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Analysis Report for AP-070

Analysis of Culebra Pumping Tests Performed Between December 2003 and August 2005

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

Task Number 1.4.2.3

Author: _____ 6/6/2006
Randall M. Roberts, 6822 Date
Repository Performance Department

Technical Review: _____ 6/6/2006
Richard L. Beauheim, 6822 Date
Repository Performance Department

QA Review: _____ 6/15/2006
Mario Chavez, 6820 Date
Carlsbad Programs Group

Management Review: _____ 6/6/2006
Mark Rigali, 6822 Date
Manager, Repository Performance Department

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1. Introduction

This report discusses the analyses of pumping tests performed in the Culebra Dolomite Member of the Rustler Formation at the Waste Isolation Pilot Plant (WIPP) site between December 2003 and August 2005. These analyses were performed between August 2005 and May 2006 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 2.30. 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-1, SNL-2, SNL-3, SNL-5, SNL-9, SNL-12, SNL-13, SNL-14, WIPP-11, WIPP-25, and C-2737. Both barometric and earth-tide effects were removed from the data sets prior to analysis.

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, post-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 1.

Figure 1. Directory structure for Culebra nSIGHTS analyses.

The nPre configuration file is stored in the folder named for the tested well (Figure 1). Transient pressure and flow-rate files are stored in the Data folder (Figure 2) and all nPre output files as well as the nPost configuration file are stored in the Post folder (Figure 3).

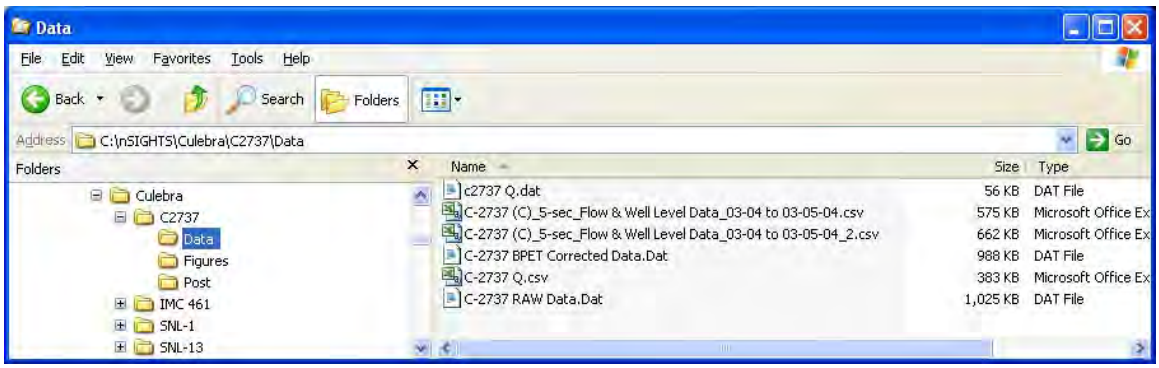

Figure 2. *Data* folder containing the pressure and flow-rate files for nPre input.

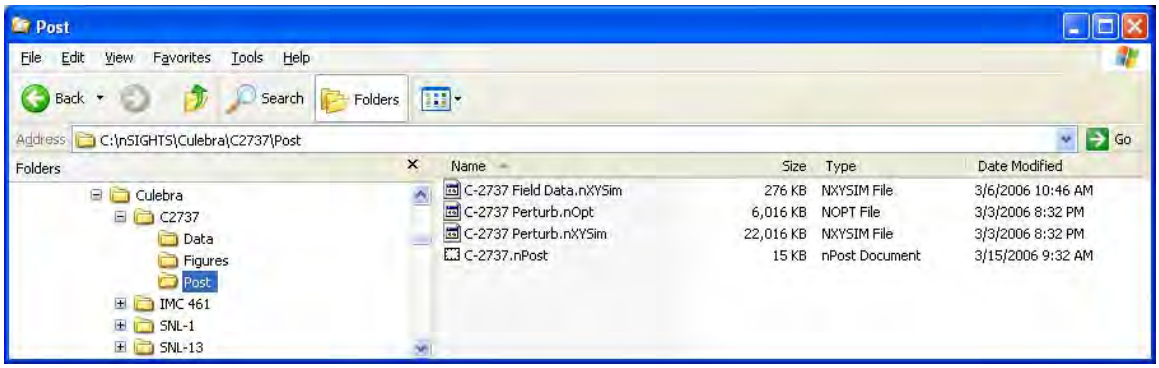

Figure 3. *Post* folder containing simulation output and post-processed data.

3. Test and Analysis Procedures

At some of the tested wells discussed in this report (e.g., SNL-1, SNL-2, SNL-12, C-2737), long-term pressure records were available leading up to the tests. When helpful, these pressure records were used to specify pre-test history sequences for the nSIGHTS test simulations.

The testing sequence at most of the wells discussed in this report consisted of a series of pumping events at more or less constant rates. Typically, a pump would be installed in the well and then turned on only long enough to bring water to ground surface. The day before the actual test was to begin, the pump would be operated just long enough to establish the rate the pump could sustain over the intended duration of the test and to set all control valves and the pump motor speed appropriate to that rate. The well would then be allowed to recover overnight before beginning the constant-rate test. In some instances (e.g., SNL-2), installing the pump and setting the rate were accomplished in the same day. In other instances (e.g., WIPP-11), the final constant-rate test was begun after only a few hours of recovery from the rate-setting event.

For analysis, these pre-test pumping events were treated in one of two ways. For SNL-1, SNL-12, and WIPP-11, the pre-test pumping events were simulated in the same way as the constant-rate test, but less weight was given to the pre-test pumping events in the parameter optimization process. For SNL-2, SNL-3, SNL-5, SNL-9, SNL-14, C-2737, and WIPP-25, the pre-test pumping events were treated as "history" periods and the associated pressures were simply specified in the simulations. All pressure recoveries were simulated.

Test analysis involved finding the values of the fitting parameters that produced the best simulated matches to the pressure data collected during the constant-rate test and subsequent recovery period. In addition to the formation properties of interest (principally transmissivity and flow dimension), tubing string radius was also included as a fitting parameter 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 shown in Table 1, however, is seen to be relatively small, so any correlation between T and other fitting parameters is not of interest.

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 adequately sample the parameter space 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 (500) 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.

4. Analysis Results

Discussions of the individual test analyses are given below. A summary of the transmissivity estimates obtained from perturbation analysis of each test is shown in Table 1.

Table 1. Transmissivity Estimates.

Well	Geometric Mean (m^2/s)	Minimum (m^2/s)	Maximum (m^2/s)	Variance
SNL-1	6.24E-04	5.97E-04	6.51E-04	2.95E-05
SNL-2	1.07E-04	1.03E-04	1.12E-04	2.32E-05
SNL-3	9.88E-04	4.32E-04	4.53E-03	7.84E-02
SNL-5	4.86E-06	2.20E-06	8.56E-06	4.31E-02
SNL-9	3.86E-05	3.56E-05	3.96E-05	5.90E-06
SNL-12	4.97E-04	4.89E-04	5.09E-04	1.01E-05
SNL-14	4.92E-05	4.81E-05	4.91E-05	2.00E-06
WIPP-11	4.27E-04	8.34E-05	2.42E-03	4.59E-01
WIPP-25	2.51E-04	2.21E-04	3.13E-04	2.50E-04
C-2737	6.62E-07	6.57E-07	6.63E-07	2.66E-08

4.1 SNL-1

On March 3, 2005, the Culebra interval in SNL-1 was acidized by injecting 48 barrels (7.63 m^3) of a 15% hydrochloric acid (HCl) solution followed by 48 barrels (7.63 m^3) of fresh water into the well. A pump was installed in the well after the acidization on March 3, 2005, and an evaluation of potential pumping rates was performed on March 4, 2005. Testing activities in SNL-1 were initiated on March 7, 2005. Three preliminary pumping episodes lasting between 19.5 minutes and 17.7 hours occurred before the final 40.46-hr test at 35 gpm. Figure 4 shows the pressure record from SNL-1 used in this analysis. The pressures measured prior to the start of the testing activities on March 7, 2005, were included in the nSIGHTS simulation as a pressure history. The pressures shown in Figure 4 were separated into 11 nSIGHTS sequences

for this analysis. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the SNL-1.nPre file and are listed in Appendix B.1.

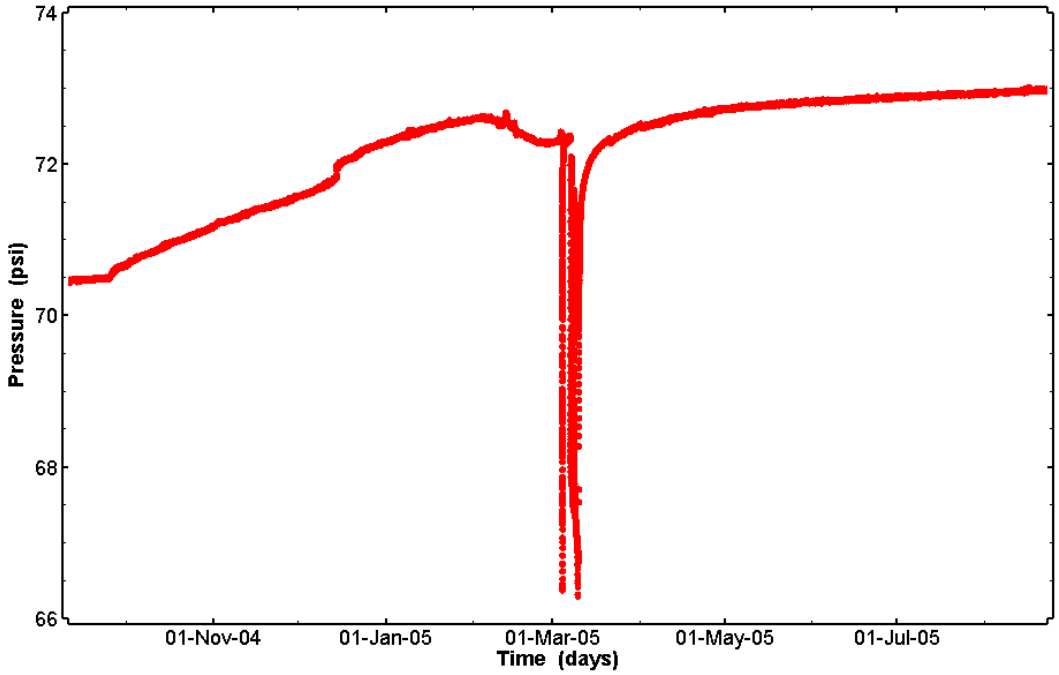

Figure 4. Pressure data from SNL-1.

The specified SNL-1 conceptual model, based on the characteristics of the final buildup period diagnostic plot shown in Figure 5, was a composite-geometry (n) system with wellbore storage and skin. The pressure derivative indicated radial flow (n = 2) until about 500 minutes elapsed time (Figure 5). After that time, the upward sloping late-time derivative indicates far-field sub-radial flow (n < 2), which could be indicative of a decrease in transmissivity with distance. The range of transmissivity (T) values estimated from the SNL-1 analysis for the radial-flow period (?) is shown in Figure 6. The SNL-1 geometric mean T value was 6.24E-4 m^2/s. The Cartesian, detailed Cartesian, and log-log pressure-buildup diagnostic simulations corresponding to the T values in Figure 6 are shown in Figures 7, 8, and 9, respectively.

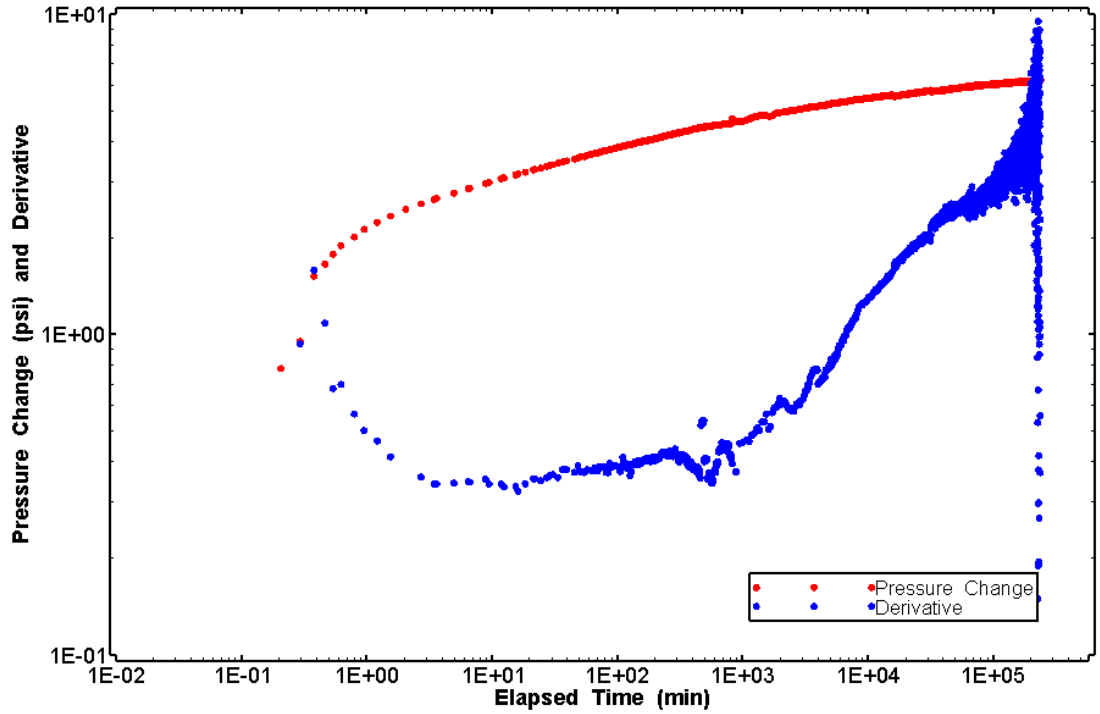

Figure 5. Log-log diagnostic plot of the final SNL-1 pressure-buildup test.

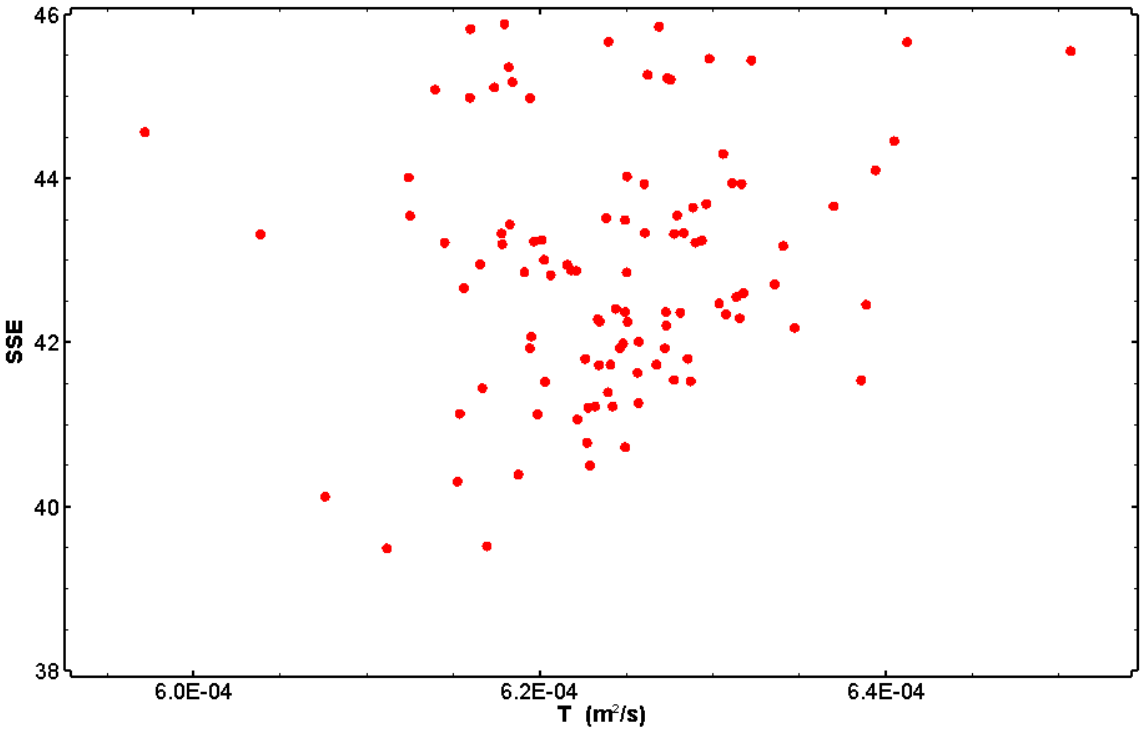

Figure 6. Estimates of transmissivity derived from the SNL-1 perturbation analysis.

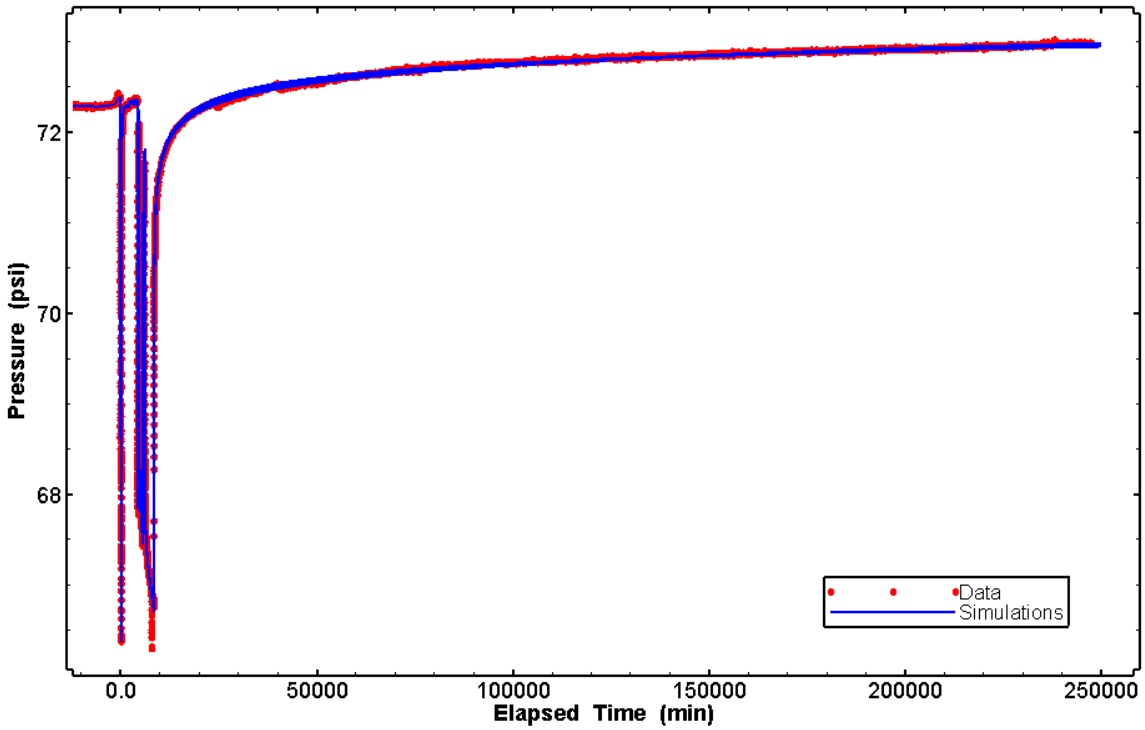

Figure 7. Simulations of the SNL-1 pressure response.

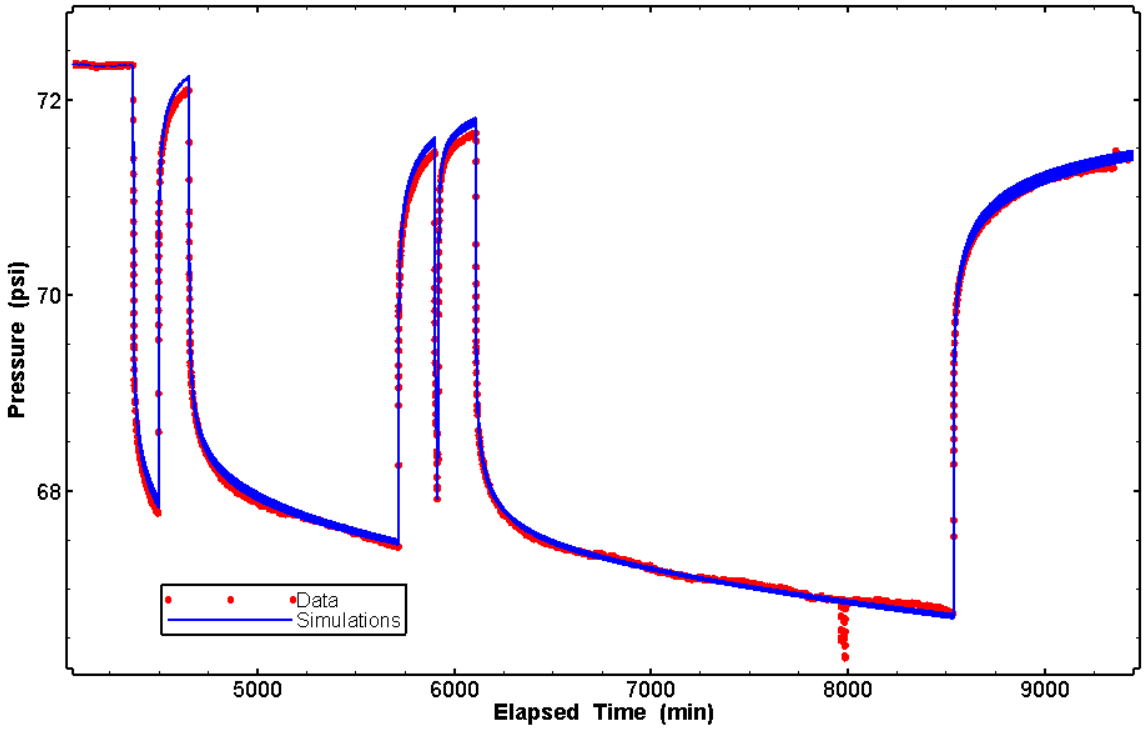

Figure 8. Detail of simulations of the SNL-1 pressure response.

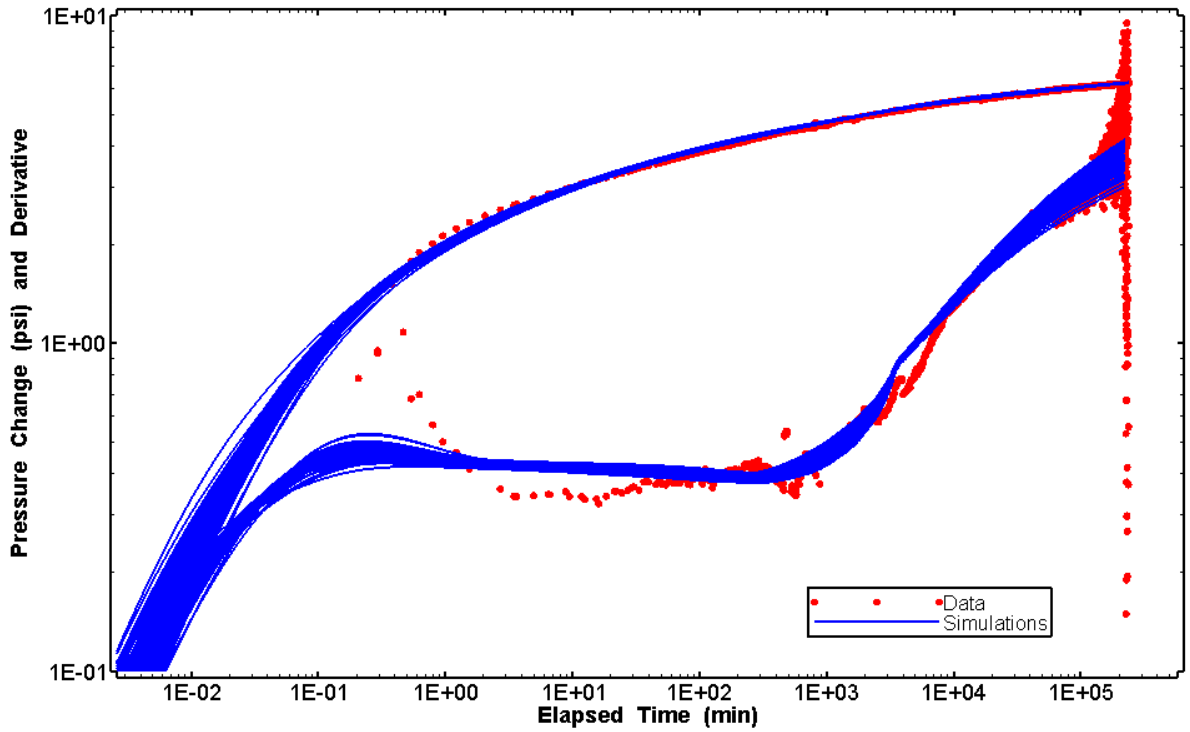

Figure 9. Simulations of pressure change and derivative during the final SNL-1 pressure-buildup test.

4.2 SNL-2

The Culebra interval in SNL-2 was acidized on January 19, 2005, by injecting 48 barrels (7.63 m^3) of a 15% HCl solution followed by 48 barrels (7.63 m^3) of fresh water into the well. A pump was installed in the well after the acidization on January 19, 2005, and an evaluation of potential pumping rates was performed that evening. A constant-rate (12 gpm) pumping test was initiated in SNL-2 on January 20, 2005, and continued for approximately 96.4 hours. The first 79 hours of pressure buildup following the end of pumping were also included in the analysis. About 79 hours after the pressure buildup began, the SNL-2 pressure response began to exhibit pressure changes not associated with SNL testing activities, precluding its usefulness for analysis. Figure 10 shows the pressure record from SNL-2 used in this analysis. The pressures measured prior to the start of the pumping test on January 19, 2005 were included in the nSIGHTS simulation as a pressure history. The pressures shown in Figure 10 were separated into four nSIGHTS sequences for this analysis. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the SNL-2.nPre file and are listed in Appendix B.2.

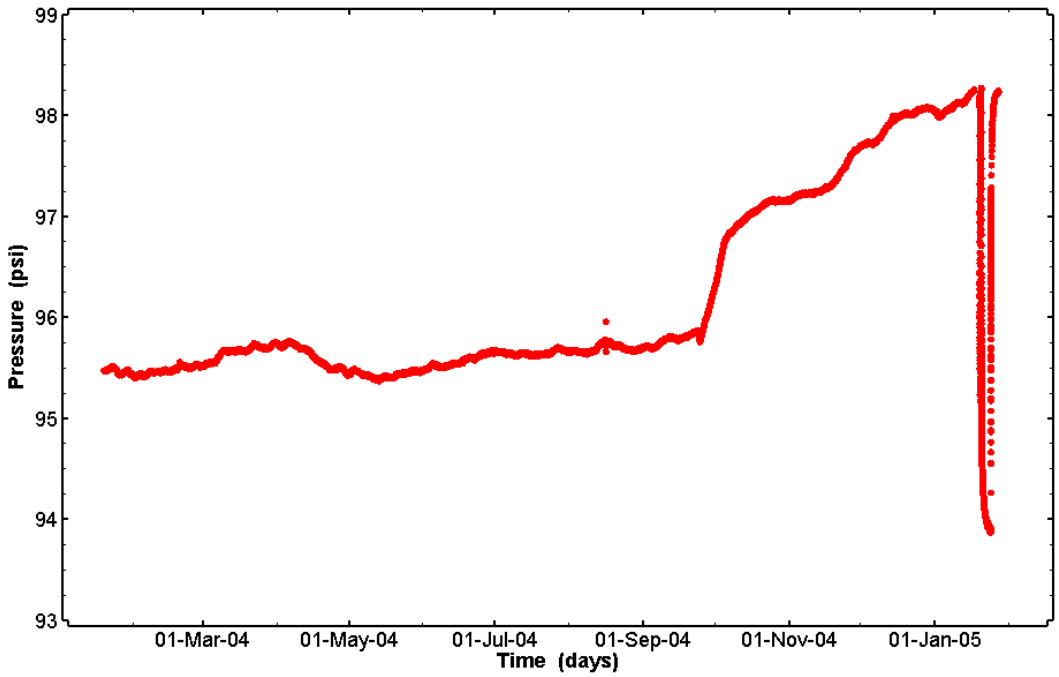

Figure 10. Pressure data from SNL-2.

The specified SNL-2 conceptual model, based on the characteristics of the buildup-period diagnostic plot shown in Figure 11, was a composite-*T* system with wellbore storage. The pressure derivative exhibits a radial stabilization between 1 and 10 minutes elapsed time (Figure 11) and then rises until approximately 100 minutes elapsed time, indicating a decrease in *T*. After that time, the downturn in the derivative probably results from the complex pre-test pressure history whose pressure changes are not associated with SNL testing activities. The range of *T* values estimated from the SNL-2 analysis corresponding to the first derivative stabilization is shown in Figure 12. The geometric mean *T* value was 1.07E-4 m^2/s. The Cartesian and log-log pressure-buildup diagnostic simulations corresponding to these *T* values are shown in Figures 13 and 14, respectively.

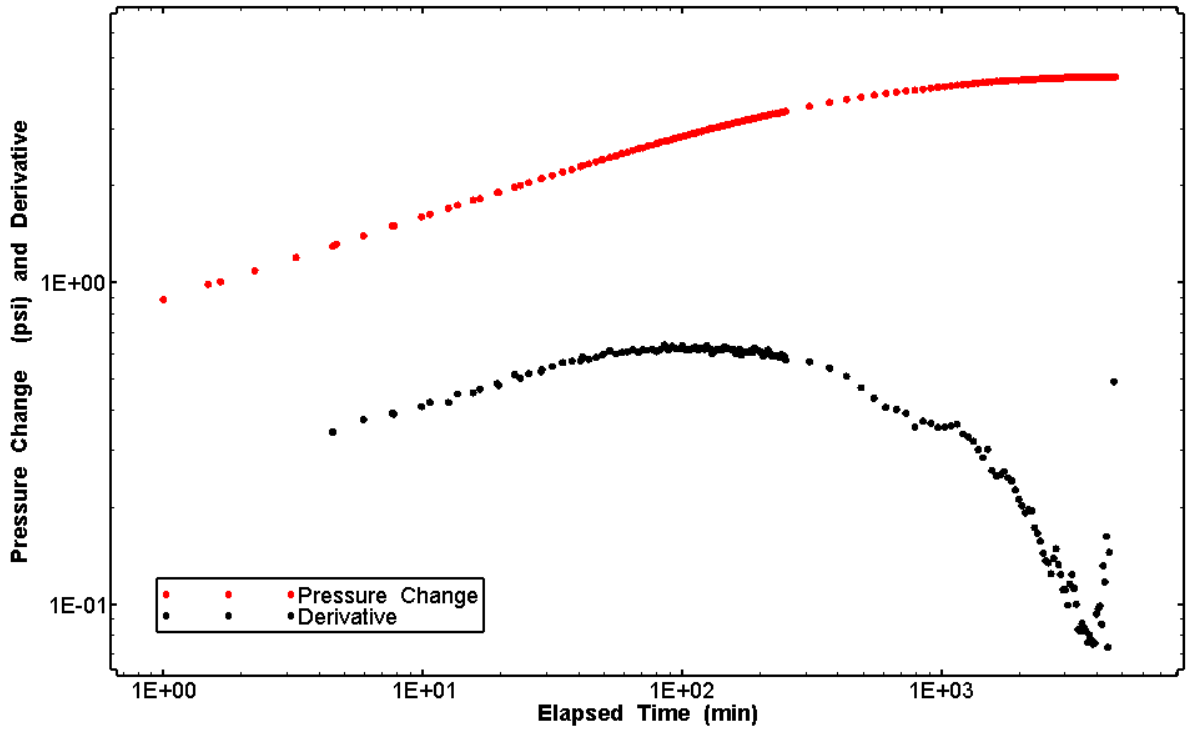

Figure 11. Log-log diagnostic plot of the final SNL-2 pressure-buildup test.

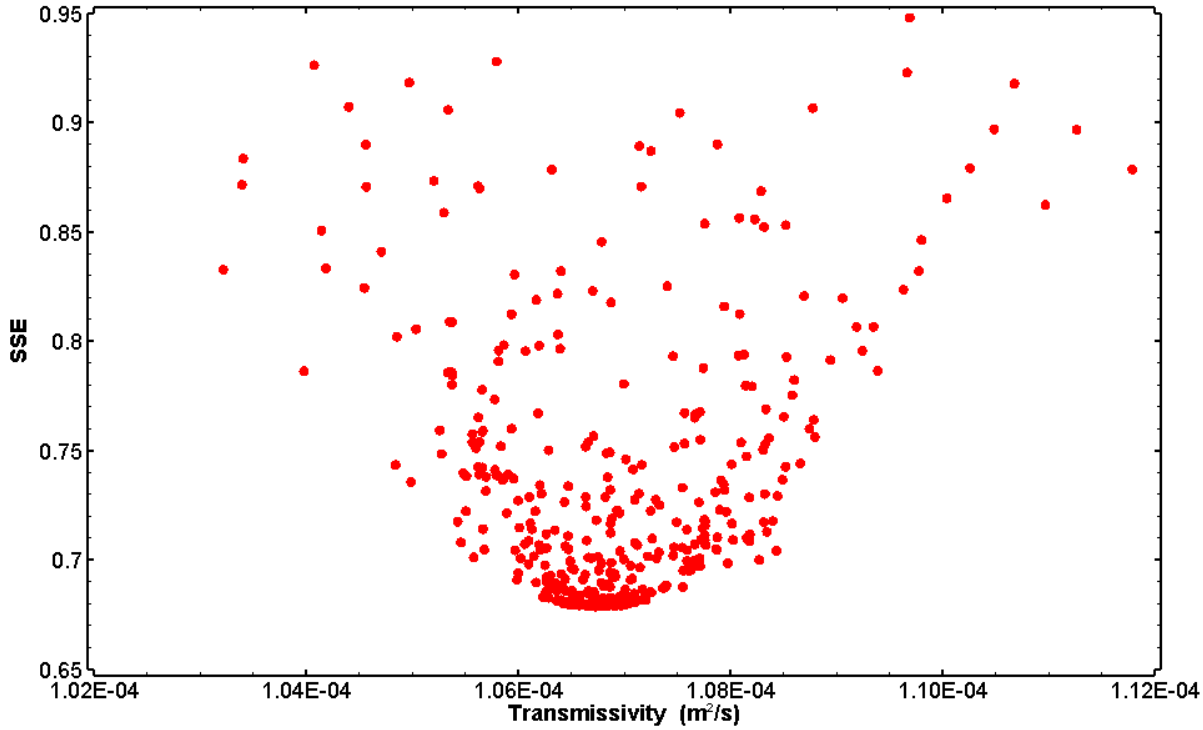

Figure 12. Estimates of transmissivity derived from the SNL-2 perturbation analysis.

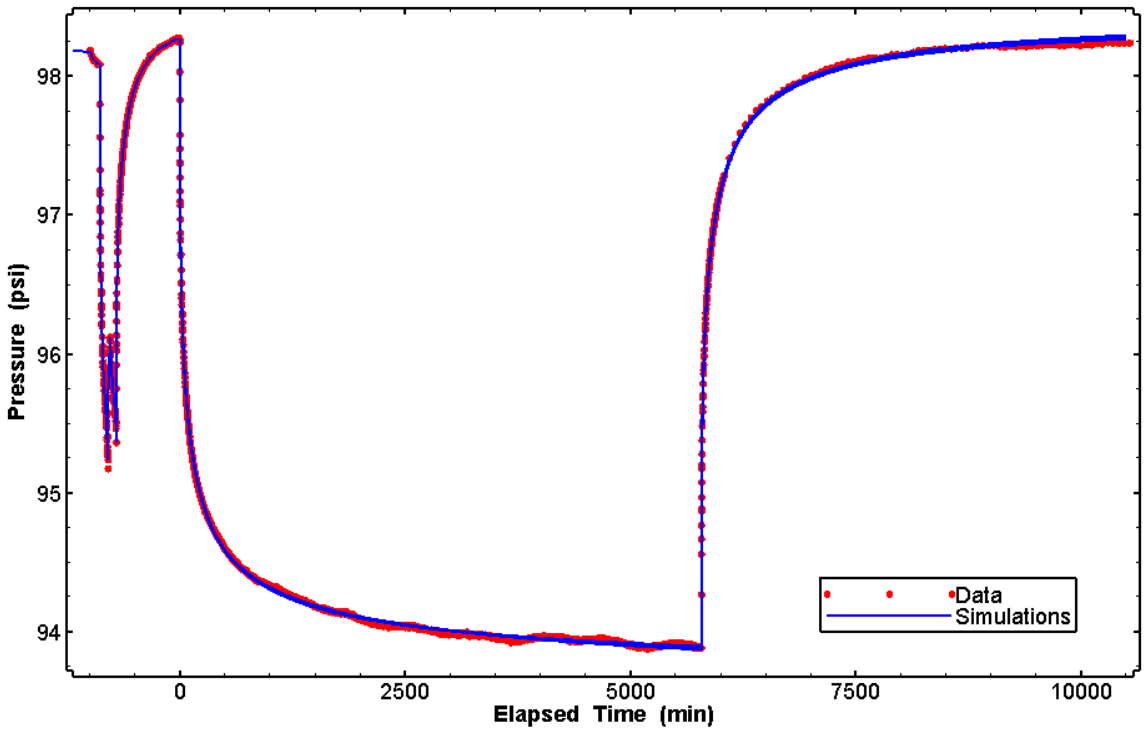

Figure 13. Simulations of the SNL-2 pressure response.

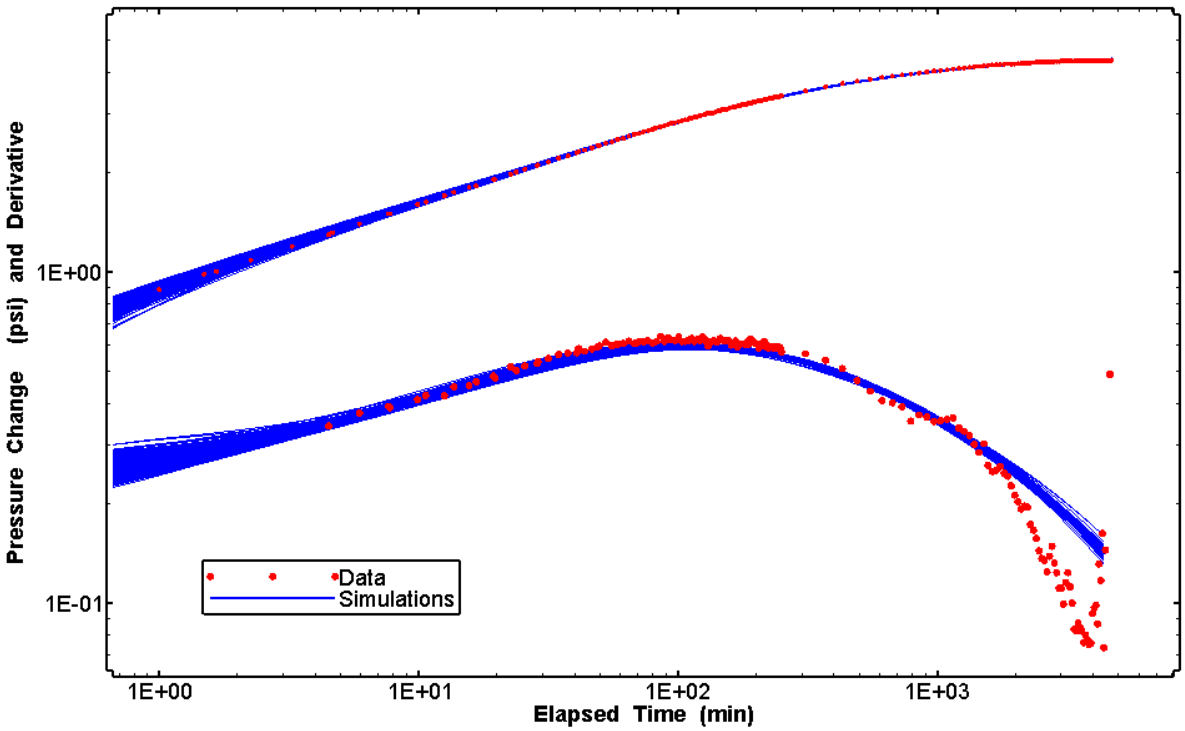

Figure 14. Simulations of pressure change and derivative during the final SNL-2 pressure-buildup test.

4.3 SNL-3

A constant-rate (10 gpm) pumping test was initiated in SNL-3 on April 14, 2004, and continued for approximately 2.2 days. The subsequent 10.4 days of pressure buildup were also included in this analysis. Figure 15 shows the pressure record from SNL-3 used in this analysis. The pressures shown in Figure 15 were separated into three nSIGHTS sequences; details of each sequence, i.e., start/end time, flow rate, etc., are specified in the SNL-3.nPre file and are listed in Appendix B.3.

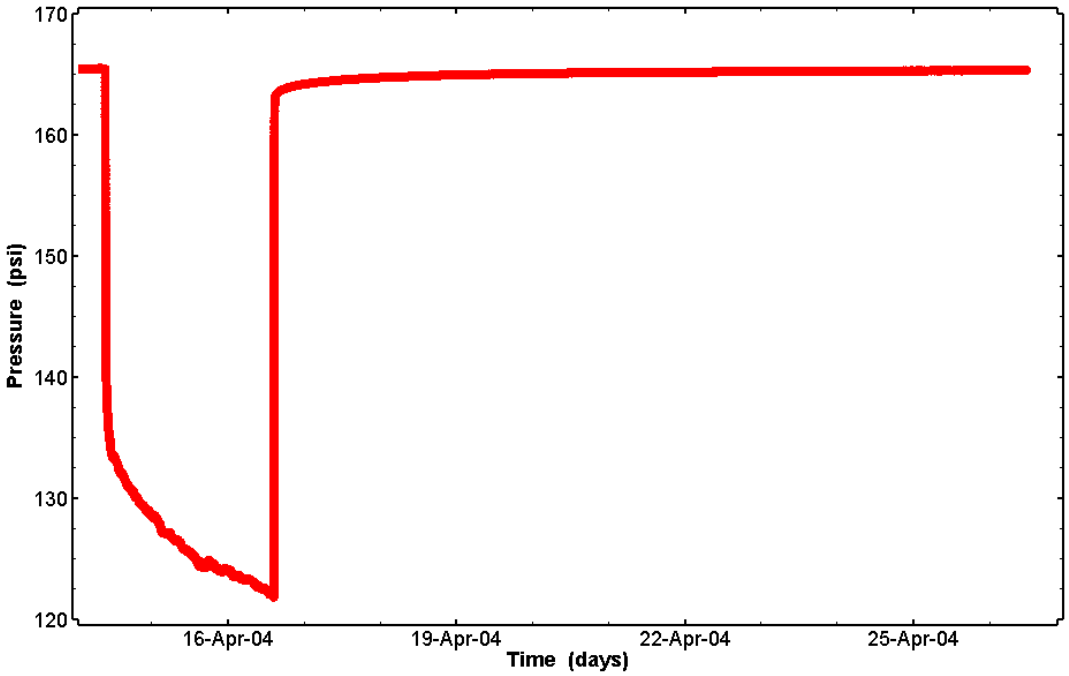

Figure 15. Pressure data from SNL-3.

