T E C H N I C A L   M E M O R A N D U M

MWH

To:	Inyo/LA Cooperative Study Team	**Date:**	April 10, 2003
From:	MWH	**Reference:**	1341515.030203
Subject:	Confining Layer Characteristics Cooperative Study - Aquifer Test Analysis **FINAL**		

INTRODUCTION

On August 1, 2002, the Los Angeles Department of Water and Power (LADWP) authorized Montgomery Watson Harza (MWH) to continue the Confining Layer Characteristics Cooperative Study with Task 3.2.3, entitled "*Compile, Analyze, and Review Existing Data Sets.*" Subtask 3.2.3.1 of this task is entitled "*Aquifer Test Analysis.*" The scope of this subtask is as follows:

> *"MWH shall analyze the existing data sets selected in the July 24, 2002 'Identification of Methods and Tools for Characterization of the Confining Layer' Technical Memorandum. LADWP will loan a copy of AQTESOLV for MS Windows software to MWH for analysis. MWH shall utilize the following analysis methods to analyze the nine selected pump test data sets.*
>
> - *Hantush-Jacob Method, 'Classic Leaky Aquifer Solution'*
> - *Hantush Method, 'Modified Leaky Aquifer Solution'*
> - *Neuman-Witherspoon Method, 'Two Aquifer, One Confining Unit Solution'*
>
> *Application of three different methods is expected to produce variable values for hydraulic conductivity. As such, MWH shall evaluate the results of this analysis to determine a representative hydraulic conductivity for each given data set. In addition, MWH shall evaluate the results of this analysis with the goal of optimizing and refining future pump testing and associated data collection efforts in the Valley."*

The purpose of this technical memorandum, which represents the deliverable for Subtask 3.2.3.1, is to summarize the results of MWH's analysis of the selected aquifer test data sets as described in the scope of work.

The technical memorandum is organized into the following sections:

- **Background** – presents a brief description of each of the three methods used to perform the aquifer test analysis.

- **Aquifer Test Analysis Strategy –** presents the general guidelines and assumptions that were utilized to conduct the aquifer test analysis.
- **Aquifer Test Analysis Results –** presents the results of the aquifer test analysis for each pumping well. The wells are organized by wellfield beginning at the northernmost wellfield and continuing south. The nine wells that were analyzed are listed in **Table 1**.
- **Summary of Findings** – presents a summary of aquifer and confining layer parameters estimated during the aquifer test analysis.
- **Recommendations for Future Aquifer Testing** – presents a bulleted list of recommendations to be considered during implementation of future aquifer testing.

Table 1
Summary of Aquifer Tests Evaluated by Wellfield

Laws	Big Pine	Independence-Oak	Symmes-Shepherd
W387 EM	V014GA	W383 EM	W395 AQ
W398 AQ	V016GA	W384 EM	
	W379 EM		
	W389 EM		

BACKGROUND

As described in more detail in the *Technical Memorandum on the Identification of Methods and Tools for Characterization of the Confining Layer* (MWH, 2002), the following three pump test analysis methods were selected for aquifer test analysis: Hantush-Jacob (1955), Hantush (1960), and Neuman-Witherspoon (1969). A brief description of each of these methods is provided below.

Hantush-Jacob Method (1955)

The Hantush-Jacob Method (1955), from this point on referred to as the Hantush-Jacob Method, is a leaky aquifer analysis method that can be used to yield confined aquifer transmissivity and storativity and confining unit vertical hydraulic conductivity. Analysis is performed by fitting observed displacement vs. time data to a mathematically defined curve. The Hantush-Jacob solution assumes no storage in the confining unit. Originally, the Hantush-Jacob Method did not account for partially penetrating wells; however, the software program utilized during this analysis has modified the solution such that analysis of partially penetrating wells was possible.

