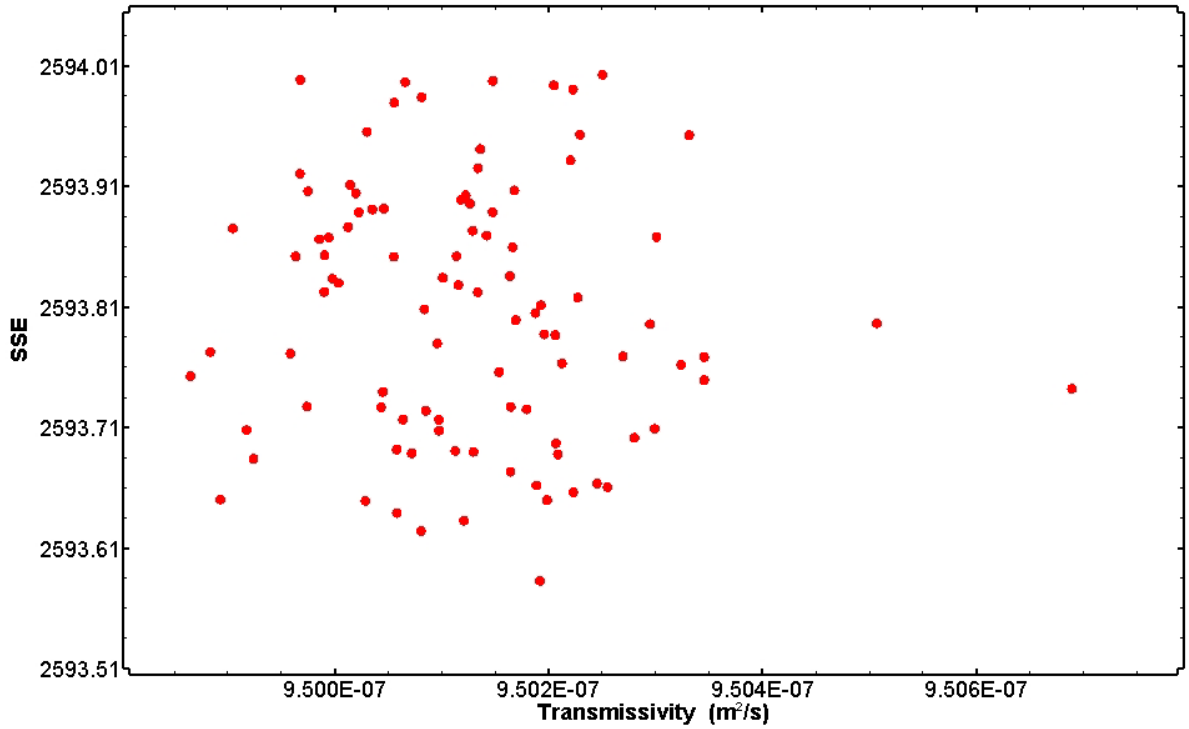


Figure 45. XY-scatter plot showing 96 estimates of transmissivity derived from the H-15 perturbation analysis.

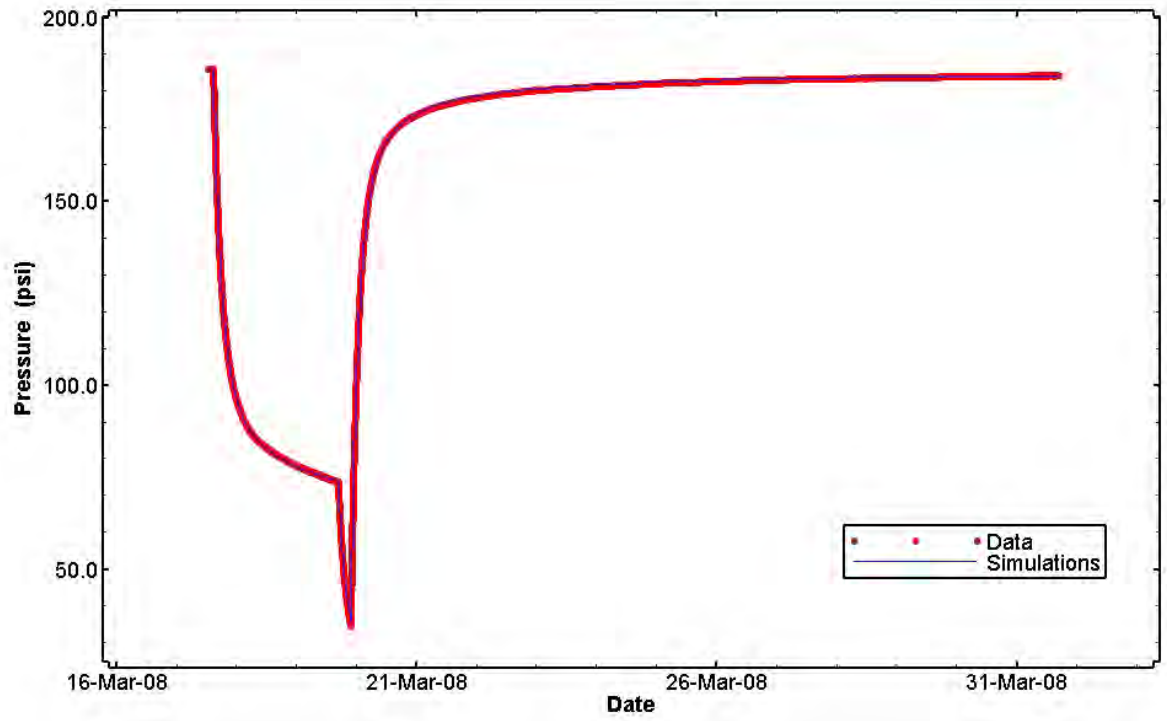


Figure 46. Linear plot showing 96 simulations of the H-15 pressure response.

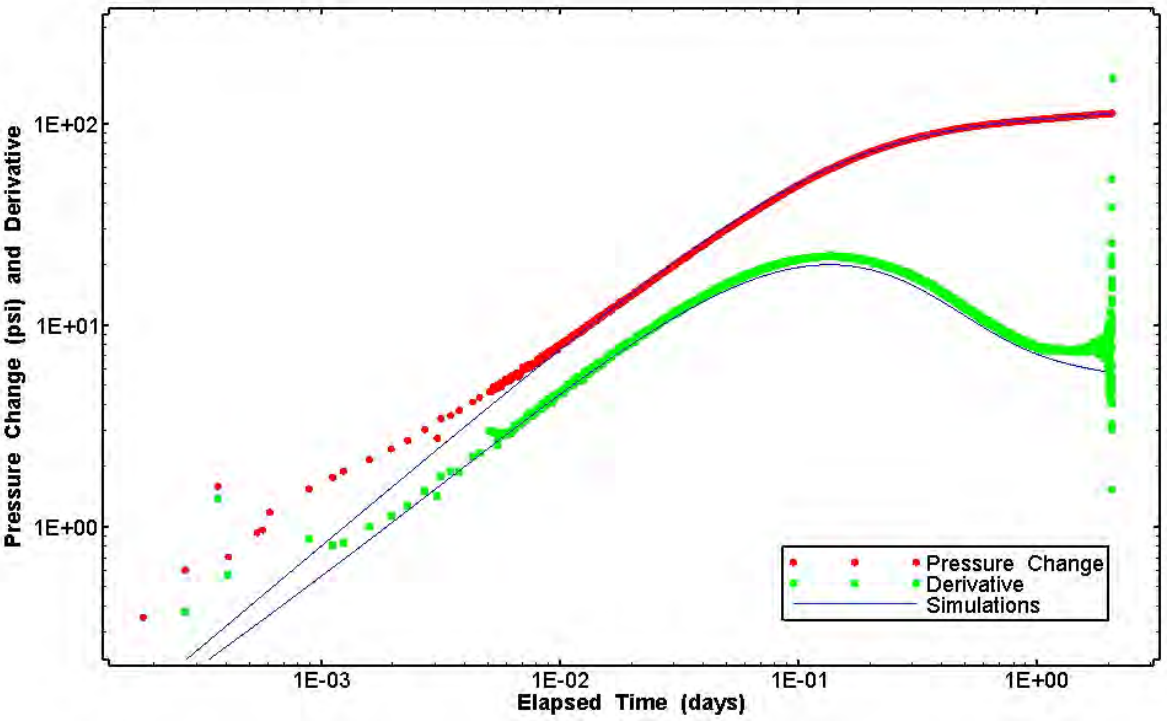


Figure 47. Log-log plot showing 96 simulations of pressure change and derivative during the H-15 pressure-drawdown test.

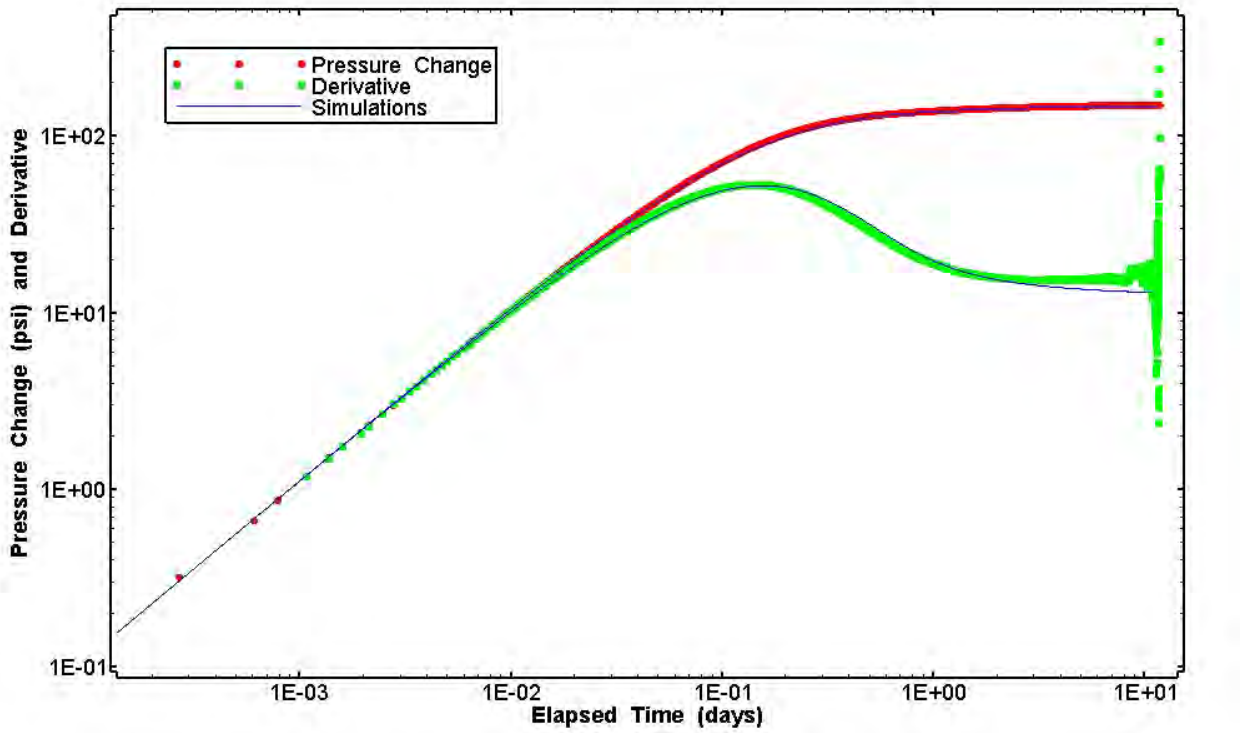


Figure 48. Log-log plot showing 96 simulations of pressure change and derivative during the H-15 pressure-buildup test.