The specified SNL-3 conceptual model, based on the characteristics of the pressure-buildup diagnostic plot shown in Figure 16, was a composite-*T* system with wellbore storage and a time-dependent skin. The observed linear upward trend in the derivative beginning at approximately 0.04 days (Figure 16) is indicative of constantly decreasing *T* in a radial flow system. The range of *T* values estimated from the SNL-3 analysis that affect the early-time fit to the linear part of the derivative is shown in Figure 17. The geometric mean of these *T* values is 9.88E-4 m^2/s. The simulated SNL-3 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 17 are shown in Figures 18 and 19, respectively.

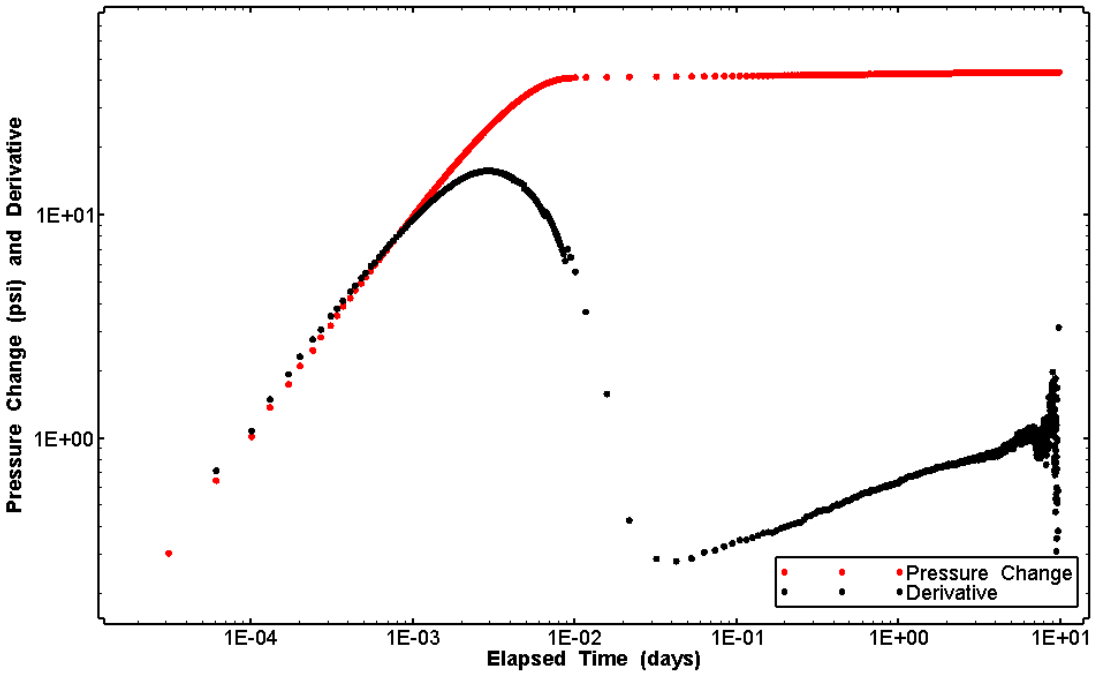

Figure 16. Log-log diagnostic plot of the SNL-3 pressure-buildup test.

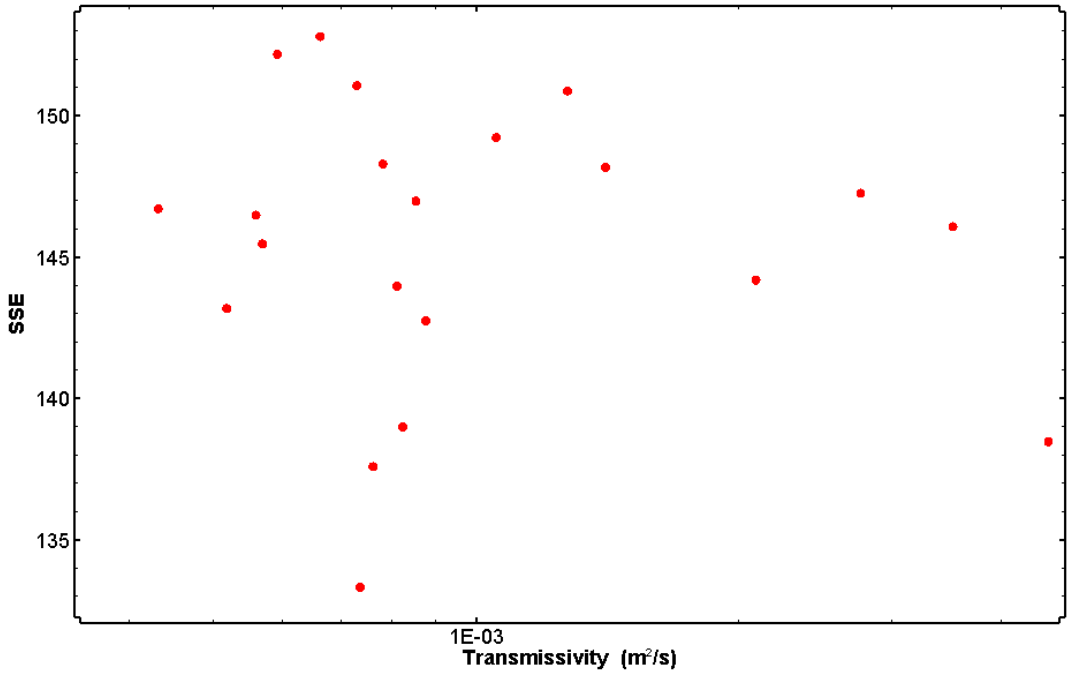

Figure 17. Estimates of transmissivity derived from the SNL-3 perturbation analysis.

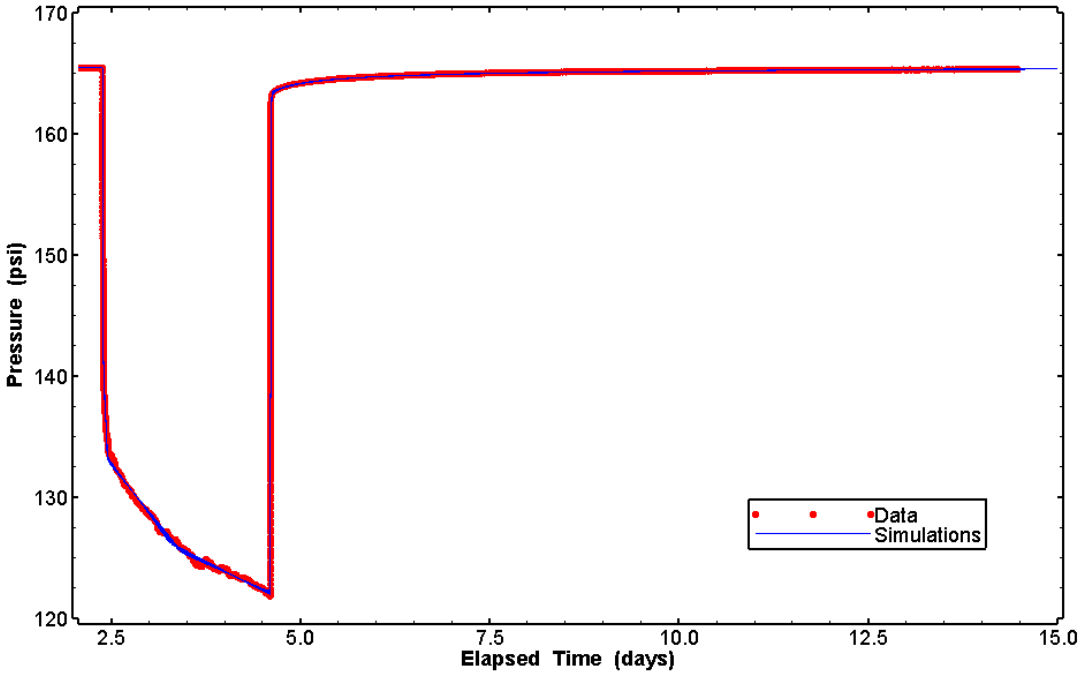

Figure 18. Simulations of the SNL-3 pressure response.

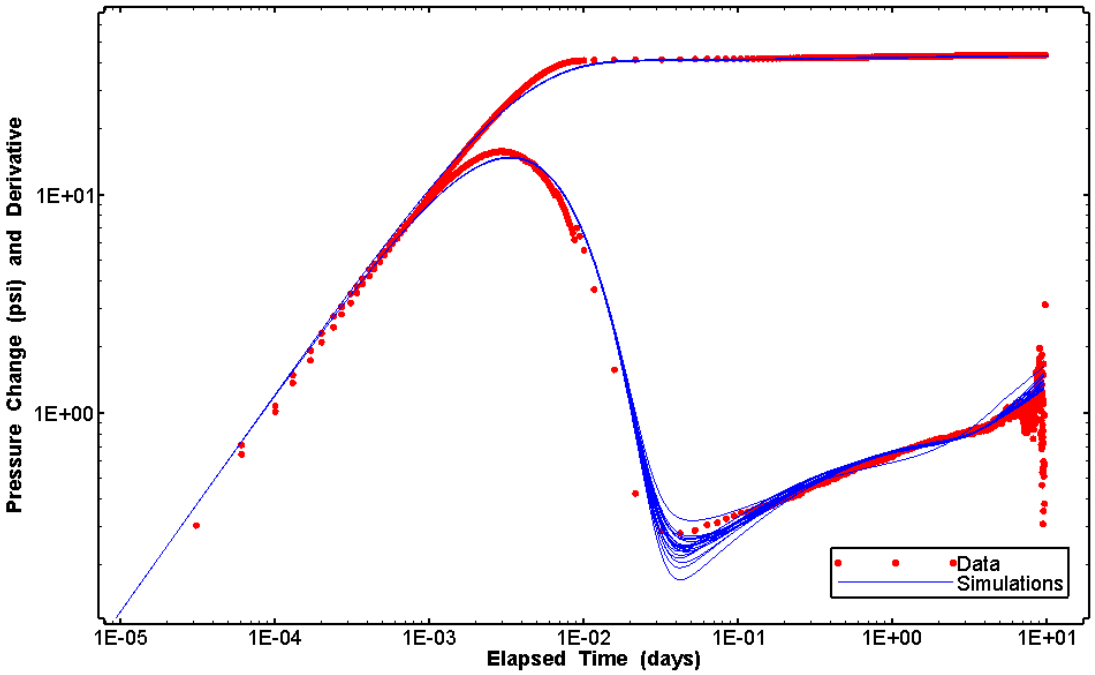

Figure 19. Simulations of pressure change and derivative during the SNL-3 pressure-buildup test.

4.4 SNL-5

Various pumping rates were evaluated in well SNL-5 over a 3.5-hr period on July 19, 2004. The actual pumping test began on July 20, 2004, had an average rate of 3.5 gpm, and lasted approximately 94.1 hr. The pressure response from July 19 – August 18, 2004 (Figure 20) was included in this analysis. The pressures shown in Figure 20 were separated into five nSIGHTS sequences for this analysis. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the SNL-5.nPre file and are listed in Appendix B.4.

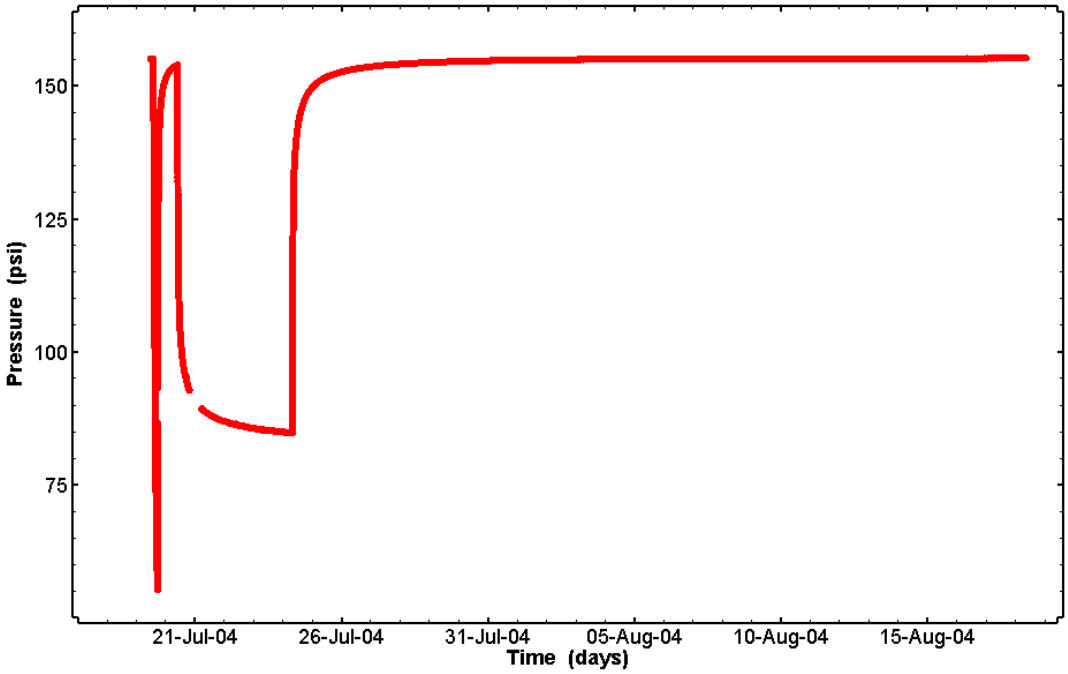

Figure 20. Pressure data from SNL-5.

The specified SNL-5 conceptual model, based on the characteristics of the final pressure-buildup diagnostic plot shown in Figure 21, was a composite-*T* system with wellbore storage. The pressure derivative appears to stabilize between approximately 90 and 300 minutes (Figure 21) and then begins to trend downward, indicating an increase in *T*. The range of *T* values estimated from the SNL-5 analysis is shown in Figure 22. Variations in *T* were estimated by optimizing both the value of *T* and the distance (*r*) at which that value occurred at three discrete points (indicated by three colors in Figure 22) in the model. Values of *T* between those three points were linearly interpolated by the code. For each simulation, the value of *T* in the model varied continuously. The match to the stabilized portion of the derivative was affected by *T* values that were changing linearly with distance between the first two populations (red and black) shown in Figure 22. The geometric mean *T* value of 4.86E-6 m^2/s was therefore calculated from these combined populations. The simulated SNL-5 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 22 are shown in Figures 23 and 24, respectively.

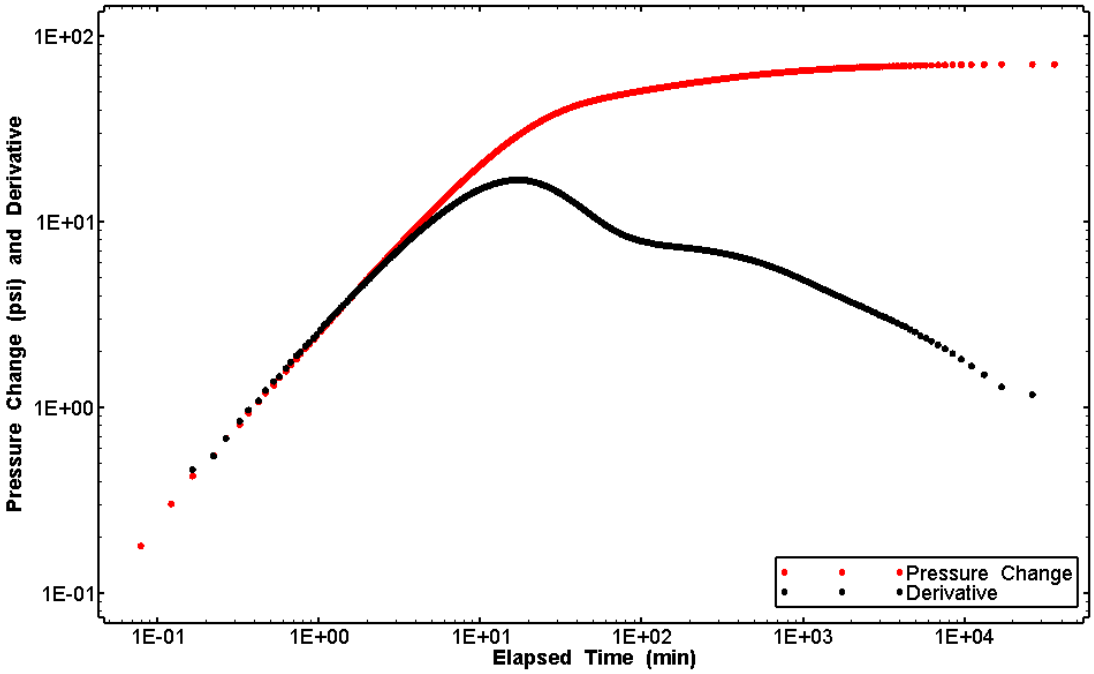

Figure 21. Log-log diagnostic plot of the final SNL-5 pressure-buildup test.

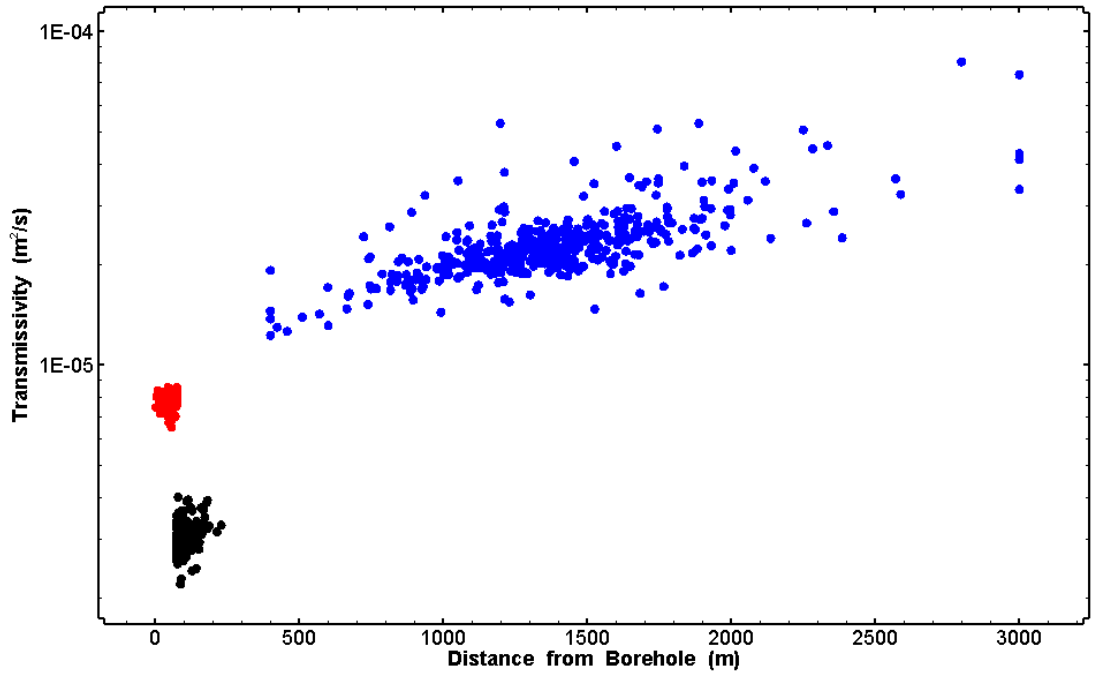

Figure 22. Estimates of transmissivity derived from the SNL-5 perturbation analysis.

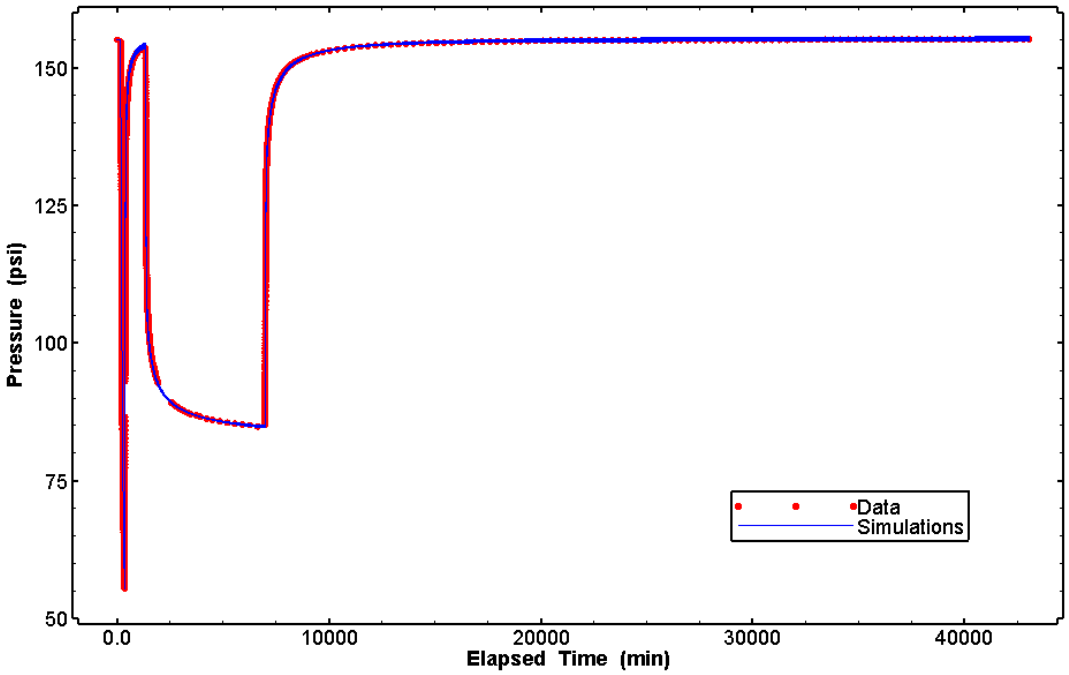

Figure 23. Simulations of the SNL-5 pressure response.

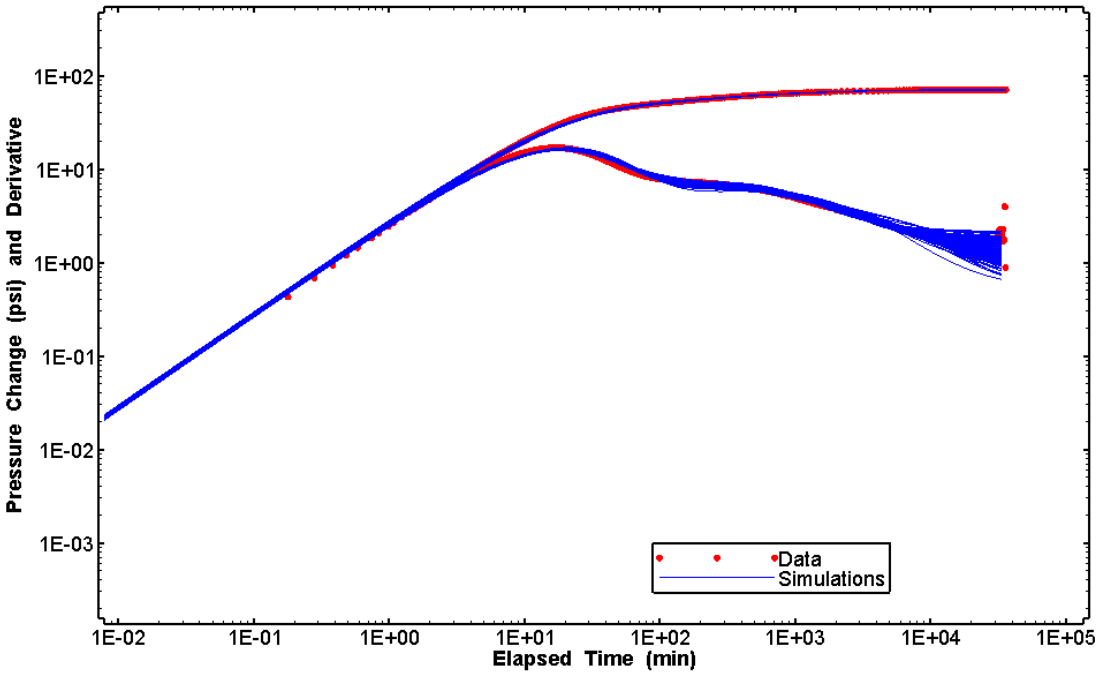

Figure 24. Simulations of pressure change and derivative during the final SNL-5 pressure-buildup test.

4.5 SNL-9

A constant-rate pumping test at 12.5 gpm was initiated in SNL-9 on December 2, 2003, and lasted approximately 90.6 hr. The pressure response from December 2, 2003 – March 17, 2004 (Figure 25) was included in this analysis. The pressures shown in Figure 25 were separated into three nSIGHTS sequences for this analysis. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the SNL-9.nPre file and are listed in Appendix B.5.

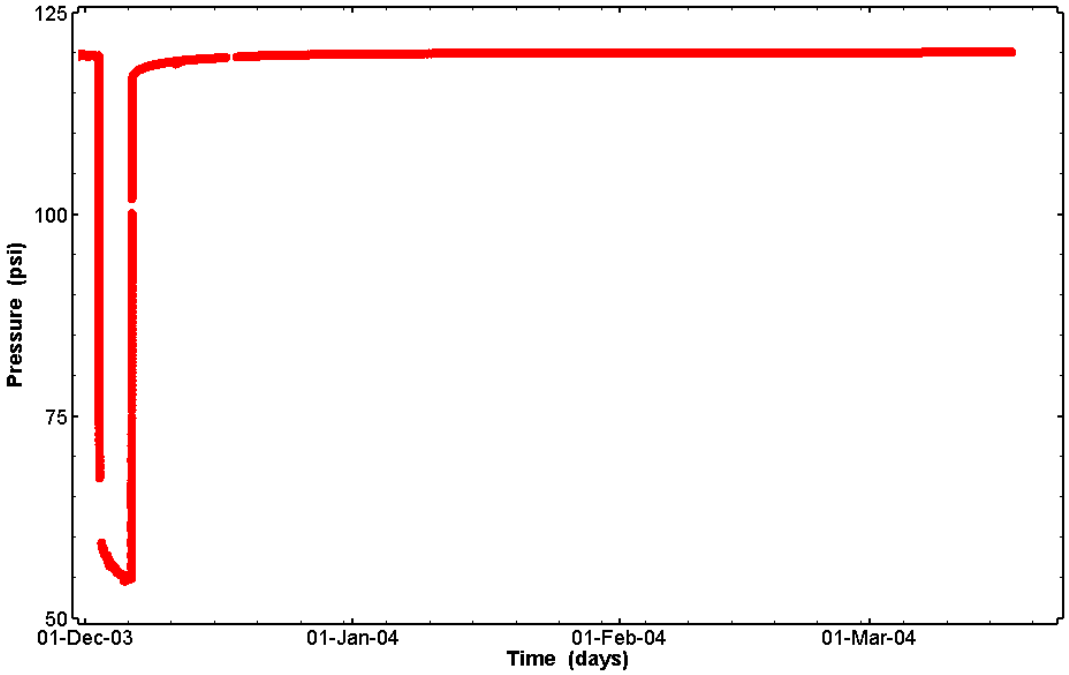

Figure 25. Pressure data from SNL-9.

The specified SNL-9 conceptual model, based on the characteristics of the final pressure-buildup diagnostic plot shown in Figure 26, was a dual-porosity system with wellbore storage and skin. The range of fracture *T* values (Figure 27) estimated from this analysis corresponds to a stabilized derivative beginning at approximately 2.0E4 minutes in Figure 26. The geometric mean *T* estimate was 3.86E-5 m^2/s. The simulated SNL-9 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 27 are shown in Figures 28 and 29, respectively.

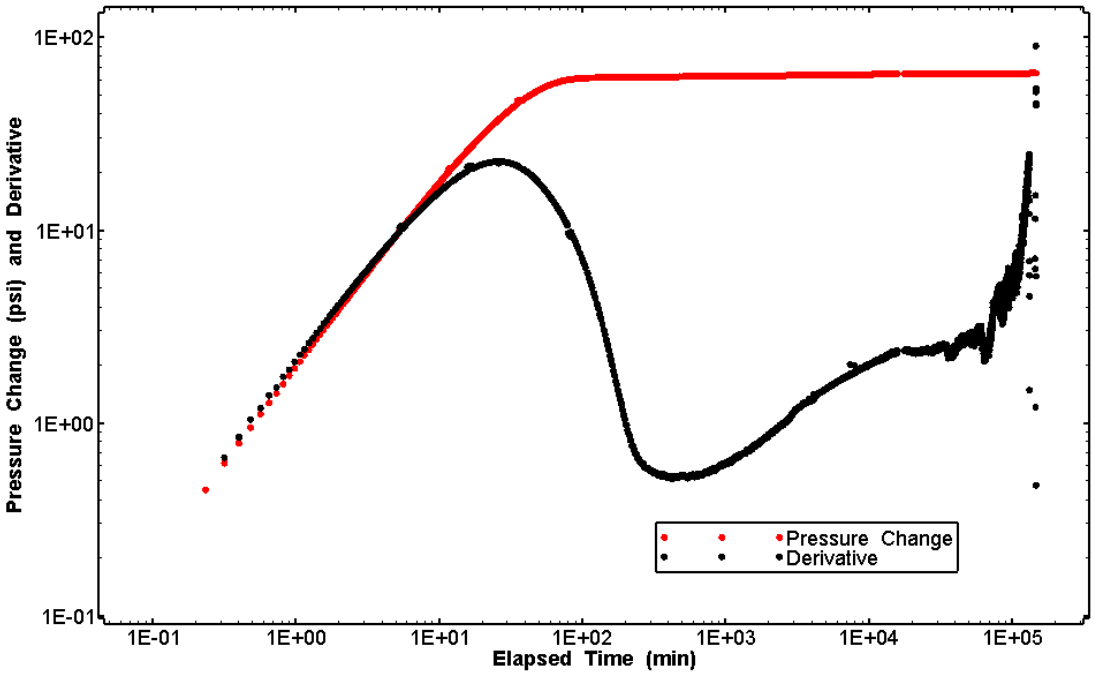

Figure 26. Log-log diagnostic plot of the SNL-9 pressure-buildup test.

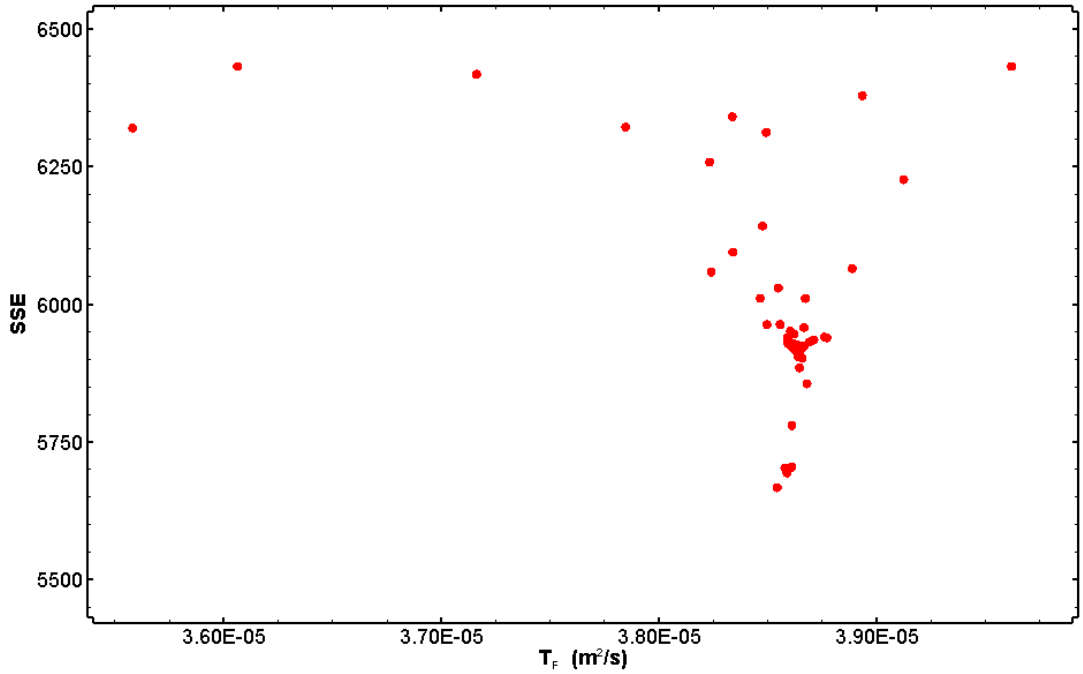

Figure 27. Estimates of transmissivity derived from the SNL-9 perturbation analysis.

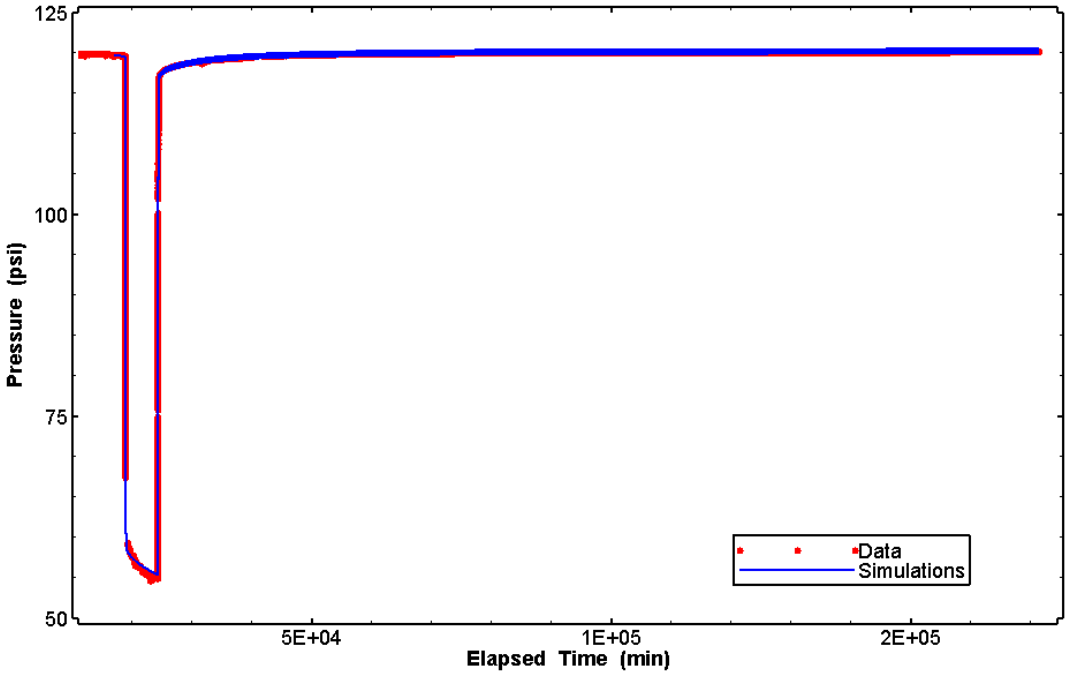

Figure 28. Simulations of the SNL-9 pressure response.

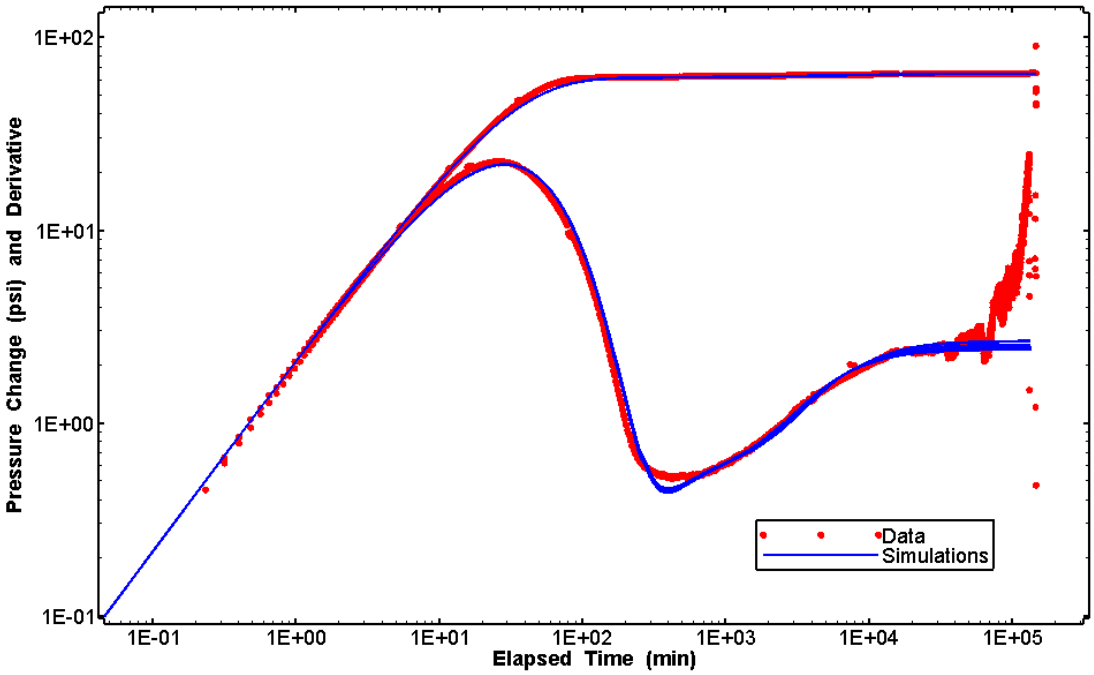

Figure 29. Simulations of pressure change and derivative during the SNL-9 pressure-buildup test.

4.6 SNL-12

Various pumping rates were evaluated in well SNL-12 over a 2.7-hr period on August 9, 2004. The actual pumping test began on August 10, 2004, had an average rate of 20 gpm, and lasted approximately 95.7 hr. The pressure response from April 12 – September 14, 2004 (Figure 30) was included in this analysis. Pressures from April 12 – August 9, 2004 were included as a pressure history in the nSIGHTS simulations. The pressures shown in Figure 30 were separated into six nSIGHTS sequences for this analysis. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the SNL-12.nPre file and are listed in Appendix B.6.

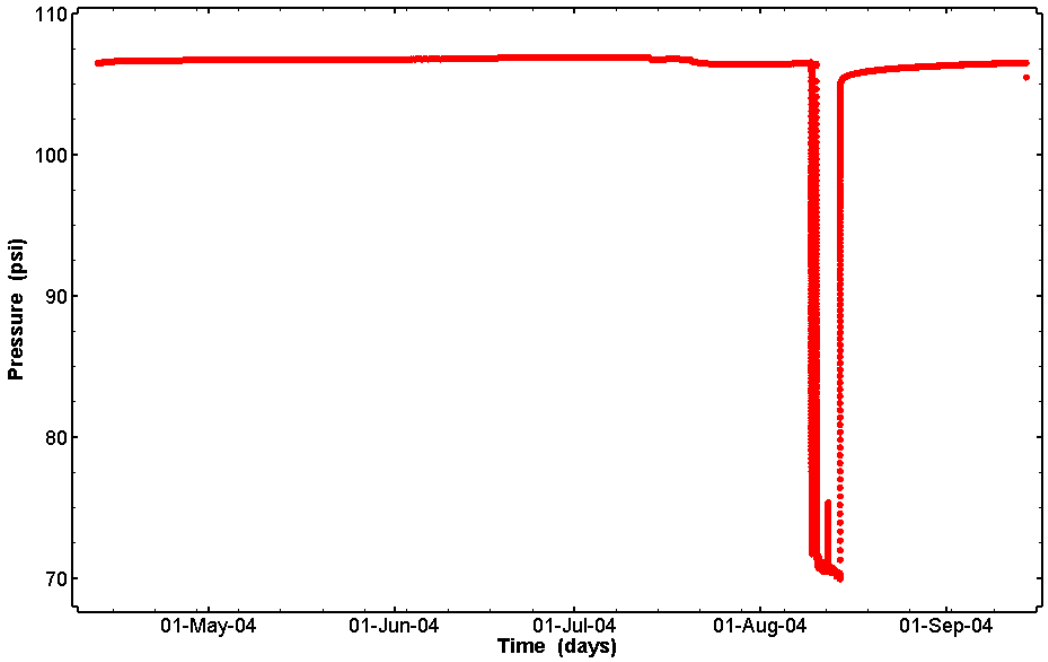

Figure 30. Pressure data from SNL-12.

The specified SNL-12 conceptual model, based on the characteristics of the final pressure-buildup diagnostic plot shown in Figure 31, was a dual-porosity and composite-*n* system with wellbore storage and a time-dependent skin. The near-field *n* was specified to be radial. The range of *T* values (Figure 32) estimated from this analysis corresponds to the derivative stabilization between approximately 1000 and 2000 minutes in Figure 31. The geometric mean *T* value was 4.97E-4 m^2/s. The simulated SNL-12 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 32 are shown in Figures 33 and 34, respectively.

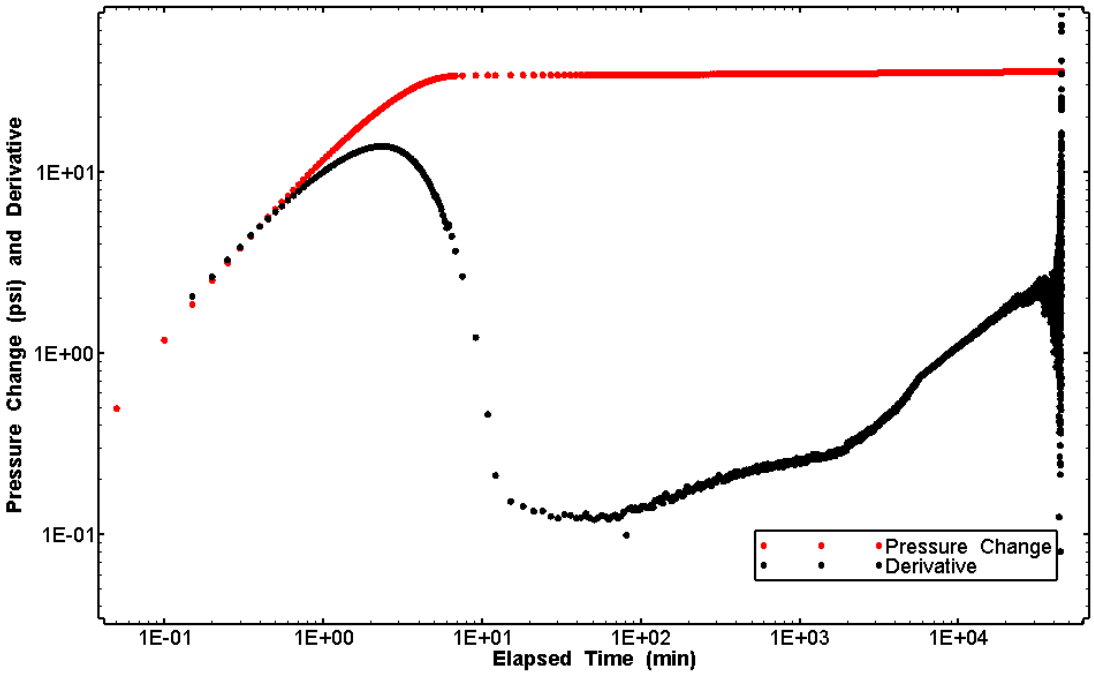

Figure 31. Log-log diagnostic plot of the final SNL-12 pressure-buildup test.