Hantush Method (1960)

The Hantush Method (1960), from this point on referred to as the Hantush Method, is a leaky aquifer analysis method that can be used to yield confined aquifer transmissivity and storativity, and the product of confining unit vertical hydraulic conductivity and storativity. Similar to the Hantush-Jacob Method, analysis is performed by fitting observed displacement vs. time data to a mathematically defined curve. This solution has also been modified to account for partially penetrating wells. Unlike the Hantush-Jacob Method, the Hantush Method does account for storage in the confining unit.

Neuman-Witherspoon Method (1969)

The Neuman-Witherspoon Method (1969), from this point on referred to as the Neuman-Witherspoon Method, is a leaky aquifer analysis method that yields the transmissivity and storativity of the confined aquifer, the vertical hydraulic conductivity and storativity of the confining unit, and the transmissivity and storativity of the unconfined aquifer. Similar to the other two methods described above, analysis is performed by fitting observed displacement vs. time data to a mathematically defined curve. This method accounts for storage in the confining unit and partially penetrating wells. However, unlike the two other methods presented above, this method also accounts for drawdown in the unpumped aquifer. [Note: This method is not to be confused with the Neuman-Witherspoon "ratio" method (1972). In order to perform the "ratio" method, observations of drawdown for wells screened throughout the confining unit must be available. No such measurements were available for any of the existing pump tests available for analysis.]

AQUIFER TEST ANALYSIS STRATEGY

In order for the results of the aquifer test analyses to be both consistent and reproducible, an analysis strategy was created to:

1. Identify data subsets to be analyzed,
2. Make assumptions for data input, and
3. Determine curve matching techniques.

The analysis strategy is outlined below:

1. Identify data subsets to be analyzed:
   - It is difficult to estimate the "distance from the center of pumping" for observation measurements obtained at the pumping well, and at small distances, the analytical solutions are quite sensitive to the distance chosen. As a result, observation well data were selected for analysis over pumping well data wherever possible. However, if adequate drawdown vs. time data were not available for an observation well, pumping well data were analyzed.
   - Observation well data were only used for wells that were screened in the same zone as the pumping well. If no observation wells screened in the same aquifer as the pumped well were utilized, data from the pumping well were selected for analysis.
   - Data collected less than 10 minutes into the aquifer test were not analyzed. This is because the "early"-time data is often suspect because the well is emptying the casing. Thus, the water that is withdrawn from the well casing is not from the aquifer, and less drawdown may be observed than would be predicted by theory. In addition, drawdown measurements were obtained manually. Therefore, from a practical standpoint, the

personnel on the site may have been rushed to take measurements as the water level fell quickly, perhaps resulting in inaccurate measurements.

- The Hantush Method can only be used to analyze early-time data; however, "early-time" is dependent on several aquifer and aquitard parameters that are unknown. For this reason, a qualitative determination was made for each data set as to which data points would be analyzed with the Hantush Method. For the purposes of this analysis, any measurements obtained after an observable change in inflection of the drawdown vs. time curve were discarded from the analysis.

2. Make assumptions for data input:
   - Aquifer Data
     - The saturated thickness of the confined aquifer was assumed to be the distance from the bottom of the confining unit to the bottom of the screened interval of the pumped well.
     - A hydraulic conductivity anisotropy ratio (vertical hydraulic conductivity:horizontal hydraulic conductivity) of 1.0 was assumed for the pumped aquifer. Analysis was conducted to determine the sensitivity of the solutions to this assumption. It was determined that for all analyses where the pumping well was fully penetrating as well as for all analyses conducted with the Neuman-Witherspoon Method, changing the hydraulic conductivity anisotropy ratio from 1.0 to 0.1 had no observable effect. Furthermore, it was determined that for wells whose screened intervals perforated at least 80 percent of the saturated aquifer, the effect observed from changing the hydraulic conductivity anisotropy ratio from 1.0 to 0.1 was non-significant. The only pumping well whose screened interval does not penetrate at least 80 percent of the saturated aquifer was well V014GA. For this well, generated solutions for the Hantush-Jacob Method and the Hantush Method could change by up to an order of magnitude if the hydraulic conductivity anisotropy ratio were decreased from 1.0 to 0.1.
   - Pumping Well Data
     - If the pumping well was screened over the full saturated aquifer thickness, (as defined above), then the well was assumed to be fully penetrating. Otherwise, the pumping well was assumed to be partially penetrating.
     - A constant pumping rate was assumed for the duration of the aquifer test. (Note: One exception was made to this assumption for well V014GA. This well was pumped for 240 minutes at one pumping rate, and then the pumping rate was doubled for the remainder of the test. This change in pumping rate was modeled during the analysis.)
     - If data from the pumping well were used for analysis, the radial distance chosen was equal to the borehole radius.
   - Observation Well Data
     - If the observation well was screened over the full saturated aquifer thickness, (as defined above), then the well was assumed to be fully penetrating. Otherwise, the observation well was assumed to be partially penetrating.