6. References

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Appendix A – Culebra and Magenta Hydraulic Tests – January 2005 to August 2008

Well	Date and Time Start DAS	Date and Time Stop DAS	Date and Time Start	Date and Time Stop	Borehole Diameter (in)	Inside Casing Diameter (in)	Interval (ft)	Specific Gravity (g/cm^3)	TROLL Filenames (ERMS# 539221)	DAS Filenames (ERMS# 543540)	Field Notebook (ERMS# 540244)	Reports
SNL-6	**9/10/2007 11:00**	**1/16/2008 10:00**	1/16/2008 ~11:05	1/16/2008 ~11:30	7.875	2.48	Culebra 1324-1346.5	1.244	SNL-6 (C3)	NA	WSWT#12	Memo: Drilling Decision for SNL-6 (ERMS #540597)
	1/16/2008 15:00	**8/27/2008 12:00**	1/16/2008 ~13:05	1/16/2008 ~13:54					SNL-6 (C4)			
IMC-461	**1/25/2005 10:20**	**1/25/2005 11:54**	1/25/2005 10:39	1/25/2005 11:15	5.125	1.913	Culebra 362-386	1.008	IMC-461 (Pslug2)	NA	WSWT#5	Letter: IMC-461, 462, and 463 (ERMS #541654)
	1/25/2005 11:22	**1/25/2005 16:07**							IMC-461 (WB2)			
	1/25/2005 11:55	**1/25/2005 16:08**	1/25/2005 11:17	1/25/2005 13:40					IMC-461(pslug3)			
	1/26/2005 09:50	**1/26/2005 13:08**							IMC-461(WB3)			
	1/25/2005 16:17	**1/26/2005 08:11**	1/25/2005 13:48	1/25/2005 15:57					IMC-461(C6)			
	1/26/2005 08:48	**1/26/2005 13:48**	1/26/2005 09:02 and 11:27	1/26/2005 11:26 and 13:47					IMC-461 (Pslug4)			
	1/26/2005 13:59	**10/3/2005 08:35**							IMC-461(C7)			
C-2737	1/10/2007 09:02	1/11/2007 13:05	1/10/2007 09:11	1/11/2007 12:12	12.25	6.241	Magenta 561-584.3	1.012	SN110382 C-2737 (SLUG1)	C2737SLUG1	WSWT#10	DOE/WIPP 01-3210
	1/15/07 ~13:41	1/16/2007 10:16	1/15/2007 14:25	1/16/2007 09:28								
H-11b2	4/21/2008 14:41	4/24/2008 14:16	2/20/2008 12:04 2/28/2008 13:02 3/5/2008 11:14	2/20/2008 13:29 2/28/2008 14:30 3/5/2008 12:48	7.875	4.95	Magenta 618-644	NA	SN123356 022008 H-11b2 (Mpump13)		Magenta #7, 8, and 9	SAND98-0049
			4/21/2008 15:08	4/24/2008 13:19				1.041	SN123356 042108 H-11b2 (Mpump14) SN123356 042208 H-11b2 (Mpump15)	H-11b2 (M) Pumping Test		
	4/30/2008 10:00	**5/22/2008 08:00**	NA	NA				NA	SN123356 043008 H-11b2 (M16)			
H-15	3/17/2008 14:07	3/20/2008 00:13	3/7/2008 16:25	3/7/2008 21:05	7.875	4.95	Magenta 748-773	1.073	H-15 (Mpump1)	NA	Magenta #8	SAND89-0202
			3/17/2008 14:48	3/19/2008 21:20					H-15(M1)			
									H-15(Mpump2)			
									SN 116450 031708 H-15(Mpump2)			

Notes:
- WSWT = WIPP Site Well Testing Scientific Notebook
- Magenta = Magenta Hydrology Scientific Notebook
- Bolded Date and Time Start DAS and Stop DAS are actually TROLL file start and stop date and time.
- IMC-461 and C-2737 Date and Time Start and Stop are date and time the slug test was initiated and date and time monitoring of response ended.
- SNL-6 Date and Time Start and Stop are date and time the bailing started and ended.
- H-11b2 and H-15 Date and Time Start and Stop refer to pump.
- Specific gravity for H-11b2 is the last specific gravity of the pumping test.

Appendix B – nSIGHTS Listings

B.1 SNL-6 nSIGHTS Listings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   06 Nov 2008
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Culebra\SNL_6\SNL 6.nPre
```

Control Settings

Main Settings

Simulation type	Forward	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	no	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	22.500	[ft]
Flow dimension	2.0	[]
Static formation pressure	591.613	[psi]
External boundary radius	1000000	[m]
Formation conductivity	1.26760E-12	[m/sec]
Formation spec. storage	1.01082E-05	[1/m]

Fluid

Fluid density	1244.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.938	[in]
Tubing string radius	1.24	[in]

Numeric

# of radial nodes	250	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

Calculated Parameters

Formation

Transmissivity	8.69320E-12	[m^2/sec]
Storativity	6.93219E-05	[]
Diffusivity	1.25403E-07	[m^2/sec]

Test Zone

Open hole well-bore storage	2.55470E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.06473	[]
First grid increment	6.68881E-03	[m]

Sequences

Sequence: H_01

Sequence type	History	
Start time	38602.625000	[day]
Duration	6.708333	[day]
Time step type	Static	
Static time step	0.011574	[day]
Type	Curve	
Wellbore storage	Open	

Sequence: S_01

Sequence type	Slug	
Start time	38609.333333	[day]
Duration	854.000004	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Initial pressure type	Absolute	
Initial pressure	60.000	[psi]

Sequence: H_02

Sequence type	History	
Start time	39463.333337	[day]
Duration	0.375000	[day]
Time step type	Static	
Static time step	0.000116	[day]
Type	Curve	
Wellbore storage	Open	

Sequence: S_02

Sequence type	Slug	
Start time	39463.708337	[day]
Duration	223.791663	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Initial pressure type	Absolute	
Initial pressure	212.100	[psi]

Test Zone Curves

Curve object to use	History Curve
Curve type	Pressure
Start sequence	H_01
End sequence	H_01
Curve time base	Test
Curve Y data units	[psi]
Curve Y data is log 10	no

Curve object to use	Pressure Curve
Curve type	Pressure
Start sequence	H_02
End sequence	H_02
Curve time base	Test
Curve Y data units	[psi]
Curve Y data is log 10	no

Simulation Results Setup

Output ID	DAT
Output type	Pressure
Pressure capture type	Test Zone
Output units	[psi]

Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[m^3/sec]

SNL-6 Optimization Settings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   06 Nov 2008
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Culebra\SNL_6\SNL 6.nPre
```

Control Settings

Main Settings

Simulation type	Optimization	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	no	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	22.500	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	150.000	[psi]
Maximum value	2000.000	[psi]
Estimate value	591.613	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-14	[m/sec]

Maximum value	1.00000E-07	[m/sec]
Estimate value	1.26760E-12	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	Optimization	
Minimum value	1.00000E-10	[1/m]
Maximum value	1.00000E-03	[1/m]
Estimate value	1.01082E-05	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1244.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.938	[in]
Tubing string radius	1.24	[in]

Numeric

# of radial nodes	250	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

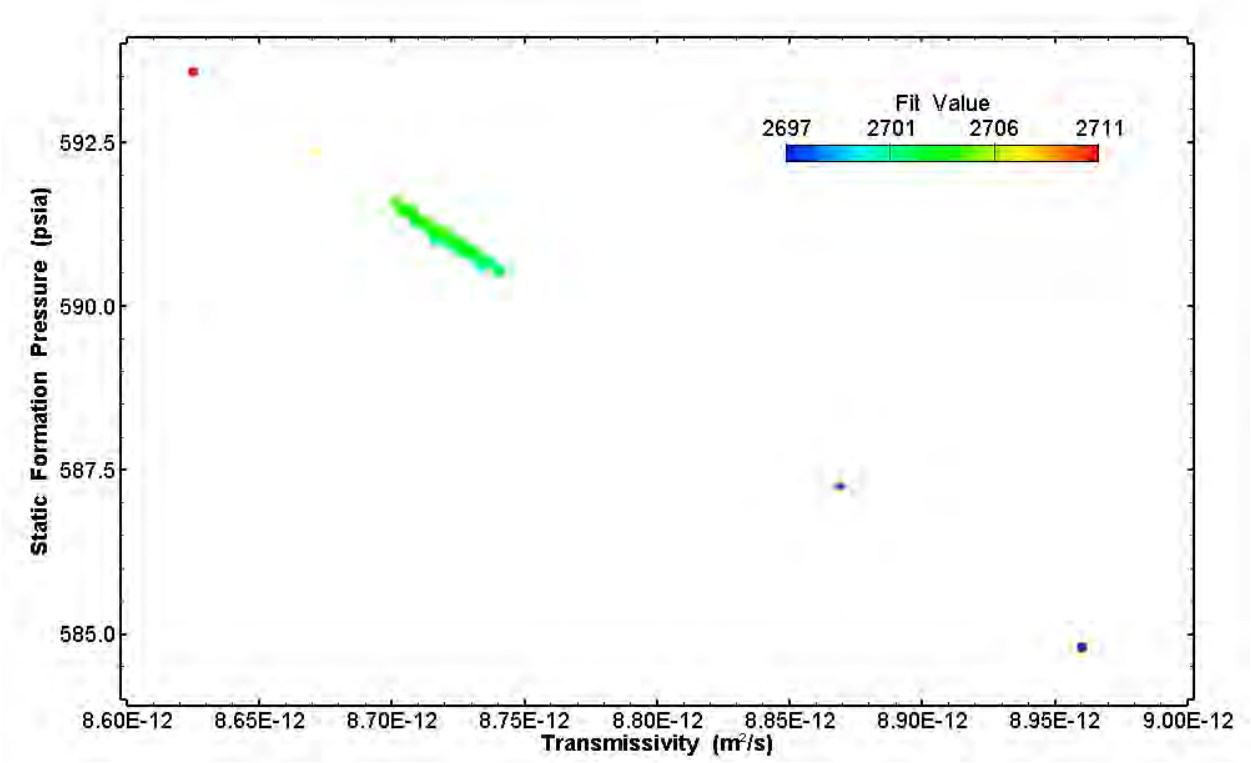

Figure B-1. Estimates of static formation pressure and transmissivity derived from the SNL-6 perturbation analysis.

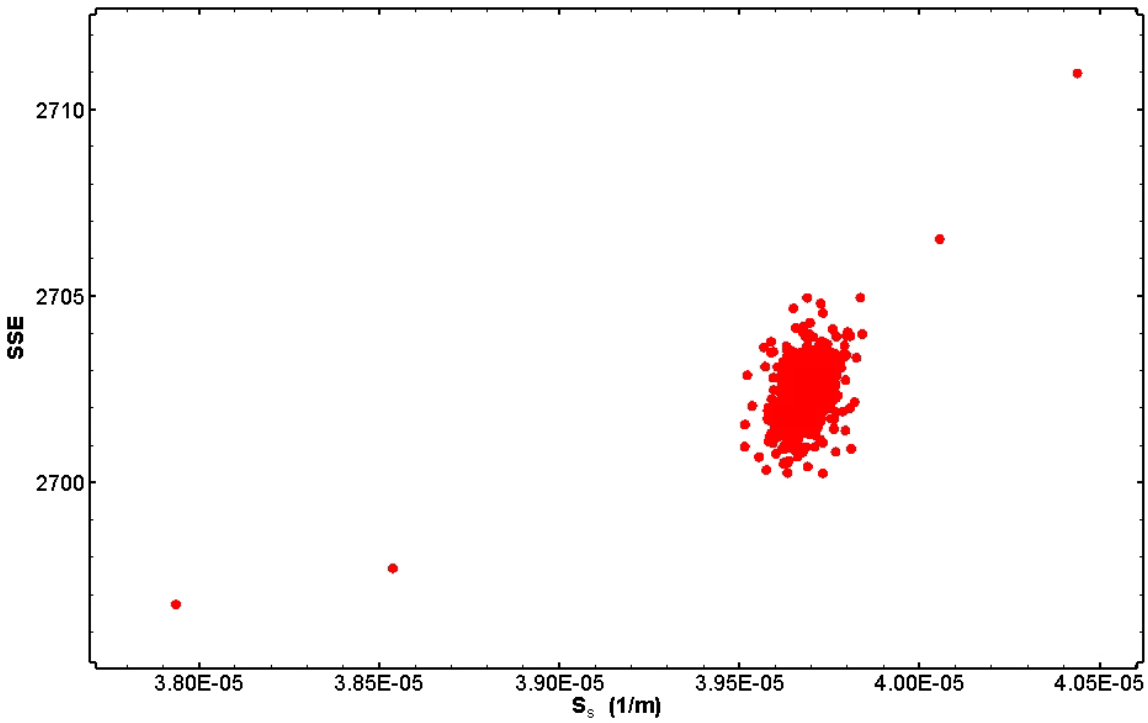

Figure B-2. X-Y scatter plot showing 497 estimates of specific storage derived from the SNL-6 perturbation analysis.