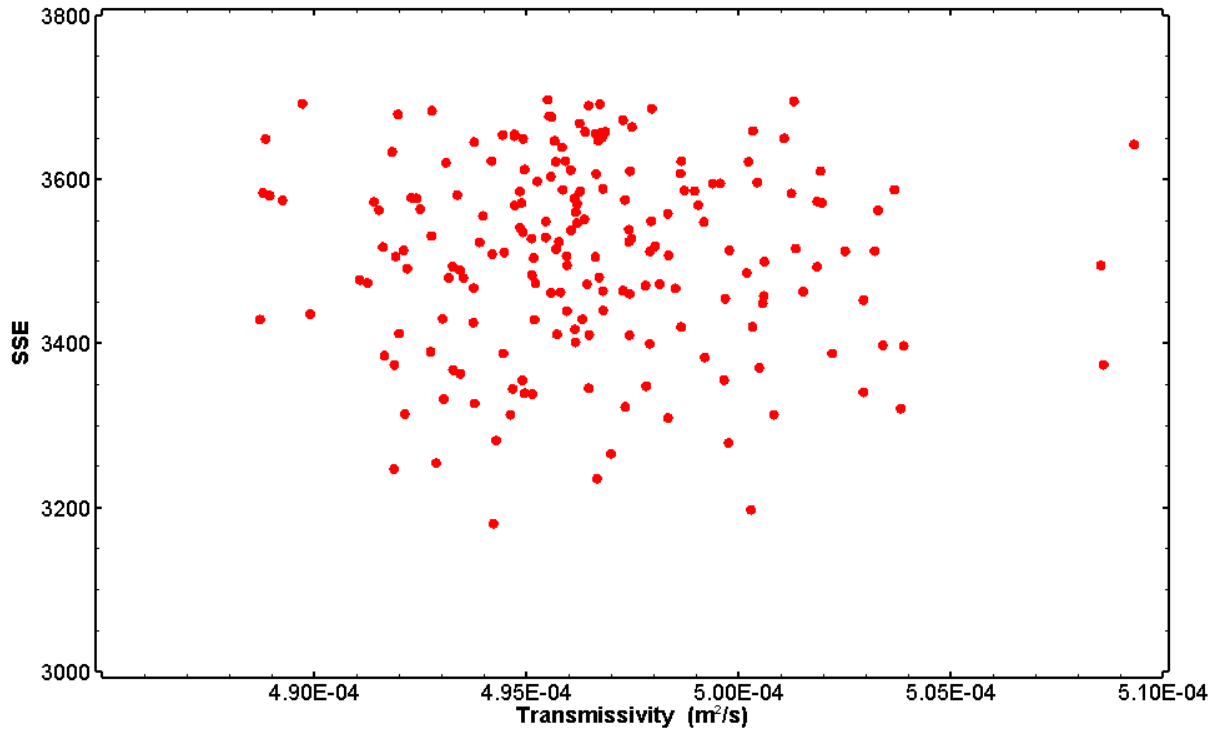

Figure 32. Estimates of transmissivity derived from the SNL-12 perturbation analysis.

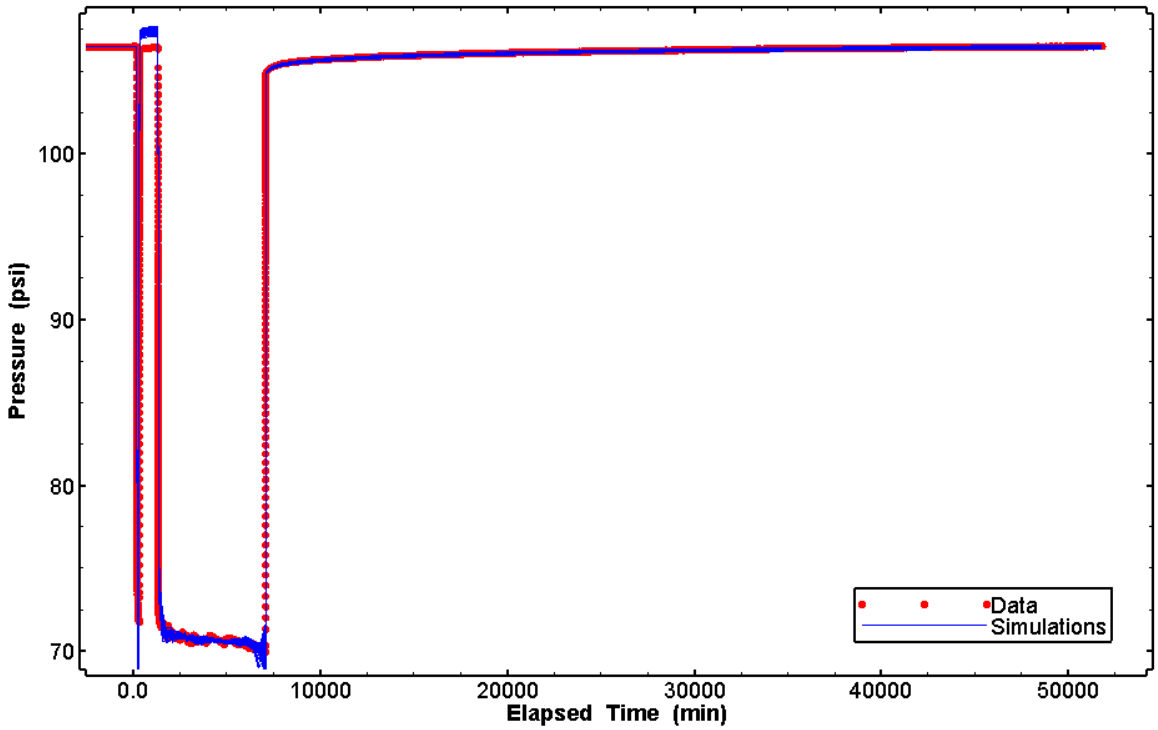

Figure 33. Simulations of the SNL-12 pressure response.

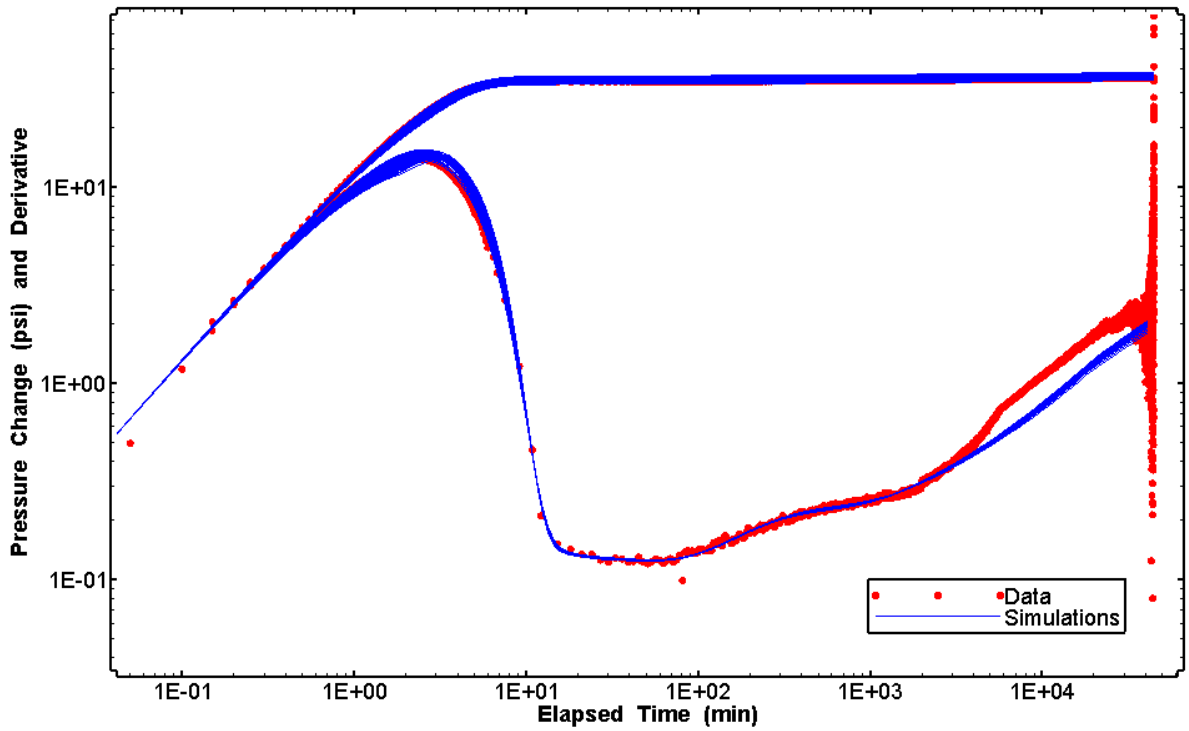

Figure 34. Simulations of pressure change and derivative during the SNL-12 pressure-buildup test.

4.7 SNL-14

Various pumping rates were evaluated in well SNL-14 over a 4.6-hr period on July 20, 2005. A constant-rate (30 gpm) pumping test was initiated in SNL-14 on August 4, 2005. Pumping ended on August 26, 2005, and the subsequent pressure buildup through January 3, 2006 was included in this analysis (Figure 35). The pressures shown in Figure 35 were separated into eight nSIGHTS sequences for this analysis. SNL-14 pressures from June 14 – August 4, 2005 were included in the nSIGHTS simulations as a pressure history. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the SNL-14.nPre file and are listed in Appendix B.7.

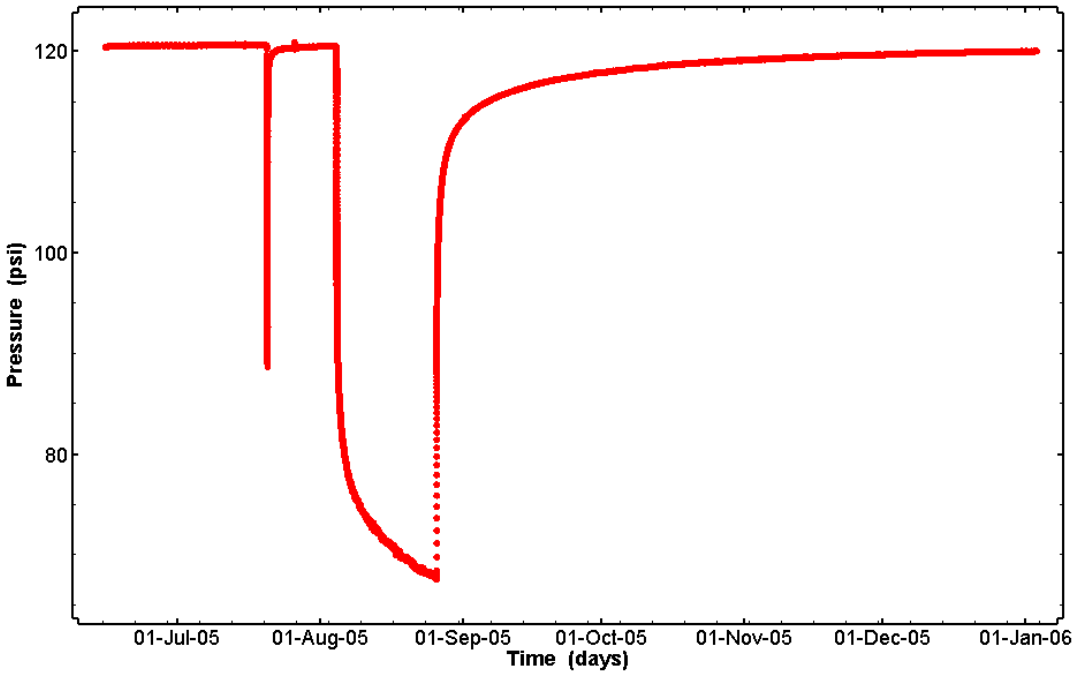

Figure 35. Pressure data from SNL-14.

The specified SNL-14 conceptual model, based on the characteristics of the final pressure-buildup diagnostic plot shown in Figure 36, was a dual-porosity system with wellbore storage, a time-dependent skin, and a linear no-flow boundary. The range of fracture *T* values (Figure 37) estimated from this analysis corresponds to the derivative stabilization that begins at approximately 3 days in Figure 36. The assumed effect of the no-flow boundary then begins to dominate the response after about 8 days (Figure 36). The fracture *T* estimates are shown in Figure 37. The geometric mean fracture *T* estimate derived from this analysis was 4.9E-5 m^2/s.

The simulated SNL-14 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 37 are shown in Figures 38 and 39, respectively.

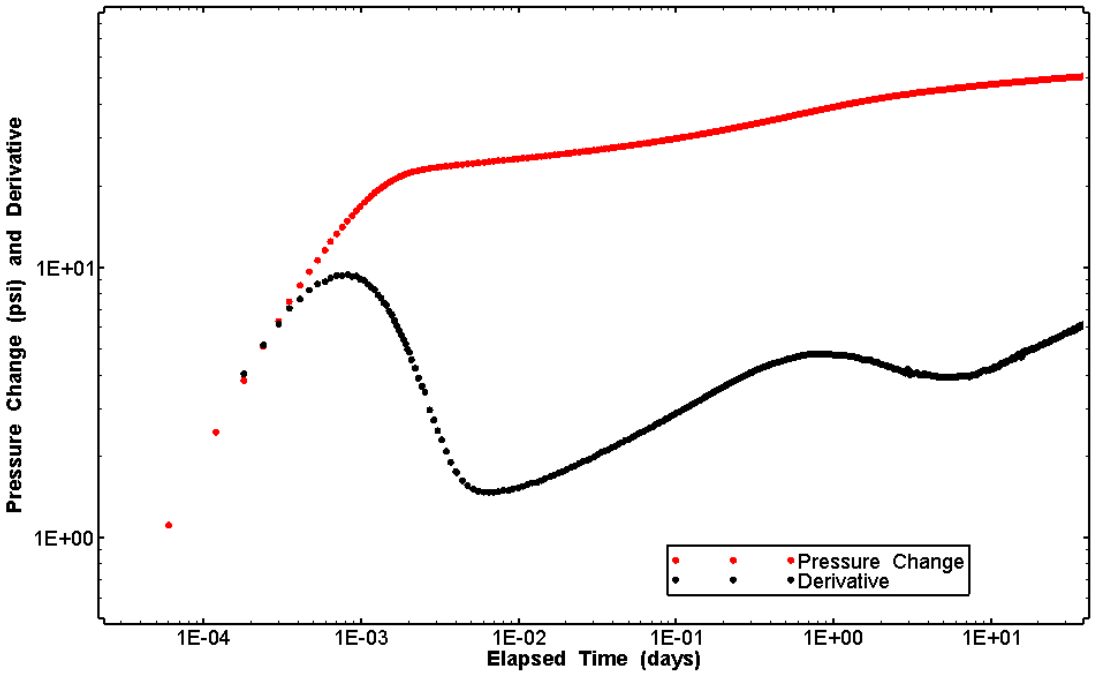

Figure 36. Log-log diagnostic plot of the final SNL-14 pressure-buildup test.

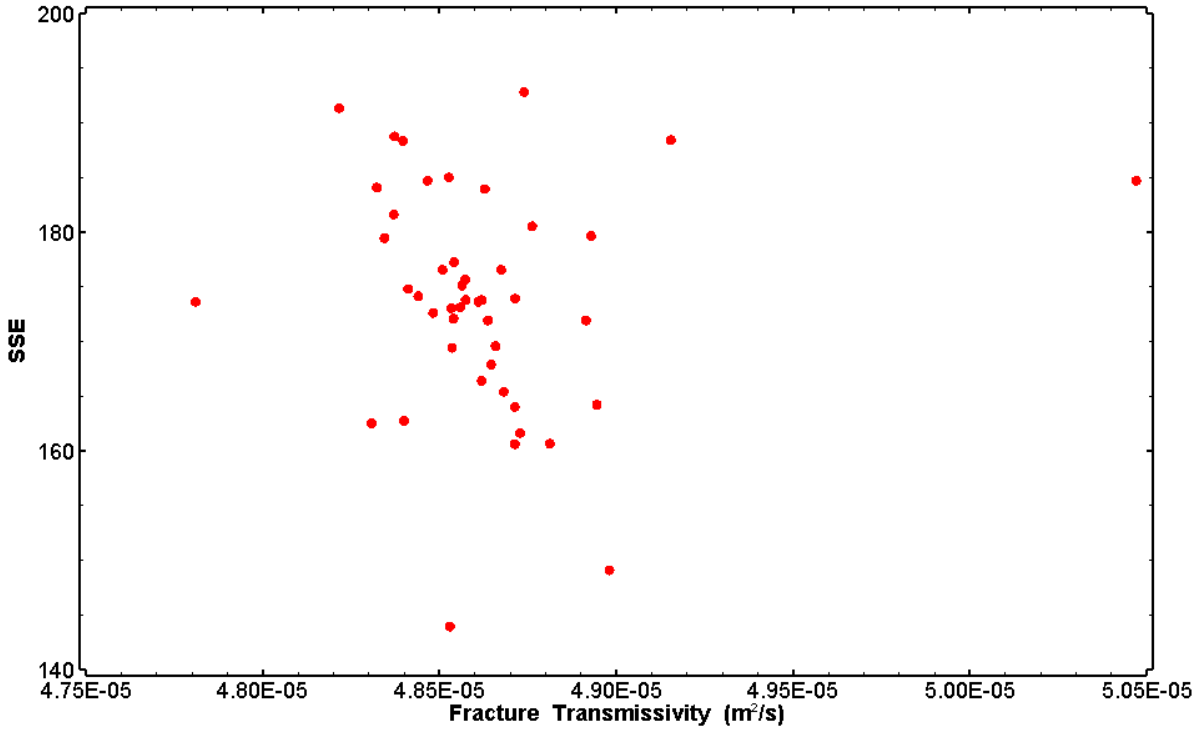

Figure 37. Estimates of transmissivity derived from the SNL-14 perturbation analysis.

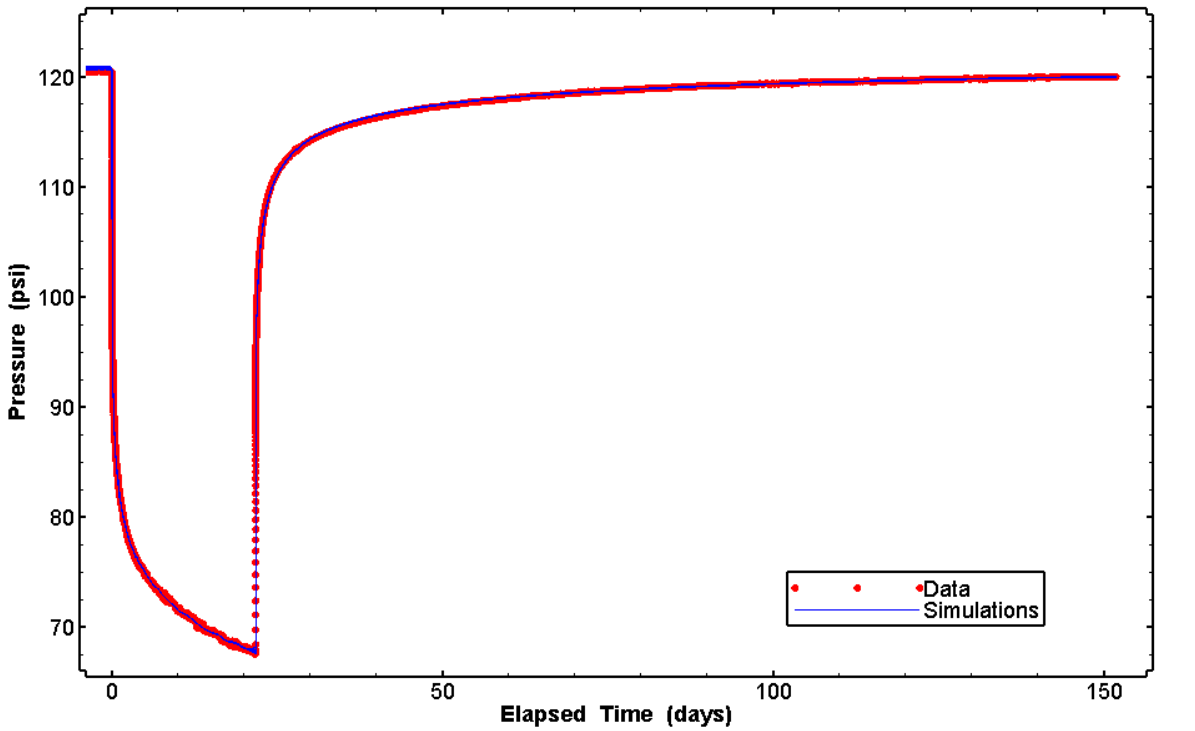

Figure 38. Simulations of the SNL-14 pressure response.

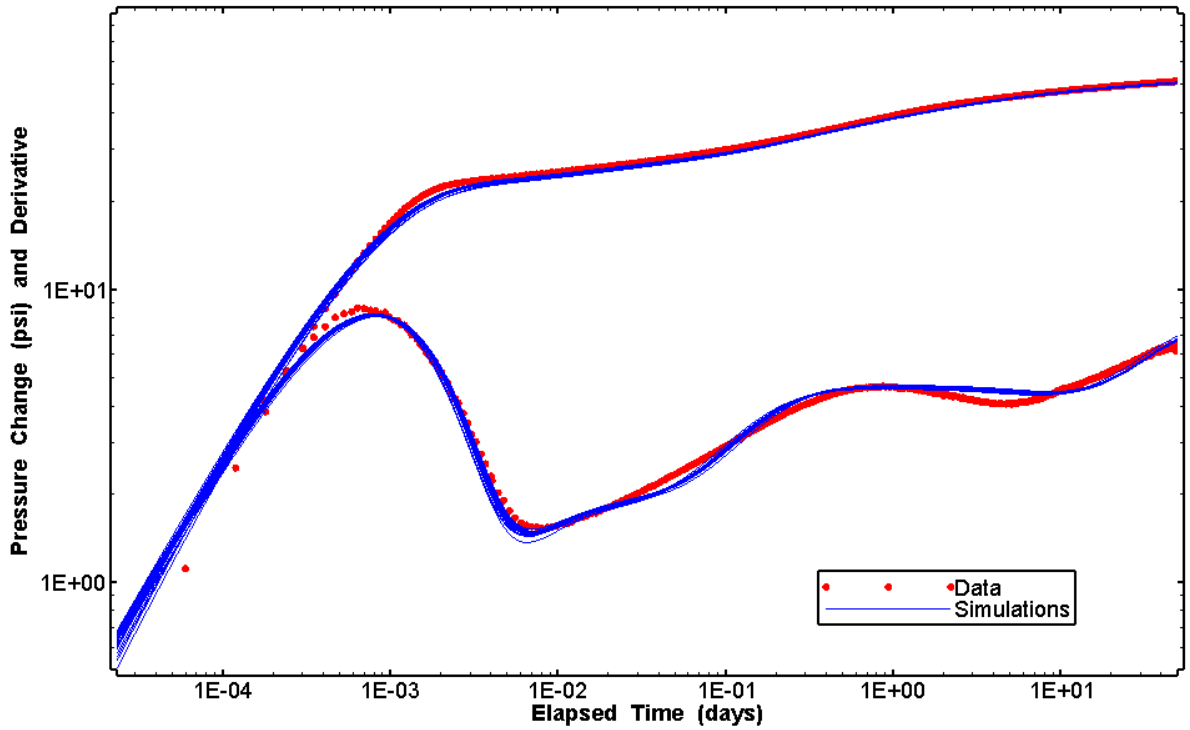

Figure 39. Simulations of pressure change and derivative during the final SNL-14 pressure-buildup test.

4.8 WIPP-11

The Culebra interval in WIPP-11 was acidized on January 5, 2005, by injecting 43 barrels (6.84 m^3) of a 15% HCl solution charged with liquid nitrogen followed by 58 barrels (9.22 m^3) of fresh water into the well. An evaluation of potential pumping rates was performed over a 3.5-hr period on January 31, 2005. The pumping test began on February 1, 2005 and continued until February 20, 2005 at a rate of 35 gpm. The pumping-test data and the subsequent pressure buildup through April 4, 2005 were included in this analysis (Figure 40). The pressures shown in Figure 40 were separated into eight nSIGHTS sequences for this analysis. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the WIPP-11.nPre file and are listed in Appendix B.8.

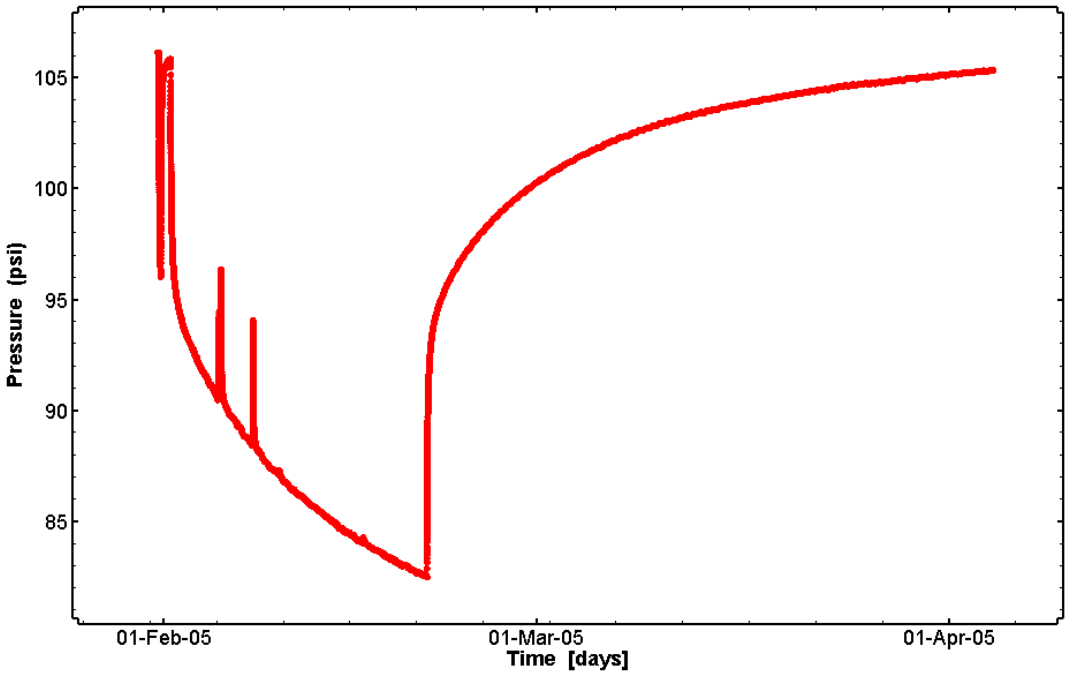

Figure 40. Pressure data from WIPP-11.

The specified WIPP-11 conceptual model, based on the characteristics of the final pressure-buildup diagnostic plot shown in Figure 41, was a composite-*T* system with wellbore storage. Relatively high *T* variability was indicated by the constantly changing slope of the derivative in Figure 41. This *T* variability was simulated by optimizing a *T(r)* function in the WIPP-11 model. Both the value of *T* and the distance from the borehole to that value were optimized using six discrete points. The value of *T* in the model was linearly interpolated between the six discrete points. An example of a single *T(r)* solution is shown in Figure 42. Note that the relationship between *T* and distance in the model depends on the value of specific storage (S_s) in the model, which was fixed at 1.0E-6 m^{-1} in this analysis. The range of estimated *T* and radius (*r*) values for the complete *T(r)* function is shown in Figure 43. Those *T* values that correspond to the derivative stabilization that begins at approximately 7.0E-4 days in Figure 41, i.e., the near-field T values, are those values that are interpolated between the first two sets of points shown in Figure 43. The geometric mean estimate of *T* derived from these first two sets of points was 4.27E-4 m^2/s. The simulated WIPP-11 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 43 are shown in Figures 44 and 45, respectively.

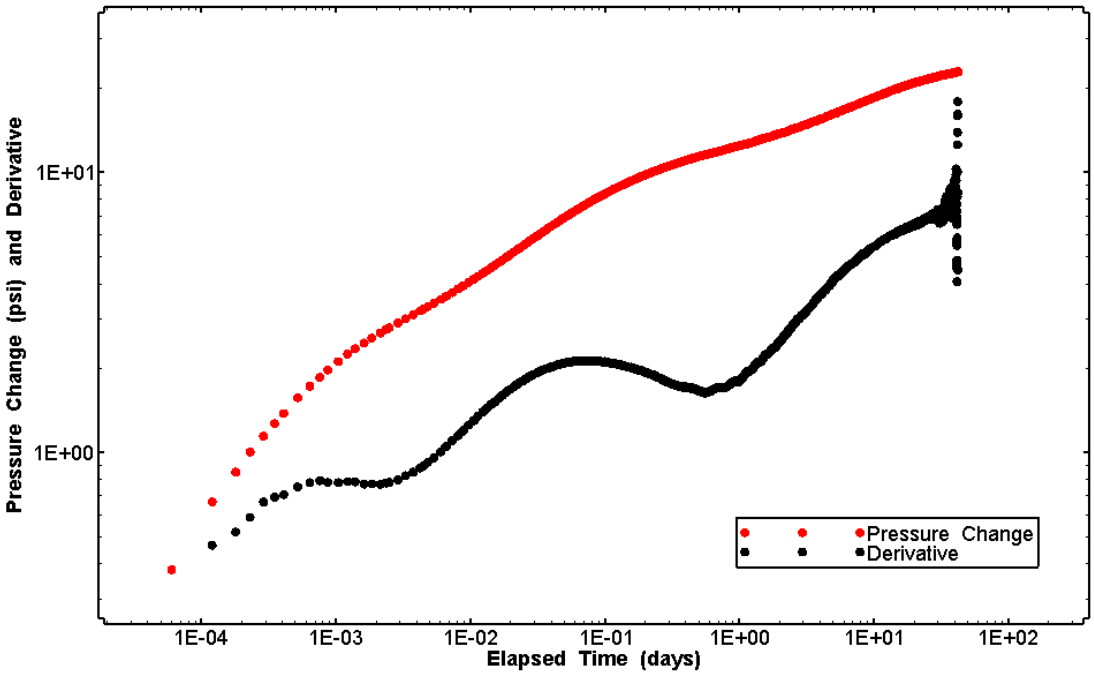

Figure 41. Log-log diagnostic plot of the final WIPP-11 pressure-buildup test.

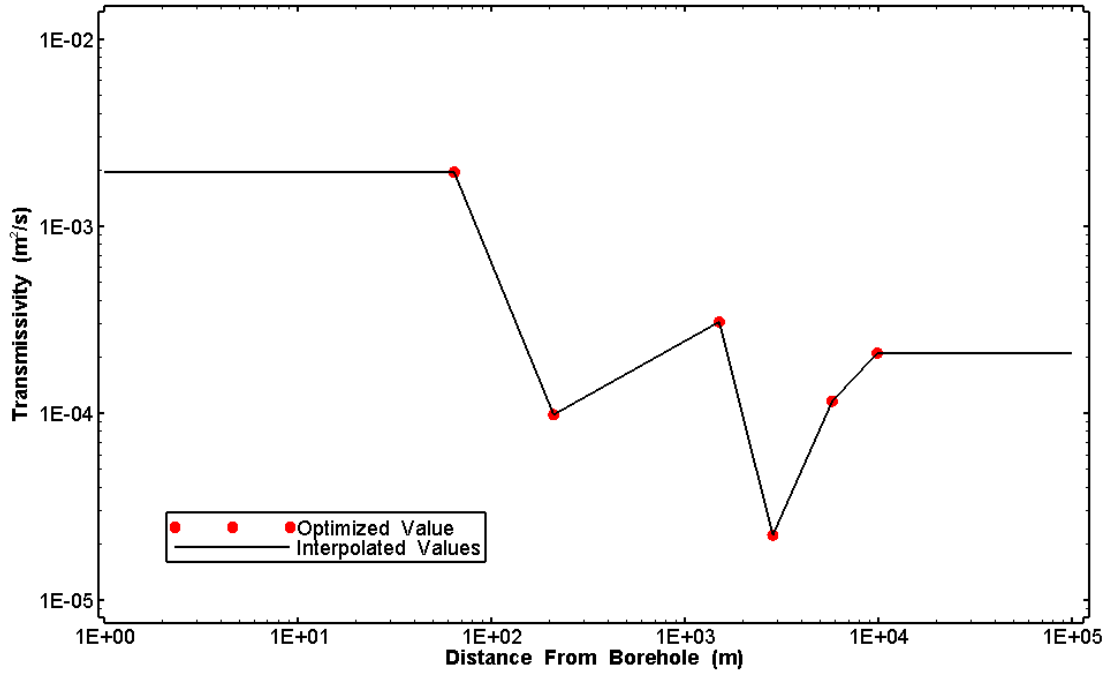

Figure 42. A single radially varying transmissivity estimate obtained from the WIPP-11 perturbation analysis.

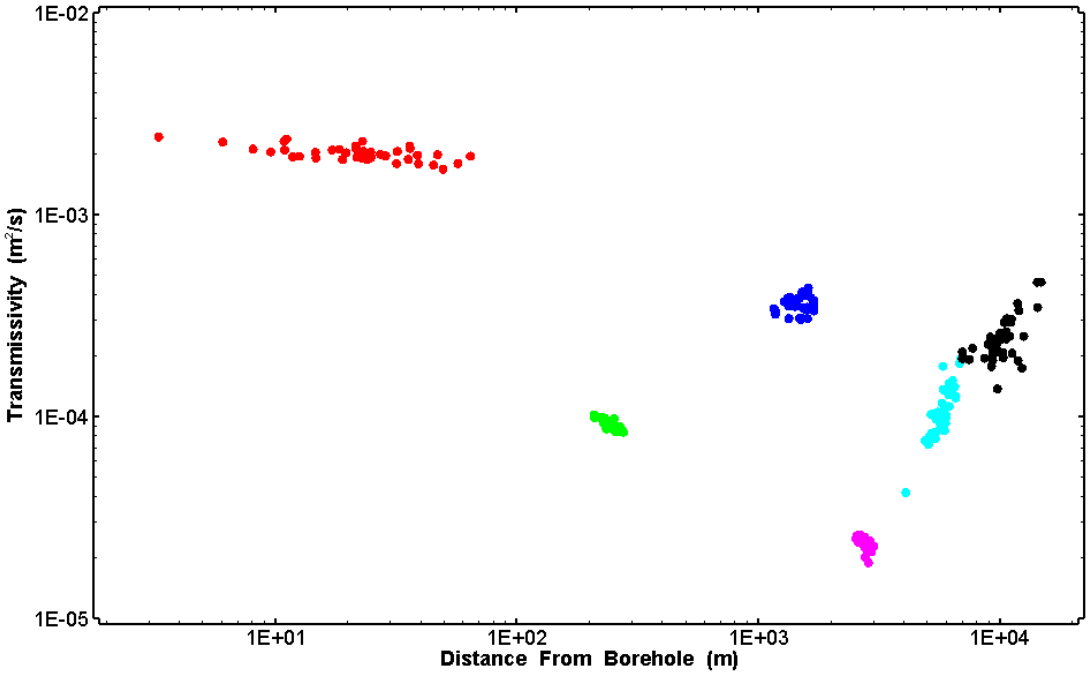

Figure 43. Estimates of radially varying transmissivity derived from the WIPP-11 perturbation analysis.

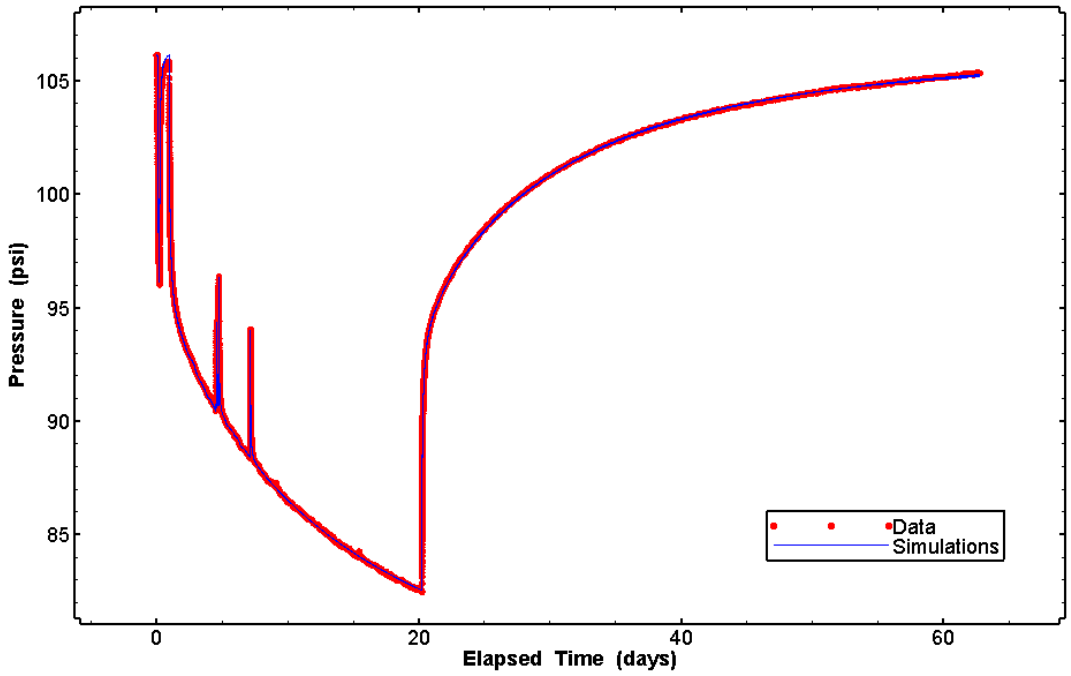

Figure 44. Simulations of the WIPP-11 pressure response.

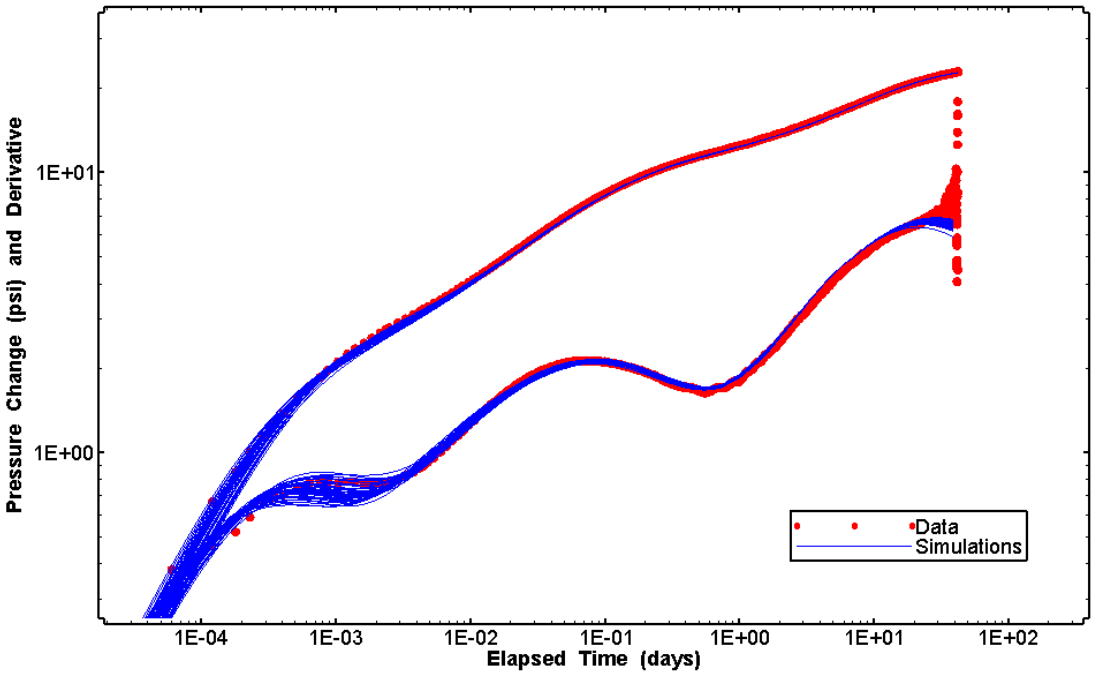

Figure 45. Simulations of pressure change and derivative during the final WIPP-11 pressure-buildup test.

4.9 WIPP-25

A constant-rate pumping test was initiated in well WIPP-25 on September 22, 2004, at a rate of 30 gpm. Pumping was interrupted for about three minutes approximately five hours after the test was started. Pumping ended on September 23, 2004, and the subsequent pressure buildup through September 29, 2004 (Figure 46), was included in this analysis. The pressures shown in Figure 46 were separated into six nSIGHTS sequences for this analysis. WIPP-25 pressures from September 20 – 22, 2004, were included in the nSIGHTS simulations as a pressure history. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the WIPP-25.nPre file and are listed in Appendix B.9.

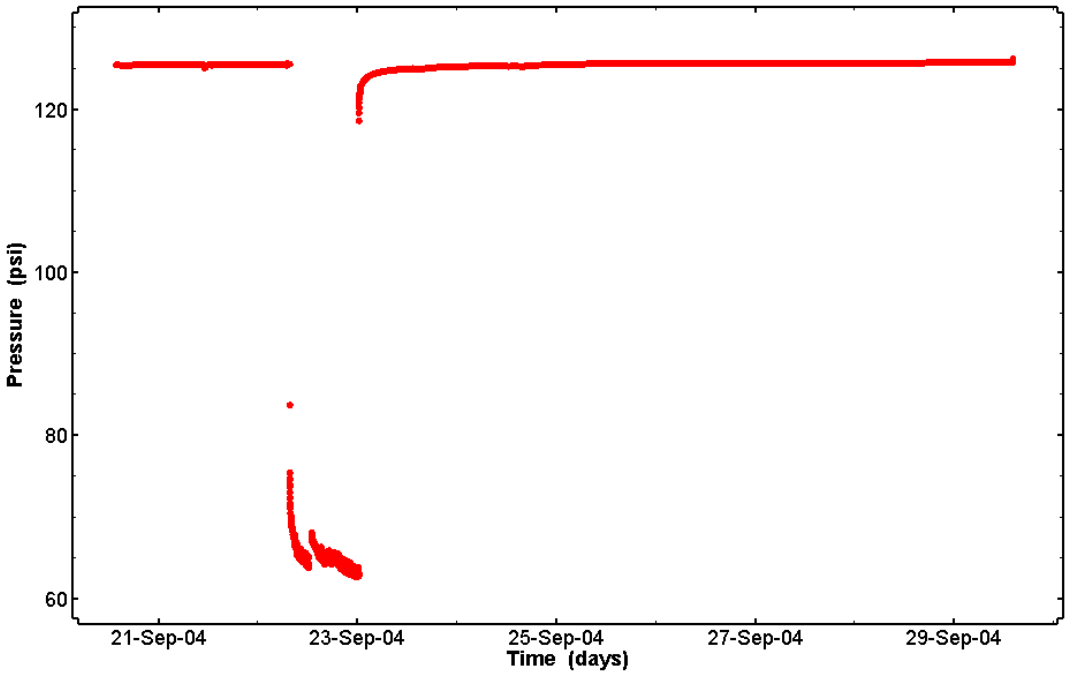

Figure 46. Pressure data from WIPP-25.