3. Determine curve-matching techniques:
   - Initially, AQTESOLV's "automatic curve-matching feature" was utilized.
   - If a match was obtained, AQTESOLV's "tweak" feature, which allows the user to make slight adjustments in the generated parameters and observe the effect on the shape of the match curve, was utilized to determine the sensitivity of the curve to variations in each of the generated parameters. Also, the generated aquifer transmissivity and storativity values were compared with existing LADWP estimates (found in the pump test packets) to check for order of magnitude agreement.
   - If the curve was sensitive to all generated parameters, no closer visual match could be obtained using the "tweak" feature, and the generated aquifer transmissivity and storativity estimates were within an order of magnitude of existing LADWP estimates, then the match obtained by the automatic curve-matching feature was selected as the "best match".
   - If any of the three criteria described in the previous bullet were not met, the parameters were adjusted manually such that the best visual match was obtained, (taking into account parameters generated by prior analyses with other solutions as well as existing LADWP estimates for aquifer transmissivity and storativity). Then, the automatic curve-matching feature was utilized once more to create the "best match".
   - At this point, the "tweak" feature was used once more to determine the sensitivity of the curve to the parameters generated. Assuming that the curve was sensitive at least to the parameters necessary to calculate vertical hydraulic conductivity, the analysis was considered complete. The reason that this criterion was applied was to assure that discrete solutions (as opposed to values within a range of possible solutions) were found for the parameters utilized to calculate confining unit properties. The AQTESOLV parameters needed to calculate vertical hydraulic conductivity (or the verticaly hydraulic conductivity/storativity product for the Hantush Method) are listed below by method (see **Appendix A** for a glossary of variables and terms):
     - Hantush-Jacob Method: aquifer transmissivity and r/B value
     - Hantush Method:aquifer transmissivity, aquifer storativity, and β_H value
     - Neuman-Witherspoon Method: aquifer transmissivity and r/B value
   - If no automatic match could be converged upon, a visual match was created by tweaking the parameters as described above to create a "representative" solution.
   - For consistency, it was determined that all parameter solutions generated by AQTESOLV as well as all calculated values based on these parameter solutions would be presented to three significant figures unless otherwise stated.

AQUIFER TEST ANALYSIS RESULTS

The results of the aquifer test analyses are presented herein by wellfield for each of the nine selected aquifer test data sets. This technical memorandum contains the following information:

- A glossary of variables and terms (**Appendix A**),
- Schematic diagrams of the nine aquifer systems analyzed (**Appendix B**),
- Drawdown vs. time data analyzed for each data set (**Appendix C**),

- Residual statistics and parameter solutions produced by the AQTESOLV analysis for each data set (**Appendices D – L**),
- Discussions of the three final solutions obtained for each data set,
- Two calculated confining unit vertical hydraulic conductivity values for each data set based on the parameter solutions for the Hantush-Jacob Method and the Neuman-Witherspoon Method as well as an estimation of the representative value for each data set. (Note: The confining unit vertical hydraulic conductivity could not be isolated with the Hantush Method, but the confining unit vertical hydraulic conductivity/storativity product is presented.), and
- A sample calculation for vertical hydraulic conductivity using the Hantush-Jacob Method and the Neuman-Witherspoon Method as well as a sample calculation for the vertical hydraulic conductivity/storativity product using the Hantush Method (**Appendix M**).