B.2 IMC-461 nSIGHTS Listings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   26 Nov 2008
QA status      QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_firstpulse.nPre
```

Control Settings

Main Settings

Simulation type	Forward
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.305	[psi]
External boundary radius	1000000	[m]
Formation conductivity	2.43870E-05	[m/sec]
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0138115	[m]

Skin zone conductivity	f(P) point	
Skin zone spec. storage	6.36987E-03	[1/m]

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

---

f(x) Points Parameters

Skin zone conductivity

Points type	f(P)	
Pressure #1	275.790	[psi]
Y value#1	1.14603E-07	[m/sec]
Pressure #2	386.106	[psi]
Y value#2	2.23772E-07	[m/sec]
Pressure #3	434.370	[psi]
Y value#3	9.03432E-07	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	1.78396E-04	[m^2/sec]
Storativity	7.31520E-06	[]
Diffusivity	2.43870E+01	[m^2/sec]

Skin Zone

Transmissivity	f(P)	
Storativity	4.65969E-02	[]
Diffusivity	f(P)	
Skin factor	f(P)	

Test Zone

Open hole well-bore storage	1.87793E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.08219	[]

First grid increment	6.75834E-03	[m]
Skin grid increment delta	0.00393	[]
Skin first grid increment	2.56118E-04	[m]
Skin last grid increment	3.09249E-04	[m]
Increment ratio	2.18541E+01	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	38377.430740	[day]
Duration	0.026320	[day]
Time step type	Static	
Static time step	0.000010	[day]
Type	Curve	
Wellbore storage	None	

Sequence: S_01

Sequence type	Slug	
Start time	38377.457060	[day]
Duration	0.011880	[day]
Time step type	Static	
Static time step	0.000010	[day]
Initial pressure type	Absolute	
Initial pressure	22.119	[psi]

Sequence: H_02

Sequence type	History	
Start time	38377.468940	[day]
Duration	0.203680	[day]
Time step type	Static	
Static time step	0.010000	[day]
Type	Curve	
Wellbore storage	None	

Test Zone Curves

Curve object to use	Create Curve	
Curve type	Pressure	
Start sequence	H_01	
End sequence	H_02	
Curve time base	Test	
Curve Y data units	[psi]	
Curve Y data is log 10	no	

Simulation Results Setup

Output ID	DAT	
Output type	Pressure	
Pressure capture type	Test Zone	
Output units	[psi]	

Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[m^3/sec]

IMC-461 nSIGHTS Optimization Settings – First Pulse

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   26 Nov 2008
QA status      QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_firstpulse.nPre
```

Control Settings

Main Settings

Simulation type	Optimization
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.305	[psi]

External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-10	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	2.43870E-05	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	0.001	[m]
Maximum value	1.0	[m]
Estimate value	0.0138115	[m]
Range type	Linear	
Sigma	1.00000E+00	
Skin zone conductivity	f(P) point	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	6.36987E-03	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   26 Nov 2008
QA status      QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_secondpulse.nPre
```

Control Settings

Main Settings

Simulation type	Forward	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	yes	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.316	[psi]
External boundary radius	1000000	[m]
Formation conductivity	2.14858E-05	[m/sec]
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0244083	[m]
Skin zone conductivity	f(P) point	
Skin zone spec. storage	8.63857E-03	[1/m]

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

f(x) Points Parameters

Skin zone conductivity

Points type	f(P)	
Pressure #1	275.790	[psi]
Y value#1	2.04531E-07	[m/sec]
Pressure #2	386.106	[psi]
Y value#2	4.32436E-07	[m/sec]
Pressure #3	434.370	[psi]
Y value#3	3.44048E-06	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	1.57173E-04	[m^2/sec]
Storativity	7.31520E-06	[]
Diffusivity	2.14858E+01	[m^2/sec]

Skin Zone

Transmissivity	f(P)	
Storativity	6.31928E-02	[]
Diffusivity	f(P)	
Skin factor	f(P)	

Test Zone

Open hole well-bore storage	1.87793E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.08155	[]
First grid increment	7.60454E-03	[m]
Skin grid increment delta	0.00650	[]
Skin first grid increment	4.24393E-04	[m]
Skin last grid increment	5.79763E-04	[m]
Increment ratio	1.31166E+01	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	38377.430740	[day]

Duration	0.069610	[day]
Time step type	Static	
Static time step	0.000010	[day]
Type	Curve	
Wellbore storage	None	

Sequence: S_01

Sequence type	Slug	
Start time	38377.500350	[day]
Duration	0.012200	[day]
Time step type	Static	
Static time step	0.000010	[day]
Initial pressure type	Absolute	
Initial pressure	22.132	[psi]

Sequence: H_02

Sequence type	History	
Start time	38377.512550	[day]
Duration	0.160070	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	None	

Test Zone Curves

Curve object to use	Create Curve	
Curve type	Pressure	
Start sequence	H_01	
End sequence	H_02	
Curve time base	Test	
Curve Y data units	[psi]	
Curve Y data is log 10	no	

Simulation Results Setup

Output ID	DAT	
Output type	Pressure	
Pressure capture type	Test Zone	
Output units	[psi]	
Output ID	DAT	
Output type	Flow Rate	
Flow rate output type	Well	
Output units	[m^3/sec]	

IMC-461 nSIGHTS Optimization Settings – Second Pulse

```
*************
nPre/32 2.41Q
*************
```

Version date 1 Mar 2007
Listing date 26 Nov 2008
QA status QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_secondpulse.nPre

---

Control Settings

Main Settings

Simulation type	Optimization	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	yes	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.316	[psi]
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-10	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	2.14858E-05	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	0.001	[m]

Maximum value	1.0	[m]
Estimate value	0.0244083	[m]
Range type	Linear	
Sigma	1.00000E+00	
Skin zone conductivity	f(P) point	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	8.63857E-03	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   26 Nov 2008
QA status      QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_thirdpulse.nPre
```

Control Settings

Main Settings

Simulation type	Forward
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single

Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.347	[psi]
External boundary radius	1000000	[m]
Formation conductivity	1.77677E-05	[m/sec]
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0389451	[m]
Skin zone conductivity	f(P) point	
Skin zone spec. storage	6.47239E-03	[1/m]

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

---

f(x) Points Parameters

Skin zone conductivity

Points type	f(P)	
Pressure #1	275.790	[psi]
Y value#1	1.00001E-08	[m/sec]
Pressure #2	386.106	[psi]
Y value#2	8.20325E-07	[m/sec]

Pressure #3	434.370	[psi]
Y value#3	4.84304E-06	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	1.29974E-04	[m^2/sec]
Storativity	7.31520E-06	[]
Diffusivity	1.77677E+01	[m^2/sec]

Skin Zone

Transmissivity	f(P)	
Storativity	4.73469E-02	[]
Diffusivity	f(P)	
Skin factor	f(P)	

Test Zone

Open hole well-bore storage	1.87793E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.08080	[]
First grid increment	8.75440E-03	[m]
Skin grid increment delta	0.00957	[]
Skin first grid increment	6.25933E-04	[m]
Skin last grid increment	9.90931E-04	[m]
Increment ratio	8.83452E+00	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	38377.430740	[day]
Duration	0.165630	[day]
Time step type	Static	
Static time step	0.000100	[day]
Type	Curve	
Wellbore storage	None	

Sequence: S_01

Sequence type	Slug	
Start time	38377.596370	[day]
Duration	0.010620	[day]
Time step type	Static	
Static time step	0.000010	[day]
Initial pressure type	Absolute	
Initial pressure	40.922	[psi]

Sequence: H_02

Sequence type	History	
Start time	38377.606990	[day]
Duration	0.065630	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	None	

Test Zone Curves

Curve object to use	Create Curve
Curve type	Pressure
Start sequence	H_01
End sequence	H_02
Curve time base	Test
Curve Y data units	[psi]
Curve Y data is log 10	no

Simulation Results Setup

Output ID	DAT
Output type	Pressure
Pressure capture type	Test Zone
Output units	[psi]

Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[m^3/sec]

IMC-461 nSIGHTS Optimization Settings – Third Pulse

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   26 Nov 2008
QA status      QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_thirdpulse.nPre
```

Control Settings

Main Settings

Simulation type	Optimization
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes

External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.347	[psi]
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-10	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	1.77677E-05	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	0.001	[m]
Maximum value	1.0	[m]
Estimate value	0.0389451	[m]
Range type	Linear	
Sigma	1.00000E+00	
Skin zone conductivity	f(P) point	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	6.47239E-03	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

****
nPre/32 2.41Q
****

Version date 1 Mar 2007
Listing date 05 Jan 2009
QA status QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_fourthpulse.nPre

---

Control Settings

Main Settings

Simulation type	Forward
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.266	[psi]
External boundary radius	1000000	[m]
Formation conductivity	2.99933E-05	[m/sec]
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0665191	[m]
Skin zone conductivity	f(P) point	
Skin zone spec. storage	1.53930E-03	[1/m]

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

---

f(x) Points Parameters

Skin zone conductivity

Points type	f(P)	
Pressure #1	275.790	[psi]
Y value#1	4.35066E-07	[m/sec]
Pressure #2	386.106	[psi]
Y value#2	7.75374E-07	[m/sec]
Pressure #3	434.370	[psi]
Y value#3	3.20684E-06	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	2.19407E-04	[m^2/sec]
Storativity	7.31520E-06	[]
Diffusivity	2.99933E+01	[m^2/sec]

Skin Zone

Transmissivity	f(P)	

Storativity	1.12603E-02	[]
Diffusivity	f(P)	
Skin factor	f(P)	

Test Zone

Open hole well-bore storage	1.87793E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.07962	[]
First grid increment	1.09063E-02	[m]
Skin grid increment delta	0.01437	[]
Skin first grid increment	9.41999E-04	[m]
Skin last grid increment	1.87754E-03	[m]
Increment ratio	5.80881E+00	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	38378.367041	[day]
Duration	0.042030	[day]
Time step type	Static	
Static time step	0.000100	[day]
Type	Curve	
Wellbore storage	None	

Sequence: S_01

Sequence type	Slug	
Start time	38378.409071	[day]
Duration	0.006930	[day]
Time step type	Static	
Static time step	0.000010	[day]
Initial pressure type	Absolute	
Initial pressure	31.384	[psi]

Sequence: H_02

Sequence type	History	
Start time	38378.416001	[day]
Duration	0.159370	[day]
Time step type	Static	
Static time step	0.000100	[day]
Type	Curve	
Wellbore storage	None	

Test Zone Curves

Curve object to use	Create Curve	
Curve type	Pressure	
Start sequence	H_01	
End sequence	H_02	
Curve time base	Test	
Curve Y data units	[psi]	

Curve Y data is log 10	no

Simulation Results Setup

Output ID	DAT
Output type	Pressure
Pressure capture type	Test Zone
Output units	[psi]
Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[m^3/sec]

IMC-461 nSIGHTS Optimization Settings – Fourth Pulse

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   05 Jan 2009
QA status      QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_fourthpulse.nPre
```

Control Settings

Main Settings

Simulation type	Optimization
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.266	[psi]
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-10	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	2.99933E-05	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	0.001	[m]
Maximum value	1.0	[m]
Estimate value	0.0665191	[m]
Range type	Linear	
Sigma	1.00000E+00	
Skin zone conductivity	f(P) point	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	1.53930E-03	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

****
nPre/32 2.41Q
****

Version date 1 Mar 2007

Listing date 26 Nov 2008
QA status QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_fifthpulse.nPre

---

Control Settings

Main Settings

Simulation type	Forward	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	yes	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.266	[psi]
External boundary radius	1000000	[m]
Formation conductivity	3.06077E-05	[m/sec]
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0279449	[m]
Skin zone conductivity	f(P) point	
Skin zone spec. storage	9.99159E-03	[1/m]

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

f(x) Points Parameters

Skin zone conductivity

Points type	f(P)	
Pressure #1	275.790	[psi]
Y value#1	2.02988E-07	[m/sec]
Pressure #2	386.106	[psi]
Y value#2	4.45711E-07	[m/sec]
Pressure #3	434.370	[psi]
Y value#3	1.93963E-06	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	2.23901E-04	[m^2/sec]
Storativity	7.31520E-06	[]
Diffusivity	3.06077E+01	[m^2/sec]

Skin Zone

Transmissivity	f(P)	
Storativity	7.30905E-02	[]
Diffusivity	f(P)	
Skin factor	f(P)	