The specified WIPP-25 conceptual model, based on the characteristics of the final pressure-buildup diagnostic plot shown in Figure 47, was an infinite-acting radial system with wellbore storage and a time-dependent skin. The range of *T* values estimated from this analysis is shown in Figure 48. The geometric mean estimate of *T* derived from this analysis was 2.51E-4 m^2/s. The simulated WIPP-25 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 48 are shown in Figures 49 and 50, respectively.

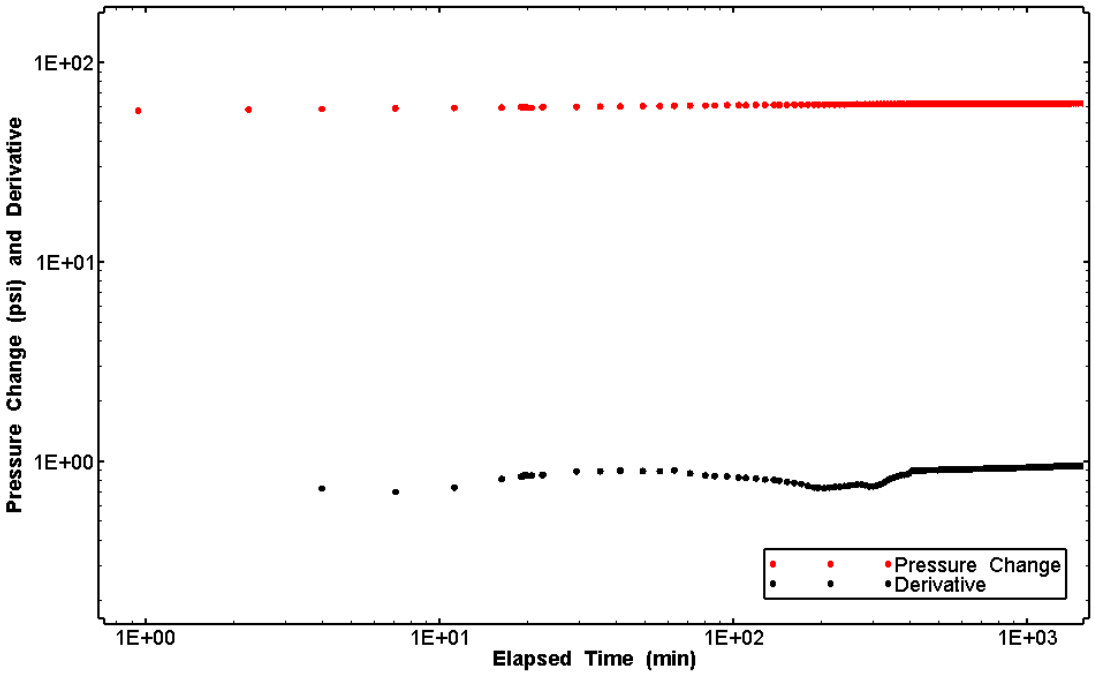

Figure 47. Log-log diagnostic plot of the final WIPP-25 pressure-buildup test.

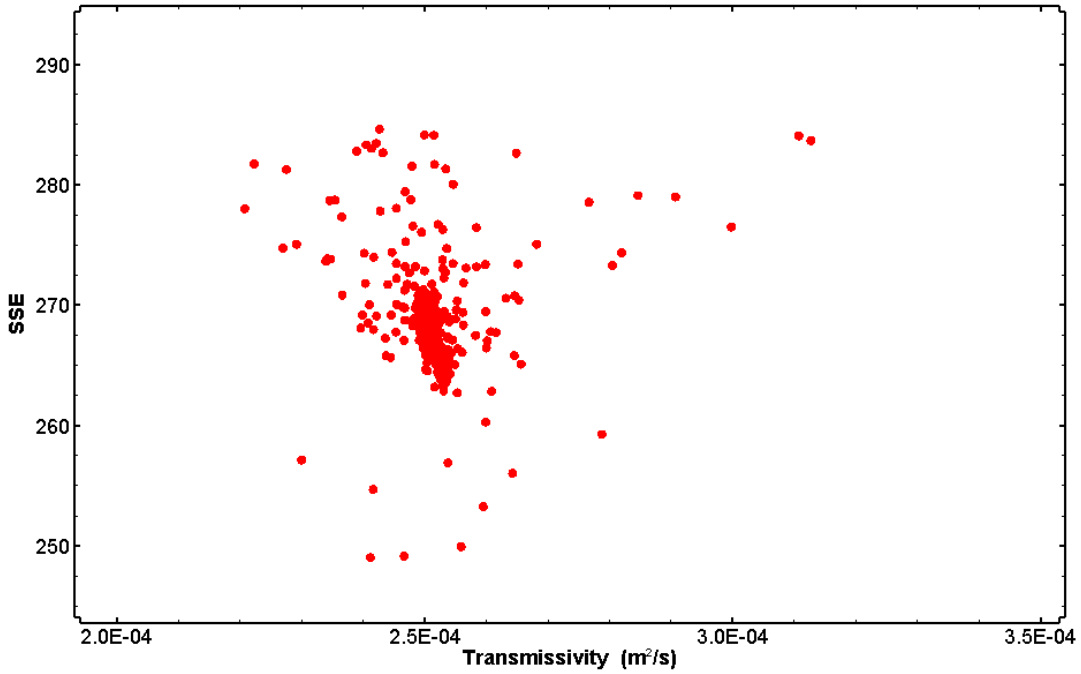

Figure 48. Estimates of transmissivity derived from the WIPP-25 perturbation analysis.

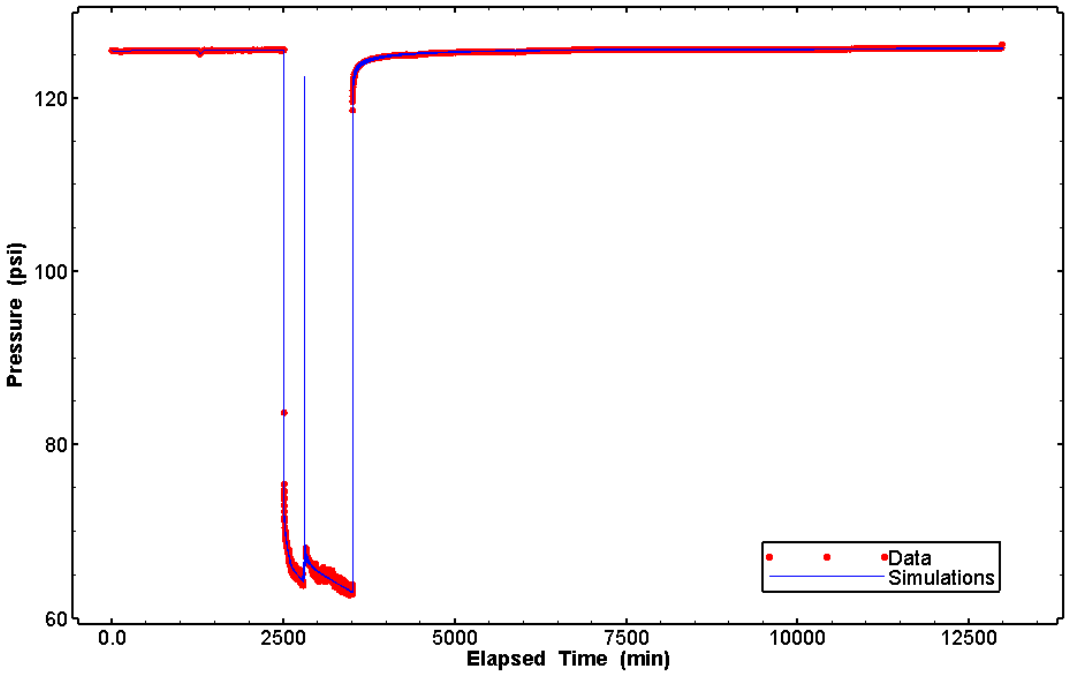

Figure 49. Simulations of the WIPP-25 pressure response.

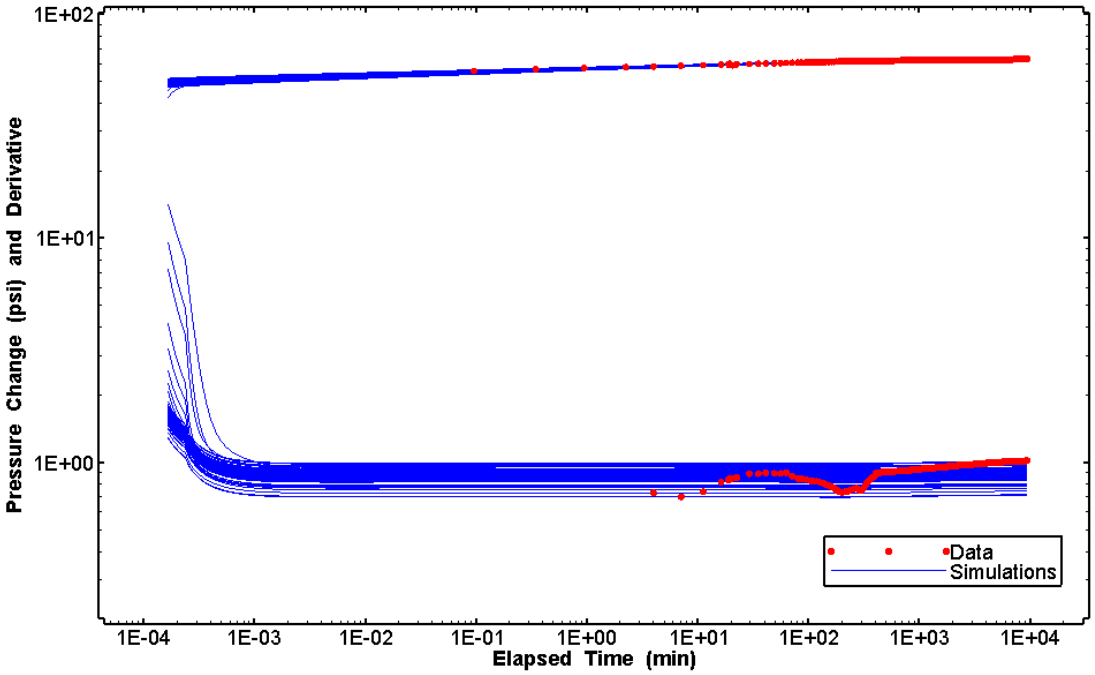

Figure 50. Simulations of pressure change and derivative during the final WIPP-25 pressure-buildup test.

4.10 C-2737

A constant-rate pumping test was initiated in well C-2737 on March 4, 2004. Pumping ended on March 5, 2004, after 10.4 hours of pumping at 0.3 gpm, and the subsequent pressure buildup through March 18, 2004, was included in this analysis (Figure 51). C-2737 pressures from January 1 – March 4, 2004, which included a series of pumping exercises in late January 2004, were included in the nSIGHTS simulations as a pressure history. The pressures shown in Figure 51 were separated into six nSIGHTS sequences for this analysis. The details of each sequence, i.e., start/end time, flow rate, etc., are specified in the C-2737.nPre file and are listed in Appendix B.10.

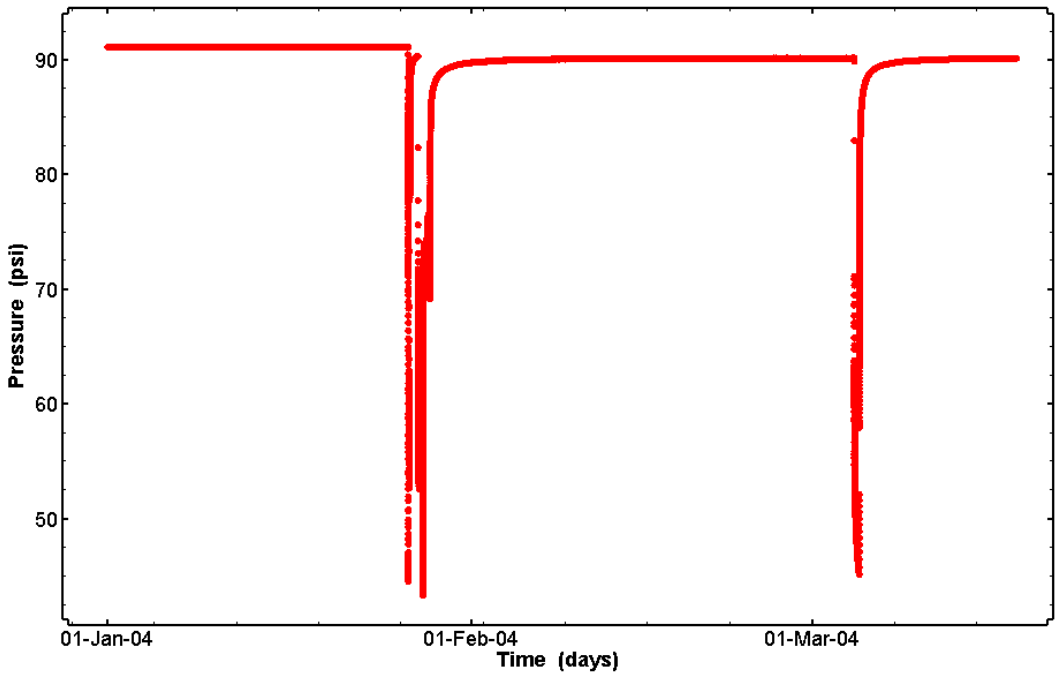

Figure 51. Pressure data from C-2737.

The specified C-2737 conceptual model, based on the characteristics of the final pressure-buildup diagnostic plot shown in Figure 52, was an infinite-acting radial system with wellbore storage and skin. The range of *T* values estimated from this analysis is shown in Figure 53. The mean estimate of *T* derived from this analysis was 6.62E-7 m^2/s. The simulated C-2737 Cartesian and log-log pressure-buildup diagnostic responses corresponding to the *T* values shown in Figure 53 are shown in Figures 54 and 55, respectively.

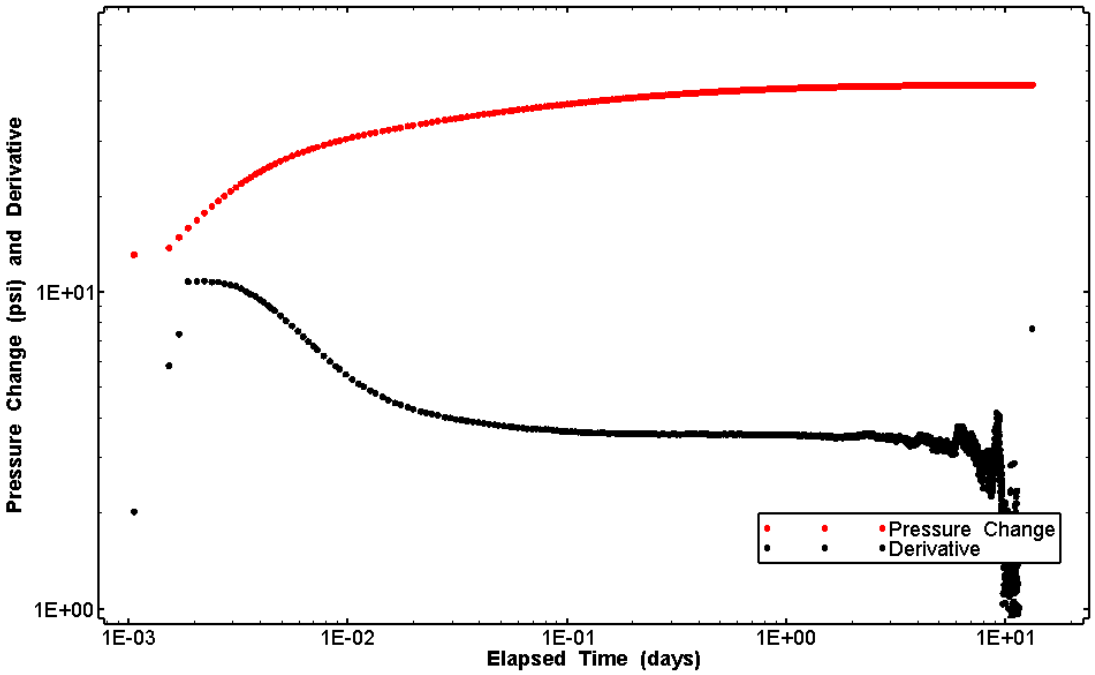

Figure 52. Log-log diagnostic plot of the final C-2737 pressure-buildup test.

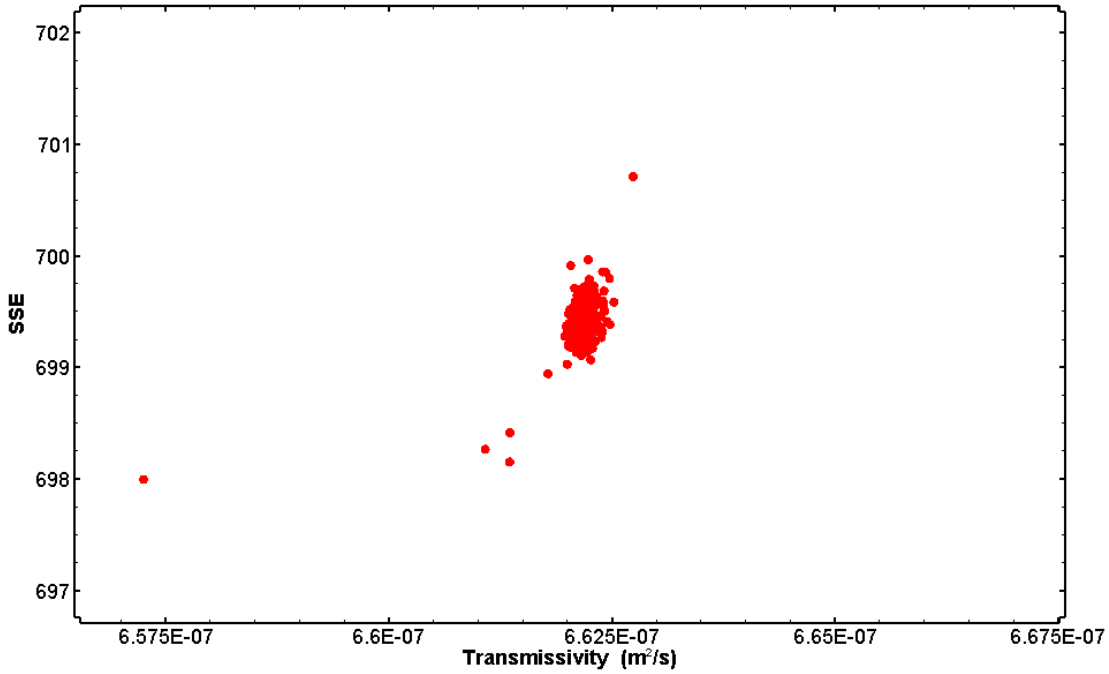

Figure 53. Estimates of transmissivity derived from the C-2737 perturbation analysis.

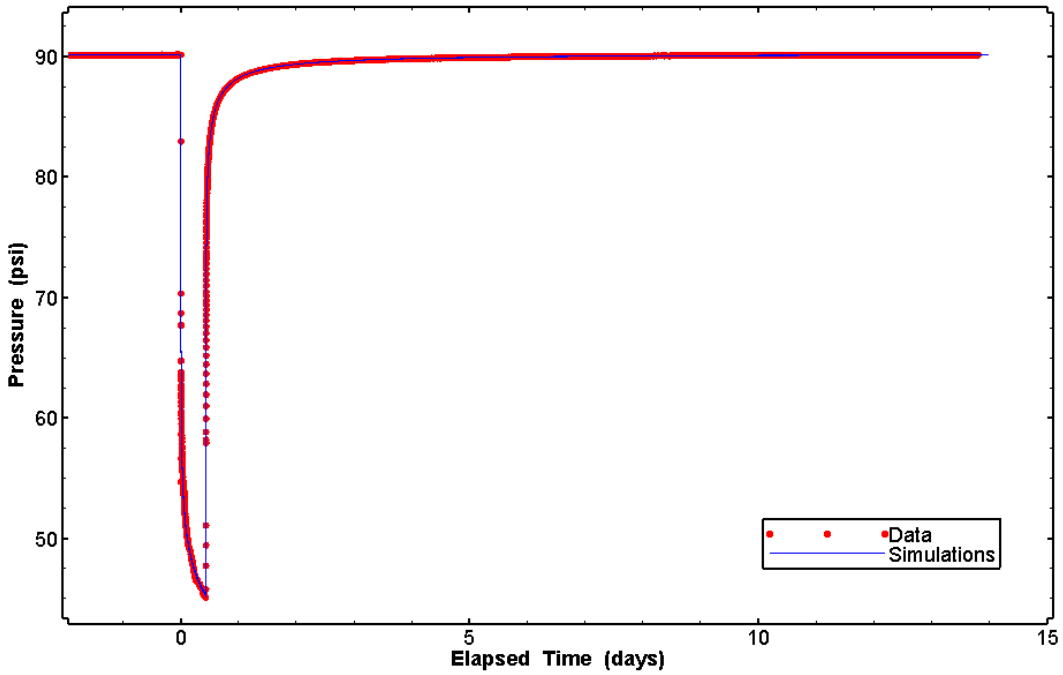

Figure 54. Simulations of the C-2737 pressure response.

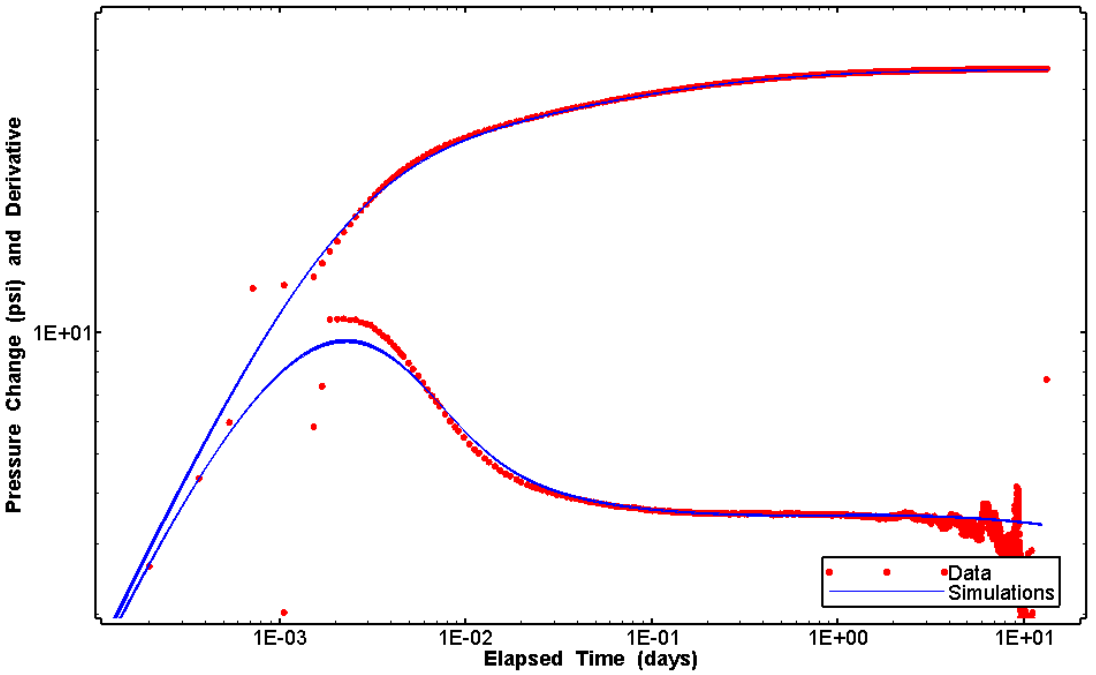

Figure 55. Simulations of pressure change and derivative during the C-2737 pressure-buildup test.

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Beauheim R.L., R.M. Roberts, T.F. Dale, M.D. Fort, and W.A. Stensrud. 1993. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretive Report*. SAND92-0533. Albuquerque, NM: Sandia National Laboratories.

Roberts R.M., R.L. Beauheim, and P.S. Domski. 1999. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Final Report*. SAND98-2537. Albuquerque, NM: Sandia National Laboratories.

Appendix A -- Culebra Pumping Tests – December 2003 to August 2005

Well	Date and Time Start DAS	Date and Time Stop DAS	Date and Time Start Pump	Date and Time Stop Pump	Borehole Diameter (in)	Inside Casing Diameter (in)	Culebra Interval (ft)	Specific Gravity (g/cm^3)	Troll Filenames (ERMS# 539221)	DAS Filenames (ERMS# 543540)	Field Notebook (ERMS# 540244)
C-2737	3/4/2004 12:40	3/5/2004 11:19	3/4/2004 14:10	3/5/2004 0:32	12.25	6.241	675-698	1.0642	C-2737 C-2737_WLBPET_11-1-2003_to_4-1-2004 corrected.xls	C-2737 (C)_5-sec_Flow & Well Level Data_03-04 to 03-05-04.csv	WIPP Notebook #2
SNL-1	3/7/2005 12:19	3/10/2005 11:53	3/7/2005 12:50	3/10/2005 10:20	11	4.33	596-624	1.0278	SNL-1 SNL-1 Final Corrected Pressure.xls	SNL-1 (C)_5-sec_Flow & Well Level Data_03-07 to 03-10-2005.csv	WIPP Notebook #6
SNL-2	1/19/2005 18:37	1/24/2005 11:51	1/19/2005 19:11	1/24/2005 10:25	12.25	4.33	456-481	1.009	SNL-2 SNL-2(C9-C14 compilation)WLBPET corrected.xls	SNL-2 (C)_5-sec_Data_01-20 to 01-24-05.csv	WIPP Notebook #5
SNL-3	4/13/2004 11:54	4/17/2004 8:23	4/13/2004 13:11	4/16/2004 14:32	12.25	4.33	755-775	1.035	SN11028 2004-04-13 105407 SNL-3(C-pump2)-F.xls	SNL-3 (C)_5-sec_Flow & Well Level Data_04-13 to 4-15-2004reviewed.xls SNL-3 (C)_5-sec_Flow & Well Level Data_04-15 to 4-17-2004reviewed.xls	WIPP Notebook #2 & 3
SNL-5	7/19/2004 13:05	7/24/04 9:19 (1)	7/19/2004 13:52	7/23/2004 7:50	11	4.33	637-660	1.011	SN13475 2004-07-19 112609 SNL-5(C-Pump1)-F.xls	SNL-5 (C)_5-sec_Flow & Well Level Data_07-2004_Part 1.csv SNL-5 (C)_5-sec_Flow & Well Level Data_07-2004_Part 2.csv	WIPP Notebook #3 &4
SNL-9	12/2/2003 14:16	12/6/2003 10:07	12/2/2003 14:38	12/6/2003 9:16	15.75	8.42	550-573	1.022	SN13590 2003-11-19 120134 SNL9(C2)-F.xls SN13590 2003-12-18 134604 snl 9 (c-3)-F.xls	SNL-9 (C)_5-sec_Data_12-02 to 12-04-03 reviewed.xls SNL-9 (C)_5-sec_Data_12-04 to 12-06-03 reviewed.xls	WIPP Notebook #2
SNL-12	8/9/2004 12:39	8/14/2004 10:00	8/9/2004 13:17	8/14/2004 8:28	12.25	4.33	547-587	1.0044	SN11358 2004-08-09 101349 SNL-12(C3-pump)-F.xls	SNL-12 (C)_5-sec_Flow & Well Level Data 083104 combined final table.xls	WIPP Notebook #4
SNL-14	8/4/2005 13:15	8/26/2005 9:35	8/4/2005 13:59	8/26/2005 7:51	11	4.85	650-677	1.060	SNL-14 SNL-14 August 2005 20-Day test Corrected PHEAD.xls	SNL14 5 Minute flow start 8-4-05 1000.xls	WIPP 30 Day Pumping Test #03
WIPP-11	1/31/2005 12:29	2/20/2005 19:06	1/31/2005 13:45	2/20/2005 18:53	12.25	8.921	844-867	1.038	SN17339 2005-01-31 132623 WIPP-11 (Cpump1BU1).xls	WIPP-11 (C)_5-sec_Flow & Well Level Data_01-31 to 02-03-	WIPP 30 Day Pumping Test #02

Well	Date and Time Start DAS	Date and Time Stop DAS	Date and Time Start Pump	Date and Time Stop Pump	Borehole Diameter (in)	Inside Casing Diameter (in)	Culebra Interval (ft)	Specific Gravity (g/cm^3)	Troll Filenames (ERMS# 539221)	DAS Filenames (ERMS# 543540)	Field Notebook (ERMS# 540244)
										05.xls WIPP-11 (C)_5-sec_Flow & Well Level Data_02-03 to 02-06-05.xls WIPP-11 (C)_5-sec_Flow & Well Level Data_02-06 to 02-07-05rev.xls WIPP-11 (C)_5-sec_Flow & Well Level Data_02-07 to 02-07-05rev.xls WIPP-11 (C)_5-sec_Flow & Well Level Data_02-07 to 02-10-05rev.xls WIPP-11 (C)_5-sec_Flow & Well Level Data_02-10 to 02-14-05rev.xls WIPP-11 (C)_5-sec_Flow & Well Level Data_02-14 to 02-17-05rev.xls WIPP-11 (C)_5-sec_Flow & Well Level Data_02-17 to 02-20-05rev.xls	
WIPP-25	9/10/2004 9:55	9/23/2004 9:00	9/10/2004 11:39	9/23/2004 0:25	7.875	4.95	447-472	1.022	SN16771 2004-09-20 135045 WIPP-25(C5Pump1)-F2.xls	WIPP-25 (C)_5-sec_Flow & Well Level Data_09-16 to 9-23-2004comments.xls	WIPP Notebook #4

Appendix B – nSIGHTS Listings

B.1 SNL-1 nSIGHTS Listings

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**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   23 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL-1\SNL-1.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	28.000	[ft]
Flow dimension	f(r) point	
Static formation pressure	73.767	[psi]
External boundary radius	1000000	[m]
Formation conductivity	7.24422E-05	[m/sec]
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	9.439796	[m]
Skin zone conductivity	7.78386E-03	[m/sec]
Skin zone spec. storage	1.00000E-07	[1/m]

Fluid

Fluid density	1027.80	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	1.5001279	[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]

---

f(x) Points Parameters

Flow dimension

Points type	f(r)	
Radius #1	0.0	[m]
Y value#1	2.0	[]
Radius #2	2445.3687063	[m]
Y value#2	1.017654	[]
Parameter curve type	Step Full	

Calculated Parameters

Formation

Transmissivity	6.18250E-04	[m^2/sec]
Storativity	8.53440E-06	[]
Diffusivity	7.24422E+01	[m^2/sec]

Skin Zone

Transmissivity	6.64305E-02	[m^2/sec]
Storativity	8.53440E-07	[]
Diffusivity	7.78386E+04	[m^2/sec]
Skin factor	-5.10339E+00	[]

Test Zone

Open hole well-bore storage	4.52547E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.05811	[]
First grid increment	5.68132E-01	[m]
Skin grid increment delta	0.10513	[]
Skin first grid increment	6.09598E-03	[m]
Skin last grid increment	9.47501E-01	[m]
Increment ratio	5.99611E-01	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	-250970.960	[min]
Duration	250979.962	[min]
Time step type	Static	
Static time step	1.000000	[day]
Type	Curve	
Wellbore storage	None	

Sequence: H_02

Sequence type	History	
Start time	9.002	[min]
Duration	4203.000	[min]
Time step type	Static	
Static time step	2.000	[min]
Type	Curve	
Wellbore storage	Open	

Sequence: H_03

Sequence type	History	
Start time	4212.002	[min]
Duration	155.728	[min]
Time step type	Static	
Static time step	0.500	[min]
Type	Curve	
Wellbore storage	Open	

Sequence: F_01

Sequence type	Flow	
Start time	4367.730	[min]
Duration	127.400	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	-40.0	[USgpm]
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	

Start time	4495.130	[min]
Duration	157.160	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Sequence: F_03

Sequence type	Flow	
Start time	4652.290	[min]
Duration	1064.064	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	-35.0	[USgpm]
Wellbore storage	Open	

Sequence: F_04

Sequence type	Flow	
Start time	5716.354	[min]
Duration	184.646	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Sequence: H_04

Sequence type	History	
Start time	5901.000	[min]
Duration	19.500	[min]
Time step type	Static	
Static time step	0.250	[min]
Type	Curve	
Wellbore storage	None	

Sequence: F_05

Sequence type	Flow	
Start time	5920.500	[min]
Duration	189.250	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Sequence: F_06

Sequence type	Flow	

Start time	6109.750	[min]
Duration	2427.790	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	-35.0	[USgpm]
Wellbore storage	Open	

Sequence: F_07

Sequence type	Flow	
Start time	8537.540	[min]
Duration	241462.460	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Test Zone Curves

Curve object to use	Pressure 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]

SNL-1 nSIGHTS Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   23 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL-1\SNL-1.nPre
```

Parameters

Formation

Formation thickness	28.000	[ft]
Flow dimension	f(r) point	
Static formation pressure	Optimization	
Minimum value	65.000	[psi]
Maximum value	80.000	[psi]
Estimate value	73.767	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-08	[m/sec]
Maximum value	1.00000E-01	[m/sec]
Estimate value	7.24422E-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	0.0001	[m]
Maximum value	10.0	[m]
Estimate value	9.439796	[m]
Range type	Log	
Sigma	1.00000E+00	
Skin zone conductivity	Optimization	
Minimum value	1.00000E-05	[m/sec]
Maximum value	1.00000E-01	[m/sec]
Estimate value	7.78386E-03	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Skin zone spec. storage	1.00000E-07	[1/m]

Fluid

Fluid density	1027.80	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	Optimization	
Minimum value	1.0	[in]
Maximum value	2.165	[in]
Estimate value	1.5001279	[in]
Range type	Linear	
Sigma	1.00000E+00	

Numeric

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

```
STP flow solution tolerance                    1.58503E-11     [USgpm]
```

SNL-1 Fitting-Parameter Estimates

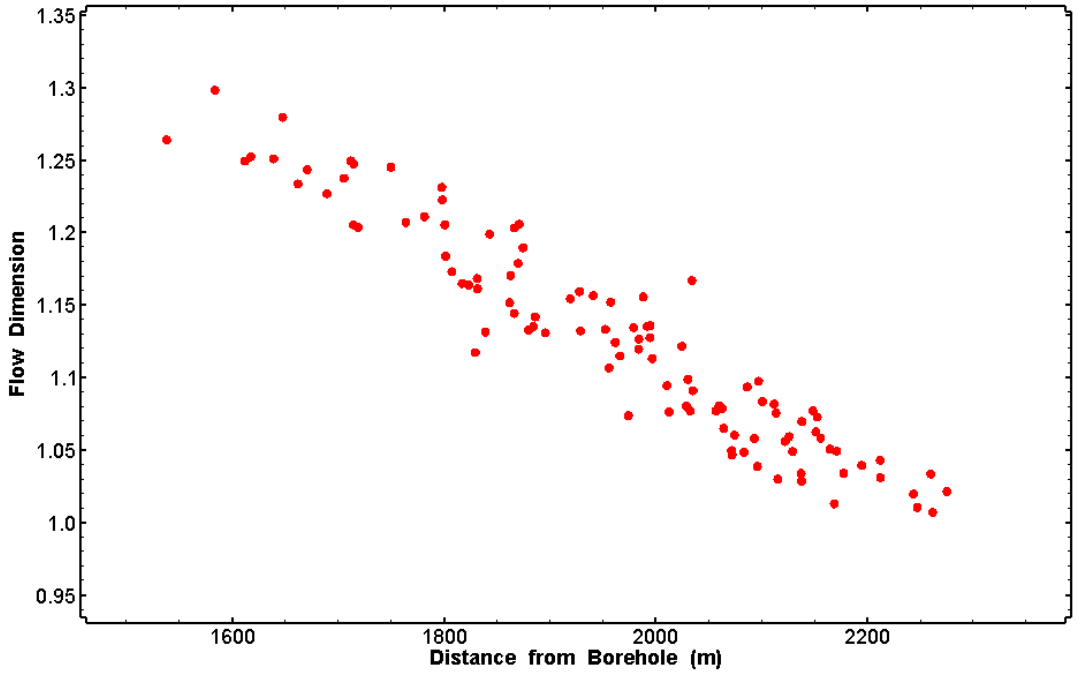

Figure B-1. Estimates of flow dimension derived from the SNL-1 perturbation analysis.

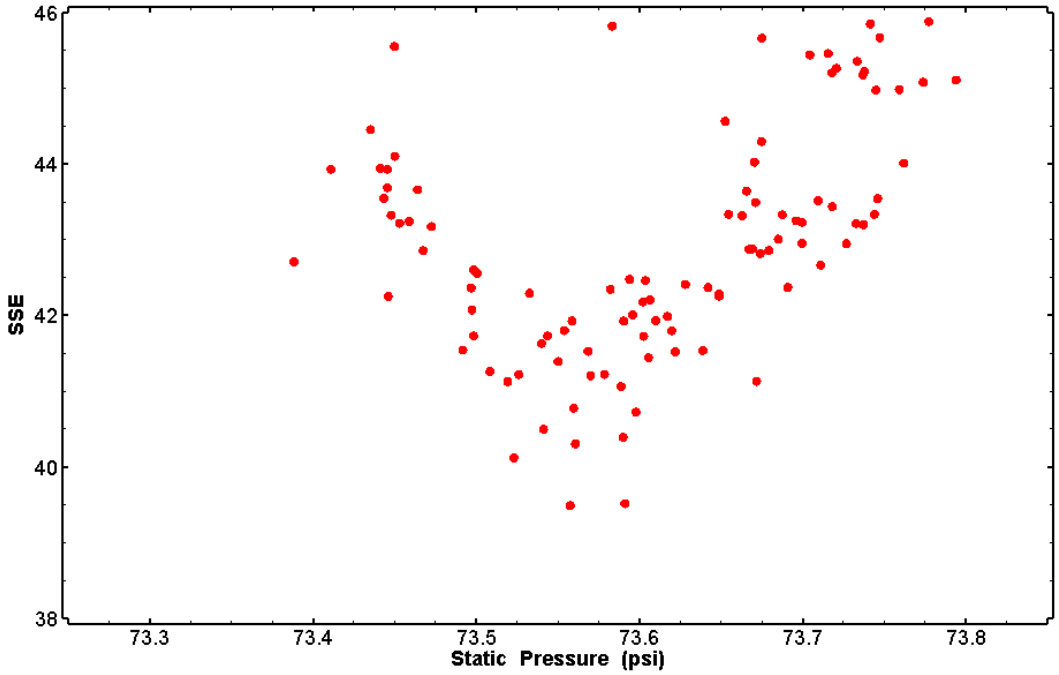

Figure B-2. Estimates of static formation pressure derived from the SNL-1 perturbation analysis.

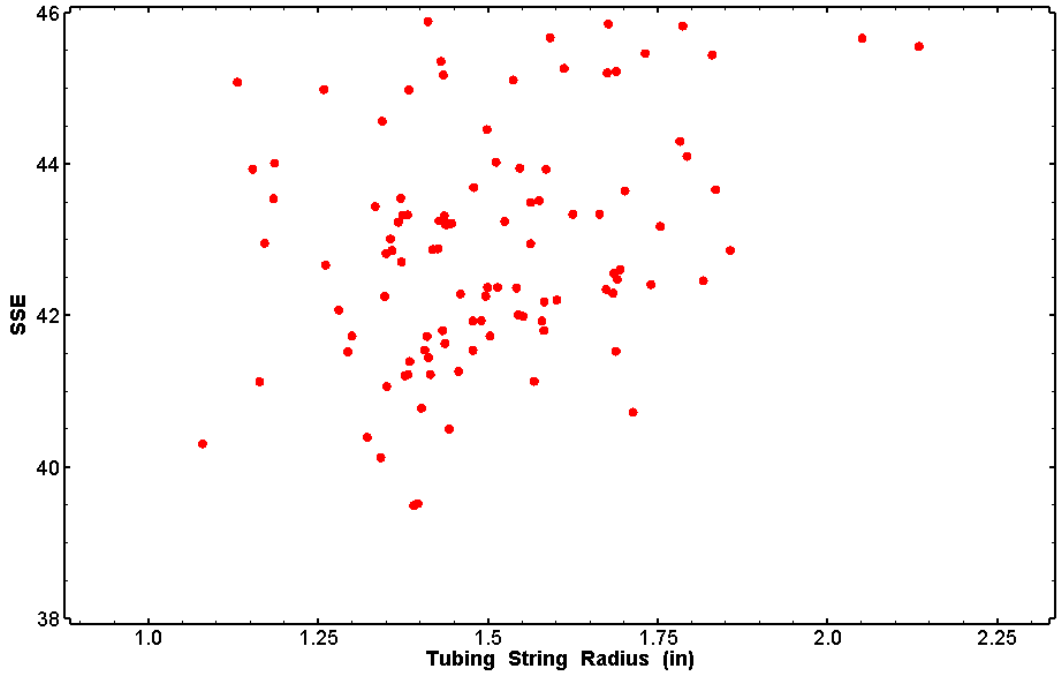

Figure B-3. Estimates of tubing string radius derived from the SNL-1 perturbation analysis.

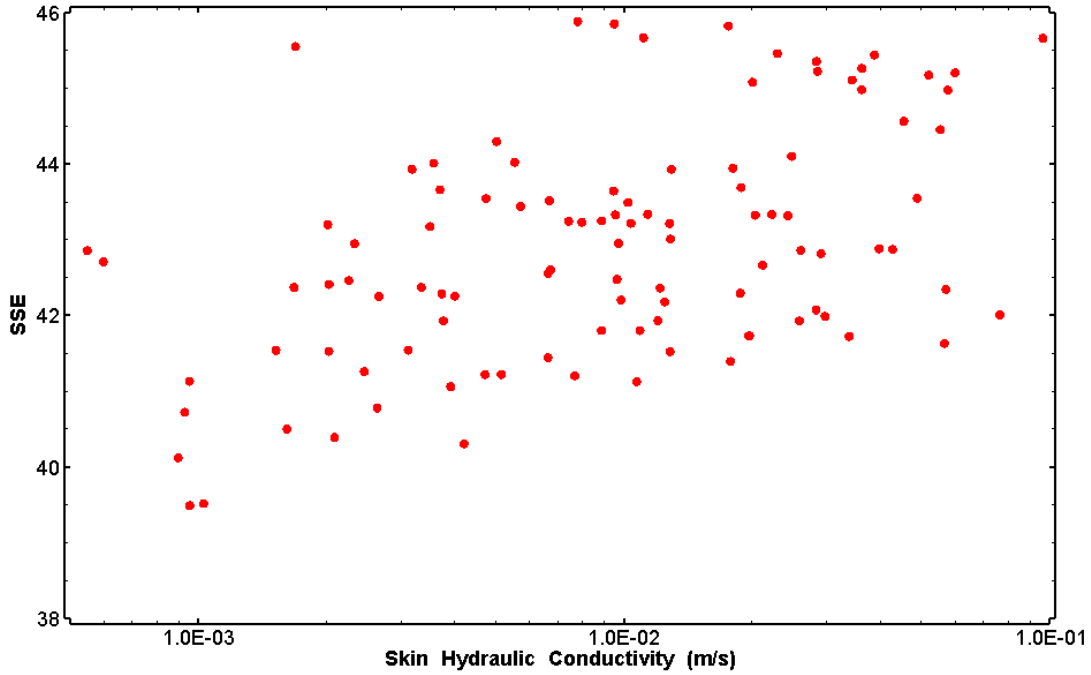

Figure B-4. Estimates of skin hydraulic conductivity derived from the SNL-1 perturbation analysis.

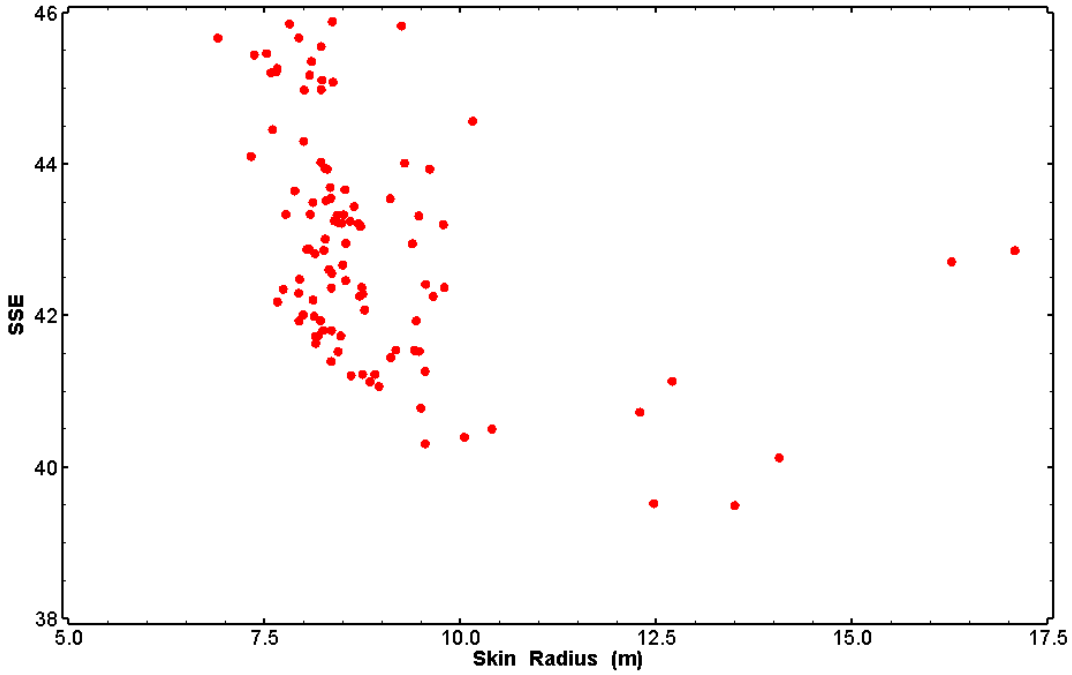

Figure B-5. Estimates of skin radius derived from the SNL-1 perturbation analysis.

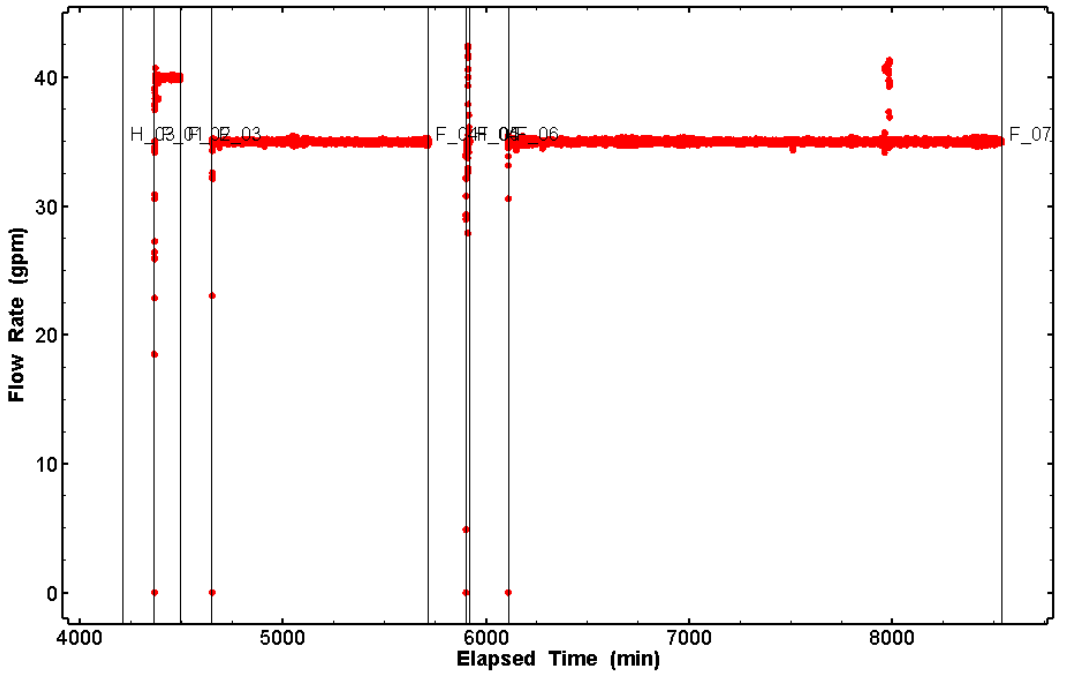

Figure B-6. Flow rates measured during the SNL-1 testing.

B.2 SNL-2 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   23 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 2\SNL-2.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	25.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	98.376	[psi]
External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	1.00000E-06	[1/m]

Fluid

Fluid density	1009.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	1.5000144	[in]

Numeric

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

f(x) Points Parameters

Formation conductivity

Points type	f(r)	
Radius #1	0.001	[m]
Y value#1	1.47460E-02	[m/sec]
Radius #2	742.6866088	[m]
Y value#2	1.31862E-05	[m/sec]
Radius #3	5782.035865	[m]
Y value#3	3.23096E-04	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	f(r)	
Storativity	7.62000E-06	[]
Diffusivity	f(r)	

Test Zone

Open hole well-bore storage	4.60910E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.06713	[]
First grid increment	3.81844E-03	[m]

Sequences

Sequence: H_01

Sequence type	History	
Start time	-527196.135	[min]
Duration	526196.135	[min]
Time step type	Static	
Static time step	500.000	[min]
Type	Curve	
Wellbore storage	None	

Sequence: H_02

Sequence type	History	
Start time	-1000.000	[min]
Duration	1002.082	[min]
Time step type	Static	
Static time step	1.000	[min]
Type	Curve	
Wellbore storage	None	

Sequence: F_01

Sequence type	Flow	
Start time	2.082	[min]
Duration	5786.254	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	-12.0	[USgpm]
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	
Start time	5788.336	[min]
Duration	4711.664	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Test Zone Curves

Curve object to use	P 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	Superposition	
DAT[1] operation	+ Pressure	
Type	Constant	
Fixed radius	0.0001	[m]
Output units	[psi]	

Output ID	DAT	
Output type	Flow Rate	
Flow rate output type	Well	