Additionally, a summary of the inputs to AQTESOLV that were used during analysis of each of the nine aquifer tests is provided in **Table 2**.

LADWP Well W387 EM (Laws Wellfield)

One observation well, well T734, was monitored in addition to the pumping well during the aquifer test conducted at well W387 EM. However, upon looking at the drawdown vs. time plot for the observation well, it was determined that this well seems to be affected by some outside pumping source and/or external influences, due to significant variation in observed drawdown at late time. For this reason, only the pumping well data from well W387 EM were chosen for analysis, and all of the measurements were analyzed, (except for data collected less than 10 minutes into the test). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well W387 EM was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 3** presents a summary of the aquifer test analysis results for well W387 EM. The final solution curves for each analysis method are presented in **Appendix D**.

It is important to note that the top 20 feet of the screened interval for well W387 EM are located in a potential confining/low permeability unit, (fine to medium sand with small gravel, 70 percent brown clay). Because the well was screened in this area, this 20-foot unit of low permeability was considered to be part of the confined aquifer. (AQTESOLV expects the screened interval of a pumping well to begin below the confining unit.) However, if analysis was performed assuming the 20-foot low permeability unit to be part of the confining unit and assuming the screened interval to start immediately below this unit, different results might be obtained.

Table 2
Summary of AQTESOLV Inputs for Aquifer Test Analysis

		Laws		Big Pine				Independence-Oak		Symmes-Shepherd
		Well W387 EM	Well W398 AQ	Well V014GA	Well V016GA	Well W379 EM	Well W389 EM	Well W383 EM	Well W384 EM	Well W395 AQ
AQUIFER CHARACTERISTIC INPUTS	Saturated Aquifer Thickness	370 feet	367 feet	65 feet	48 feet	200 feet	200 feet	355 feet	340 feet	462 feet
	Kr/Kz Ratio	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1
	Confining Unit Thickness[1] (see Appendix B – Schematic Diagrams)	50 feet	109 feet	190 feet	140 feet	100 feet	110 feet	150 feet	50 feet	30 feet
PUMPING WELL INPUTS	Fully vs. Partially Penetrating Well	Partially	Partially	Partially	Partially	Fully	Fully	Partially	Fully	Partially
	Distance from Base of Confining Unit to Top of Perforated Interval	40 feet	17 feet	25 feet	8 feet	0 feet	0 feet	54 feet	0 feet	32 feet
	Distance from Base of Confining Unit to Bottom of Perforated Interval	370 feet	367 feet	65 feet	48 feet	200 feet	200 feet	355 feet	340 feet	462 feet
	Pumping Rate	482.6 ft^3/min (3610 gpm)	401.0 ft^3/min (3000 gpm)	12.7 ft^3/min (95 pgm) for time $\leq$ 240 min 25.4 ft^3/min (190 gpm) for time > 240 min	34.6 ft^3/min (259 gpm)	409.1 ft^3/min (3060 gpm)	418.4 ft^3/min (3130 gpm)	297.0 ft^3/min (2222 gpm)	126.9 ft^3/min (949 gpm)	407.7 ft^3/min (3050 gpm)
INPUTS FOR WELL SELECTED FOR DATA ANALYSIS	Well Name	W387 EM	W398 AQ	V014GA	V016GA	T627	T736	T632	T633	W395 AQ
	Radial Distance from Pumping Well	1.17 feet (based on 28" borehole diameter)	1.17 feet (based on 28" borehole diameter)	0.667 feet (based on 16" borehole diameter)	0.625 feet (based on 15" borehole diameter)	57 feet	48.5 feet	81.5 feet	88.5 feet	1.17 feet (based on 28" borehole diameter)
	Fully vs. Partially Penetrating Well	Partially	Partially	Partially	Partially	Partially	Partially	Partially	Partially	Partially
	Distance from Base of Confining Unit to Top of Perforated Interval	40 feet	17 feet	25 feet	8 feet	100 feet	100 feet	160 feet	200 feet	32 feet
	Distance from Base of Confining Unit to Bottom of Perforated Interval	370 feet	367 feet	65 feet	48 feet	150 feet	150 feet	200 feet	240 feet	462 feet
	Number of Time vs. Drawdown Measurements Analyzed	42	32	40	17	25	45	47	51	65