Test Zone

Open hole well-bore storage	1.87793E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.08136	[]
First grid increment	7.88538E-03	[m]
Skin grid increment delta	0.00729	[]
Skin first grid increment	4.76228E-04	[m]
Skin last grid increment	6.75749E-04	[m]
Increment ratio	1.16691E+01	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	38378.367041	[day]
Duration	0.138749	[day]
Time step type	Static	
Static time step	0.000100	[day]
Type	Curve	
Wellbore storage	None	

Sequence: S_01

Sequence type	Slug	
Start time	38378.505790	[day]
Duration	0.009160	[day]
Time step type	Static	
Static time step	0.000010	[day]
Initial pressure type	Absolute	
Initial pressure	13.810	[psi]

Sequence: H_02

Sequence type	History	
Start time	38378.514950	[day]
Duration	0.060420	[day]
Time step type	Static	
Static time step	0.000100	[day]
Type	Curve	
Wellbore storage	None	

Test Zone Curves

Curve object to use	Create Curve	
Curve type	Pressure	
Start sequence	H_01	
End sequence	H_02	
Curve time base	Test	
Curve Y data units	[psi]	
Curve Y data is log 10	no	

Simulation Results Setup

Output ID	DAT	
Output type	Pressure	
Pressure capture type	Test Zone	
Output units	[psi]	
Output ID	DAT	
Output type	Flow Rate	
Flow rate output type	Well	
Output units	[m^3/sec]	

IMC-461 nSIGHTS Optimization Settings – Fifth Pulse

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   26 Nov 2008
QA status      QA: Q
Config file
C:\SANDIA_PROJECTS\WIPP_wells\Culebra\IMC_461\IMC_461_fifthpulse.nPre
```

Control Settings

Main Settings

Simulation type	Optimization	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	yes	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	24.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	60.266	[psi]
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-10	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	3.06077E-05	[m/sec]
Range type	Log	
Sigma	1.00000E+00	

Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	0.001	[m]
Maximum value	1.0	[m]
Estimate value	0.0279449	[m]
Range type	Linear	
Sigma	1.00000E+00	
Skin zone conductivity	f(P) point	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	9.99159E-03	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1008.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.5625	[in]
Tubing string radius	0.957	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.00000E-15	[m^3/sec]

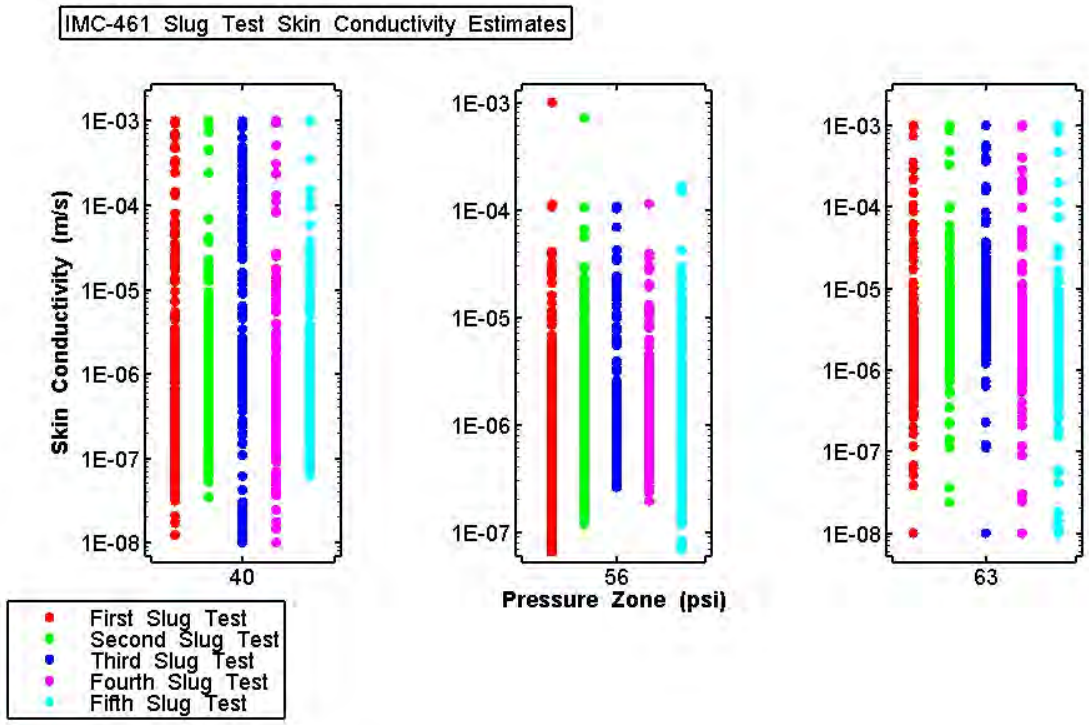

Figure B-3. A comparison of skin conductivity estimates for the five IMC-461 slug test perturbation analyses.

B.3 C-2737 nSIGHTS Listings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   07 Jan 2009
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Magenta\CopyofC2737\C-
2737_first.nPre
```

Control Settings

Main Settings

Simulation type	Forward	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	yes	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	23.300	[ft]
Flow dimension	2.0	[]
Static formation pressure	150.683	[psi]
External boundary radius	1000000	[m]
Formation conductivity	2.09942E-08	[m/sec]
Formation spec. storage	8.77373E-06	[1/m]

Skin

Radial thickness of skin	2.9999972	[m]

Skin zone conductivity	3.36784E-08	[m/sec]
Skin zone spec. storage	1.00000E-07	[1/m]

Fluid

Fluid density	1012.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	6.125	[in]
Tubing string radius	0.995	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

Calculated Parameters

Formation

Transmissivity	1.49097E-07	[m^2/sec]
Storativity	6.23096E-05	[]
Diffusivity	2.39284E-03	[m^2/sec]

Skin Zone

Transmissivity	2.39179E-07	[m^2/sec]
Storativity	7.10185E-07	[]
Diffusivity	3.36784E-01	[m^2/sec]
Skin factor	-1.13358E+00	[]

Test Zone

Open hole well-bore storage	2.02200E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.06365	[]
First grid increment	2.07382E-01	[m]
Skin grid increment delta	0.06142	[]
Skin first grid increment	9.85570E-03	[m]
Skin last grid increment	1.87996E-01	[m]
Increment ratio	1.10312E+00	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	39091.739900	[day]
Duration	0.639270	[day]
Time step type	Log	

First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: H_02

Sequence type	History	
Start time	39092.379170	[day]
Duration	0.003590	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: S_01

Sequence type	Slug	
Start time	39092.382760	[day]
Duration	1.125573	[day]
Time step type	Log	
First log step	1.15741E-03	[day]
# of time steps	250	
Initial pressure type	Absolute	
Initial pressure	51.362	[psi]

Sequence: H_03

Sequence type	History	
Start time	39093.508333	[day]
Duration	4.094447	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: H_04

Sequence type	History	
Start time	39097.602780	[day]
Duration	2.518054	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Test Zone Curves

Curve object to use	Create Curve
Curve type	Pressure
Start sequence	H_01
End sequence	H_04
Curve time base	Test
Curve Y data units	[psi]
Curve Y data is log 10	no

Simulation Results Setup

Output ID	DAT
Output type	Pressure
Pressure capture type	Test Zone
Output units	[psi]

Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[USgpm]

C-2737 Slug-Withdrawal Optimization Settings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   07 Jan 2009
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Magenta\CopyofC2737\C-
2737_first.nPre
```

Control Settings

Main Settings

Simulation type	Optimization
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	23.300	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	140.000	[psi]
Maximum value	165.000	[psi]
Estimate value	150.683	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-09	[m/sec]
Maximum value	1.00000E-05	[m/sec]
Estimate value	2.09942E-08	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	Optimization	
Minimum value	1.00000E-07	[1/m]
Maximum value	1.00000E-04	[1/m]
Estimate value	8.77373E-06	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Skin

Radial thickness of skin	Optimization	
Minimum value	0.0001	[m]
Maximum value	3.0	[m]
Estimate value	2.9999972	[m]
Range type	Log	
Sigma	1.00000E+00	
Skin zone conductivity	Optimization	
Minimum value	1.00000E-10	[m/sec]
Maximum value	1.00000E-04	[m/sec]
Estimate value	3.36784E-08	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-07	[1/m]
Maximum value	1.00000E-05	[1/m]
Estimate value	1.00000E-07	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1012.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	6.125	[in]
Tubing string radius	0.995	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

****
nPre/32 2.41Q
****

Version date 1 Mar 2007
Listing date 07 Jan 2009
QA status QA: Q
Config file C:\SANDIA_PROJECTS\WIPP_wells\Magenta\CopyofC2737\C-2737_second.nPre

---

Control Settings

Main Settings

Simulation type	Forward
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	23.300	[ft]
Flow dimension	2.0	[]
Static formation pressure	151.358	[psi]

External boundary radius	1000000	[m]
Formation conductivity	2.94316E-08	[m/sec]
Formation spec. storage	6.84488E-06	[1/m]

Skin

Radial thickness of skin	0.1188325	[m]
Skin zone conductivity	2.42957E-08	[m/sec]
Skin zone spec. storage	6.15783E-06	[1/m]

Fluid

Fluid density	1000.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	6.125	[in]
Tubing string radius	0.995	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

Calculated Parameters

Formation

Transmissivity	2.09019E-07	[m^2/sec]
Storativity	4.86113E-05	[]
Diffusivity	4.29980E-03	[m^2/sec]

Skin Zone

Transmissivity	1.72544E-07	[m^2/sec]
Storativity	4.37319E-05	[]
Diffusivity	3.94550E-03	[m^2/sec]
Skin factor	1.19962E-01	[]

Test Zone

Open hole well-bore storage	2.04627E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.07592	[]
First grid increment	2.16451E-02	[m]
Skin grid increment delta	0.01158	[]
Skin first grid increment	1.81224E-03	[m]
Skin last grid increment	3.15968E-03	[m]
Increment ratio	6.85041E+00	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	39091.739900	[day]
Duration	0.639270	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: H_02

Sequence type	History	
Start time	39092.379170	[day]
Duration	0.003590	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: H_03

Sequence type	History	
Start time	39092.382760	[day]
Duration	5.215850	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: H_04

Sequence type	History	
Start time	39097.598610	[day]
Duration	0.004170	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: S_01

Sequence type	Slug	
Start time	39097.602780	[day]
Duration	1.397220	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Initial pressure type	Absolute	
Initial pressure	182.669	[psi]

Test Zone Curves

Curve object to use	Create Curve
Curve type	Pressure
Start sequence	H_01
End sequence	S_01
Curve time base	Test
Curve Y data units	[psi]
Curve Y data is log 10	no

Simulation Results Setup

Output ID	DAT
Output type	Pressure
Pressure capture type	Test Zone
Output units	[psi]

Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[USgpm]

C-2737 Slug-Injection Optimization Settings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   07 Jan 2009
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Magenta\CopyofC2737\C-
2737_second.nPre
```

Control Settings

Main Settings

Simulation type	Optimization
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	23.300	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	140.000	[psi]
Maximum value	165.000	[psi]
Estimate value	151.358	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-09	[m/sec]
Maximum value	1.00000E-05	[m/sec]
Estimate value	2.94316E-08	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	Optimization	
Minimum value	1.00000E-07	[1/m]
Maximum value	1.00000E-04	[1/m]
Estimate value	6.84488E-06	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Skin

Radial thickness of skin	0.1188325	[m]
Skin zone conductivity	2.42957E-08	[m/sec]
Skin zone spec. storage	6.15783E-06	[1/m]

Fluid

Fluid density	1000.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	6.125	[in]
Tubing string radius	0.995	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