```
  Output units                                    [USgpm]
```

SNL-2 Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   23 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 2\SNL-2.nPre
```

Parameters

Formation

Formation thickness	25.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	86.000	[psi]
Maximum value	110.000	[psi]
Estimate value	98.376	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	1.00000E-06	[1/m]

Fluid

Fluid density	1009.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	Optimization	
Minimum value	1.5	[in]
Maximum value	4.0	[in]
Estimate value	1.5000144	[in]
Range type	Linear	
Sigma	1.00000E+00	

Numeric

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

SNL-2 Fitting Parameter Estimates

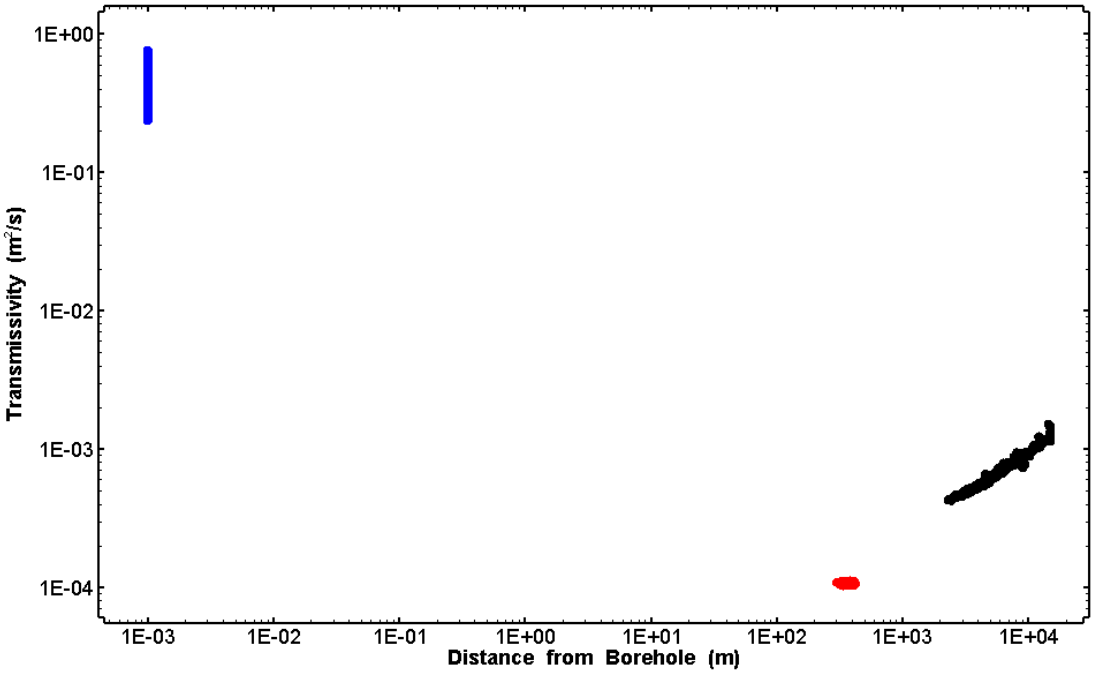

Figure B-7. Estimates of radially varying transmissivity derived from the SNL-2 perturbation analysis.

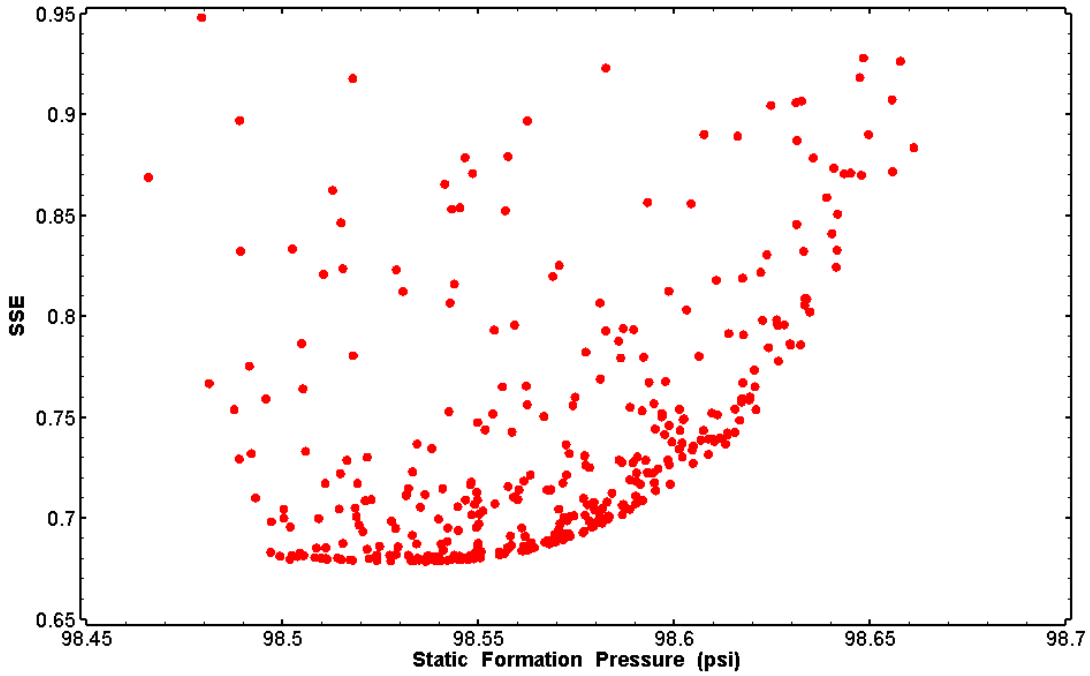

Figure B-8. Estimates of static formation pressure derived from the SNL-2 perturbation analysis.

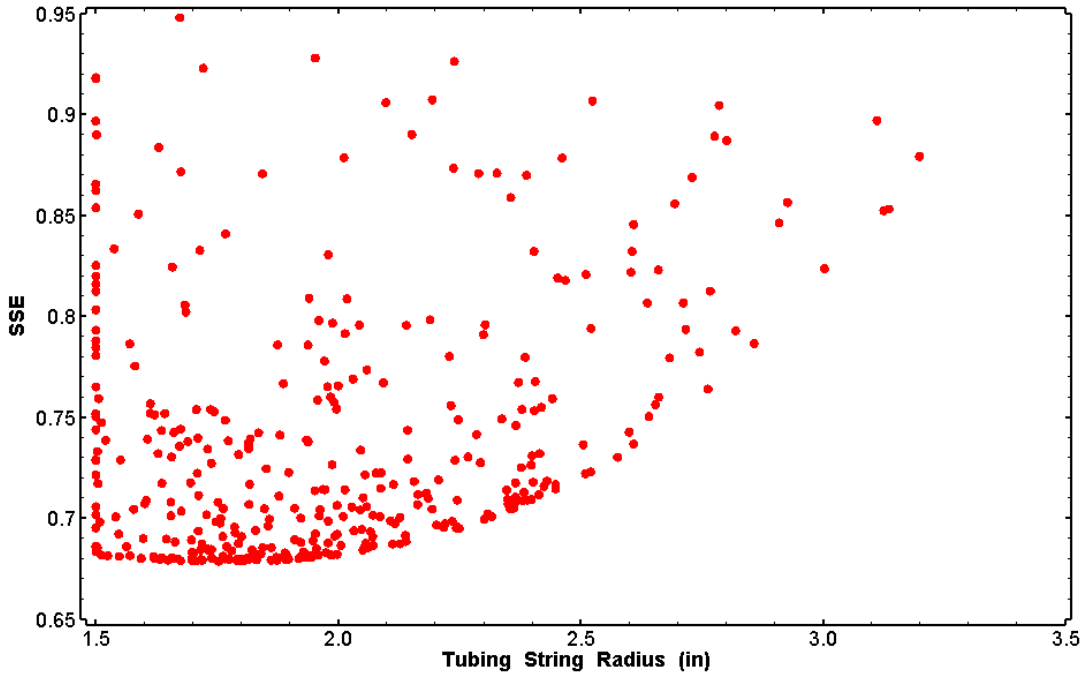

Figure B-9. Estimates of tubing string radius derived from the SNL-2 perturbation analysis.

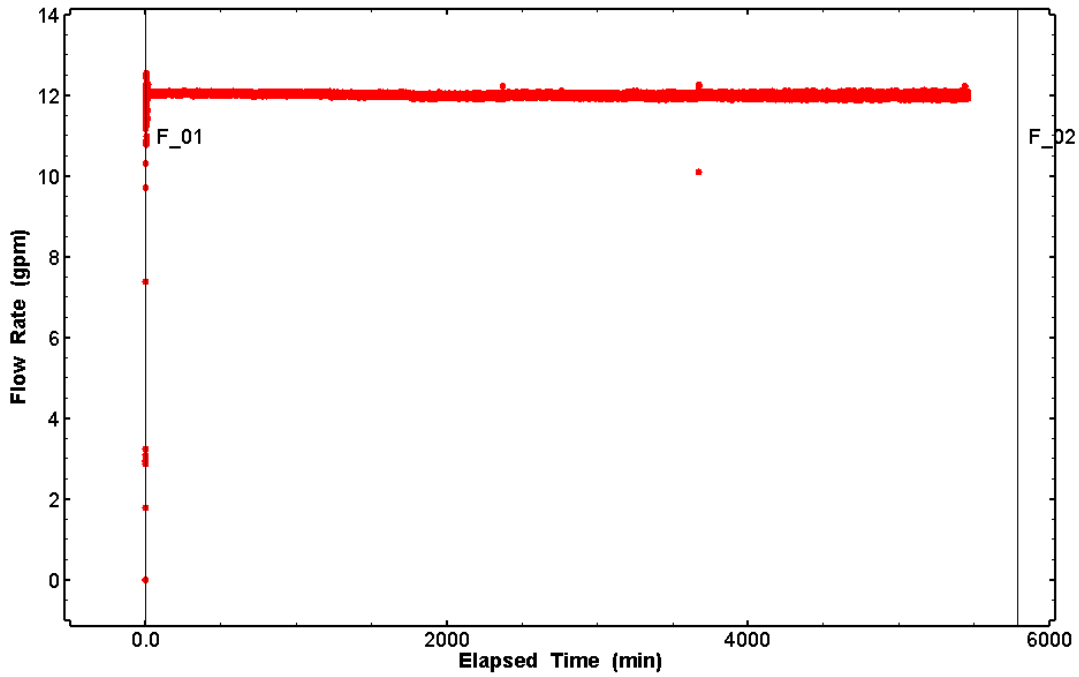

Figure B-10. Flow rates measured during the SNL-2 testing.

B.3 SNL-3 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   27 Apr 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 3\SNL-3.nPre
```

Control Settings

Test Description

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	20.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	165.540	[psi]
External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0000173	[m]
Skin zone conductivity	f(t) point	
Skin zone spec. storage	1.00000E-06	[1/m]

Fluid

Fluid density	1035.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	1.8	[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]

---

f(x) Points Parameters

Formation conductivity

Points type	f(r)	
Radius #1	6.0299749	[m]
Y value#1	1.53552E-04	[m/sec]
Radius #2	763.3368394	[m]
Y value#2	1.74206E-05	[m/sec]
Radius #3	2588.6872667	[m]
Y value#3	9.99827E-06	[m/sec]
Parameter curve type	Linear	

Skin zone conductivity

Points type	f(t)	
Time #1	206444.160000	[day]
Y value#1	6.83458E-10	[m/sec]
Time #2	207131.761160	[day]
Y value#2	3.20516E-10	[m/sec]
Time #3	211592.768300	[day]
Y value#3	2.50530E-10	[m/sec]
Time #4	289669.414910	[day]
Y value#4	2.08608E-10	[m/sec]
Time #5	403870.639170	[day]
Y value#5	1.91428E-10	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	f(r)	
Storativity	6.09600E-06	[]
Diffusivity	f(r)	

Skin Zone

Transmissivity	f(t)	
Storativity	6.09600E-06	[]
Diffusivity	f(t)	
Skin factor	f(r)	

Test Zone

Open hole well-bore storage	6.47025E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.08400	[]
First grid increment	4.82025E-03	[m]
Skin grid increment delta	0.00001	[]
Skin first grid increment	3.53484E-07	[m]
Skin last grid increment	3.53593E-07	[m]
Increment ratio	1.36322E+04	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	1.454250	[day]
Duration	0.935190	[day]
Time step type	Static	
Static time step	0.050000	[day]
Type	Fixed	
Fixed value	165.444	[psi]
Wellbore storage	Open	

Sequence: F_01

Sequence type	Flow	
Start time	2.389440	[day]
Duration	2.216029	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	-10.0	[USgpm]
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	

Start time	4.605469	[day]
Duration	10.394531	[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	

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]	

SNL-3 Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   27 Apr 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 3\SNL-3.nPre
```

Parameters

Formation

Formation thickness	20.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	140.000	[psi]
Maximum value	180.000	[psi]
Estimate value	165.540	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	1.0E-05	[m]
Maximum value	1.0	[m]
Estimate value	0.0000173	[m]

Range type	Log	
Sigma	1.00000E+00	
Skin zone conductivity	f(t) point	
Skin zone spec. storage	1.00000E-06	[1/m]

Fluid

Fluid density	1035.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	1.8	[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]

SNL-3 Fitting Parameter Estimates

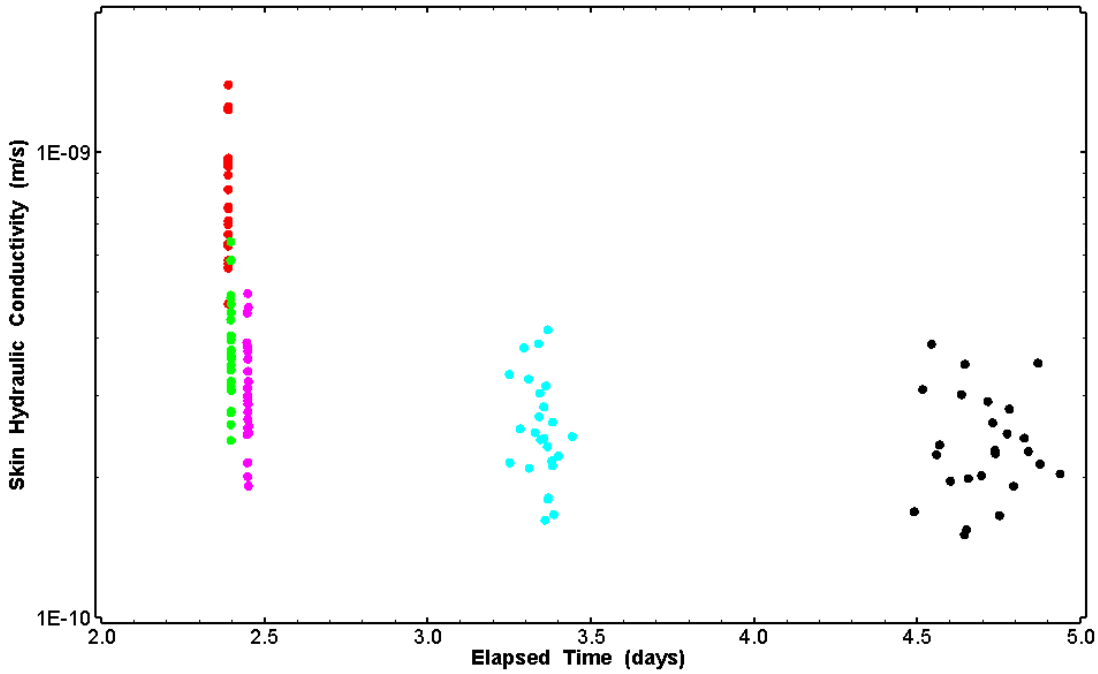

Figure B-11. Estimates of time-varying skin hydraulic conductivity derived from the SNL-3 perturbation analysis.

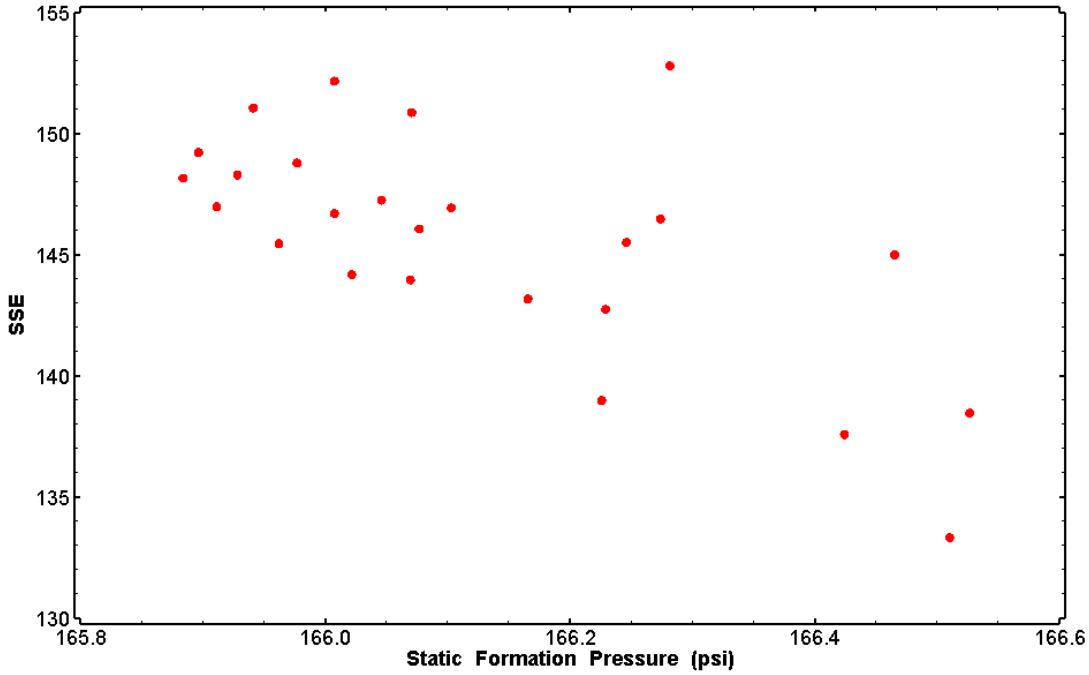

Figure B-12. Estimates of static formation pressure derived from the SNL-3 perturbation analysis.

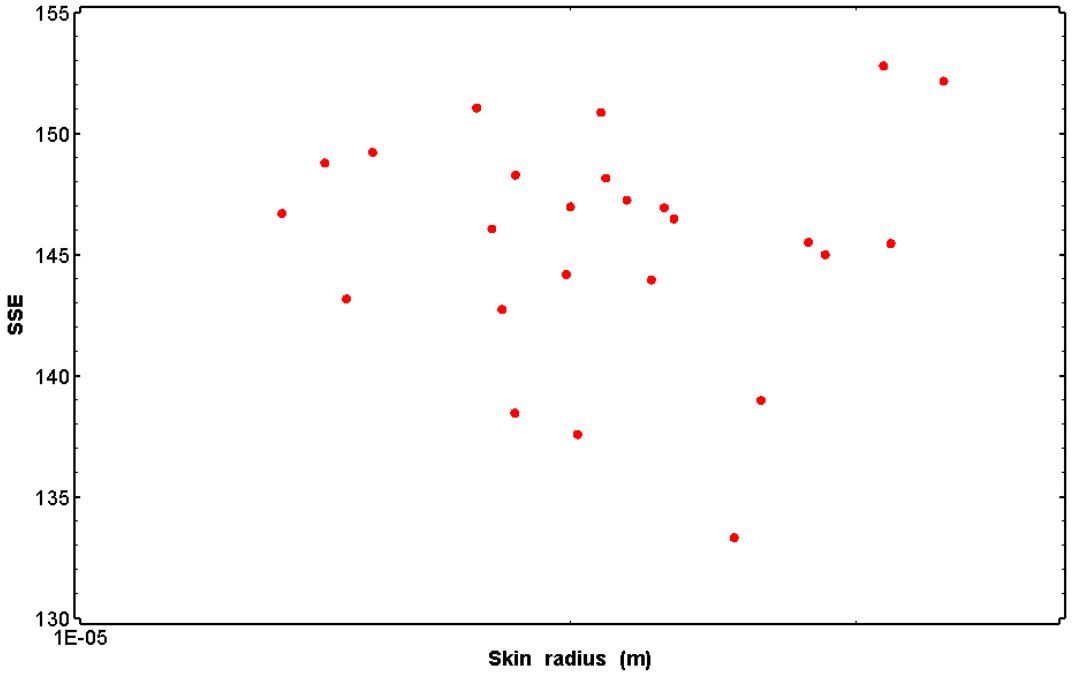

Figure B-13. Estimates of skin radius derived from the SNL-3 perturbation analysis.

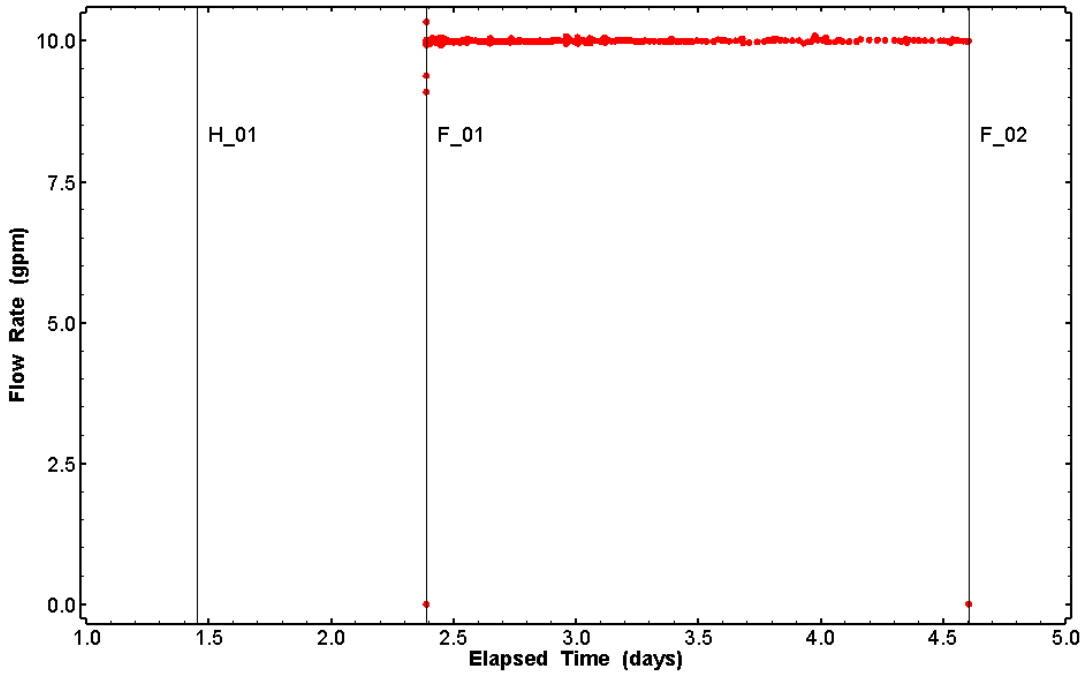

Figure B-14. Flow rates measured during the SNL-3 testing.

B.4 SNL-5 nSIGHTS Listings

```
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   27 Apr 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 5\SNL-5.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	7.0104	[m]
Flow dimension	2.0	[]
Static formation pressure	155.335	[psi]
External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	9.48085E-07	[1/m]

Fluid

Fluid density	1011.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	1.8175729	[in]

Numeric

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

f(x) Points Parameters

Formation conductivity

Points type	f(r)	
Radius #1	50.369803	[m]
Y value#1	1.09028E-06	[m/sec]
Radius #2	82.8396426	[m]
Y value#2	4.21197E-07	[m/sec]
Radius #3	1248.930036	[m]
Y value#3	3.24706E-06	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	f(r)	
Storativity	6.64645E-06	[]
Diffusivity	f(r)	

Test Zone

Open hole well-bore storage	6.75381E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.06713	[]
First grid increment	3.81844E-03	[m]

Sequences

Sequence: H_01

Sequence type	History	
Start time	0.000	[min]
Duration	145.114	[min]
Time step type	Static	
Static time step	1.000	[min]
Type	Curve	
Wellbore storage	Open	

Sequence: H_02

Sequence type	History	
Start time	145.114	[min]
Duration	206.947	[min]
Time step type	Static	
Static time step	0.167	[min]
Type	Curve	
Wellbore storage	Open	

Sequence: F_01

Sequence type	Flow	
Start time	352.061	[min]
Duration	983.687	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	
Start time	1335.748	[min]
Duration	5647.770	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	-3.5	[USgpm]
Wellbore storage	Open	

Sequence: F_03

Sequence type	Flow	
Start time	6983.518	[min]
Duration	36116.482	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Test Zone Curves

Curve object to use	P 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	[USgpm]	
Output ID	P_S_01	
Output type	Pressure	
Pressure capture type	Superposition	
P_S_01[1] operation	+ Pressure	
Type	Constant	
Fixed radius	0.001	[m]
Output units	[psi]	

SNL-5 Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   27 Apr 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 5\SNL-5.nPre
```

Parameters

Formation

Formation thickness	7.0104	[m]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	140.000	[psi]
Maximum value	175.000	[psi]
Estimate value	155.335	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-04	[1/m]
Estimate value	9.48085E-07	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1011.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	Optimization	
Minimum value	1.2	[in]
Maximum value	2.166	[in]
Estimate value	1.8175729	[in]
Range type	Linear	
Sigma	1.00000E+00	

Numeric

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

SNL-5 Fitting Parameter Estimates

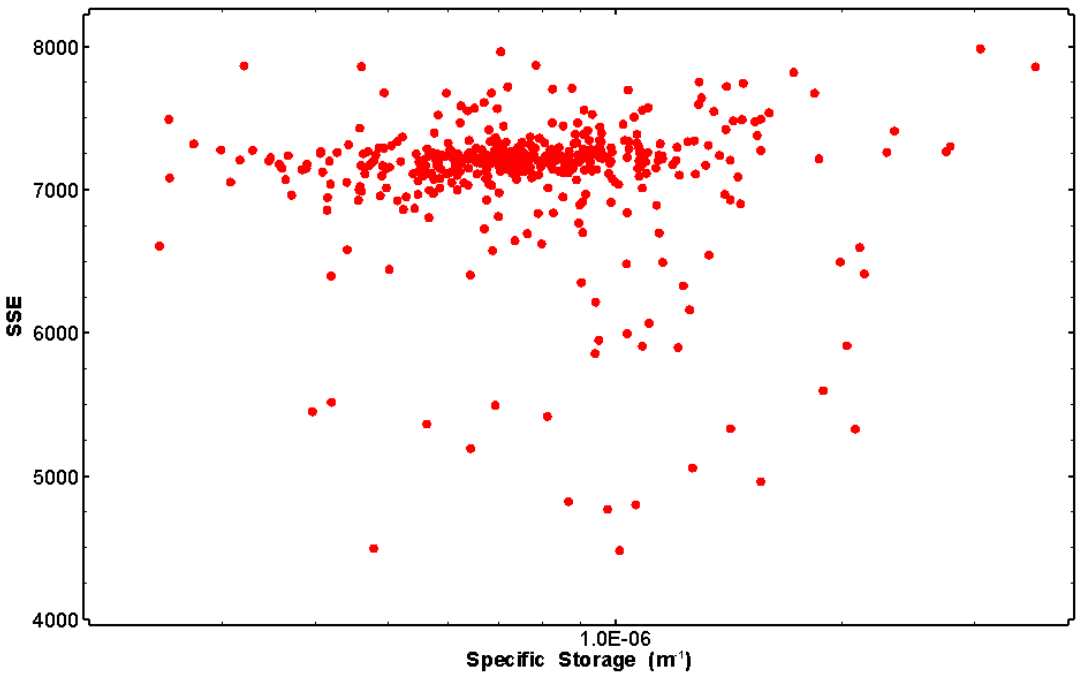

Figure B-15. Estimates of specific storage derived from the SNL-5 perturbation analysis.

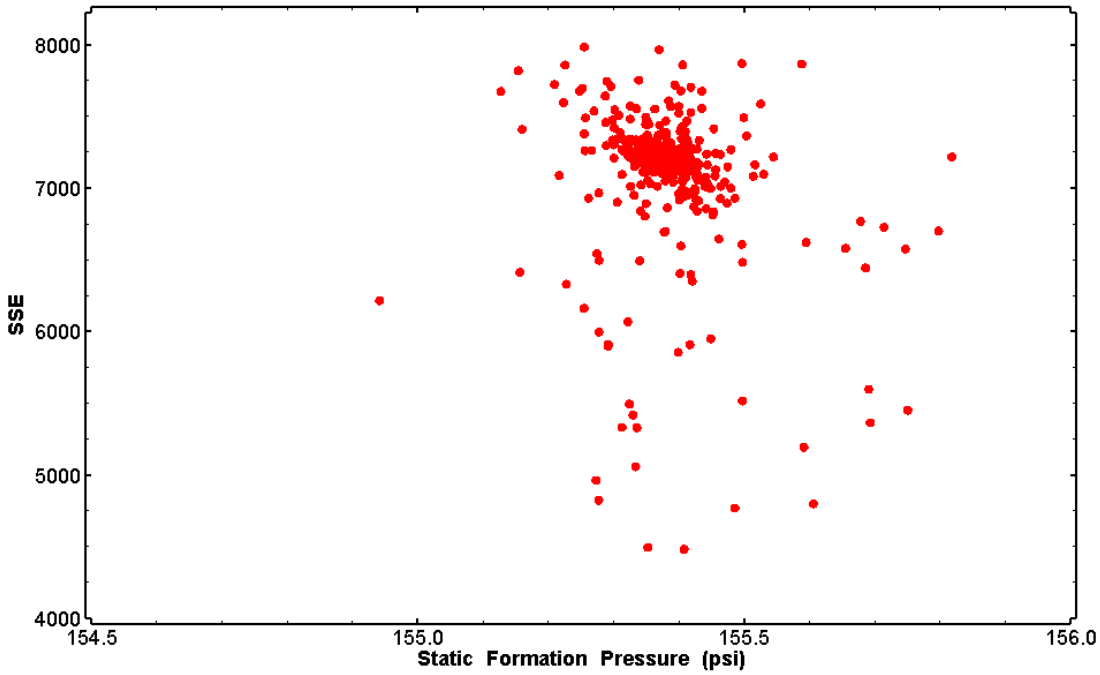

Figure B-16. Estimates of static formation pressure derived from the SNL-5 perturbation analysis.

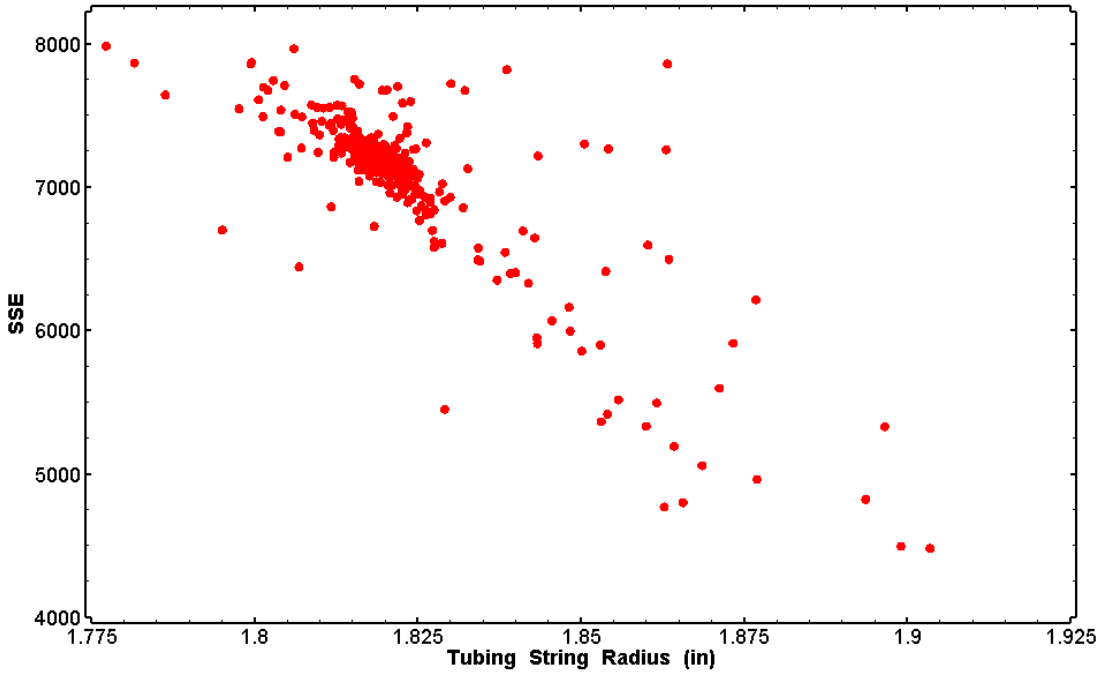

Figure B-17. Estimates of tubing string radius derived from the SNL-5 perturbation analysis.

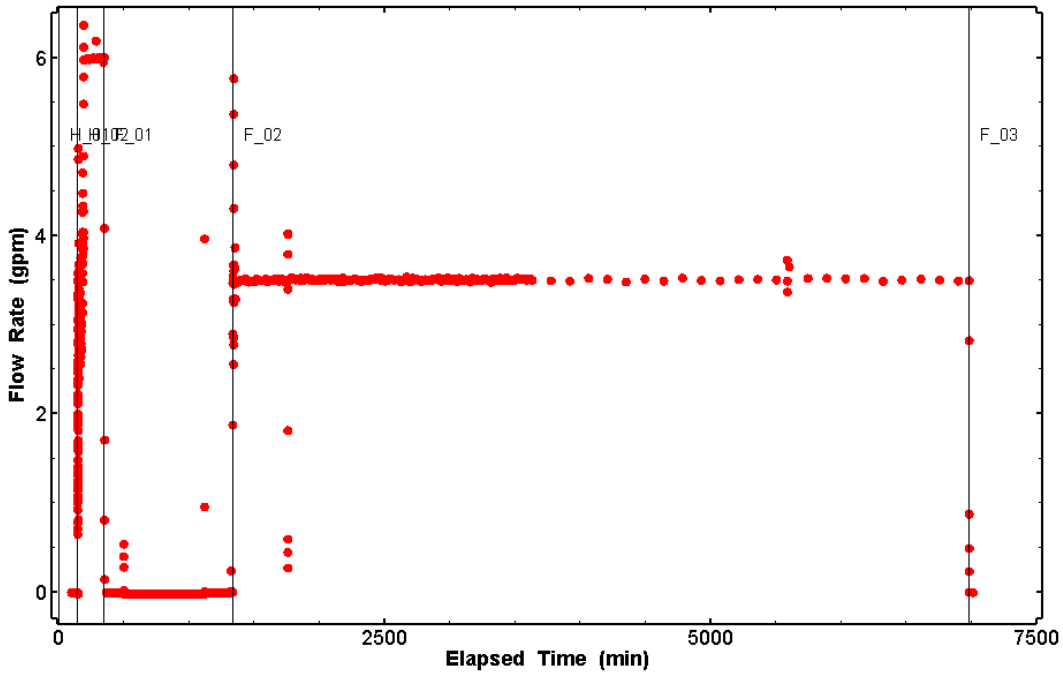

Figure B-18. Flow rates measured during the SNL-5 testing.