[1]The confining unit thickness is not an input used during AQTESOLV analysis. However, it is provided in this table as it is needed to calculate vertical hydraulic conductivity values from the parameters yielded by AQTESOLV analysis.

Table 3
Summary of Aquifer Test Analysis Results for Well W387 EM

Analysis Results	Aquifer Test Analysis Method		
	Hantush-Jacob (1955)	**Hantush (1960)**	**Neuman-Witherspoon (1969)**
Residual Statistics[1]			
Mean	-0.0001757	-0.00002489	-0.002161
Variance	0.2422	0.2699	0.2456
Standard Error	0.4921	0.5196	0.4956
Parameter Solutions[2]			
T [gpd/ft]	57,100	56,800	53,600
S [unitless]	4.25×10^{-3}	3.75×10^{-3}	2.73×10^{-3}
r/B [unitless]	1.34×10^{-3}	Not Applicable	1.34×10^{-3}
β_H [unitless]	Not Applicable	2.97×10^{-4}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	3.30×10^{-4}
T^U [gpd/ft]	Not Applicable	Not Applicable	$\mathbf{1.34 \times 10^{-1}}$
S^U [unitless]	Not Applicable	Not Applicable	$\mathbf{1.00 \times 10^{0}}$

1 Residual statistics presented for the Hantush Method should not be compared with values from the other two methods as this analysis was performed only on a subset of the data used for analysis with the other two methods.
2 Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush-Jacob (1955) Analysis

Analysis with the Hantush-Jacob Method produced a solution curve that provides a very good visual match with the pumping well data. Calculated transmissivity and storativity values agree with earlier estimates by the LADWP (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity.

Hantush (1960) Analysis

Analysis with the Hantush Method was conducted only on the first 420 minutes of data, (excluding the first 10 minutes). This analysis produced a solution curve that provides a good visual match with the pumping well data, and calculated transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity/storativity product.

Neuman-Witherspoon (1969) Analysis

Analysis with the Neuman-Witherspoon Method produced a solution curve that provides a very good visual match with the pumping well data. Calculated confined aquifer transmissivity and storativity values agree with earlier LADWP estimates (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity. (However, it should be noted that the calculated unconfined aquifer transmissivity and storativity values can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well W387 EM

Calculated vertical hydraulic conductivity values for the confining unit present at well W387 EM are presented in **Table 4**. (Note: A sample calculation of these values is presented in **Appendix M**.) From this table, it is observed that the confining unit vertical hydraulic conductivity values calculated from the Hantush-Jacob solution and the Neuman-Witherspoon solution are virtually identical. The representative confining unit vertical hydraulic conductivity near well W387 EM is estimated to be an average of the two solutions, or 3.64 gpd/ft^2.

Table 4
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well W387 EM

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	3.73	Not Applicable
Hantush (1960)[1]	Not Applicable	0.0110
Neuman-Witherspoon (1969)	3.54	Not Applicable
Representative Value	**3.64**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

LADWP Well W398 AQ (Laws Wellfield)

The pumping well data were selected for analysis of the aquifer test conducted at well W398 AQ. No observation wells screened in the same aquifer as well W398 AQ were monitored during this test. All of the pumping well data were analyzed, (except for data collected less than 10 minutes into the test). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well W398 AQ was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 5** presents a summary of the aquifer test analysis results for well W398 AQ. The final solution curves for each analysis method are presented in **Appendix E**.