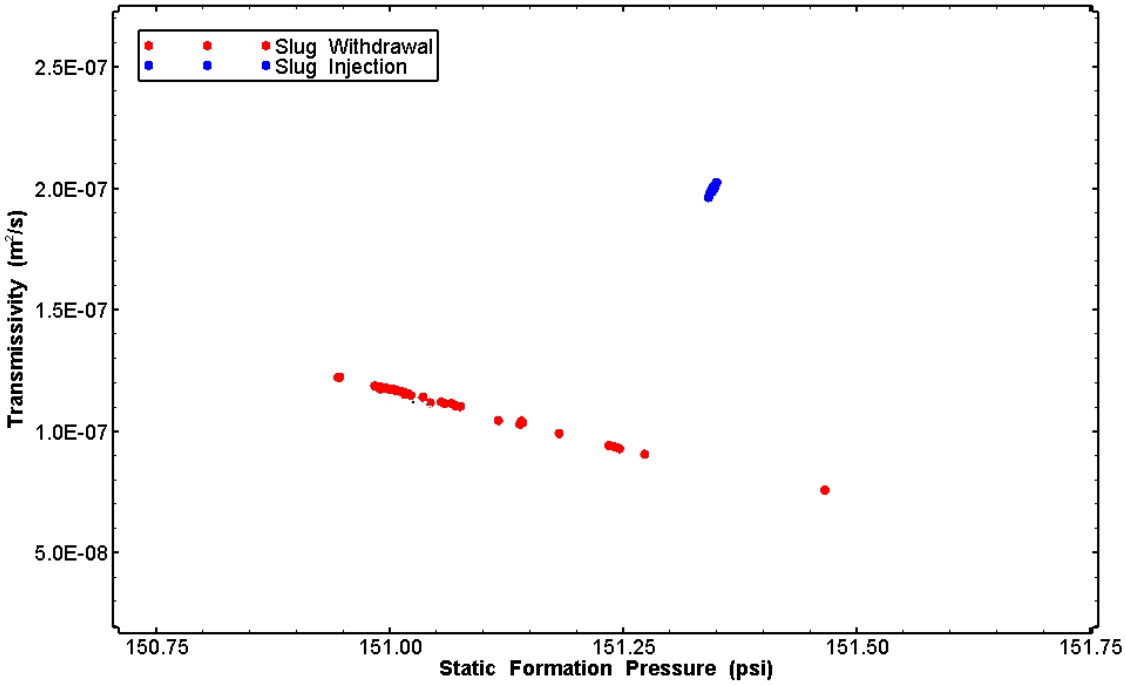

Figure B-4. Estimates of formation transmissivity and static formation pressure derived from the C-2737 perturbation analysis.

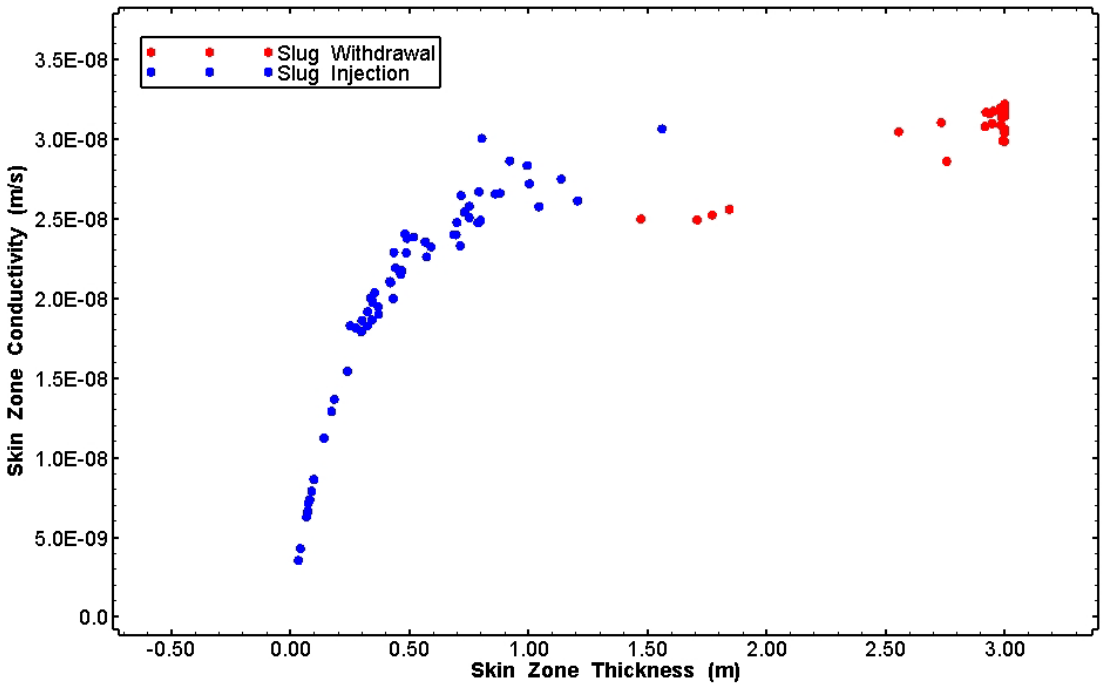

Figure B-5. Estimates of skin zone conductivity and skin zone thickness derived from the C-2737 perturbation analysis.

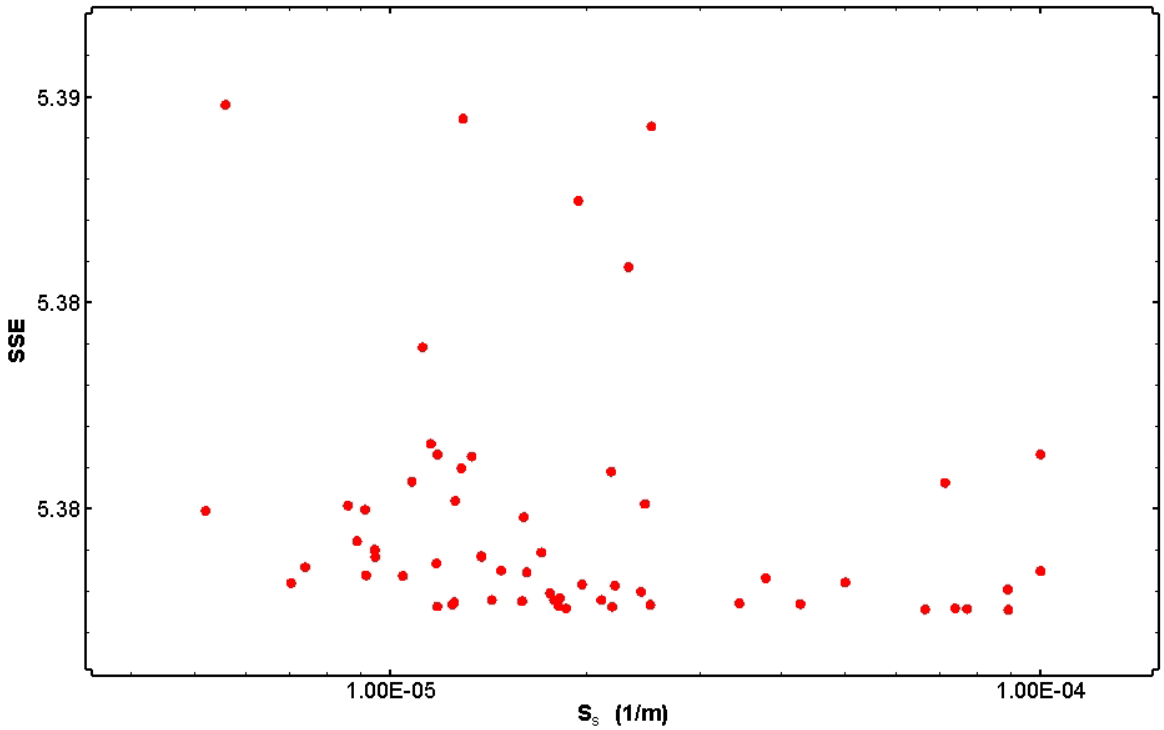

Figure B-6. XY-scatter plot showing 43 estimates of specific storage derived from the C-2737 slug-withdrawal test perturbation analysis

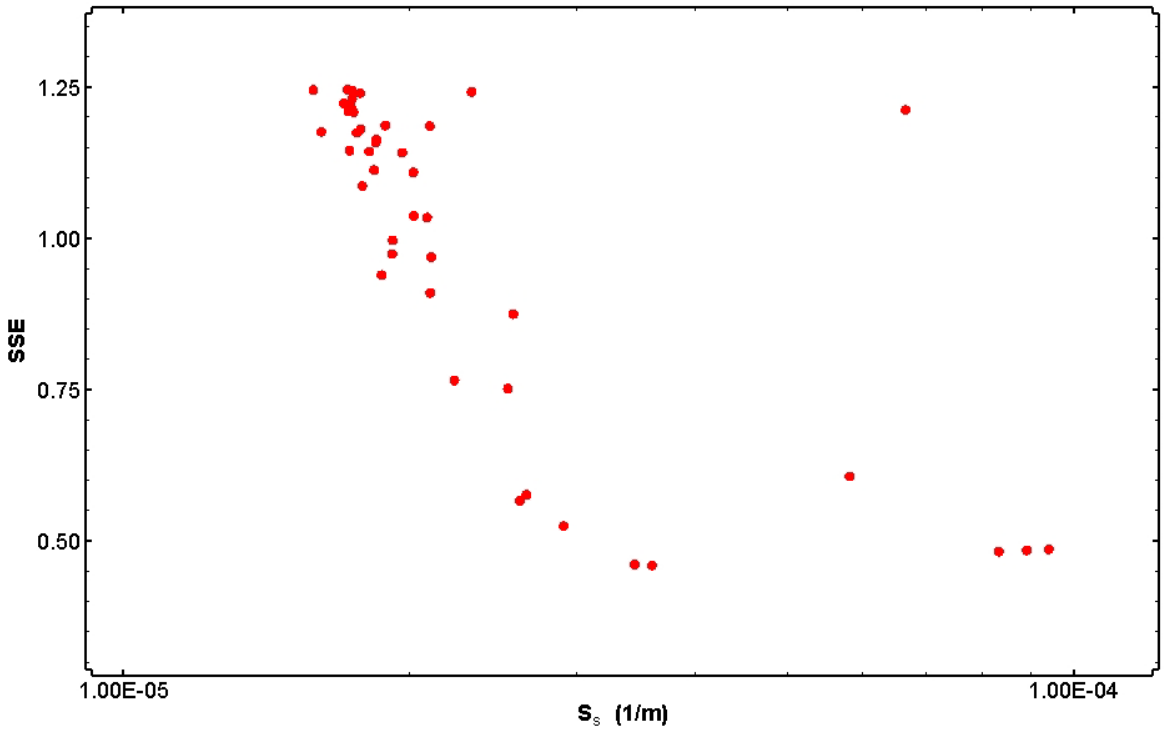

Figure B-7. XY-scatter plot showing 59 estimates of specific storage derived from the C-2737 slug-injection test perturbation analysis