B.5 SNL-9 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   28 Apr 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 9\SNL-9.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	Dual	
Matrix block type	Prismatic	
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	23.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	120.303	[psi]
External boundary radius	1000000	[m]

Fracture

Fracture conductivity	5.39328E-04	[m/sec]
Fracture spec. storage	2.61158E-08	[1/m]

Matrix

Matrix volume factor	0.990000	[decimal]
Geometry factor (Alpha)	1200	[1/m^2]
Matrix conductivity	1.01579E-12	[m/sec]
Matrix spec. storage	3.59532E-04	[1/m]

Skin

Radial thickness of skin	0.0904817	[m]
Skin zone conductivity	4.44686E-05	[m/sec]
Skin zone spec. storage	6.94574E-07	[1/m]

Fluid

Fluid density	1022.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	4.21	[in]
Tubing string radius	4.0	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
# of matrix nodes	1	[]

Calculated Parameters

Dual Porosity

Fracture thickness	0.070104	[m]
Matrix thickness	6.940296	[m]
Lambda - interporosity flow	2.58442E-06	[]
Omega - storativity ratio	7.33720E-07	[]
Beta - transient parameter	3.52236E+00	[]

Skin Zone

Transmissivity	3.11743E-04	[m^2/sec]
Storativity	4.86924E-06	[]
Diffusivity	6.40228E+01	[m^2/sec]
Skin factor	6.82275E+00	[]

Test Zone

Open hole well-bore storage	3.23900E-06	[m^3/Pa]

Grid Properties

Grid increment delta	0.07758	[]
First grid increment	1.59248E-02	[m]
Skin grid increment delta	0.01251	[]
Skin first grid increment	1.34639E-03	[m]
Skin last grid increment	2.45472E-03	[m]

Increment ratio	6.48740E+00	[]
Number of nodes	249	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	17000.000	[min]
Duration	1876.000	[min]
Time step type	Static	
Static time step	100.000	[min]
Type	Curve	
Wellbore storage	None	

Sequence: F_01

Sequence type	Flow	
Start time	18876.000	[min]
Duration	5438.598	[min]
Time step type	Static	
Static time step	1.000	[min]
Type	Fixed	
Fixed value	-12.5	[USgpm]
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	
Start time	24314.598	[min]
Duration	147090.402	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Test Zone Curves

Curve object to use	Pressure 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	

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]

SNL-9 Optimization Settings

****
nPre 2.30Q
****

Version date	22 July 2005
Listing date	28 Apr 2006
QA status	QA:Q
Config file	C:\nSIGHTS\Culebra\SNL 9\SNL-9.nPre

Parameters

Formation

Formation thickness	23.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	120.303	[psi]
External boundary radius	1000000	[m]

Fracture

Fracture conductivity	5.39328E-04	[m/sec]
Fracture spec. storage	2.61158E-08	[1/m]

Matrix

Matrix volume factor	0.990000	[decimal]
Geometry factor (Alpha)	1200	[1/m^2]
Matrix conductivity	1.01579E-12	[m/sec]
Matrix spec. storage	3.59532E-04	[1/m]

Skin

Radial thickness of skin	0.0904817	[m]
Skin zone conductivity	4.44686E-05	[m/sec]
Skin zone spec. storage	6.94574E-07	[1/m]

Fluid

Fluid density	1021.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	4.21	[in]
Tubing string radius	4.0	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
# of matrix nodes	1	[]

SNL-9 Fitting Parameter Estimates

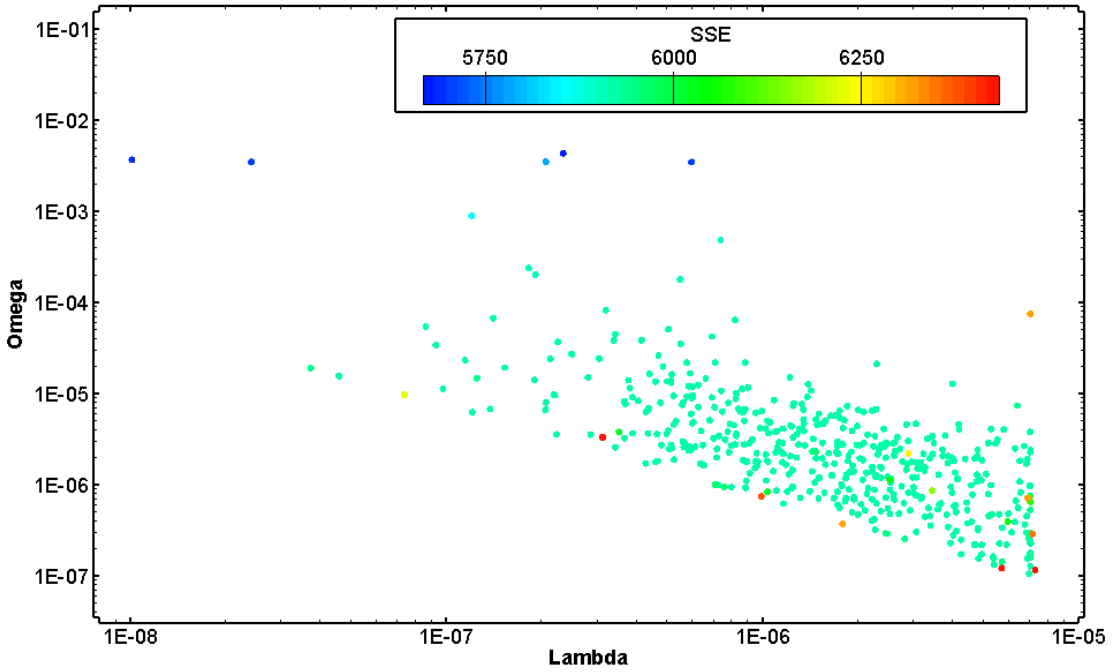

Figure B-19. Estimates of lambda and omega derived from the SNL-9 perturbation analysis.

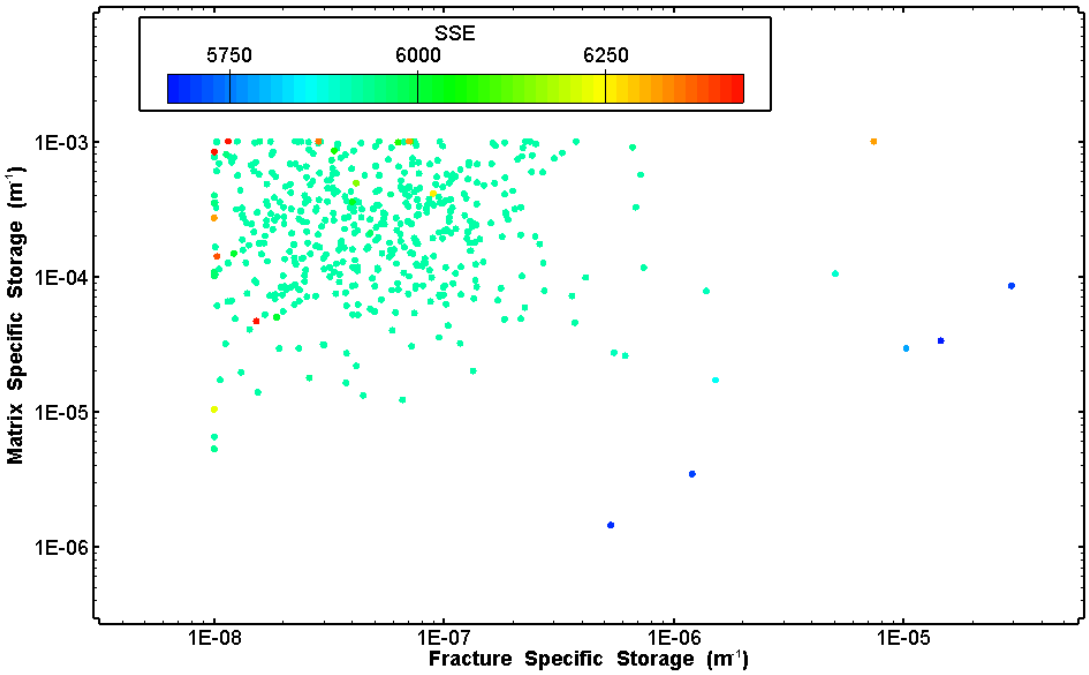

Figure B-20. Estimates of fracture and matrix specific storage derived from the SNL-9 perturbation analysis.

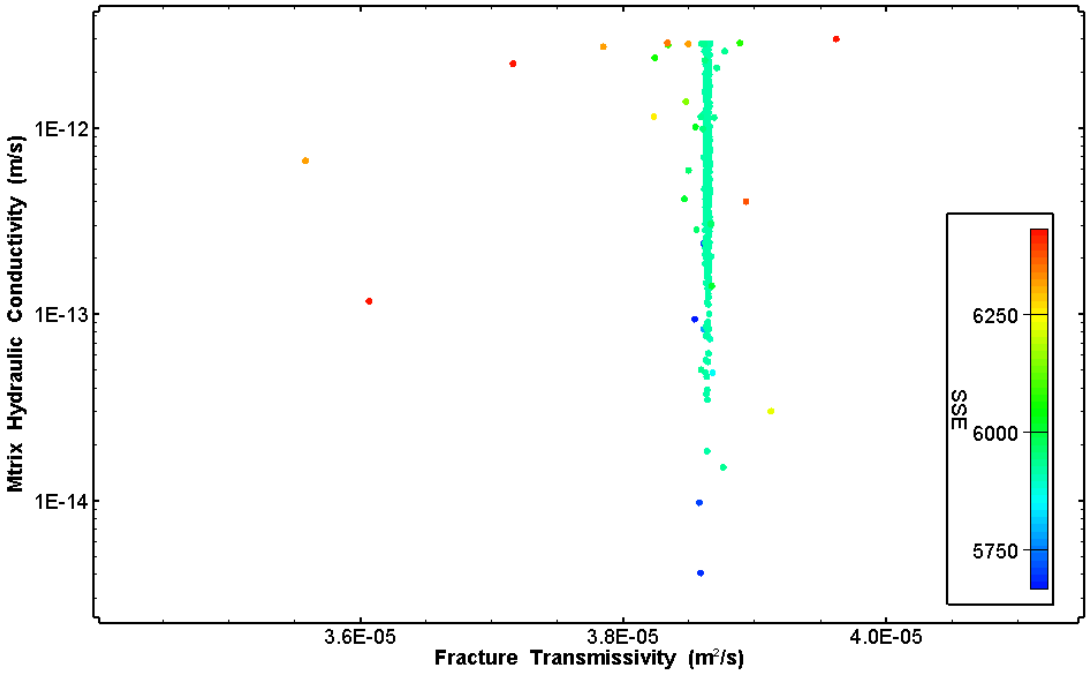

Figure B-21. Estimates of fracture transmissivity and matrix hydraulic conductivity derived from the SNL-9 perturbation analysis.

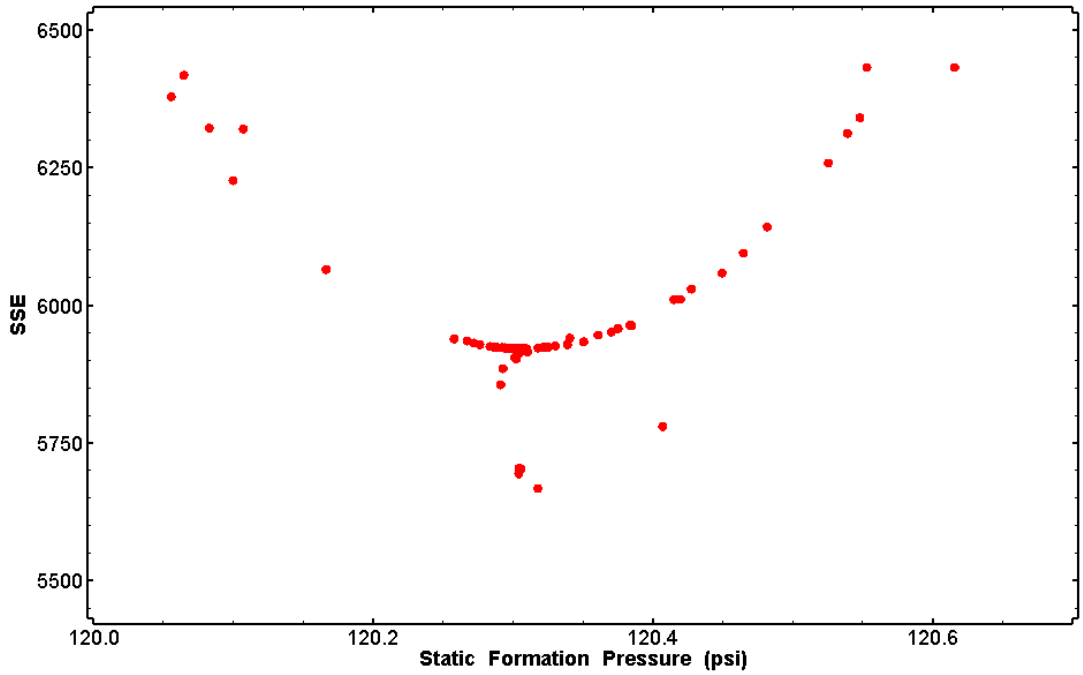

Figure B-22. Estimates of static formation pressure derived from the SNL-9 perturbation analysis.

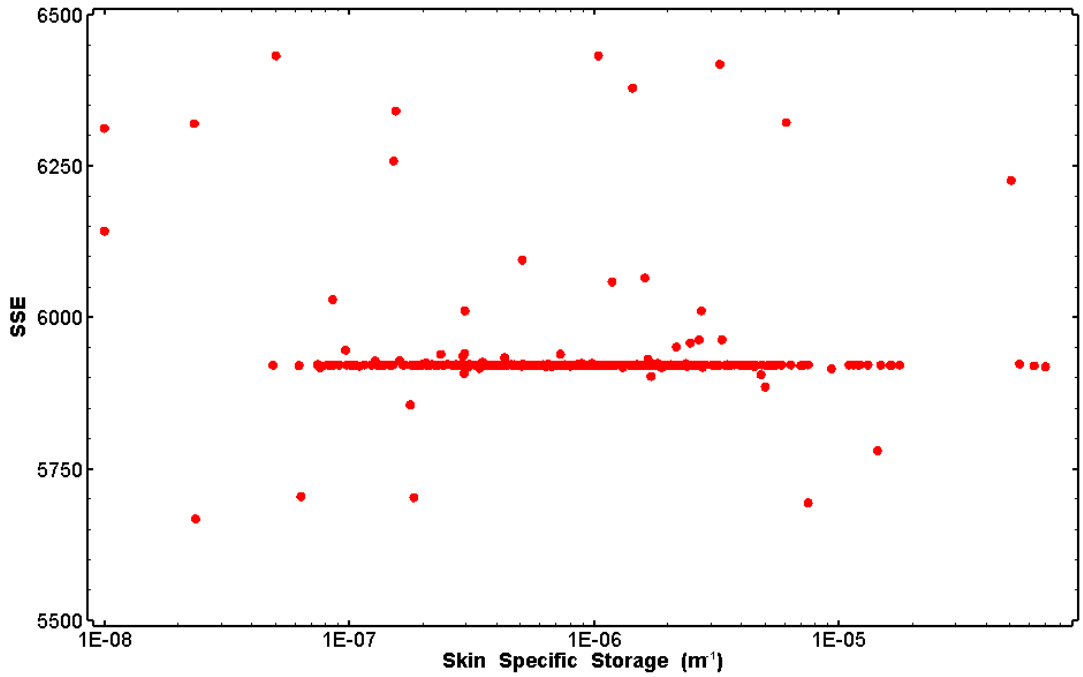

Figure B-23. Estimates of skin specific storage derived from the SNL-9 perturbation analysis.

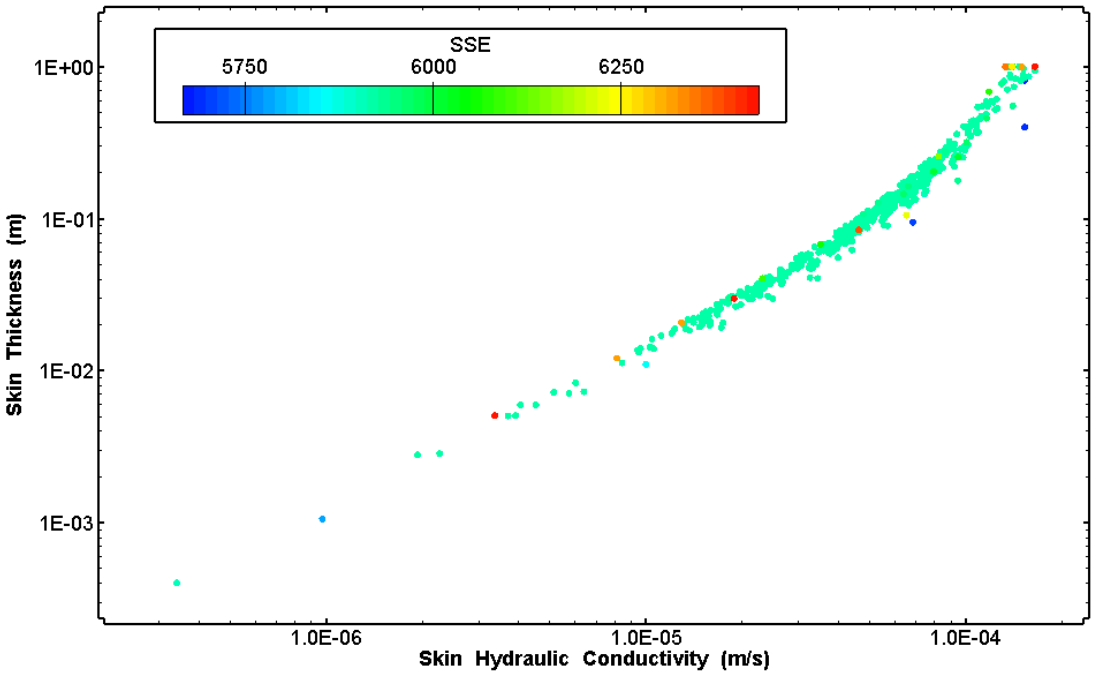

Figure B-24. Estimates of skin hydraulic conductivity and radius derived from the SNL-9 perturbation analysis.

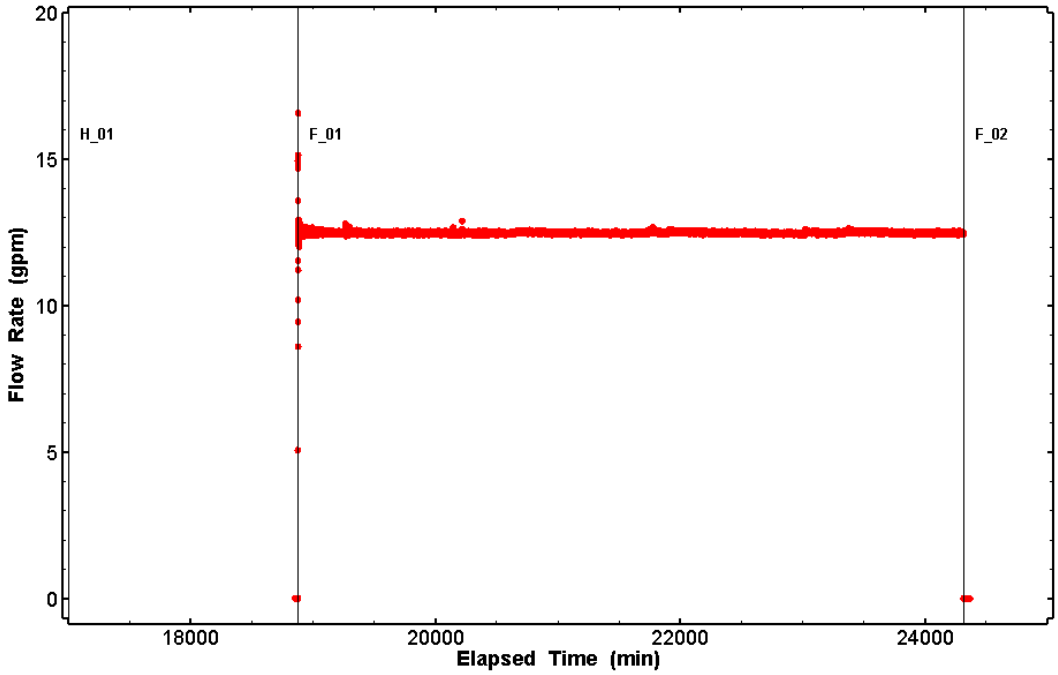

Figure B-25. Flow rates measured during the SNL-9 testing.

B.6 SNL-12 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   22 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 12\SNL-12.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	Dual	
Matrix block type	Prismatic	
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	40.000	[ft]
Flow dimension	f(r) point	
Static formation pressure	112.680	[psi]
External boundary radius	1000000	[m]

Fracture

Fracture conductivity	4.15134E-03	[m/sec]
Fracture spec. storage	2.28474E-10	[1/m]

Matrix

Matrix volume factor	0.990000	[decimal]
Geometry factor (Alpha)	1200	[1/m^2]
Matrix conductivity	5.66514E-12	[m/sec]
Matrix spec. storage	1.24864E-04	[1/m]

Skin

Radial thickness of skin	0.0005369	[m]
Skin zone conductivity	f(t) point	
Skin zone spec. storage	1.91614E-07	[1/m]

Fluid

Fluid density	1004.40	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	2.0	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
# of matrix nodes	6	[]

---

f(x) Points Parameters

Flow dimension

Points type	f(r)	
Radius #1	0.3592	[m]
Y value#1	2.0	[]
Radius #2	135.1541817	[m]
Y value#2	-0.0525097	[]
Parameter curve type	Step Full	

Skin zone conductivity

Points type	f(t)	
Time #1	9060.179	[min]
Y value#1	2.03363E-06	[m/sec]
Time #2	16558.731	[min]
Y value#2	6.32041E-07	[m/sec]
Time #3	25671.391	[min]
Y value#3	9.71358E-07	[m/sec]
Time #4	74202.915	[min]
Y value#4	9.22399E-07	[m/sec]
Time #5	90410.819	[min]
Y value#5	7.20814E-07	[m/sec]
Time #6	219981.144	[min]
Y value#6	7.27608E-07	[m/sec]

Time #7	420613.154	[min]
Y value#7	7.51564E-07	[m/sec]
Time #8	425649.101	[min]
Y value#8	6.52393E-07	[m/sec]
Time #9	426283.773	[min]
Y value#9	3.34698E-06	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Dual Porosity

Fracture thickness	0.12192	[m]
Matrix thickness	12.07008	[m]
Lambda - interporosity flow	4.95207E-07	[]
Omega - storativity ratio	1.84827E-08	[]
Beta - transient parameter	2.67930E+01	[]

Skin Zone

Transmissivity	f(t)	
Storativity	2.33616E-06	[]
Diffusivity	f(t)	
Skin factor	f(t)	

Test Zone

Open hole well-bore storage	3.56965E-02	[STB/psi]

Grid Properties

Grid increment delta	0.08395	[]
First grid increment	4.86293E-03	[m]
Skin grid increment delta	0.00020	[]
Skin first grid increment	1.09048E-05	[m]
Skin last grid increment	1.10091E-05	[m]
Increment ratio	4.41718E+02	[]
Number of nodes	1244	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	-171261.852	[min]
Duration	171436.852	[min]
Time step type	Static	
Static time step	200.000	[min]
Type	Curve	
Wellbore storage	None	

Sequence: H_02

Sequence type	History	

Start time	175.000	[min]
Duration	11.050	[min]
Time step type	Static	
Static time step	0.100	[min]
Type	Curve	
Wellbore storage	None	

Sequence: F_01

Sequence type	Flow	
Start time	186.050	[min]
Duration	162.350	[min]
Time step type	Static	
Static time step	0.167	[min]
Type	Curve	
Wellbore storage	Open	

Sequence: F_02

Sequence type	Flow	
Start time	348.400	[min]
Duration	1004.400	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Open	

Sequence: F_03

Sequence type	Flow	
Start time	1352.800	[min]
Duration	5742.050	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Curve	
Wellbore storage	Open	

Sequence: F_04

Sequence type	Flow	
Start time	7094.850	[min]
Duration	44709.150	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# 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	Flow Rate
Start sequence	F_01
End sequence	F_04

```
Curve time base                                  Test
Curve Y data units                             [USgpm]
Curve Y data is log 10                             no

Curve object to use                          P 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                                 [USgpm]

Output ID                                      BOUND
  Output type                                Pressure
  Pressure capture type                 Superposition
   BOUND[1] operation                     + Pressure
    Type                                    Constant
    Fixed radius                              0.0001     [m]
  Output units                                  [psi]
```

SNL-12 nSIGHTS Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   22 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 12\SNL-12 - dbl poro - sans
Bourdet.nPre
```

Parameters

Formation

```
Formation thickness                              40.000     [ft]
Flow dimension                                f(r) point
Static formation pressure                    Optimization
   Minimum value                                103.000     [psi]
```

Maximum value	115.000	[psi]
Estimate value	112.680	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]

Fracture

Fracture conductivity	Optimization	
Minimum value	1.00000E-06	[m/sec]
Maximum value	1.00000E-01	[m/sec]
Estimate value	4.15134E-03	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Fracture spec. storage	Optimization	
Minimum value	1.00000E-11	[1/m]
Maximum value	1.00000E-05	[1/m]
Estimate value	2.28474E-10	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Matrix

Matrix volume factor	0.990000	[decimal]
Geometry factor (Alpha)	1200	[1/m^2]
Matrix conductivity	Optimization	
Minimum value	1.00000E-14	[m/sec]
Maximum value	1.00000E-07	[m/sec]
Estimate value	5.66514E-12	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Matrix spec. storage	Optimization	
Minimum value	1.00000E-07	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	1.24864E-04	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Skin

Radial thickness of skin	Optimization	
Minimum value	1.0E-05	[m]
Maximum value	10.0	[m]
Estimate value	0.0005369	[m]
Range type	Log	
Sigma	1.00000E+00	
Skin zone conductivity	f(t) point	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-07	[1/m]
Maximum value	1.00000E-02	[1/m]
Estimate value	1.91614E-07	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1004.40	[kg/m^3]

Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.165	[in]
Tubing string radius	2.0	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
# of matrix nodes	6	[]

SNL-12 Fitting Parameter Estimates

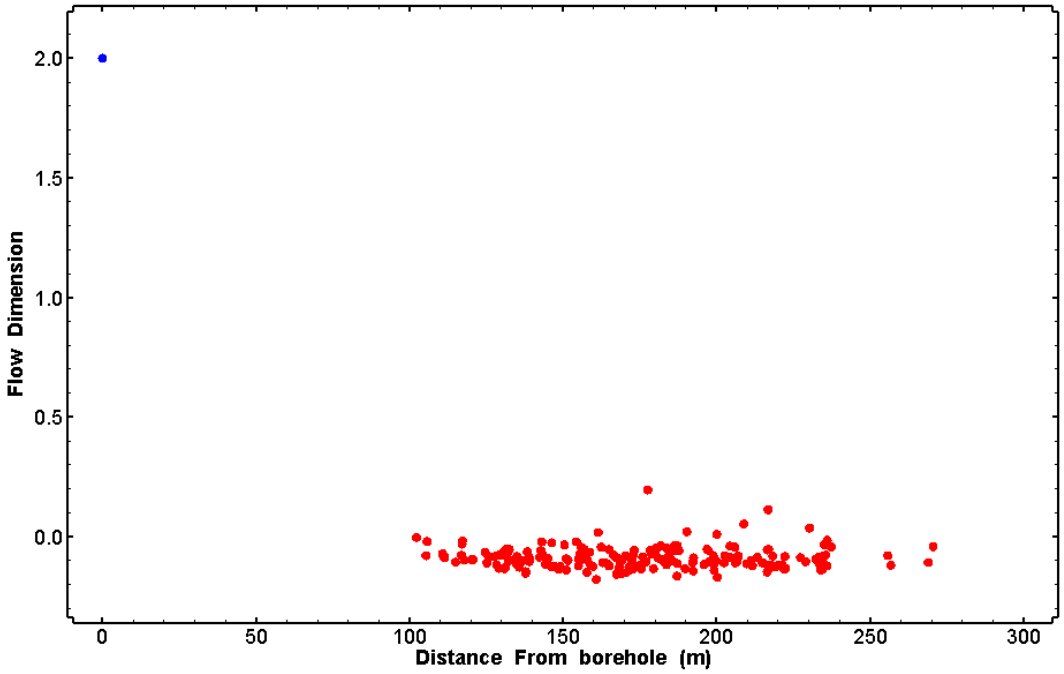

Figure B-26. Estimates of radially varying flow dimension derived from the SNL-12 perturbation analysis.

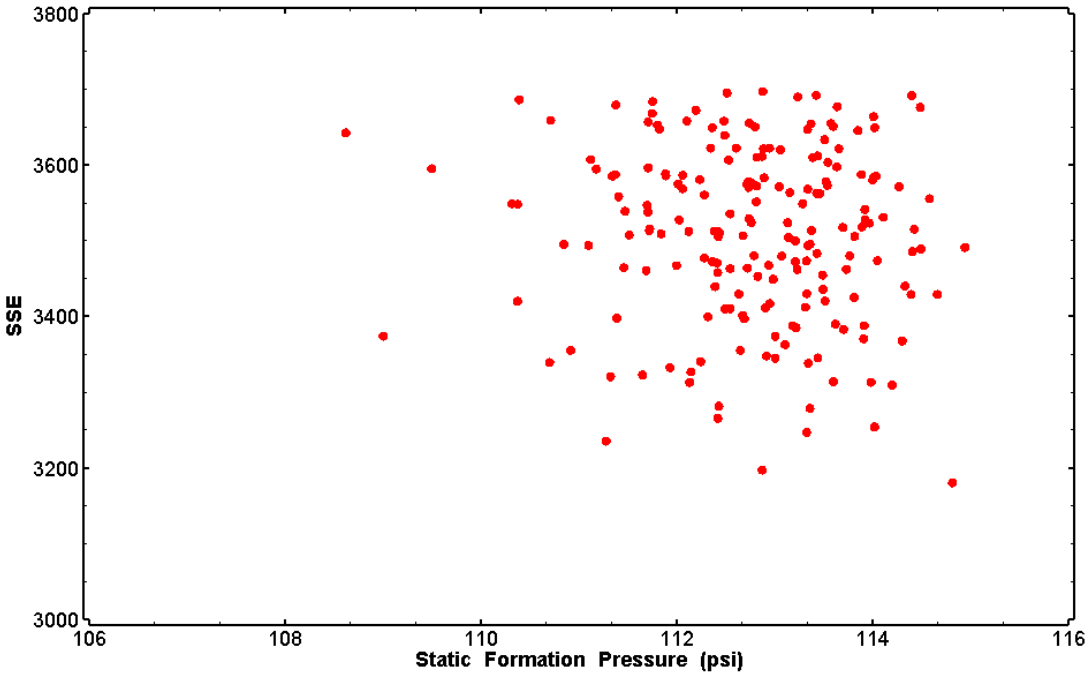

Figure B-27. Estimates of static formation pressure derived from the SNL-12 perturbation analysis.

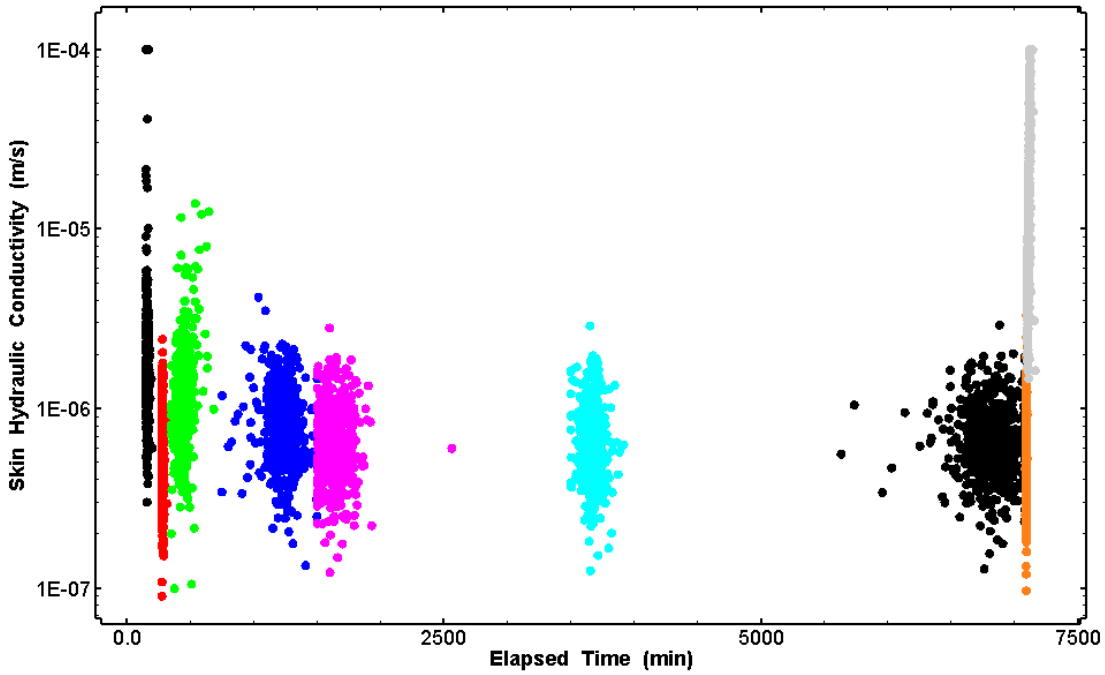

Figure B-28. Estimates of time-varying skin hydraulic conductivity derived from the SNL-12 perturbation analysis.

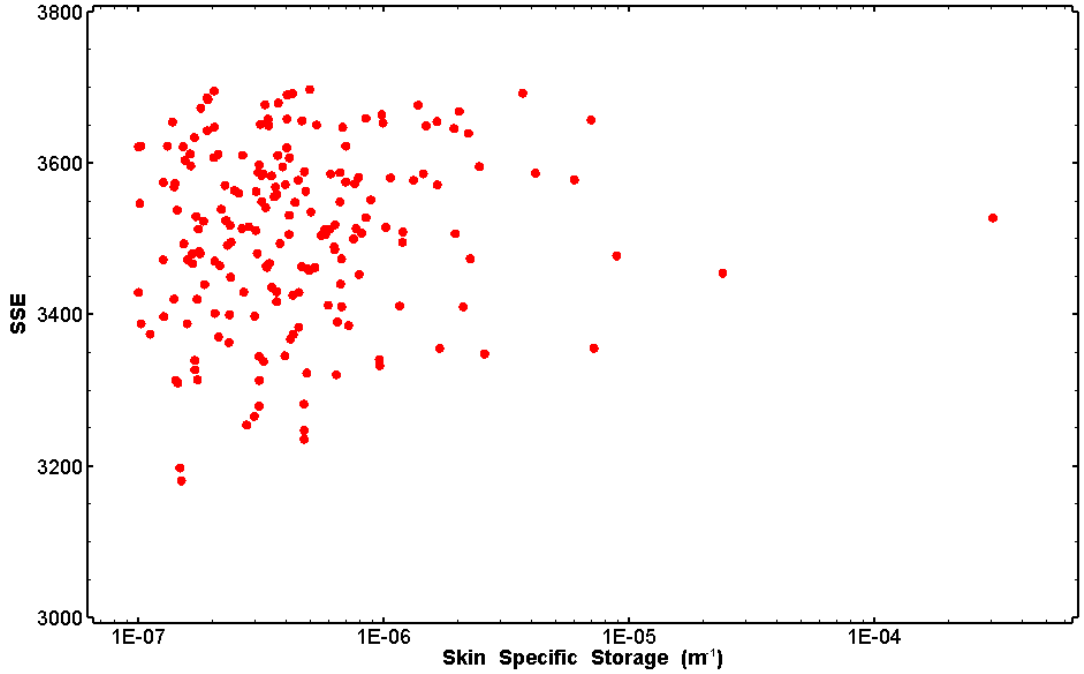

Figure B-29. Estimates of skin specific storage derived from the SNL-12 perturbation analysis.

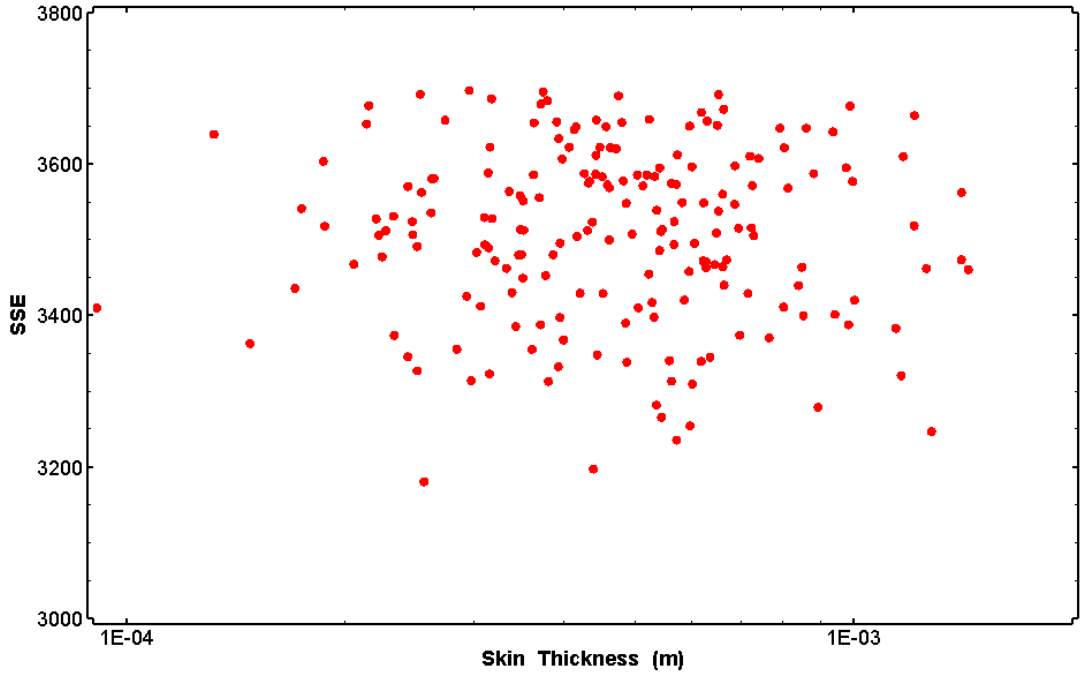

Figure B-30. Estimates of skin radius derived from the SNL-12 perturbation analysis.

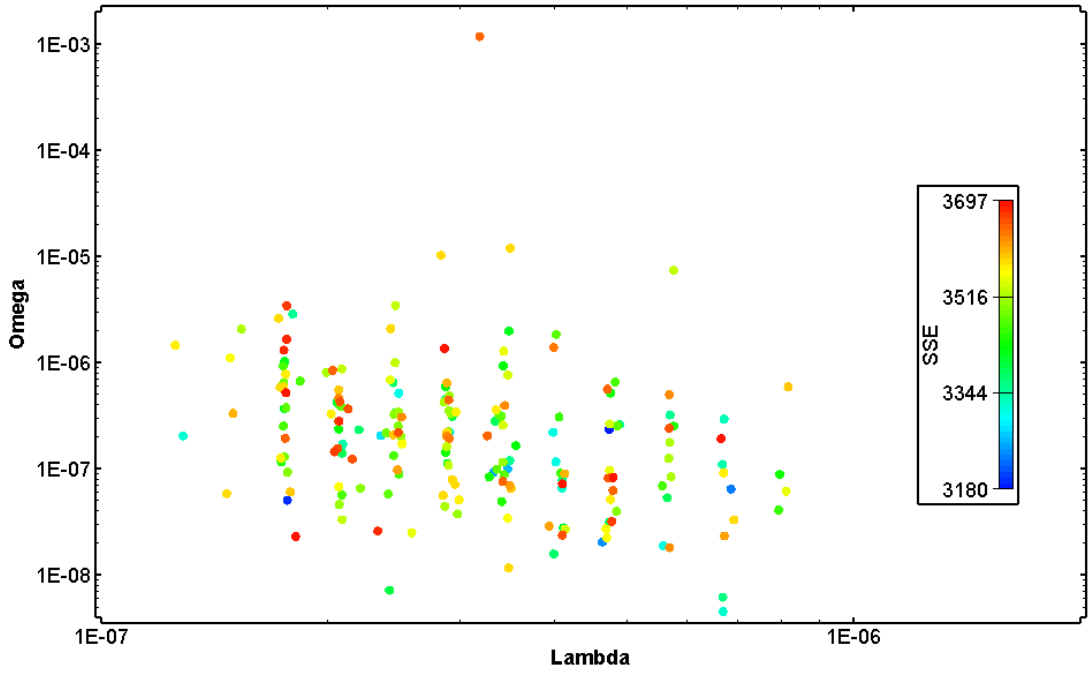

Figure B-31. Estimates of fracture and matrix specific storage derived from the SNL-12 perturbation analysis.

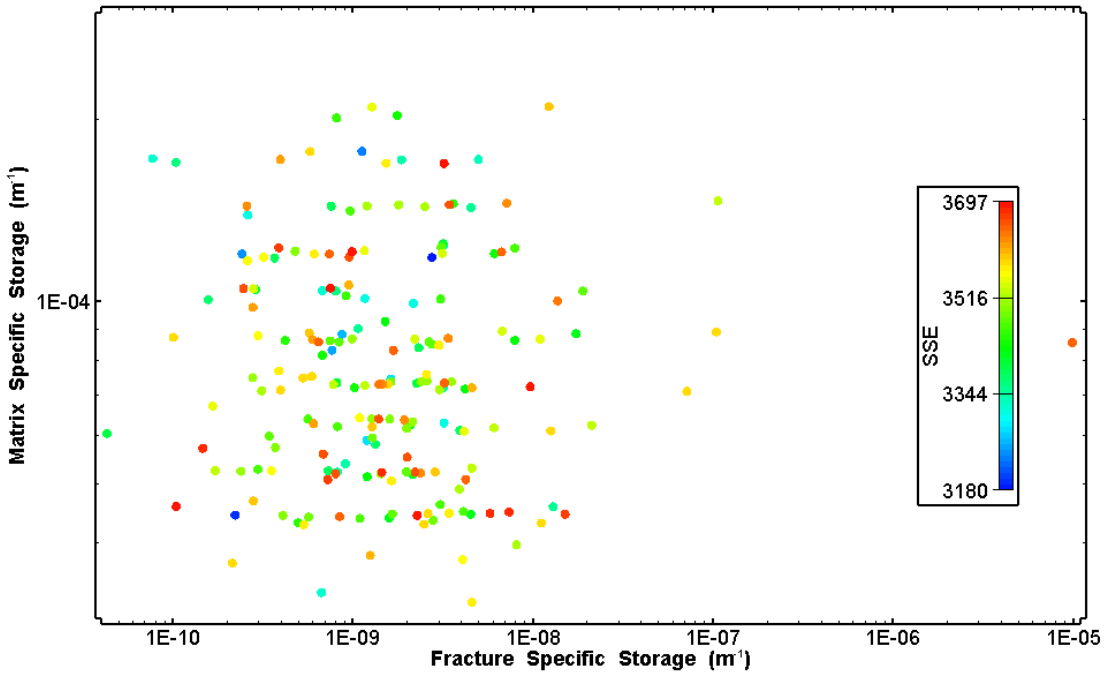

Figure B-32. Estimates of fracture and matrix specific storage derived from the SNL-12 perturbation analysis.

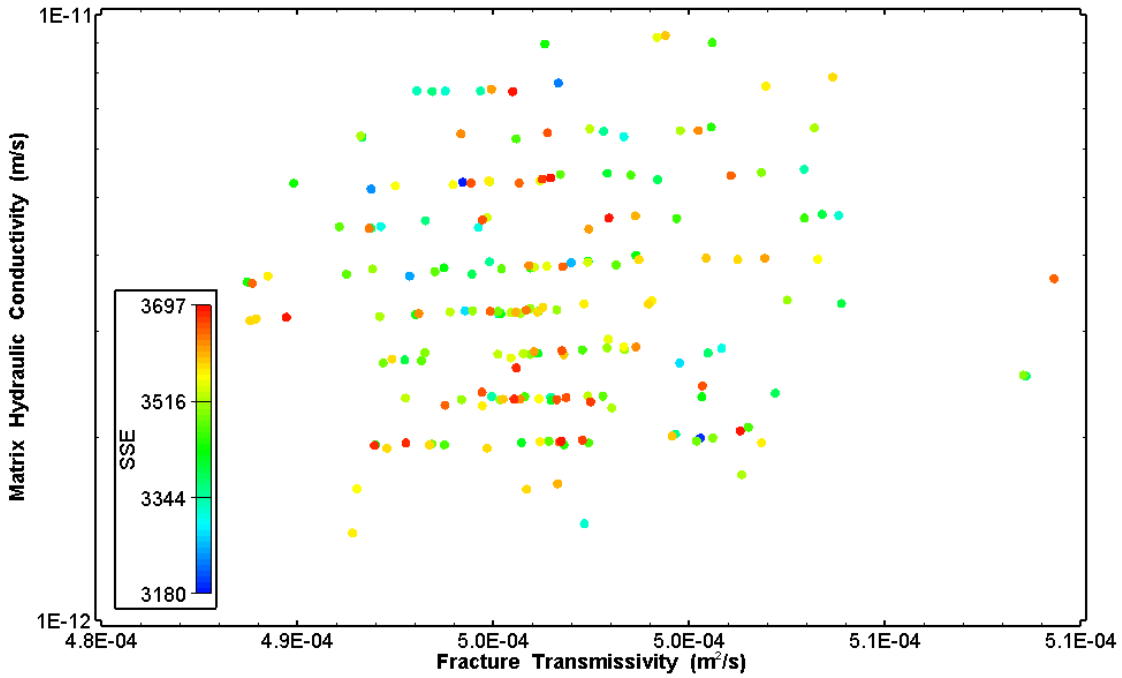

Figure B-33. Estimates of fracture transmissivity and matrix hydraulic conductivity derived from the SNL-12 perturbation analysis.

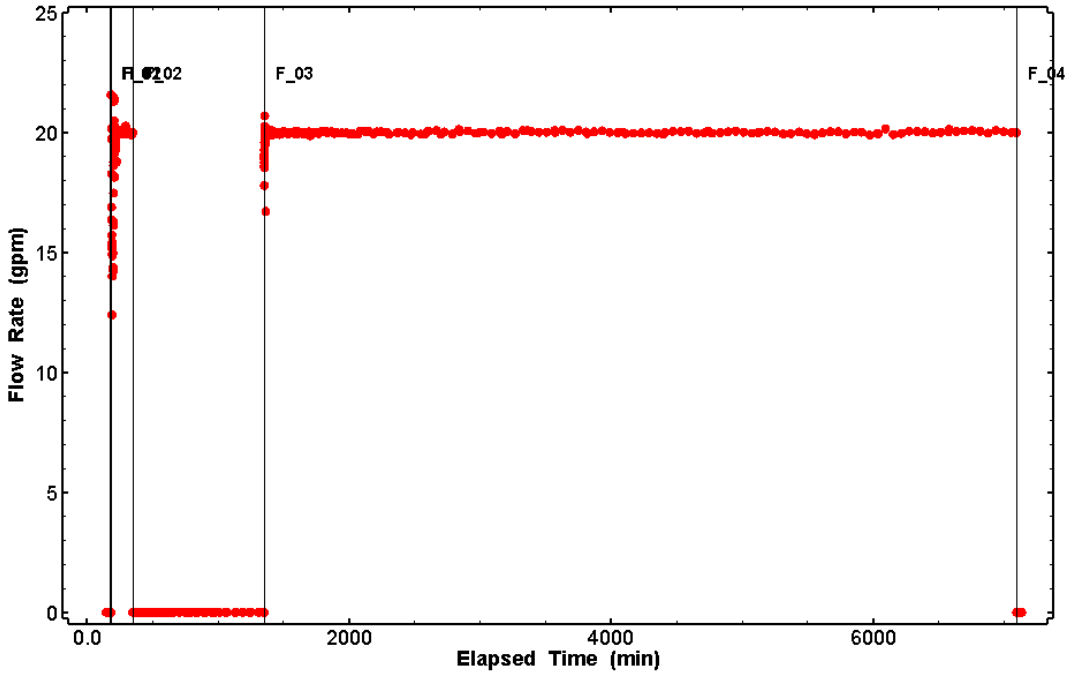

Figure B-34. Flow rates measured during the SNL-12 testing.

B.7 SNL-14 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   23 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 14\SNL-14.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	Dual	
Matrix block type	Prismatic	
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	27.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	121.316	[psi]
External boundary radius	1000000	[m]

Fracture

Fracture conductivity	6.08099E-04	[m/sec]
Fracture spec. storage	3.79982E-07	[1/m]

Matrix

Matrix volume factor	0.990000	[decimal]
Geometry factor (Alpha)	1200	[1/m^2]
Matrix conductivity	2.96239E-12	[m/sec]
Matrix spec. storage	4.22988E-05	[1/m]

Skin

Radial thickness of skin	5.5191819	[m]
Skin zone conductivity	f(t) point	
Skin zone spec. storage	1.00000E-06	[1/m]

Fluid

Fluid density	1060.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.425	[in]
Tubing string radius	1.7229424	[in]

Numeric

# of radial nodes	250	[]
# of skin nodes	50	[]
# of matrix nodes	4	[]

---

f(x) Points Parameters

Skin zone conductivity

Points type	f(t)	
Time #1	0.000000	[day]
Y value#1	1.37594E-03	[m/sec]
Time #2	175807.917390	[day]
Y value#2	1.17065E-03	[m/sec]
Time #3	1874850.258500	[day]
Y value#3	1.12243E-03	[m/sec]
Time #4	2399873.998100	[day]
Y value#4	3.11687E-02	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Dual Porosity

Fracture thickness	0.082296	[m]
Matrix thickness	8.147304	[m]
Lambda - interporosity flow	2.21789E-06	[]
Omega - storativity ratio	9.07320E-05	[]
Beta - transient parameter	2.44445E-02	[]

Skin Zone

Transmissivity	f(t)	
Storativity	8.22960E-06	[]
Diffusivity	f(t)	
Skin factor	f(t)	

Test Zone

Open hole well-bore storage	5.78831E-07	[m^3/Pa]

Grid Properties

Grid increment delta	0.06078	[]
First grid increment	3.49749E-01	[m]
Skin grid increment delta	0.09197	[]
Skin first grid increment	5.93353E-03	[m]
Skin last grid increment	4.90366E-01	[m]
Increment ratio	7.13240E-01	[]
Number of nodes	846	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	-50.010420	[day]
Duration	34.960420	[day]
Time step type	Static	
Static time step	0.100000	[day]
Type	Curve	
Wellbore storage	None	

Sequence: H_02

Sequence type	History	
Start time	-15.050000	[day]
Duration	0.020000	[day]
Time step type	Static	
Static time step	0.000100	[day]
Type	Curve	
Wellbore storage	None	

Sequence: H_03

Sequence type	History	
Start time	-15.030000	[day]
Duration	0.033890	[day]
Time step type	Static	
Static time step	0.000500	[day]
Type	Curve	
Wellbore storage	None	

Sequence: H_04

Sequence type	History	

Start time	-14.996110	[day]
Duration	0.013550	[day]
Time step type	Static	
Static time step	0.000116	[day]
Type	Curve	
Wellbore storage	None	

Sequence: H_05

Sequence type	History	
Start time	-14.982560	[day]
Duration	14.982560	[day]
Time step type	Static	
Static time step	0.005000	[day]
Type	Curve	
Wellbore storage	None	

Sequence: H_06

Sequence type	History	
Start time	0.000000	[day]
Duration	0.166450	[day]
Time step type	Static	
Static time step	0.001157	[day]
Type	Curve	
Wellbore storage	None	

Sequence: F_01

Sequence type	Flow	
Start time	0.166450	[day]
Duration	21.650400	[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	21.816850	[day]
Duration	130.183150	[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	P Curve	
Curve type	Pressure	
Start sequence	H_01	
End sequence	H_06	
Curve time base	Test	
Curve Y data units	[psi]	

Curve Y data is log 10	no
Curve object to use	Q Curve
Curve type	Flow Rate
Start sequence	F_01
End sequence	F_01
Curve time base	Test
Curve Y data units	[USgpm]
Curve Y data is log 10	no

Simulation Results Setup

Output ID	DAT	
Output type	Pressure	
Pressure capture type	Superposition	
DAT[1] operation	+ Pressure	
Type	Constant	
Fixed radius	1.0	[m]
DAT[2] operation	- Delta P	
Type	Constant	
Fixed radius	1220.866283	[m]
Output units	[psi]	

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

SNL-14 Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   23 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\SNL 14\SNL-14.nPre
```