Hantush-Jacob (1955) Analysis

Automatic curve matching analysis of the data from well W398 AQ with the Hantush-Jacob Method was not successful. AQTESOLV was unable to converge on a reasonable solution. This failure is attributed to the low quality of the data. The data imply that there were numerous changes in pumping rate. In order to generate some estimate of the aquifer properties near well W398 AQ, a visual match was obtained by setting the transmissivity and storativity near earlier estimates by the LADWP (LADWP, 1991). Next, the parameters were tweaked as little as possible to obtain a reasonable visual match. The results of this match are presented in **Table 5**. However, other solutions are possible, and these values should be used with caution as they were estimated based on visual inspection alone.

Table 5
Summary of Aquifer Test Analysis Results for Well W398 AQ

Analysis Results	**Aquifer Test Analysis Method**		
	Hantush-Jacob (1955)	**Hantush (1960)**	**Neuman-Witherspoon (1969)**
Residual Statistics[1]			
Mean	Not Applicable	Not Applicable	Not Applicable
Variance	Not Applicable	Not Applicable	Not Applicable
Standard Error	Not Applicable	Not Applicable	Not Applicable
Parameter Solutions[2]			
T [gpd/ft]	81,600	74,400	71,100
S [unitless]	5.76×10^{-4}	1.02×10^{-3}	1.41×10^{-3}
r/B [unitless]	3.72×10^{-4}	Not Applicable	8.32×10^{-4}
β_H [unitless]	Not Applicable	4.57×10^{-4}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	3.98×10^{-4}
T^U [gpd/ft]	Not Applicable	Not Applicable	$\mathbf{1.08 \times 10^{+3}}$
S^U [unitless]	Not Applicable	Not Applicable	1.00×10^{-1}

[1] No residual information is available as AQTESOLV could not converge on a solution for this data set.
[2] All solutions presented in this table are estimated only and should be used with caution.
[3] Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush (1960) Analysis

Similar to the Hantush-Jacob Method, automatic curve-matching analysis with the Hantush Method was unsuccessful. Again AQTESOLV could not converge on a solution; therefore, an estimated solution was obtained by creating a reasonable visual match as described above. The results of this match are presented in **Table 5**, but again, these results are not unique and should be used with caution.

Neuman-Witherspoon (1969) Analysis

As with the other two methods, automatic curve-matching analysis with the Neuman-Witherspoon Method was unsuccessful. Again AQTESOLV could not converge on a solution, so an estimated solution was obtained by creating a reasonable visual match as described above. The results of this match are presented in **Table 5**, but again, these results are not unique and should be used with caution. (Note also that the calculated unconfined aquifer transmissivity can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well W398 AQ

Calculated vertical hydraulic conductivity values for the confining unit present at well W398 AQ are presented in **Table 6**. A comparison between the confining unit vertical hydraulic conductivity values calculated by the Hantush-Jacob Method and the Neuman-Witherspoon Method reveals that the two values are within an order of magnitude of each other. However, these values are based on highly questionable parameter solutions, and with the low quality of available data, there is no reason to rely in the results generated by either method. For this reason, the representative confining unit vertical hydraulic conductivity near well W398 AQ is estimated to be an average of the two solutions, or 2.41 gpd/ft^2.

Table 6
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well W398 AQ

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	0.897	Not Applicable
Hantush (1960)[1]	Not Applicable	0.0202
Neuman-Witherspoon (1969)	3.92	Not Applicable
Representative Value	**2.41**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

U.S. Geological Survey Well V014GA (Big Pine Wellfield)

The pumping well data were selected for analysis of the aquifer test conducted at well V014GA. No observation wells screened in the same aquifer as well V014GA were monitored during this test. All of the pumping well data were analyzed, (except for data collected less than 10 minutes into the test and less than 10 minutes after the change in pumping rate at 240 minutes). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well V014GA was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 7** presents a summary of the aquifer test analysis results for well V014GA. The final solution curves for each analysis method are presented in **Appendix F**.