B.4 H-11b2 nSIGHTS Listings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   14 Jan 2009
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Magenta\H-11b2\h-11b2(m).nPre
```

Control Settings

Main Settings

Simulation type	Forward	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	yes	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	26.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	171.942	[psi]
External boundary radius	1000000	[m]
Formation conductivity	1.97204E-08	[m/sec]
Formation spec. storage	1.00000E-08	[1/m]

Skin

Radial thickness of skin	0.1068659	[m]
Skin zone conductivity	1.94818E-03	[m/sec]

Skin zone spec. storage	9.92250E-03	[1/m]

Fluid

Fluid density	1041.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.9375	[in]
Tubing string radius	0.795	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

Calculated Parameters

Formation

Transmissivity	1.56280E-07	[m^2/sec]
Storativity	7.92480E-08	[]
Diffusivity	1.97204E+00	[m^2/sec]

Skin Zone

Transmissivity	1.54389E-02	[m^2/sec]
Storativity	7.86338E-02	[]
Diffusivity	1.96340E-01	[m^2/sec]
Skin factor	-7.26829E-01	[]

Test Zone

Open hole well-bore storage	1.25487E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.07734	[]
First grid increment	1.66355E-02	[m]
Skin grid increment delta	0.01483	[]
Skin first grid increment	1.49458E-03	[m]
Skin last grid increment	3.04606E-03	[m]
Increment ratio	5.46131E+00	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	39559.111111	[day]
Duration	0.499999	[day]
Time step type	Static	
Static time step	0.000116	[day]

Type	Curve	
Wellbore storage	None	

Sequence: H_02

Sequence type	History	
Start time	39559.611110	[day]
Duration	0.346400	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: F_01

Sequence type	Flow	
Start time	39559.957510	[day]
Duration	1.734160	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	-0.2	[USgpm]
Wellbore storage	Open	

Sequence: H_03

Sequence type	History	
Start time	39561.691670	[day]
Duration	0.904860	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	
Start time	39562.596530	[day]
Duration	27.111803	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Test Zone Curves

Curve object to use	Create Curve	
Curve type	Pressure	
Start sequence	H_01	
End sequence	F_02	
Curve time base	Test	
Curve Y data units	[psi]	
Curve Y data is log 10	no	

Simulation Results Setup

Output ID	DAT
Output type	Pressure
Pressure capture type	Test Zone
Output units	[psi]

Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[USgpm]

H-11b2 nSIGHTS Optimization Settings

Version date	1 Mar 2007
Listing date	14 Jan 2009
QA status	QA: Q
Config file	C:\SANDIA_PROJECTS\WIPP_wells\Magenta\H-11b2\h-11b2(m).nPre

Control Settings

Main Settings

Simulation type	Optimization
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	26.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	165.000	[psi]
Maximum value	190.000	[psi]
Estimate value	171.942	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-09	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	1.97204E-08	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	1.00000E-08	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	0.001	[m]
Maximum value	5.0	[m]
Estimate value	0.1068659	[m]
Range type	Linear	
Sigma	1.00000E+00	
Skin zone conductivity	Optimization	
Minimum value	1.00000E-08	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	1.94818E-03	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	9.92250E-03	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1041.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.9375	[in]
Tubing string radius	0.795	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

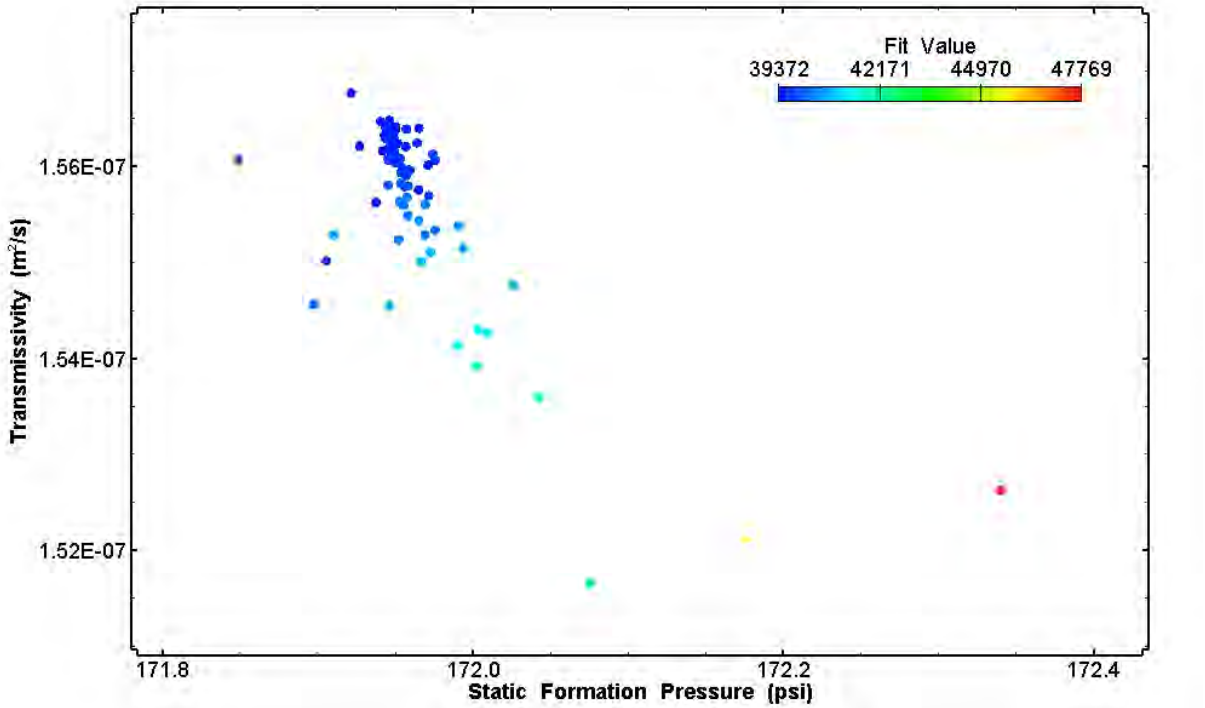

Figure B-8. Estimates of formation transmissivity and static formation pressure derived from the H-11b2 perturbation analysis.

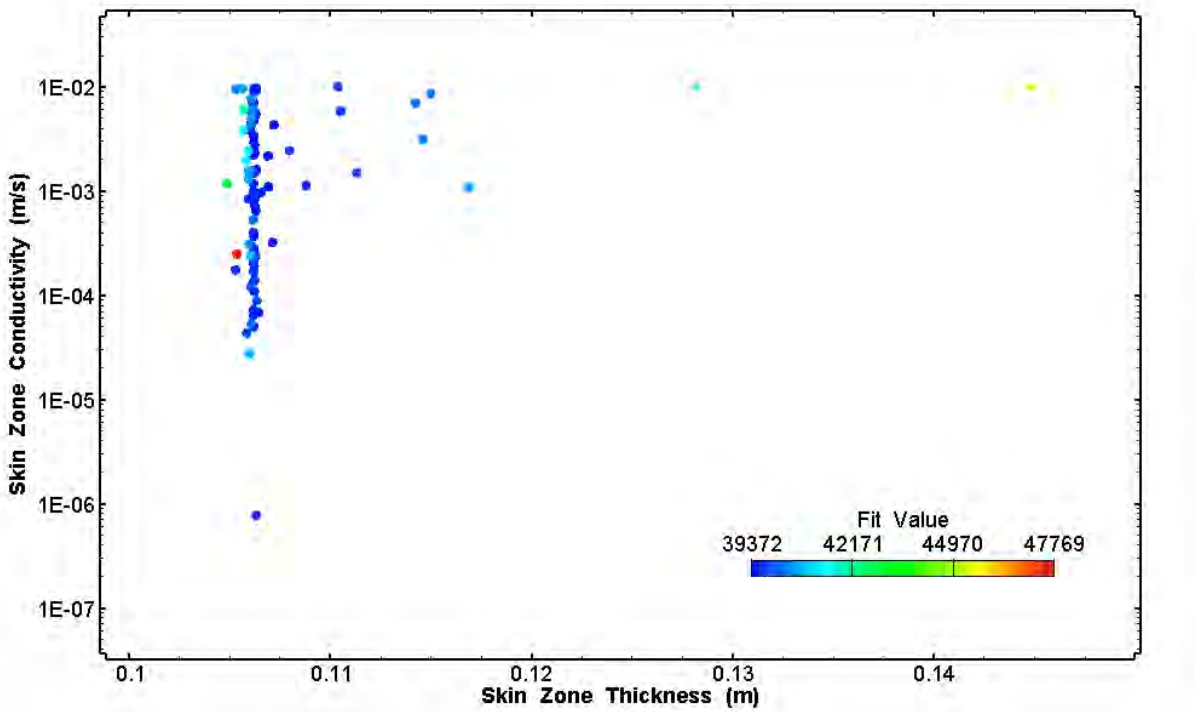

Figure B-9. Estimates of skin zone conductivity and skin zone thickness derived from the H-11b2 perturbation analysis.

B.5 H-15 nSIGHTS Listings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   25 Nov 2008
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Magenta\H-15\H-15(m).nPre
```

Control Settings

Main Settings

Simulation type	Forward	
Simulation subtype	Normal	
Phase to simulate	Liquid	
Skin zone ?	yes	
External boundary	Fixed Pressure	
Curve data source	Objects	

Liquid Phase Settings

Aquifer type	Confined	
Aquifer horizontal permeability	Isotropic	
System porosity	Single	
Compensate flow dimension geometry	yes	
Leakage	None	

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	25.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	185.750	[psi]
External boundary radius	1000000	[m]
Formation conductivity	1.24693E-07	[m/sec]
Formation spec. storage	1.50767E-07	[1/m]

Skin

Radial thickness of skin	0.4105964	[m]
Skin zone conductivity	8.73378E-03	[m/sec]

Skin zone spec. storage	1.50815E-03	[1/m]

Fluid

Fluid density	1073.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.9375	[in]
Tubing string radius	0.795	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

Calculated Parameters

Formation

Transmissivity	9.50160E-07	[m^2/sec]
Storativity	1.14884E-06	[]
Diffusivity	8.27059E-01	[m^2/sec]

Skin Zone

Transmissivity	6.65514E-02	[m^2/sec]
Storativity	1.14921E-02	[]
Diffusivity	5.79106E+00	[m^2/sec]
Skin factor	-1.63029E+00	[]

Test Zone

Open hole well-bore storage	1.21745E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.07280	[]
First grid increment	3.85601E-02	[m]
Skin grid increment delta	0.03327	[]
Skin first grid increment	3.38355E-03	[m]
Skin last grid increment	1.67093E-02	[m]
Increment ratio	2.30771E+00	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	39524.530000	[day]
Duration	0.088700	[day]
Time step type	Static	
Static time step	0.000116	[day]

Type	Curve	
Wellbore storage	Open	

Sequence: F_01

Sequence type	Flow	
Start time	39524.618700	[day]
Duration	2.079200	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	-1.0	[USgpm]
Wellbore storage	Open	

Sequence: H_02

Sequence type	History	
Start time	39526.697900	[day]
Duration	0.001420	[day]
Time step type	Static	
Static time step	0.000010	[day]
Type	Curve	
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	
Start time	39526.699320	[day]
Duration	0.209280	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	-1.5	[USgpm]
Wellbore storage	Open	

Sequence: F_03

Sequence type	Flow	
Start time	39526.908600	[day]
Duration	11.802700	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Test Zone Curves

Curve object to use	Create Curve	
Curve type	Pressure	
Start sequence	H_01	
End sequence	F_03	
Curve time base	Test	
Curve Y data units	[psi]	
Curve Y data is log 10	no	

Simulation Results Setup

Output ID	DAT
Output type	Pressure
Pressure capture type	Test Zone
Output units	[psi]

Output ID	DAT
Output type	Flow Rate
Flow rate output type	Well
Output units	[USgpm]

H-15 Optimization Settings

```
*************
nPre/32 2.41Q
*************

Version date   1 Mar 2007
Listing date   25 Nov 2008
QA status      QA: Q
Config file    C:\SANDIA_PROJECTS\WIPP_wells\Magenta\H-15\H-15(m).nPre
```

Control Settings

Main Settings

Simulation type	Optimization
Simulation subtype	Normal
Phase to simulate	Liquid
Skin zone ?	yes
External boundary	Fixed Pressure
Curve data source	Objects

Liquid Phase Settings

Aquifer type	Confined
Aquifer horizontal permeability	Isotropic
System porosity	Single
Compensate flow dimension geometry	yes
Leakage	None

Test Zone Settings

Test zone volume can vary	no	
Test zone compressibility can vary	no	
Test zone temperature can vary	no	
Default test-zone temperature	20.00	[C]
Solution variable	Pressure	
Allow negative head/pressure	yes	

Parameters

Formation

Formation thickness	25.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	185.750	[psi]
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-08	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	1.24693E-07	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Formation spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	1.50767E-07	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Skin

Radial thickness of skin	Optimization	
Minimum value	0.001	[m]
Maximum value	5.0	[m]
Estimate value	0.4105964	[m]
Range type	Linear	
Sigma	1.00000E+00	
Skin zone conductivity	Optimization	
Minimum value	1.00000E-12	[m/sec]
Maximum value	1.00000E-02	[m/sec]
Estimate value	8.73378E-03	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-12	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	1.50815E-03	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1073.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.9375	[in]
Tubing string radius	0.795	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
Pressure solution tolerance	1.45038E-11	[psi]
STP flow solution tolerance	1.58503E-11	[USgpm]