---

f(x) Points Parameters

Skin zone conductivity

Points type	f(t)	
Time #1	0.000000	[day]
Y value#1	Optimized	
Time #2	Optimized	
Minimum	86400.000000	[day]
Estimat	175807.917390	[day]
Maximum	734400.000000	[day]
Y value#2	Optimized	
Time #3	Optimized	
Minimum	735264.000000	[day]

```
   Estimat                          1874850.258500     [day]
   Maximum                          1944000.000000     [day]
 Y value#3                               Optimized
 Time #4                                 Optimized
   Minimum                          1944864.000000     [day]
   Estimat                          2399873.998100     [day]
   Maximum                          3456000.000000     [day]
 Y value#4                               Optimized

X opt range type                           Linear
X opt sigma                          1.00000E+00

Y opt minimum value                  1.00000E-06     [m/sec]
Y opt maximum value                  1.00000E-01     [m/sec]
Y opt range type                             Log
Y opt sigma                          1.00000E+00

Parameter curve type                       Linear
```

SNL-14 Fitting Parameter Estimates

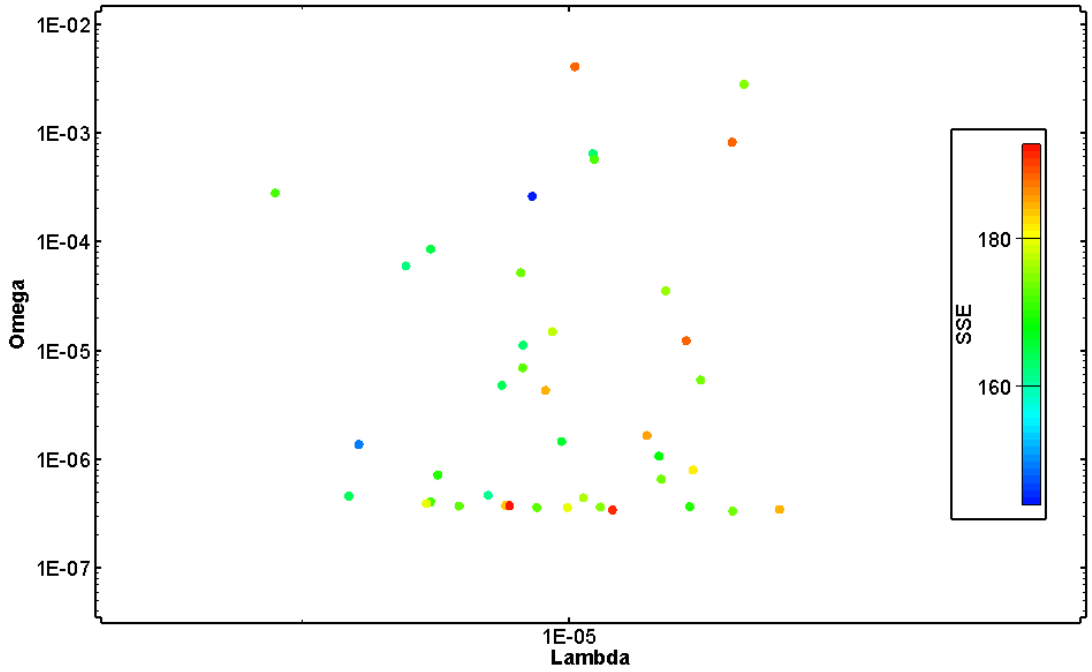

Figure B-35. Estimates of Lambda and Omega derived from the SNL-14 perturbation analysis.

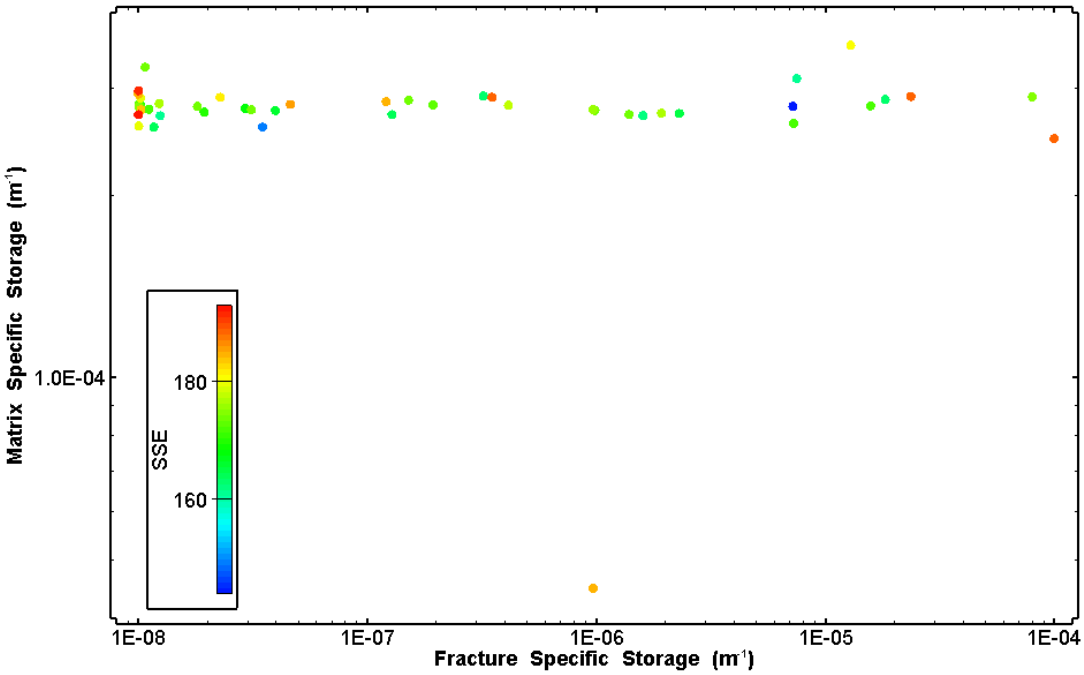

Figure B-36. Estimates of fracture and matrix specific storage derived from the SNL-14 perturbation analysis.

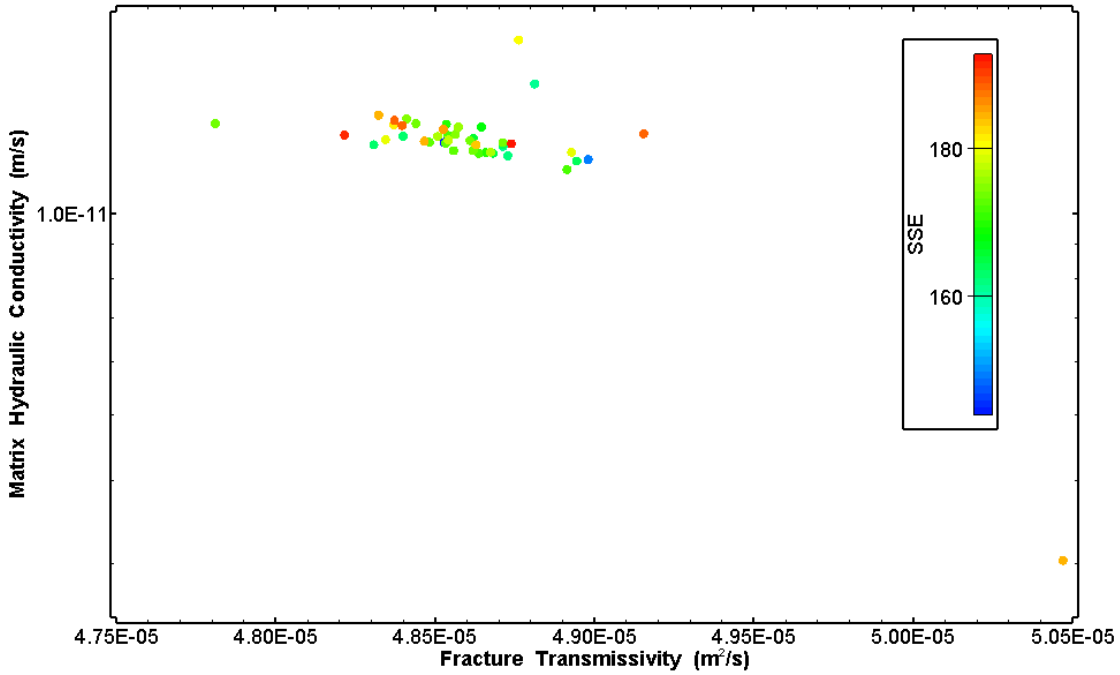

Figure B-37. Estimates of fracture transmissivity and matrix hydraulic conductivity derived from the SNL-14 perturbation analysis.

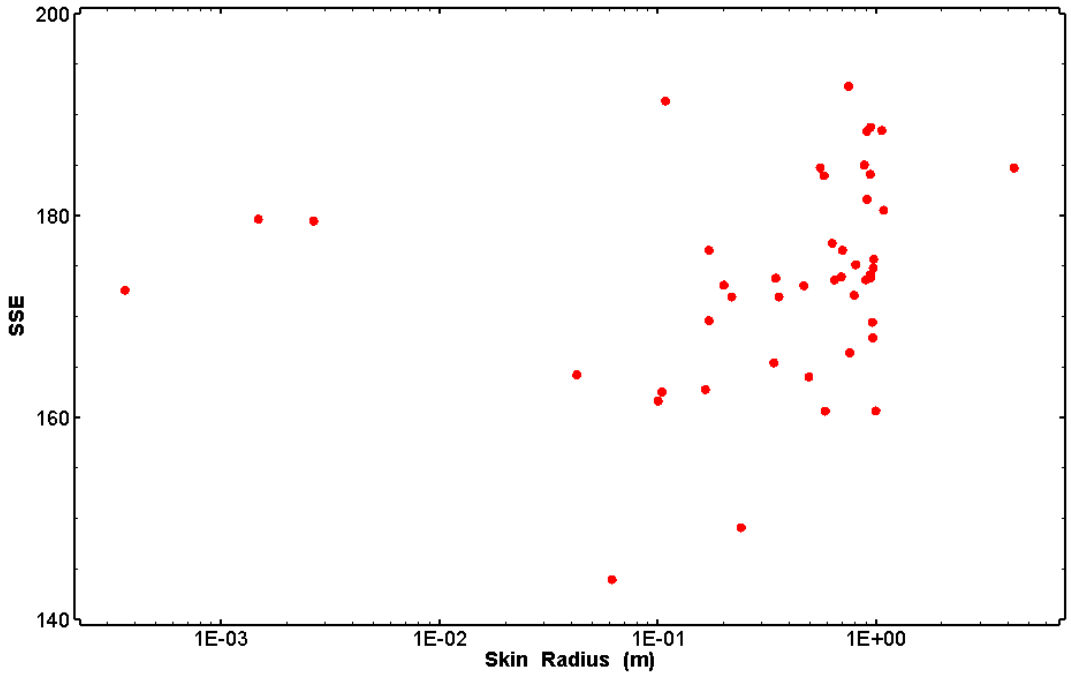

Figure B-38. Estimates of skin radius derived from the SNL-14 perturbation analysis.

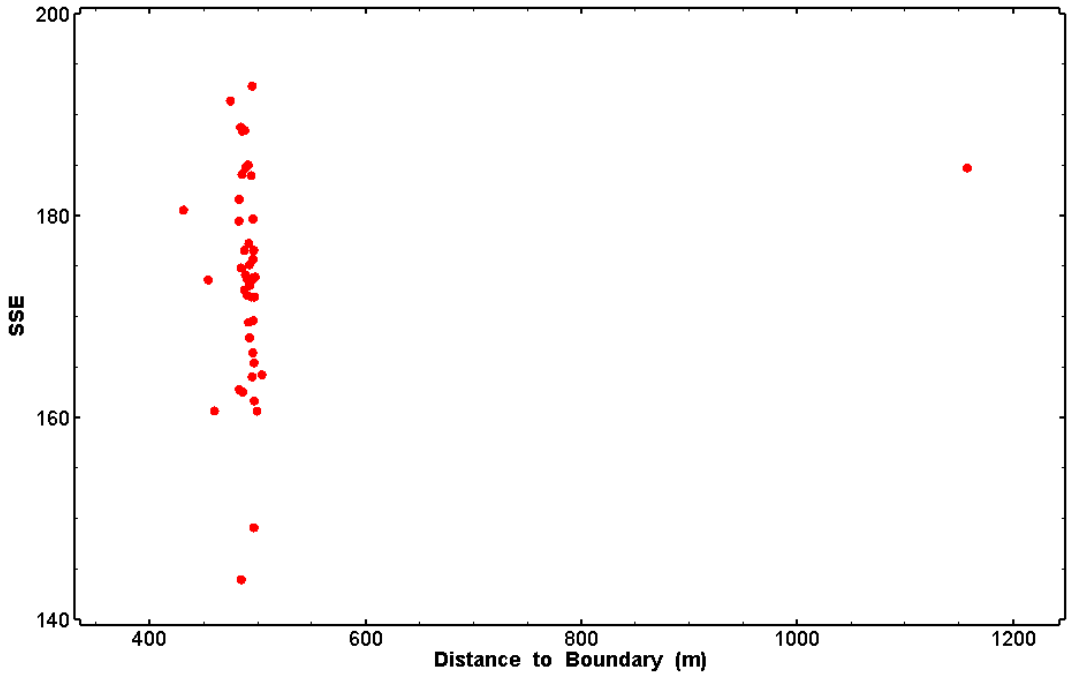

Figure B-39. Estimates of distance to linear no-flow boundary derived from the SNL-14 perturbation analysis.

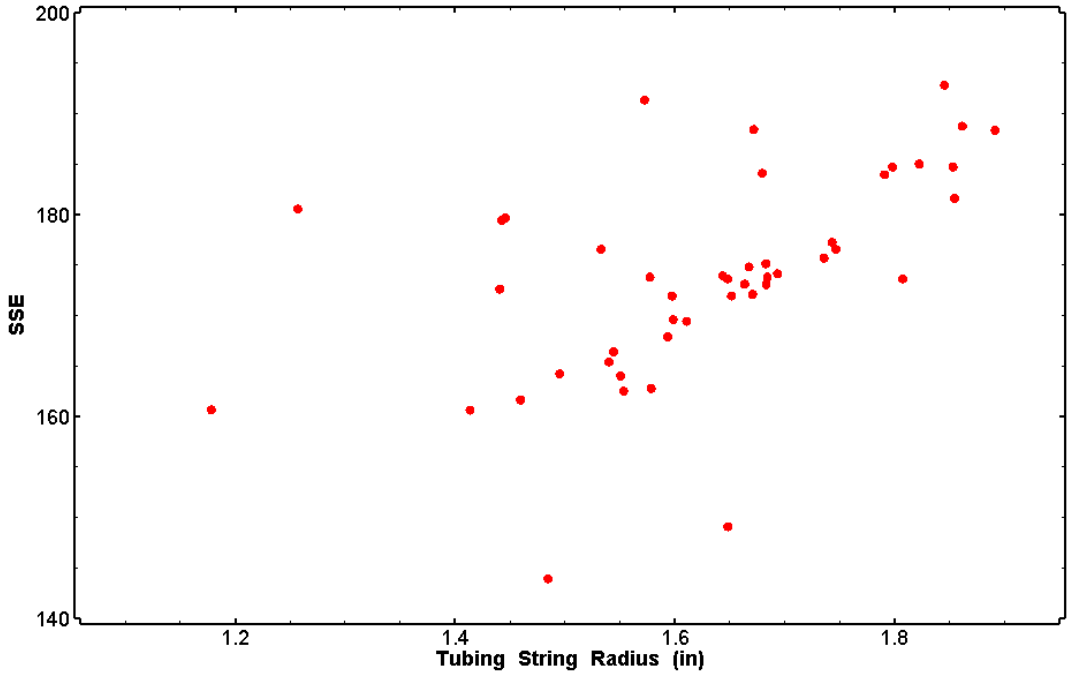

Figure B-40. Estimates of tubing string radius derived from the SNL-14 perturbation analysis.

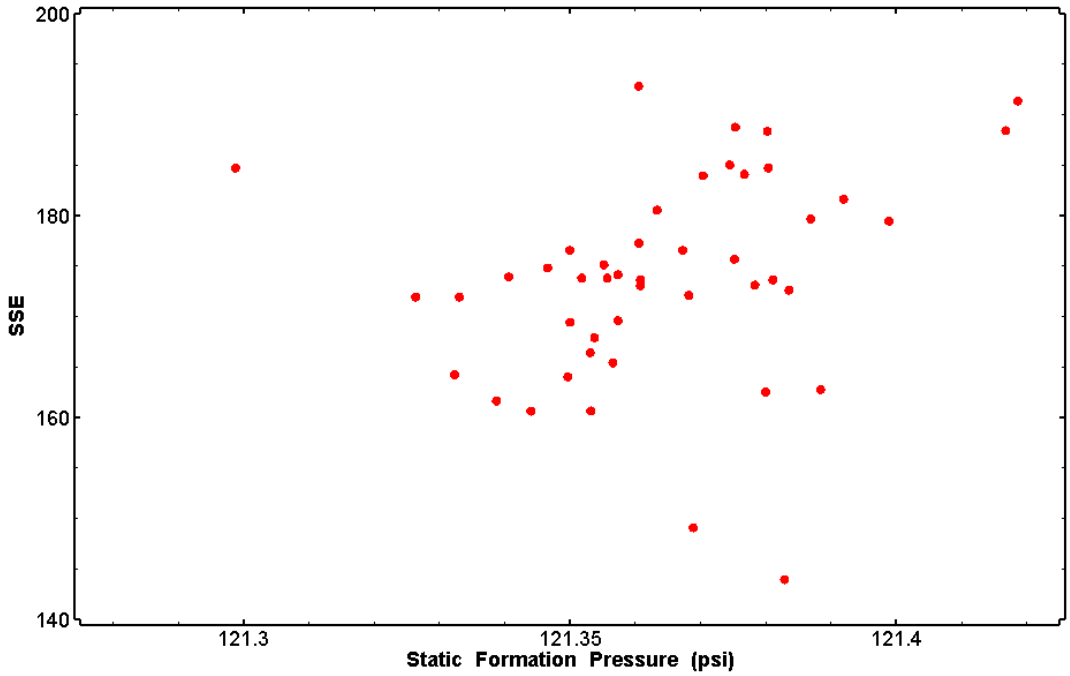

Figure B-41. Estimates of static formation pressure derived from the SNL-14 perturbation analysis.

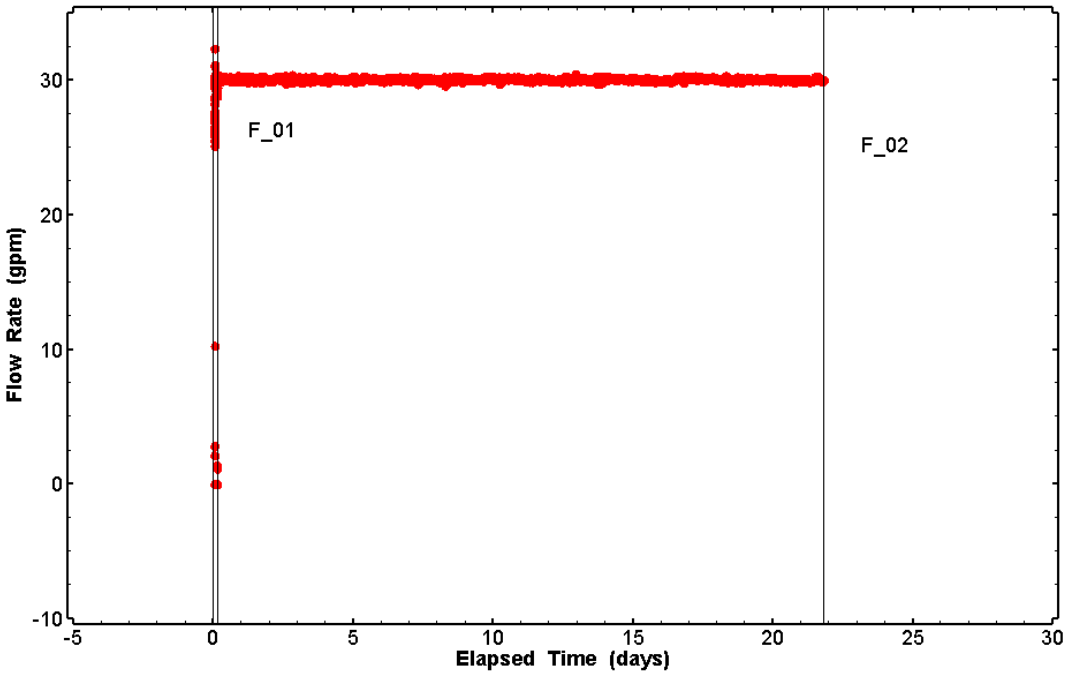

Figure B-42. Flow rates measured during the SNL-14 testing.

B.8 WIPP-11 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   02 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\WIPP 11\WIPP 11 - new Ss.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	23.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	106.497	[psi]
External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0047474	[m]
Skin zone conductivity	6.61728E-04	[m/sec]

Skin zone spec. storage	1.00000E-04	[1/m]

Fluid

Fluid density	1038.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	4.4605	[in]
Tubing string radius	0.405	[ft]

Numeric

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

---

f(x) Points Parameters

Formation conductivity

Points type	f(r)	
Radius #1	28.16815	[m]
Y value#1	2.43671E-04	[m/sec]
Radius #2	277.5993399	[m]
Y value#2	1.02754E-05	[m/sec]
Radius #3	1300.4607014	[m]
Y value#3	6.22036E-05	[m/sec]
Radius #4	2540.1901332	[m]
Y value#4	3.63627E-06	[m/sec]
Radius #5	5805.4107287	[m]
Y value#5	1.03456E-05	[m/sec]
Radius #6	9934.8825796	[m]
Y value#6	4.00114E-05	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	f(r)	
Storativity	7.01040E-06	[]
Diffusivity	f(r)	

Skin Zone

Transmissivity	4.63898E-03	[m^2/sec]
Storativity	7.01040E-04	[]
Diffusivity	6.61728E+00	[m^2/sec]
Skin factor	f(r)	

Test Zone

Open hole well-bore storage	4.69662E-06	[m^3/Pa]

Grid Properties

Grid increment delta	0.08016	[]
First grid increment	9.85224E-03	[m]
Skin grid increment delta	0.00084	[]
Skin first grid increment	9.49505E-05	[m]
Skin last grid increment	9.88463E-05	[m]
Increment ratio	9.96724E+01	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	0.000000	[day]
Duration	0.074990	[day]
Time step type	Static	
Static time step	0.000100	[day]
Type	Curve	
Wellbore storage	None	

Sequence: F_01

Sequence type	Flow	
Start time	0.074990	[day]
Duration	0.147470	[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	0.222460	[day]
Duration	0.742120	[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	

Sequence: H_02

Sequence type	History	
Start time	0.964580	[day]
Duration	0.010410	[day]
Time step type	Static	
Static time step	0.001000	[day]
Type	Curve	

Wellbore storage	None	

Sequence: F_03

Sequence type	Flow	
Start time	0.974990	[day]
Duration	3.525010	[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	4.500000	[day]
Duration	2.658910	[day]
Time step type	Static	
Static time step	0.001000	[day]
Type	Curve	
Wellbore storage	Open	

Sequence: F_04

Sequence type	Flow	
Start time	7.158910	[day]
Duration	13.067870	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	-35.0	[USgpm]
Wellbore storage	Open	

Sequence: F_05

Sequence type	Flow	
Start time	20.226780	[day]
Duration	42.573220	[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	Pressure	
Curve type	Pressure	
Start sequence	H_01	
End sequence	H_03	
Curve time base	Test	
Curve Y data units	[psi]	
Curve Y data is log 10	no	
Curve object to use	Q Curve	

```
Curve type                                    Flow Rate
Start sequence                                     F_01
End sequence                                       F_03
Curve time base                                    Test
Curve Y data units                              [USgpm]
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]
```

OutputFiles

XY Forward Output

```
Write file ?                                       yes
File nameC:\nSIGHTS\Culebra\WIPP 11\Post\WIPP-11.nXYSim
Run ID                                         Perturb
If file exists                                 Overwrite
Output data                                AutoSimData
```

WIPP-11 Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   02 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\WIPP 11\WIPP 11 - new Ss.nPre
```

Parameters

Formation