Hantush-Jacob (1955) Analysis

Analysis with the Hantush-Jacob Method produced a solution curve that provides a relatively good visual match with the pumping well data collected at well V014GA. However, the curve does not fit the data obtained before the increase in pumping rate. The calculated transmissivity value agrees well with earlier estimates by the LADWP (LADWP, 1985). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity.

Table 7
Summary of Aquifer Test Analysis Results for Well V014GA

Analysis Results	Aquifer Test Analysis Method		
	Hantush-Jacob (1955)	**Hantush (1960)**	**Neuman-Witherspoon (1969)**
Residual Statistics[1]			
Mean	-0.1378	-0.0002322	-0.0358
Variance	0.0315	0.0004548	0.01982
Standard Error	0.1775	0.02133	0.1408
Parameter Solutions[2]			
T [gpd/ft]	40,600	36,200	32,600
S [unitless]	3.41×10^{-3}	2.75×10^{-2}	1.41×10^{-3}
r/B [unitless]	4.56×10^{-4}	Not Applicable	4.96×10^{-4}
β_H [unitless]	Not Applicable	5.16×10^{-4}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	1.11×10^{-4}
T^U [gpd/ft]	Not Applicable	Not Applicable	$\mathbf{1.13 \times 10^{0}}$
S^U [unitless]	Not Applicable	Not Applicable	1.58×10^{-2}

[1] Residual statistics presented for the Hantush Method should not be compared with values from the other two methods as this analysis was performed only on a subset of the data used for analysis with the other two methods.
[2] Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush (1960) Analysis

Analysis with the Hantush Method was conducted only on the first 240 minutes of data, (excluding the first 10 minutes). This analysis produced a solution curve that provides a relatively good visual match with the pumping well data, and the calculated transmissivity value agrees well with earlier LADWP estimates (LADWP, 1985). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity/storativity product.

Neuman-Witherspoon (1969) Analysis

Analysis with the Neuman-Witherspoon Method produced a solution curve that provides a relatively good match with the pumping well data. However, the curve does not match the data obtained immediately after the increase in pumping rate. Calculated confined aquifer transmissivity agrees well with earlier LADWP estimates (LADWP, 1985). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity. (However, it should be noted that the calculated unconfined aquifer transmissivity can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well V014GA

Calculated vertical hydraulic conductivity values for the confining unit present at well V014GA are presented in **Table 8**. From this table, it is observed that the confining unit vertical hydraulic conductivity values calculated from the Hantush-Jacob solution and the Neuman-Witherspoon solution are virtually identical. The representative confining unit vertical hydraulic conductivity near well V014GA is therefore estimated as the average of the two values, or 3.52 gpd/ft^2.

Table 8
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well V014GA

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	3.60	Not Applicable
Hantush (1960)[1]	Not Applicable	1.81
Neuman-Witherspoon (1969)	3.43	Not Applicable
Representative Value	**3.52**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

U.S. Geological Survey Well V016GA (Big Pine Wellfield)

The pumping well data were selected for analysis of the aquifer test conducted at well V016GA. No observation wells screened in the same aquifer as well V016GA were monitored during this test. Only early-time pumping well data were analyzed, (excluding data collected less than 10 minutes into the test), as changes in the pumping rate at time greater than 150 minutes adversely affected the quality of the data. A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well V016GA was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 9** presents a summary of the aquifer test analysis results for well V016GA. The final solution curves for each analysis method are presented in **Appendix G**.

Hantush-Jacob (1955) Analysis

Automatic curve-matching analysis of the data from well V016GA with the Hantush-Jacob Method was not successful. AQTESOLV was unable to converge on a reasonable solution. This failure is attributed to the fact that only 150 minutes of acceptable data exist for this well. In order to generate some estimate of the aquifer properties near well V016GA, a visual match was obtained by setting the transmissivity near the earlier estimates by the LADWP, (LADWP, 1985), and by setting the storativity close to the value obtained at well V014GA (which is located very close to well V016GA). Then, the parameters were tweaked as little as possible to obtain a reasonable visual match. The results of this match are presented in **Table 9**. However, other solutions are possible, and these values should be used with caution as they were estimated based on visual inspection alone.