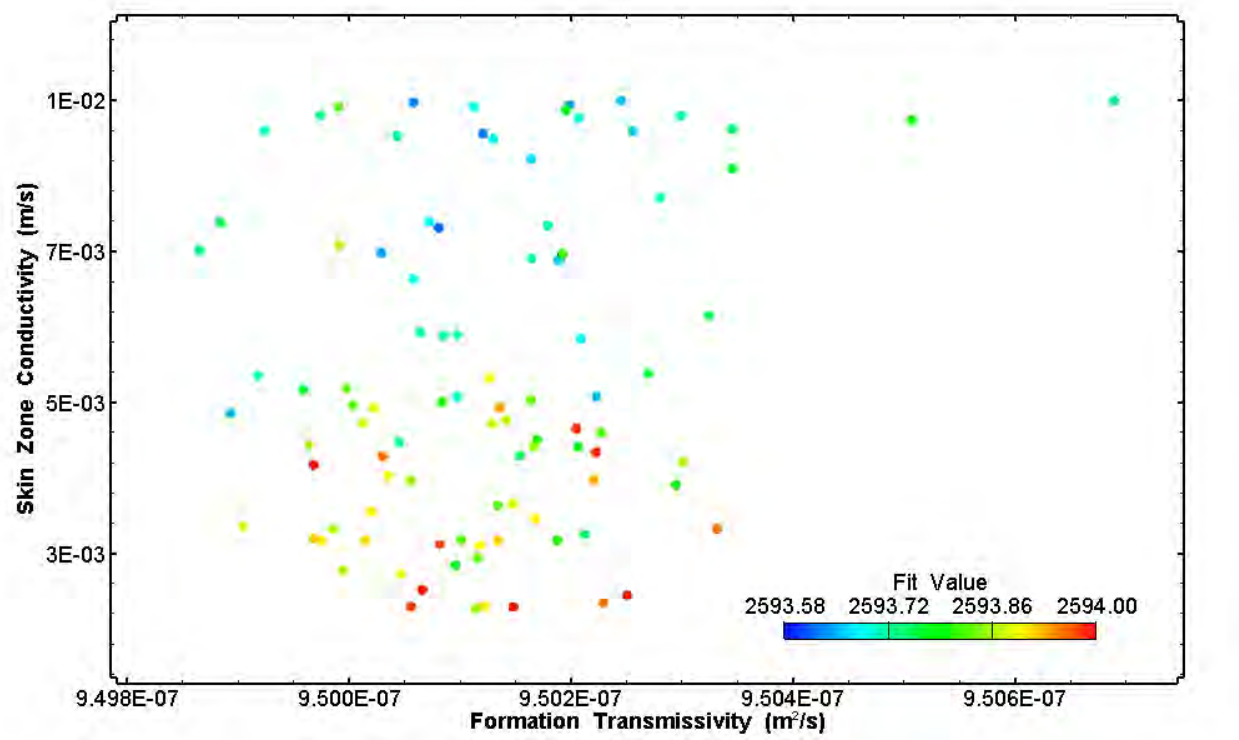

Figure B-10. Estimates of skin hydraulic conductivity and formation transmissivity derived from the H-15 perturbation analysis.

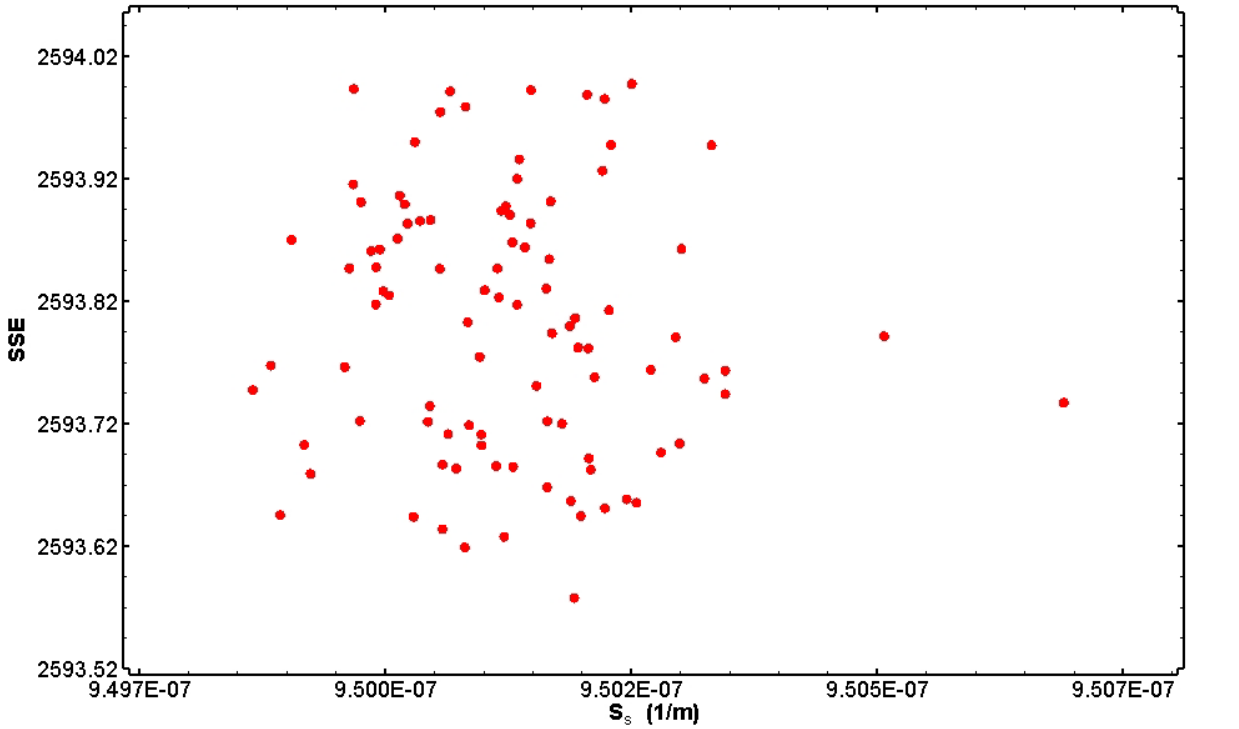

Figure B-11. XY-scatter plot showing 96 estimates of specific storage derived from the H-15 perturbation analysis.

Appendix C – File Directories

Table C-1. File descriptions.

File Extension	Function/Use
<filename>.nPre	Files used for initial well test analysis.
<filename>X.nPre	Files used to generate perturbation analysis of .nPre results.
.nPost	Post-processing files used to visualize .nPre and perturbation analysis.
.nOpt	Optimization data used for post processing in .nPost files.
<filename>.nXYSim	Simulation data used for post processing in .nPost files.
<filename>FieldData.nXYSim	Field data used for post processing in .nPost files.
.jpg	Graphic output from .nPost files.
.csv,.xls, .dat	Data files used as input for .nPre files.

D:\>dir/s
Volume in drive D is AP-070_AnalysisRpt_2-09_Disk1
Volume Serial Number is 4999-834C

Directory of AP-070_AnalysisRpt_2-09_disk1\

02/16/2009 03:19 PM <DIR> Culebra
02/16/2009 03:16 PM <DIR> Magenta
0 File(s) 0 bytes

Directory of AP-070_AnalysisRpt_2-09_Disk1\Culebra

02/16/2009 03:19 PM <DIR> .
02/25/2041 03:44 PM <DIR> ..
02/16/2009 03:19 PM <DIR> SNL_6
0 File(s) 0 bytes

Directory of AP-070_AnalysisRpt_2-09_Disk1\Culebra\SNL_6

02/16/2009 03:19 PM <DIR> .
02/25/2041 03:44 PM <DIR> ..
02/16/2009 03:20 PM <DIR> Data
02/16/2009 03:20 PM <DIR> Figures
02/16/2009 03:19 PM <DIR> Post
11/06/2008 09:35 AM 33,089 SNL 6.nPre
11/05/2008 03:14 PM 20,075 SNL_6X.nPre
2 File(s) 53,164 bytes

Directory of AP-070_AnalysisRpt_2-09_Disk1\Culebra\SNL_6\Data

02/16/2009 03:20 PM <DIR> .

```
02/25/2041  03:44 PM    <DIR>          ..
02/01/2007  10:41 AM         1,071,616 SN102927 SNL-6(C1) 2006-01-30.xls
10/06/2008  09:42 AM           489,558 SNL 6.csv
10/06/2008  09:27 AM            10,240 SNL-6 Pressure History_new.xls
03/06/2008  10:06 AM         3,564,032 SNL-6(C-C4) 11-18-2005 to 2-26-2008.xls
03/06/2008  10:06 AM            28,160 SNL-6.xls
03/06/2008  10:10 AM           476,081 SNL-6c.dat
               6 File(s)      5,639,687 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Culebra\SNL_6\Figures

02/16/2009  03:20 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
11/06/2008  09:12 AM            85,850 Pf vs T.JPG
10/07/2008  07:56 AM            66,552 SNL-6 Cartesian History.JPG
10/07/2008  01:01 PM            67,060 SNL-6 Cartesian Horsetail.JPG
10/07/2008  12:59 PM            71,097 SNL-6 Cartesian.JPG
01/06/2009  09:53 AM            67,748 SNL-6 Ss vs SSE.JPG
11/06/2008  09:11 AM            60,866 SSE vs Pf.JPG
11/06/2008  09:11 AM            73,780 SSE vs T.JPG
               7 File(s)        492,953 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Culebra\SNL_6\Post

02/16/2009  03:19 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
01/06/2009  09:56 AM            18,219 SNL-6.nPost
10/07/2008  07:39 AM         1,941,504 SNL-6_Field Data.nXYSim
11/05/2008  04:43 PM         6,160,384 SNL6.nOpt
11/05/2008  04:43 PM        86,032,384 SNL6.nXYSim
               4 File(s)     94,152,491 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta

02/16/2009  03:16 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
02/16/2009  03:18 PM    <DIR>          C2737
02/16/2009  03:18 PM    <DIR>          H-11b2
02/16/2009  03:16 PM    <DIR>          H-15
               0 File(s)              0 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\C2737

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
01/06/2009  12:23 PM            26,459 C-2737_first.nPre
```

```
01/06/2009  12:37 PM            19,081 C-2737_firstX.nPre
01/06/2009  02:10 PM            27,742 C-2737_second.nPre
01/06/2009  03:43 PM            20,354 C-2737_secondX.nPre
02/16/2009  03:19 PM    <DIR>          Data
02/16/2009  03:19 PM    <DIR>          Figures
02/16/2009  03:18 PM    <DIR>          Post
               4 File(s)         93,636 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\C2737\Data

02/16/2009  03:19 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
06/18/2008  12:57 PM           720,539 SN110382 C-2737(Slug1) 2007-02-01 16-28-4
5b.csv
06/18/2008  12:32 PM         5,391,360 SN110382 C-2737(Slug1) 2007-02-01 16-28-4
5b.xls
               2 File(s)      6,111,899 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\C2737\Figures

02/16/2009  03:19 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
10/06/2008  08:50 AM            82,066 C-2737 Cartesian Horsetail_01.JPG
10/06/2008  08:51 AM            88,224 C-2737 Cartesian Horsetail_02.JPG
10/01/2008  02:27 PM            84,156 C-2737 Cartesian.JPG
01/07/2009  09:56 AM           137,508 C-2737 Ramey A Slug 1 Horsetail.JPG
01/07/2009  09:58 AM           137,017 C-2737 Ramey A Slug 2 Horsetail.JPG
01/07/2009  09:57 AM           125,411 C-2737 Ramey B Slug 1 Horsetail.JPG
01/07/2009  09:58 AM           139,015 C-2737 Ramey B Slug 2 Horsetail.JPG
01/06/2009  09:44 AM            66,208 C-2737 Ss vs SSE_01.JPG
01/06/2009  09:43 AM            55,682 C-2737 Ss vs SSE_02.JPG
01/07/2009  11:47 AM            53,155 C-2737 Ss vs SSE_1.JPG0009.JPG
01/07/2009  11:47 AM            60,133 C-2737 Ss vs SSE_2.JPG0009.JPG
01/07/2009  09:55 AM            60,309 C-2737 SSE_01.JPG
01/07/2009  09:55 AM            68,362 C-2737 SSE_02.JPG
01/07/2009  10:00 AM           103,253 Kskin vs Lskin.JPG
01/07/2009  10:00 AM            75,163 T vs Pf.JPG
              15 File(s)      1,335,662 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\C2737\Post

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
01/06/2009  12:53 PM         6,160,384 C-2737_first.nOpt
01/06/2009  12:53 PM        28,688,384 C-2737_first.nXYSim
01/06/2009  02:13 PM           237,568 C-2737_first_Field Data.nXYSim
```

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01/06/2009  03:51 PM         6,160,384 C-2737_second.nOpt
01/06/2009  03:51 PM        28,688,384 C-2737_second.nXYSim
01/06/2009  03:26 PM           245,760 C-2737_second_Field Data.nXYSim
01/08/2009  08:37 AM            35,579 C2737.nPost
               7 File(s)     70,216,443 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-11b2