```
Formation thickness                            23.000     [ft]
Flow dimension                                    2.0     []
Static formation pressure                  Optimization
   Minimum value                               100.000     [psi]
   Maximum value                               120.000     [psi]
   Estimate value                              106.497     [psi]
   Range type                                   Linear
   Sigma                                  1.00000E+00
```

External boundary radius	1000000	[m]
Formation conductivity	f(r) point	
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	Optimization	
Minimum value	1.0E-05	[m]
Maximum value	10.0	[m]
Estimate value	0.0047474	[m]
Range type	Log	
Sigma	1.00000E+00	
Skin zone conductivity	Optimization	
Minimum value	1.00000E-08	[m/sec]
Maximum value	1.00000E-03	[m/sec]
Estimate value	6.61728E-04	[m/sec]
Range type	Log	
Sigma	1.00000E+00	
Skin zone spec. storage	1.00000E-04	[1/m]

Fluid

Fluid density	1038.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	4.4605	[in]
Tubing string radius	Optimization	
Minimum value	0.200	[ft]
Maximum value	1.000	[ft]
Estimate value	0.405	[ft]
Range type	Linear	
Sigma	1.00000E+00	

Numeric

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

WIPP-11 Fitting Parameter Estimates

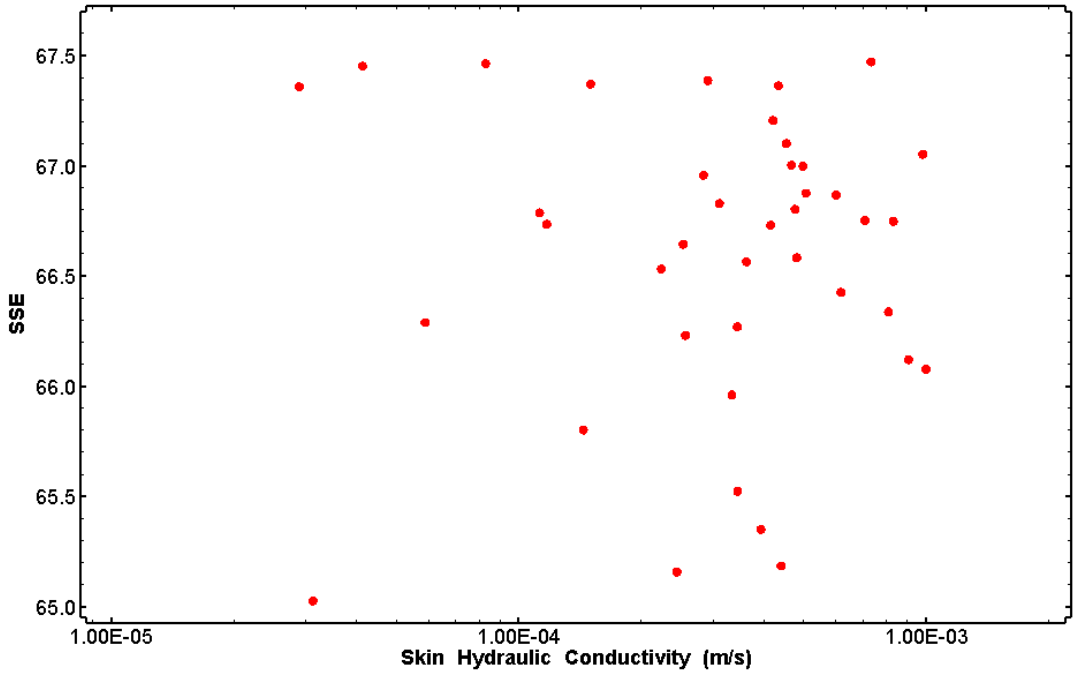

Figure B-43. Estimates of skin hydraulic conductivity derived from the WIPP-11 perturbation analysis.

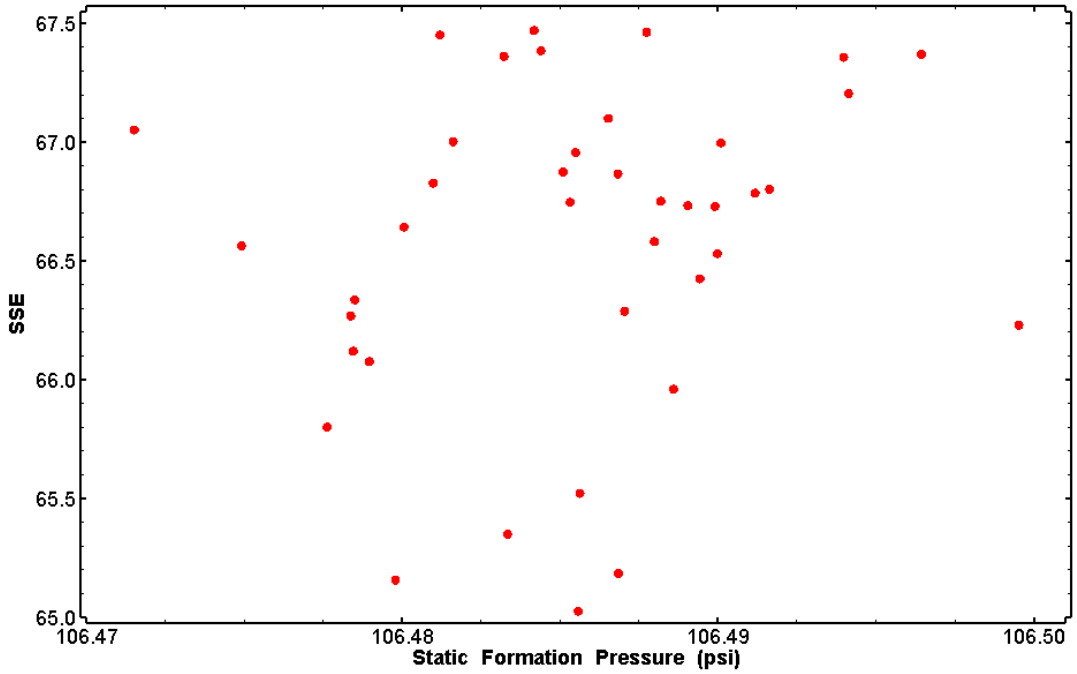

Figure B-44. Estimates of static formation pressure derived from the WIPP-11 perturbation analysis.

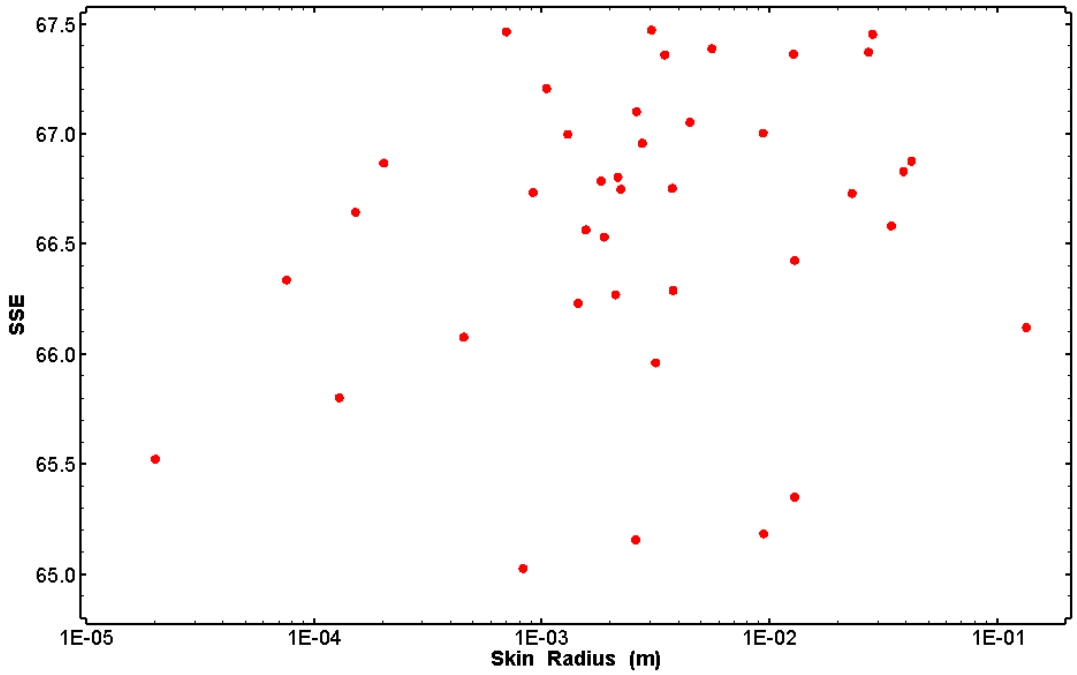

Figure B-45. Estimates of skin radius derived from the WIPP-11 perturbation analysis.

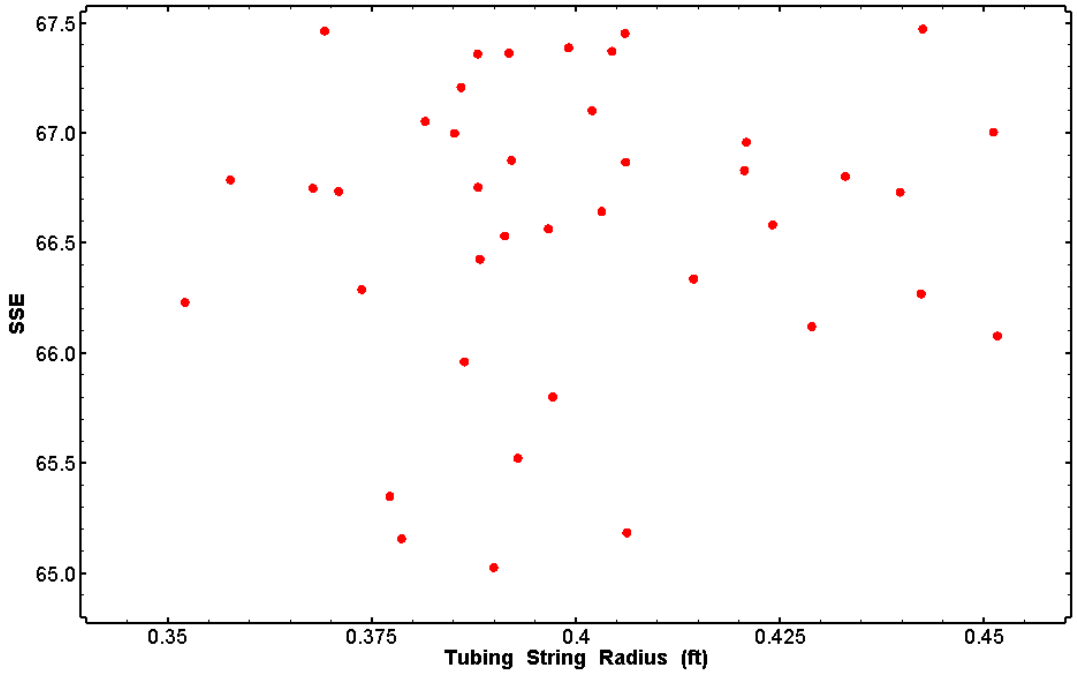

Figure B-46. Estimates of tubing string radius derived from the WIPP-11 perturbation analysis.

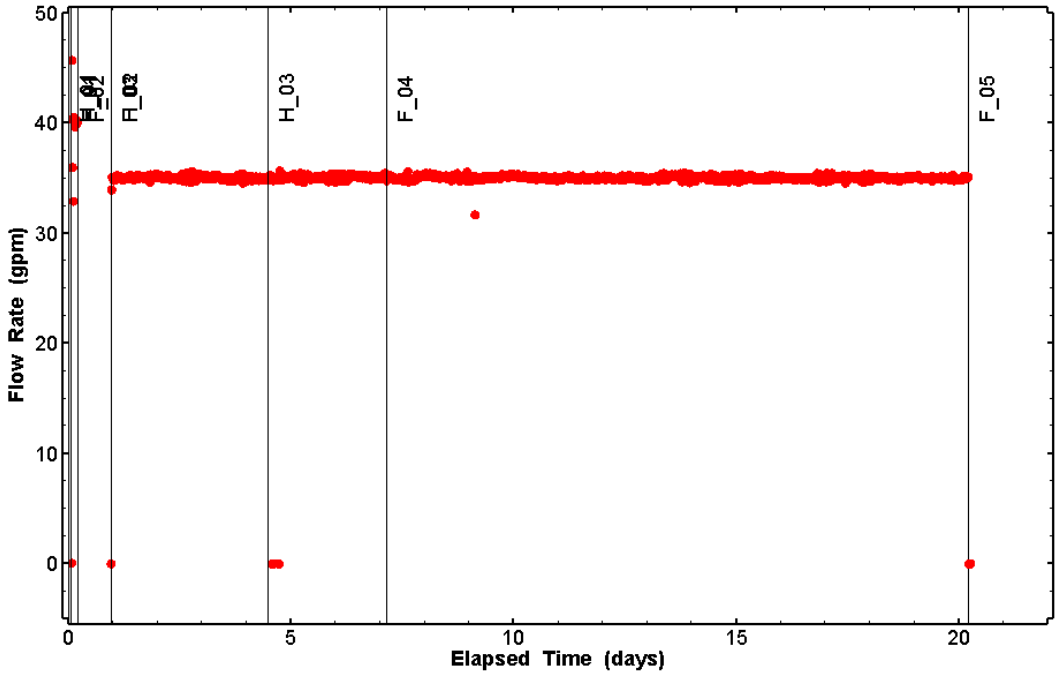

Figure B-47. Flow rates measured during the WIPP-11 testing.

B.9 WIPP-25 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   02 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\WIPP 25\WIPP-25.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	125.722	[psi]
External boundary radius	1000000	[m]
Formation conductivity	3.39004E-05	[m/sec]
Formation spec. storage	1.00000E-06	[1/m]

Skin

Radial thickness of skin	0.0086243	[m]
Skin zone conductivity	f(t) point	

Skin zone spec. storage	1.88034E-08	[1/m]

Fluid

Fluid density	1022.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.475	[in]
Volume change from normal	0.45	[m^3]
Test-zone compressibility	1.55482E-08	[1/Pa]

Numeric

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

---

f(x) Points Parameters

Skin zone conductivity

Points type	f(t)	
Time #1	150650.393	[min]
Y value#1	1.80134E-07	[m/sec]
Time #2	156107.611	[min]
Y value#2	1.67710E-07	[m/sec]
Time #3	167920.057	[min]
Y value#3	1.63584E-07	[m/sec]
Time #4	169548.382	[min]
Y value#4	1.72878E-07	[m/sec]
Time #5	190423.149	[min]
Y value#5	1.67647E-07	[m/sec]
Time #6	239999.335	[min]
Y value#6	1.56946E-07	[m/sec]
Parameter curve type	Linear	

Calculated Parameters

Formation

Transmissivity	2.40239E+02	[ft^2/day]
Storativity	7.62000E-06	[]
Diffusivity	3.15275E+07	[ft^2/day]

Skin Zone

Transmissivity	f(t)	
Storativity	1.43282E-07	[]
Diffusivity	f(t)	
Skin factor	f(t)	

Test Zone

Test-zone volume	0.5446069	[m^3]
Isolated well-bore storage	8.46767E-09	[m^3/Pa]

Grid Properties

Grid increment delta	0.08268	[]
First grid increment	6.16212E-03	[m]
Skin grid increment delta	0.00262	[]
Skin first grid increment	1.65152E-04	[m]
Skin last grid increment	1.87317E-04	[m]
Increment ratio	3.28967E+01	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	0.000	[min]
Duration	2510.000	[min]
Time step type	Static	
Static time step	30.000	[min]
Type	Curve	
Wellbore storage	None	

Sequence: H_02

Sequence type	History	
Start time	2510.000	[min]
Duration	3.200	[min]
Time step type	Static	
Static time step	0.167	[min]
Type	Curve	
Wellbore storage	None	

Sequence: F_01

Sequence type	Flow	
Start time	2513.200	[min]
Duration	302.016	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	-30.0	[USgpm]
Wellbore storage	Isolated	

Sequence: F_02

Sequence type	Flow	
Start time	2815.216	[min]
Duration	3.336	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	

Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	Isolated	

Sequence: F_03

Sequence type	Flow	
Start time	2818.552	[min]
Duration	695.202	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	-30.0	[USgpm]
Wellbore storage	Isolated	

Sequence: F_04

Sequence type	Flow	
Start time	3513.754	[min]
Duration	9486.246	[min]
Time step type	Log	
First log step	1.66667E-04	[min]
# of time steps	250	
Type	Fixed	
Fixed value	0.0	[USgpm]
Wellbore storage	None	

Test Zone Curves

Curve object to use	P 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	[USgpm]

WIPP-25 Optimization Settings

****
nPre 2.30Q

****

Version date 22 July 2005
Listing date 02 May 2006
QA status QA:Q
Config file C:\nSIGHTS\Culebra\WIPP 25\WIPP-25.nPre

Parameters

Formation

Formation thickness	25.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	120.000	[psi]
Maximum value	130.000	[psi]
Estimate value	125.722	[psi]
Range type	Linear	
Sigma	1.00000E+00	
External boundary radius	1000000	[m]
Formation conductivity	Optimization	
Minimum value	1.00000E-08	[m/sec]
Maximum value	1.00000E-04	[m/sec]
Estimate value	3.39004E-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	0.0001	[m]
Maximum value	10.0	[m]
Estimate value	0.0086243	[m]
Range type	Log	
Sigma	1.00000E+00	
Skin zone conductivity	f(t) point	
Skin zone spec. storage	Optimization	
Minimum value	1.00000E-08	[1/m]
Maximum value	1.00000E-04	[1/m]
Estimate value	1.88034E-08	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1022.00	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	2.475	[in]
Volume change from normal	0.45	[m^3]
Test-zone compressibility	Optimization	
Minimum value	4.00000E-10	[1/Pa]
Maximum value	1.00000E-05	[1/Pa]

Estimate value	1.55482E-08	[1/Pa]
Range type	Log	
Sigma	1.00000E+00	

Numeric

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

WIPP-25 Fitting Parameter Estimates

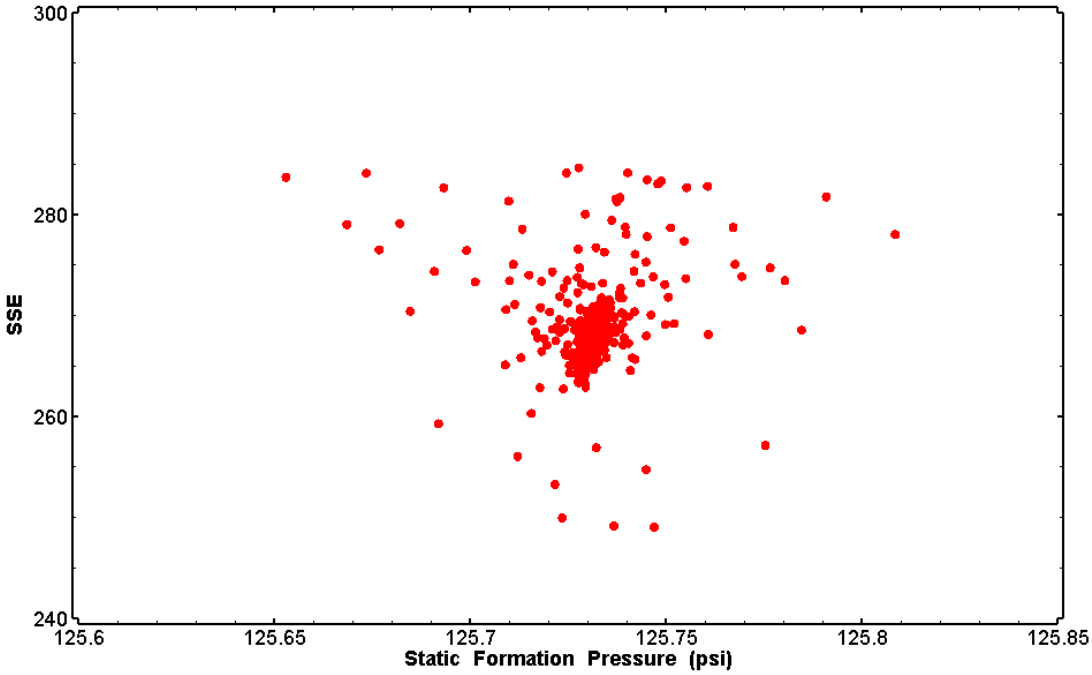

Figure B-48. Estimates of static formation pressure derived from the WIPP-25 perturbation analysis.

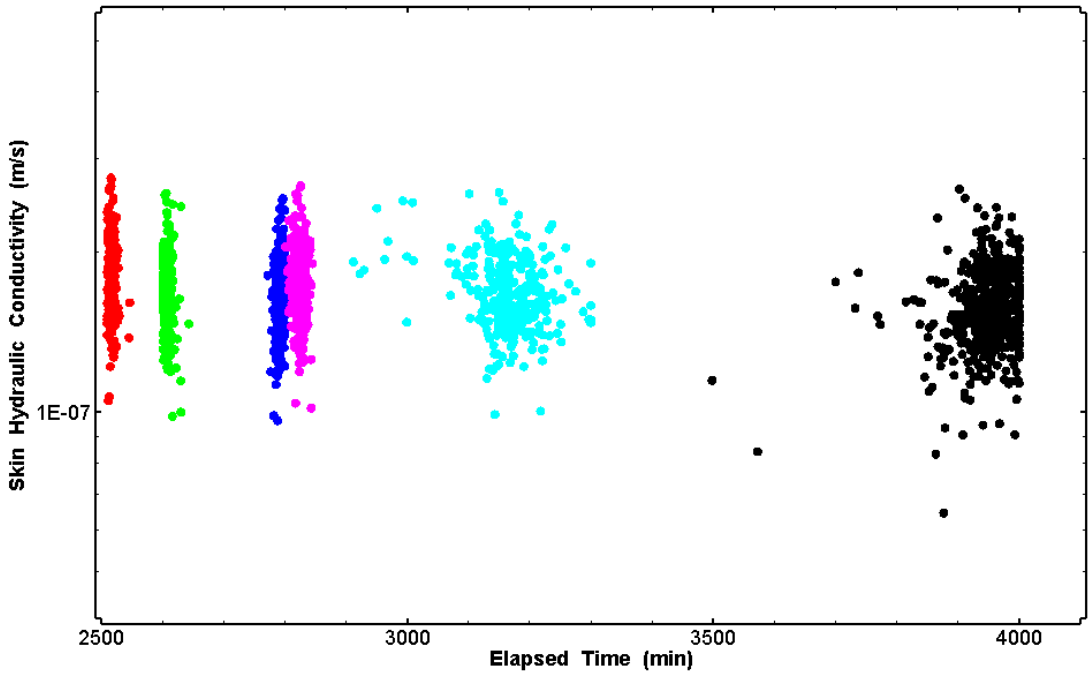

Figure B-49. Estimates of time-varying skin hydraulic conductivity derived from the WIPP-25 perturbation analysis.

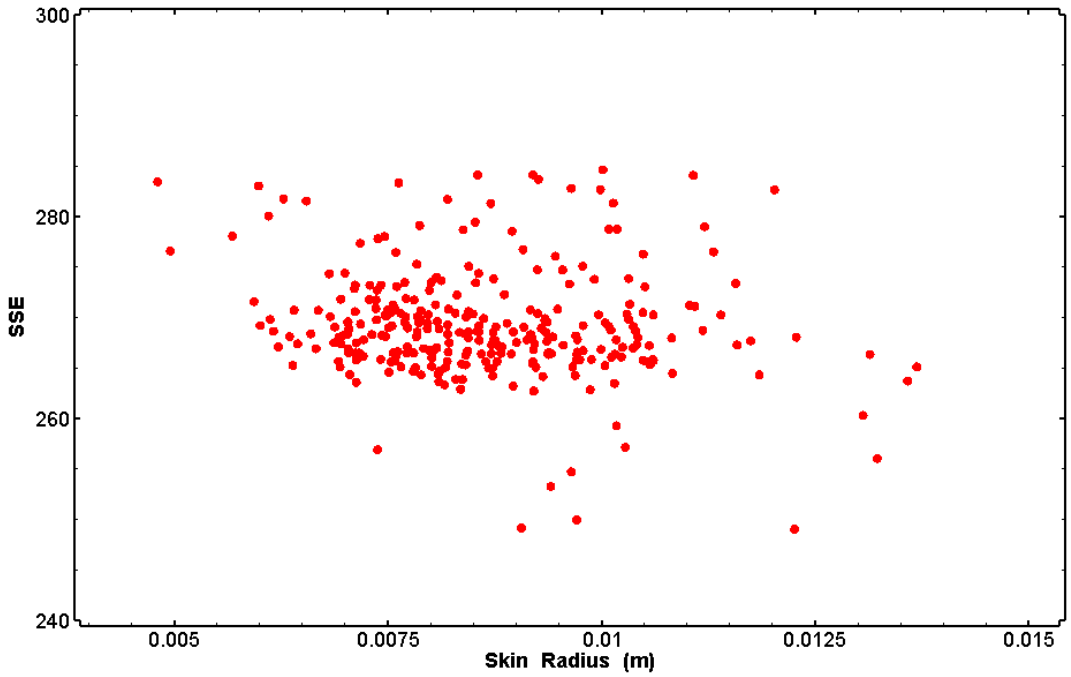

Figure B-50. Estimates of skin radius derived from the WIPP-25 perturbation analysis.

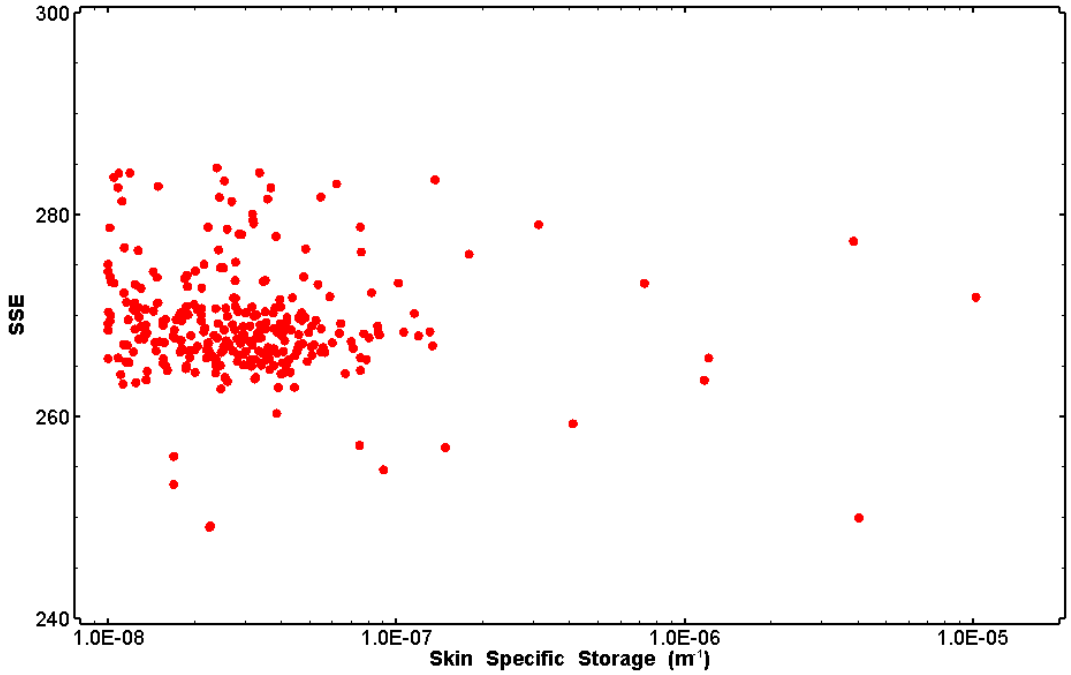

Figure B-51. Estimates of skin specific storage derived from the WIPP-25 perturbation analysis.

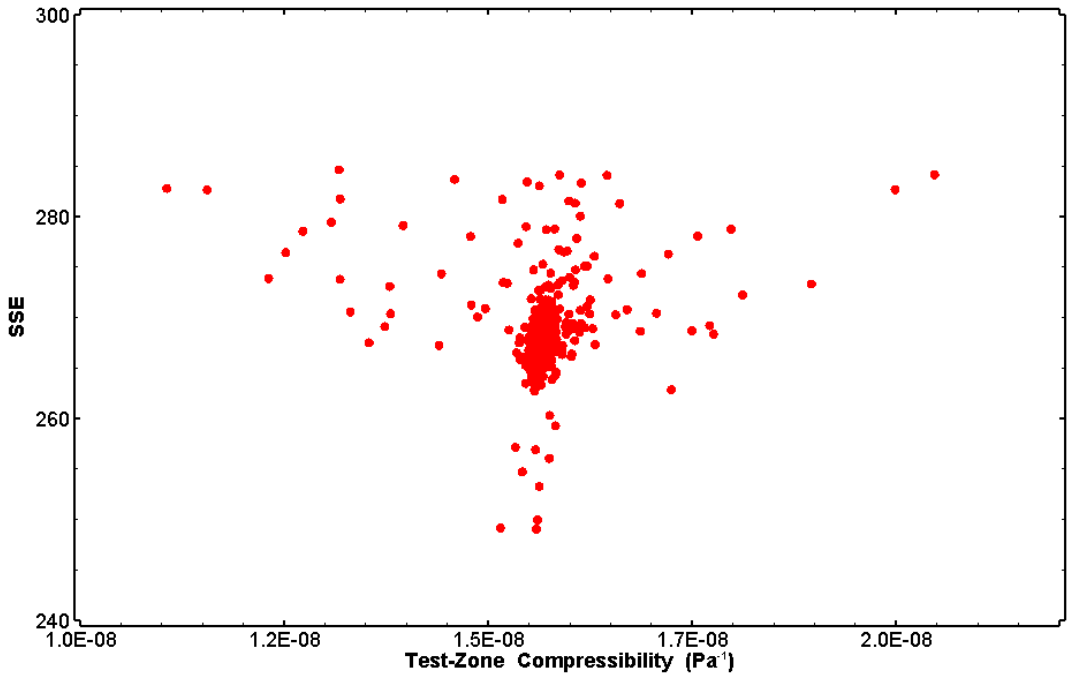

Figure B-52. Estimates of test-zone compressibility derived from the WIPP-25 perturbation analysis.

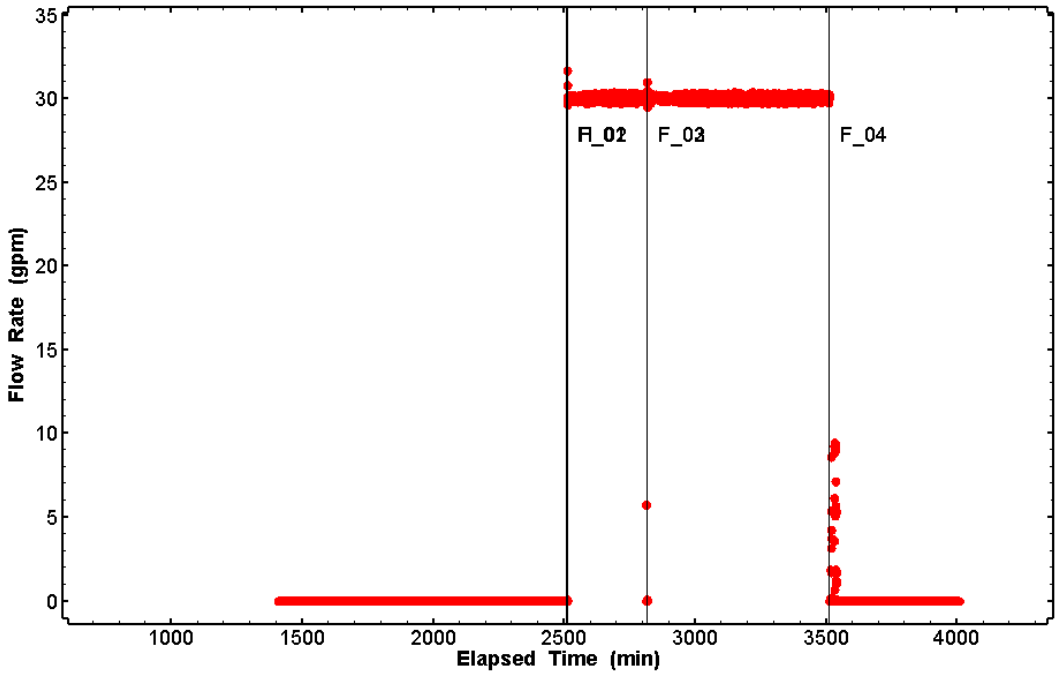

Figure B-53. Flow rates measured during the WIPP-25 testing.

B.10 C-2737 nSIGHTS Listings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   02 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\C2737\C-2737.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	23.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	90.241	[psi]
External boundary radius	1000000	[m]
Formation conductivity	9.91966E-08	[m/sec]
Formation spec. storage	5.47899E-07	[1/m]

Skin

Radial thickness of skin	0.093313	[m]
Skin zone conductivity	2.75487E-07	[m/sec]

Skin zone spec. storage	1.86613E-06	[1/m]

Fluid

Fluid density	1064.20	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.1205	[in]
Volume change from normal	0.0	[m^3]
Test-zone compressibility	1.09951E-07	[1/Pa]

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	6.95408E-07	[m^2/sec]
Storativity	3.84099E-06	[]
Diffusivity	1.81049E-01	[m^2/sec]

Skin Zone

Transmissivity	1.93128E-06	[m^2/sec]
Storativity	1.30823E-05	[]
Diffusivity	1.47625E-01	[m^2/sec]
Skin factor	-4.97913E-01	[]

Test Zone

Test-zone volume	0.1383593	[m^3]
Isolated well-bore storage	1.52128E-08	[m^3/Pa]

Grid Properties

Grid increment delta	0.07825	[]
First grid increment	1.40469E-02	[m]
Skin grid increment delta	0.01588	[]
Skin first grid increment	1.26864E-03	[m]
Skin last grid increment	2.71870E-03	[m]
Increment ratio	5.16679E+00	[]

Sequences

Sequence: H_01

Sequence type	History	
Start time	-63.533180	[day]

Duration	25.573060	[day]
Time step type	Static	
Static time step	0.500000	[day]
Type	Curve	
Wellbore storage	Isolated	

Sequence: H_02

Sequence type	History	
Start time	-37.960120	[day]
Duration	0.827080	[day]
Time step type	Static	
Static time step	0.003000	[day]
Type	Curve	
Wellbore storage	Isolated	

Sequence: H_03

Sequence type	History	
Start time	-37.133040	[day]
Duration	1.133040	[day]
Time step type	Static	
Static time step	0.003000	[day]
Type	Curve	
Wellbore storage	Isolated	

Sequence: H_04

Sequence type	History	
Start time	-36.000000	[day]
Duration	36.004460	[day]
Time step type	Static	
Static time step	0.100000	[day]
Type	Curve	
Wellbore storage	Isolated	

Sequence: F_01

Sequence type	Flow	
Start time	0.004460	[day]
Duration	0.434640	[day]
Time step type	Log	
First log step	1.15741E-07	[day]
# of time steps	250	
Type	Fixed	
Fixed value	-0.3	[USgpm]
Wellbore storage	Isolated	

Sequence: F_02

Sequence type	Flow	
Start time	0.439100	[day]
Duration	13.560900	[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	Isolated

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 Optimization Settings

```
**********
nPre 2.30Q
**********

Version date   22 July 2005
Listing date   02 May 2006
QA status      QA:Q
Config file    C:\nSIGHTS\Culebra\C2737\C-2737.nPre
```

Parameters

Formation

Formation thickness	23.000	[ft]
Flow dimension	2.0	[]
Static formation pressure	Optimization	
Minimum value	85.000	[psi]
Maximum value	95.000	[psi]
Estimate value	90.241	[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	9.91966E-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-05	[1/m]
Estimate value	5.47899E-07	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Skin

Radial thickness of skin	Optimization	
Minimum value	0.0001	[m]
Maximum value	10.0	[m]
Estimate value	0.093313	[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	2.75487E-07	[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	1.86613E-06	[1/m]
Range type	Log	
Sigma	1.00000E+00	

Fluid

Fluid density	1064.20	[kg/m^3]
Fluid thermal exp. coeff.	0.00000E+00	[1/C]

Test-Zone

Well radius	3.1205	[in]
Volume change from normal	0.0	[m^3]
Test-zone compressibility	Optimization	
Minimum value	1.00000E-08	[1/Pa]
Maximum value	1.00000E-05	[1/Pa]
Estimate value	1.09951E-07	[1/Pa]
Range type	Log	
Sigma	1.00000E+00	

Numeric

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

C-2737 Fitting Parameter Estimates

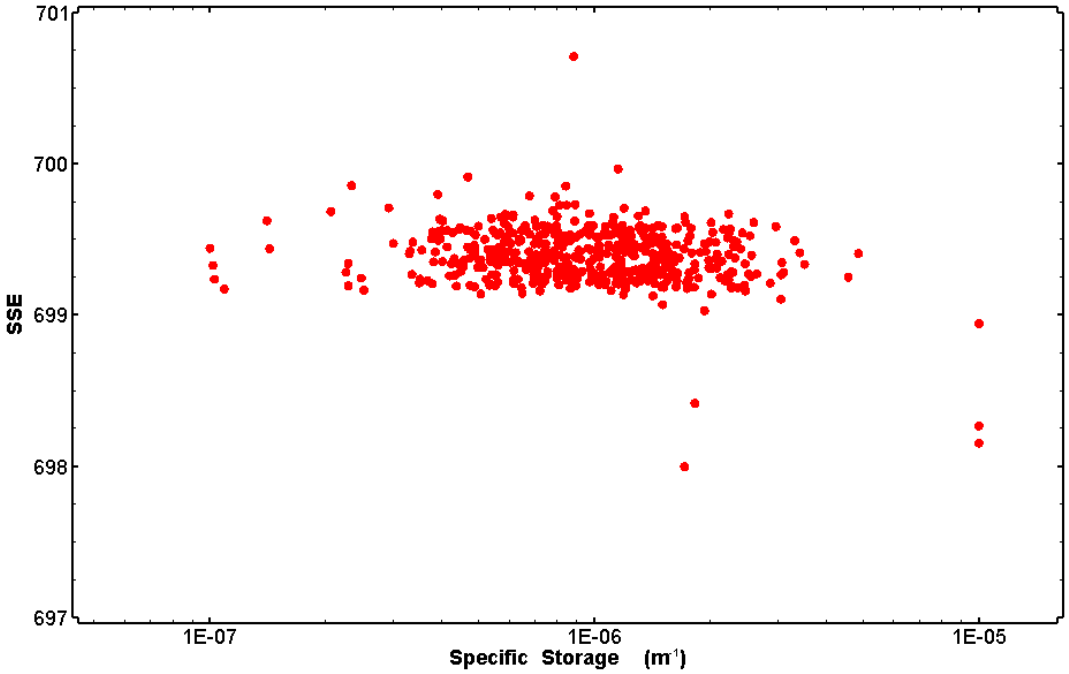

Figure B-54. Estimates of specific storage derived from the C-2737 perturbation analysis.

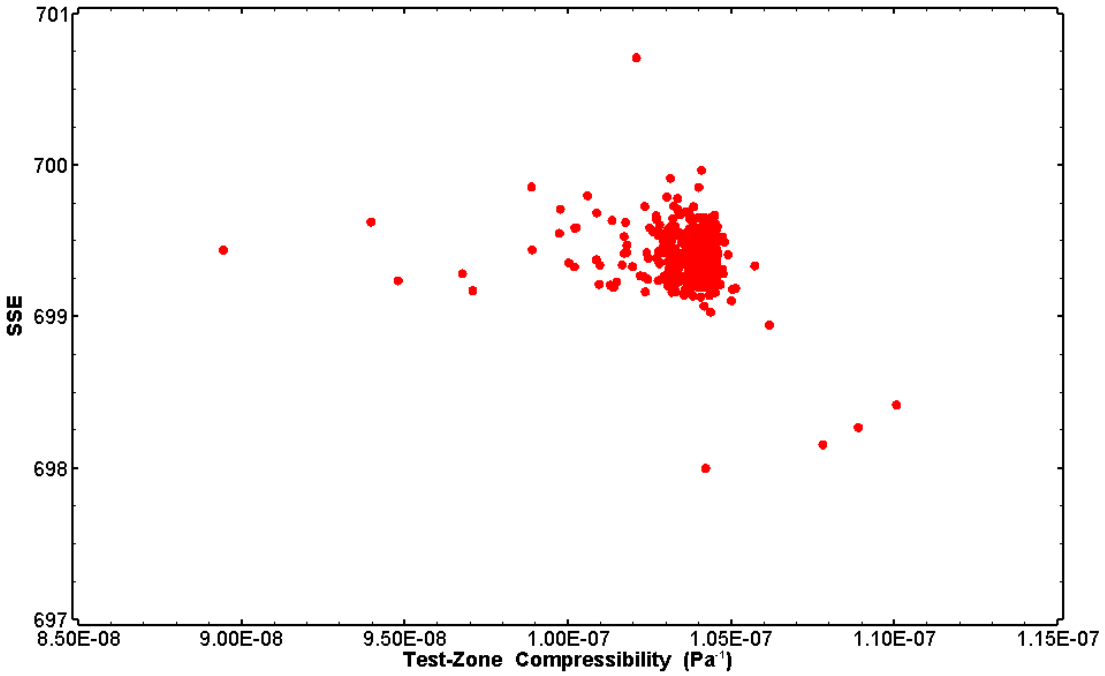

Figure B-55. Estimates of test-zone compressibility derived from the C-2737 perturbation analysis.

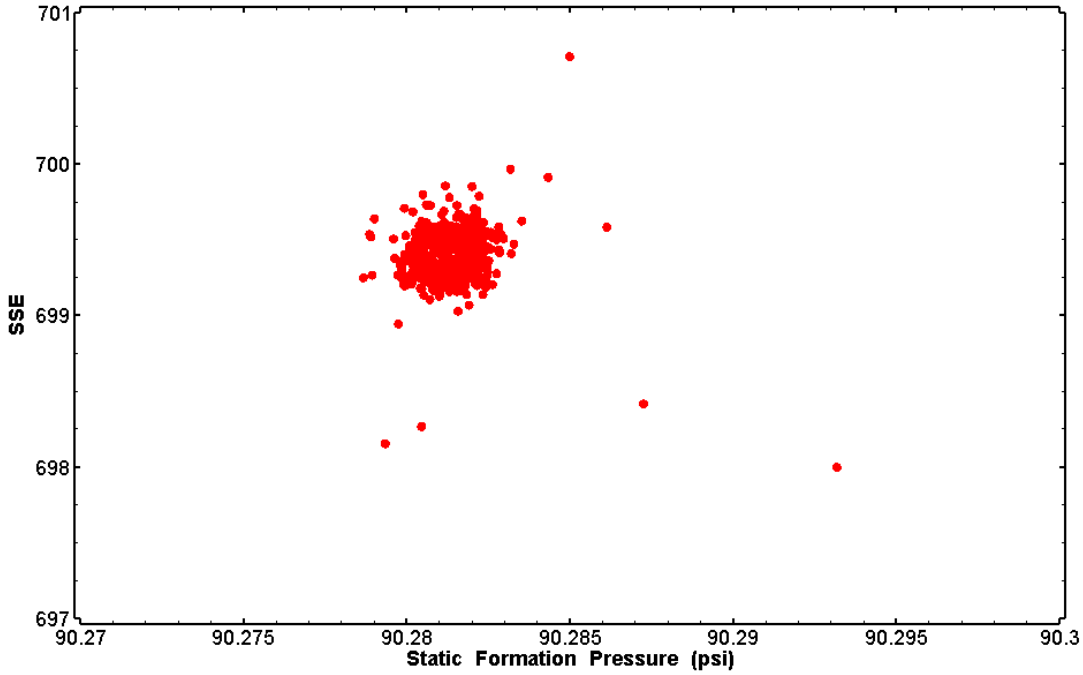

Figure B-56. Estimates of static formation pressure derived from the C-2737 perturbation analysis.

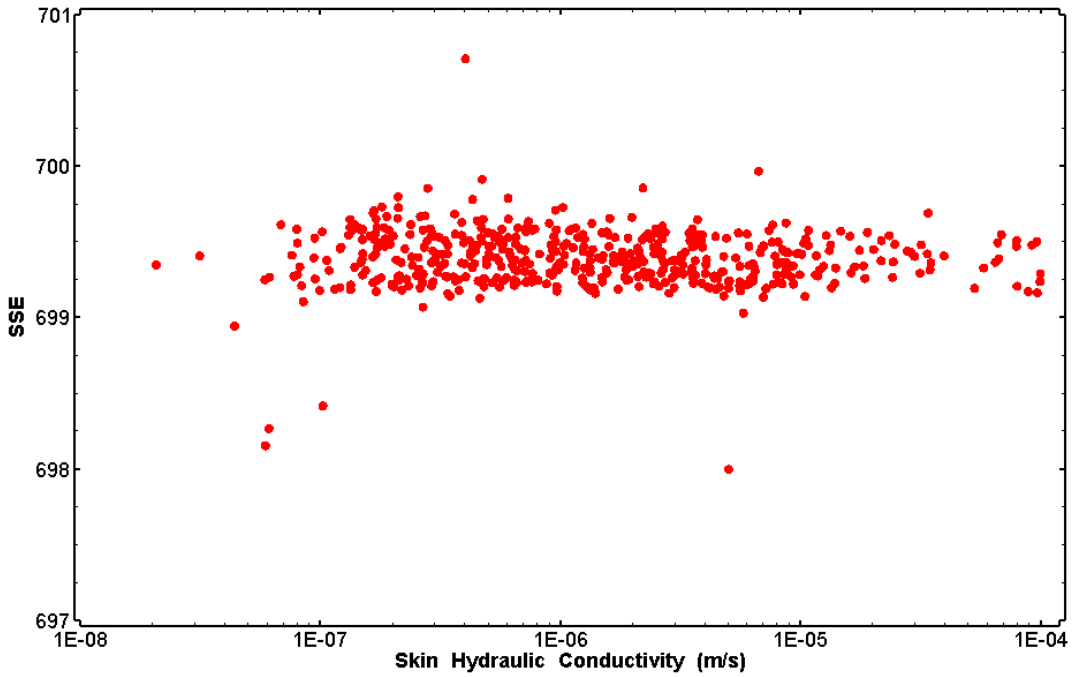

Figure B-57. Estimates of skin hydraulic conductivity derived from the C-2737 perturbation analysis.

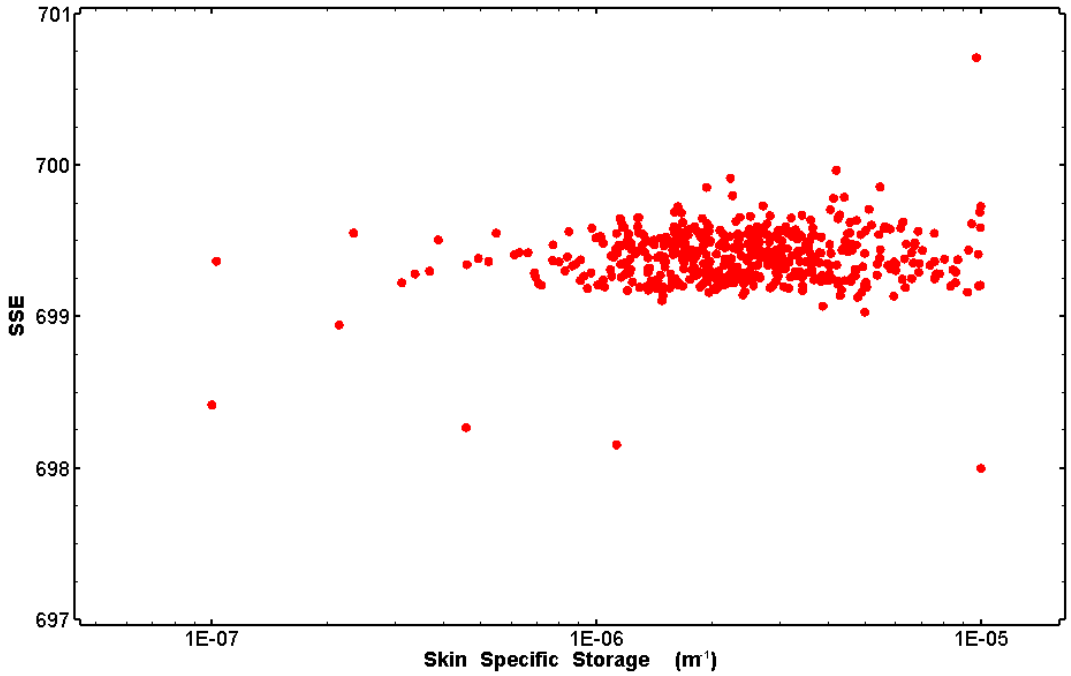

Figure B-58. Estimates of skin specific storage derived from the C-2737 perturbation analysis.

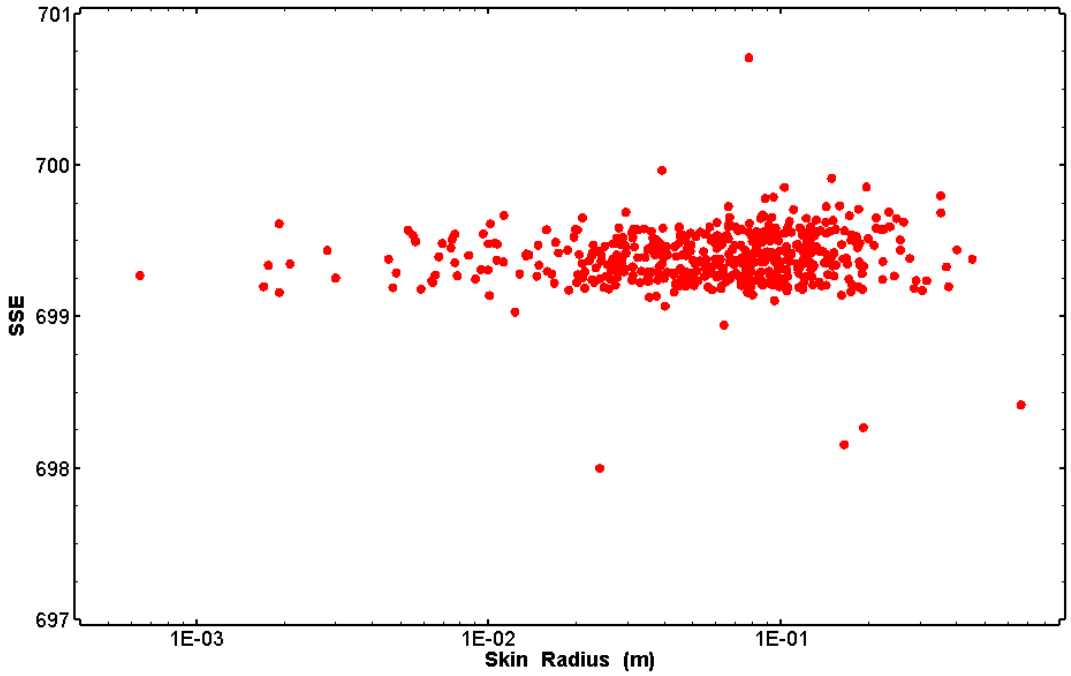

Figure B-59. Estimates of skin radius derived from the C-2737 perturbation analysis.

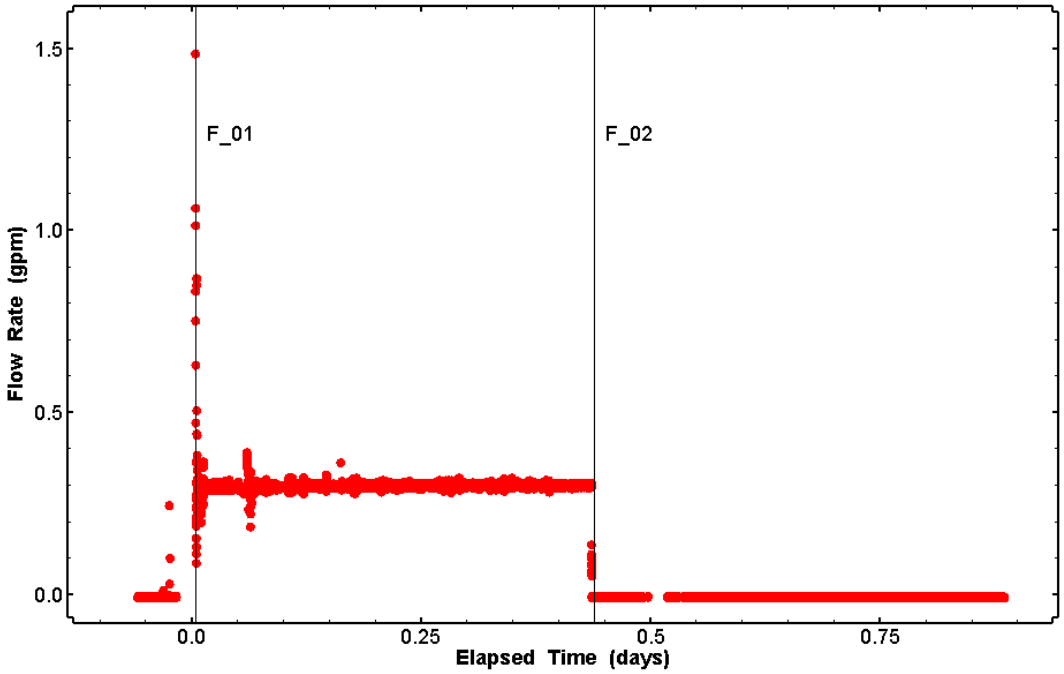

Figure B-60. Flow rates measured during the C-2737 testing.