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
02/16/2009  03:18 PM    <DIR>          Data
02/16/2009  03:18 PM    <DIR>          Figures
01/15/2009  02:08 PM            37,370 h-11b2(m).nPre
01/14/2009  10:23 AM            25,246 h-11b2(m)X.nPre
02/16/2009  03:18 PM    <DIR>          Post
               2 File(s)         62,616 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-11b2\Data

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
01/15/2009  02:06 PM           507,224 H-11b2 (M)_5-sec_Flow Data_04-21 to 04-22
-2008.csv
01/15/2009  02:06 PM           860,189 H-11b2 (M)_5-sec_Flow Data_04-22 to 04-24
-2008.csv
10/02/2008  02:25 PM            66,920 h-11b2(m)_pressures.csv
               3 File(s)      1,434,333 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-11b2\Figures

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
10/02/2008  03:25 PM            87,900 H-11b2(m) Cartesian Horsetail.JPG
10/02/2008  03:25 PM            80,938 H-11b2(m) Cartesian.JPG
07/23/2008  01:25 PM           109,015 H-11b2(m) log-log Diag.JPG
11/25/2008  12:25 PM           127,433 H-11b2(m) log-log Horsetail.JPG
01/15/2009  02:13 PM           105,555 H-11b2(m) Pumping Rates.JPG
11/25/2008  12:26 PM            67,461 H-11b2(m) SSE.JPG
11/25/2008  12:48 PM            88,708 Kskin vs Lskin.JPG
11/25/2008  12:49 PM            81,229 T vs Pf.JPG
               8 File(s)        748,239 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-11b2\Post

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
```

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01/15/2009  02:13 PM            23,225 H-11b2.nPost
11/06/2008  06:24 PM           176,128 H-11b2_Field Data.nXYSim
11/06/2008  07:20 PM         6,160,384 H-11b2_Perturb.nOpt
11/06/2008  07:20 PM        34,832,384 H-11b2_Perturb.nXYSim
               4 File(s)     41,192,121 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-15

02/16/2009  03:16 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
02/16/2009  03:18 PM    <DIR>          Data
02/16/2009  03:18 PM    <DIR>          Figures
01/14/2009  02:13 PM            53,828 H-15(m).nPre
11/06/2008  08:19 PM            33,522 H-15(m)X.nPre
02/16/2009  03:16 PM    <DIR>          Post
               2 File(s)         87,350 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-15\Data

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
04/07/2008  10:04 AM               213 H-15 (M) Pumping Test_SpGrav.csv
04/07/2008  10:04 AM            56,800 H-15 (M)_15-min_All Data_03-17 to 03-19-2
008.csv
04/07/2008  10:04 AM         1,491,787 H-15 (M)_5-sec_Flow Data_03-17 to 03-19-2
008.csv
04/07/2008  10:05 AM           989,102 pumping_rates.csv
04/09/2008  02:41 PM           641,783 response.csv
07/09/2008  01:50 PM           213,817 response2.csv
               6 File(s)      3,393,502 bytes

 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-15\Figures

02/16/2009  03:18 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
11/25/2008  12:31 PM           137,539 H-15 (m) Bourdet1 Horsetail.JPG
11/04/2008  02:22 PM           119,321 H-15 (m) Bourdet3 Horsetail.JPG
10/01/2008  01:33 PM            82,035 H-15 (m) Cartesian Horsetail.JPG
10/01/2008  01:34 PM            70,302 H-15 (m) Cartesian.JPG
01/14/2009  02:27 PM            79,176 H-15 (m) Pumping Data.JPG
01/06/2009  09:35 AM           100,277 H-15 (m) Ss vs SSE.JPG
11/25/2008  12:30 PM            98,537 H-15 (m) SSE Extract.JPG
07/23/2008  11:41 AM           108,998 H-15 Bourdet Diagnostic.JPG
11/25/2008  12:57 PM           116,123 T vs Kskin.JPG
               9 File(s)        912,308 bytes
```

```
 Directory of AP-070_AnalysisRpt_2-09_Disk1\Magenta\H-15\Post

02/16/2009  03:16 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
11/04/2008  02:16 PM         1,101,824 H-15(m)_Field Data.nXYSim
11/06/2008  10:24 PM         6,160,384 H-15(m)_Perturb.nOpt
11/06/2008  10:24 PM        86,032,384 H-15(m)_Perturb.nXYSim
01/14/2009  02:26 PM            19,935 H-15.nPost
               4 File(s)     93,314,527 bytes

    Total Files Listed:
              85 File(s)    319,240,931 bytes
              54 Dir(s)     276,731,904 bytes free
```

```
Volume in drive D is AP_070_AnalysisRpt_2-09_Disk2
 Volume Serial Number is 4999-8A74

 Directory of AP_070_AnalysisRpt_2-09_Disk2\

02/16/2009  03:48 PM    <DIR>          Culebra
               0 File(s)              0 bytes

 Directory of AP_070_AnalysisRpt_2-09_Disk2\Culebra

02/16/2009  03:48 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
02/16/2009  03:48 PM    <DIR>          IMC_461
               0 File(s)              0 bytes

 Directory of AP_070_AnalysisRpt_2-09_Disk2\Culebra\IMC_461

02/16/2009  03:48 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
02/16/2009  03:55 PM    <DIR>          Data
02/16/2009  03:55 PM    <DIR>          Figures
11/17/2008  03:45 PM            25,765 IMC_461_fifthpulse.nPre
11/17/2008  03:47 PM            18,143 IMC_461_fifthpulseX.nPre
11/07/2008  10:32 AM            25,701 IMC_461_firstpulse.nPre
11/07/2008  10:33 AM            18,147 IMC_461_firstpulseX.nPre
01/05/2009  02:07 PM            25,764 IMC_461_fourthpulse.nPre
01/05/2009  09:49 AM            18,145 IMC_461_fourthpulseX.nPre
11/19/2008  02:59 PM            25,701 IMC_461_secondpulse.nPre
11/19/2008  02:59 PM            18,149 IMC_461_secondpulseX.nPre
11/18/2008  04:21 PM            25,700 IMC_461_thirdpulse.nPre
11/18/2008  04:21 PM            18,146 IMC_461_thirdpulseX.nPre
```

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02/16/2009  03:48 PM    <DIR>          Post
              10 File(s)        219,361 bytes

 Directory of AP_070_AnalysisRpt_2-09_Disk2\Culebra\IMC_461\Data

02/16/2009  03:55 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
02/01/2005  09:07 AM            19,008 20 psi CRE deriv.dat
01/31/2005  04:32 PM            19,656 20 psi.dat
02/01/2005  09:08 AM            18,324 30 psi CRE deriv.dat
01/31/2005  04:32 PM            19,116 30 psi.dat
02/01/2005  09:09 AM            20,484 40 psi CRE deriv.dat
01/31/2005  04:32 PM            21,528 40 psi.dat
01/25/2005  03:43 PM            31,608 40psi deriv.dat
02/01/2005  09:20 AM            19,836 50 psi CRE deriv.dat
01/31/2005  04:33 PM            21,456 50 psi.dat
06/10/2008  10:34 AM             1,946 C6.txt
06/10/2008  10:08 AM            18,338 IMC-461 (pslug2).csv
01/31/2005  03:57 PM             7,139 IMC-461 (pslug2).txt
01/25/2005  11:56 AM            49,152 IMC-461 (pslug2).xls
06/10/2008  10:09 AM            62,888 IMC-461 (pslug3).csv
01/31/2005  05:05 PM            23,975 IMC-461 (pslug3).txt
01/25/2005  04:09 PM           133,120 IMC-461 (pslug3).xls
06/10/2008  10:09 AM            75,361 IMC-461 (pslug4).csv
01/31/2005  03:59 PM            29,418 IMC-461 (pslug4).txt
01/26/2005  01:48 PM           155,136 IMC-461 (pslug4).xls
06/26/2008  07:48 AM            81,016 IMC-461 (pslugs2&3).csv
07/03/2008  03:09 PM            13,824 IMC-461 Initial Estimates.xls
06/30/2008  12:26 PM            19,968 Pressure ring explanation.xls
              22 File(s)        862,297 bytes

 Directory of AP_070_AnalysisRpt_2-09_Disk2\Culebra\IMC_461\Figures

02/16/2009  03:55 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
10/01/2008  01:15 PM            59,911 All_tests.JPG
07/21/2008  06:46 AM            95,470 IMC-461 Cartesian Horsetail_p1.JPG
07/21/2008  07:01 AM            85,980 IMC-461 Cartesian Horsetail_p2.JPG
07/21/2008  07:00 AM            92,520 IMC-461 Cartesian Horsetail_p3.JPG
01/05/2009  01:33 PM           100,003 IMC-461 Cartesian Horsetail_p4.JPG
07/21/2008  07:10 AM            77,223 IMC-461 Cartesian Horsetail_p5.JPG
11/25/2008  09:43 AM           133,653 IMC-461 Ramey A Horsetail_p1.JPG
11/25/2008  09:45 AM           126,250 IMC-461 Ramey A Horsetail_p2.JPG
11/25/2008  09:48 AM           126,153 IMC-461 Ramey A Horsetail_p3.JPG
01/05/2009  01:36 PM           126,812 IMC-461 Ramey A Horsetail_p4.JPG
11/25/2008  10:01 AM           125,622 IMC-461 Ramey A Horsetail_p5.JPG
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11/25/2008  09:43 AM         118,176 IMC-461 Ramey B Horsetail_p1.JPG
11/25/2008  09:45 AM         119,962 IMC-461 Ramey B Horsetail_p2.JPG
11/25/2008  09:49 AM         117,273 IMC-461 Ramey B Horsetail_p3.JPG
01/05/2009  01:37 PM         116,370 IMC-461 Ramey B Horsetail_p4.JPG
11/25/2008  10:00 AM         123,194 IMC-461 Ramey B Horsetail_p5.JPG
07/22/2008  12:55 PM         129,061 SkinT comparison.JPG
01/05/2009  01:40 PM         206,635 Skin_K_compare.JPG
01/14/2009  01:58 PM          99,111 T comparison.JPG
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 Directory of AP_070_AnalysisRpt_2-09_Disk2\Culebra\IMC_461\Post

02/16/2009  03:48 PM    <DIR>          .
02/25/2041  03:44 PM    <DIR>          ..
01/14/2009  02:00 PM          35,778 IMC-461_comparison.nPost
11/25/2008  09:59 AM          57,344 IMC-461_fifth Field Data.nXYSim
11/17/2008  07:25 PM      72,990,720 IMC-461_fifth Perturb.nXYSim
11/25/2008  10:01 AM          12,743 IMC-461_fifthpulse.nPost
11/17/2008  07:25 PM       6,160,384 IMC-461_fifth_Perturb.nOpt
11/25/2008  09:39 AM          53,248 IMC-461_first Field Data.nXYSim
11/07/2008  12:45 PM      95,252,480 IMC-461_first Perturb.nXYSim
11/25/2008  09:44 AM          12,744 IMC-461_firstpulse.nPost
11/07/2008  12:45 PM       6,160,384 IMC-461_first_Perturb.nOpt
01/05/2009  01:13 PM          53,248 IMC-461_fourth Field Data.nXYSim
01/05/2009  11:29 AM      67,244,032 IMC-461_fourth Perturb.nXYSim
01/05/2009  01:39 PM          12,748 IMC-461_fourthpulse.nPost
01/05/2009  11:29 AM       6,160,384 IMC-461_fourth_Perturb.nOpt
11/25/2008  09:40 AM          57,344 IMC-461_second Field Data.nXYSim
11/19/2008  07:25 PM     169,537,536 IMC-461_second Perturb.nXYSim
11/25/2008  09:31 AM          12,748 IMC-461_secondpulse.nPost
11/19/2008  07:25 PM       6,160,384 IMC-461_second_Perturb.nOpt
07/25/2008  12:52 PM          53,248 IMC-461_third Field Data.nXYSim
11/18/2008  06:19 PM      70,922,240 IMC-461_third Perturb.nXYSim
11/25/2008  09:50 AM          12,746 IMC-461_thirdpulse.nPost
11/18/2008  06:19 PM       6,160,384 IMC-461_third_Perturb.nOpt
          21 File(s)    507,122,867 bytes

    Total Files Listed:
          72 File(s)    510,383,904 bytes
          15 Dir(s)      85,614,592 bytes free
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