Table 9
Summary of Aquifer Test Analysis Results for Well V016GA

Analysis Results	Aquifer Test Analysis Method		
	Hantush-Jacob (1955)	**Hantush (1960)**	**Neuman-Witherspoon (1969)**
Residual Statistics[1]			
Mean	Not Applicable	Not Applicable	Not Applicable
Variance	Not Applicable	Not Applicable	Not Applicable
Standard Error	Not Applicable	Not Applicable	Not Applicable
Parameter Solutions[2,3]			
T [gpd/ft]	25,700	23,800	19,900
S [unitless]	3.16×10^{-4}	5.65×10^{-4}	1.59×10^{-3}
r/B [unitless]	7.41×10^{-4}	Not Applicable	2.69×10^{-3}
β_H [unitless]	Not Applicable	4.80×10^{-4}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	4.18×10^{-4}
T^U [gpd/ft]	Not Applicable	Not Applicable	**$1.08 \times 10^{+3}$**
S^U [unitless]	Not Applicable	Not Applicable	8.91×10^{-2}

[1] No residual information is available as AQTESOLV could not converge on a solution for this data set.
[2] All solutions presented in this table are estimated only and should be used with caution.
[3] Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush (1960) Analysis

Similar to the Hantush-Jacob Method, automatic curve-matching analysis with the Hantush Method was unsuccessful. Again AQTESOLV could not converge on a solution; therefore, an estimated solution was obtained by creating a reasonable visual match as described above. The results of this match are presented in **Table 9**, but again, these results are not unique and should be used with caution.

Neuman-Witherspoon (1969) Analysis

As with the other two methods, automatic curve-matching analysis with the Neuman-Witherspoon Method was unsuccessful. Again AQTESOLV could not converge on a solution; therefore, an estimated solution was obtained by creating a reasonable visual match as described above. The results of this match are presented in **Table 9**, but again, these results are not unique and should be used with caution. (Note also that the calculated unconfined aquifer transmissivity can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well V016GA

Calculated vertical hydraulic conductivity values for the confining unit present at well V016GA are presented in **Table 10**. A comparison between the confining unit vertical hydraulic conductivity values calculated by the Hantush-Jacob Method and the Neuman-Witherspoon Method reveals that the latter value is approximately one order of magnitude higher than the former value. However, these values are based on highly questionable parameter solutions, and with the limited data available, there is no reason to favor the results of either method. For this reason, the representative confining unit vertical hydraulic conductivity near well V016GA is estimated to be an average of the two solutions, or 24.4 gpd/ft^2.

Table 10
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well V016GA

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	4.33	Not Applicable
Hantush (1960)[1]	Not Applicable	0.0152
Neuman-Witherspoon (1969)	44.4	Not Applicable
Representative Value	**24.4**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

LADWP Well W379 EM (Big Pine Wellfield)

Two observation wells, well T627 and well W378 EM, were monitored in addition to the pumping well during the aquifer test conducted at well W379 EM. However, well W378 EM is located almost 700 feet from well W379 EM whereas well T627 is located only 57 feet from the pumping well. Because of the distance of well W378 EM from the pumping well, there is an increased likelihood that this well could be influenced by external factors other than the pumping of well W379 EM. For this reason, observation measurements from well T627 only were chosen for analysis. All of the observation well data from well T627 were analyzed, (except for data collected less than 10 minutes into the test). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well W379 EM was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 11** presents a summary of the aquifer test analysis results for well W379 EM. The final solution curves for each analysis method are presented in **Appendix H**.

Hantush-Jacob (1955) Analysis

Analysis with the Hantush-Jacob Method produced a solution curve that provides a good visual match with the observation data collected at well T627. Calculated transmissivity and storativity values agree well with earlier estimates by the LADWP (LADWP, 1992). The curve shape is sensitive to aquifer transmissivity; however, not enough late-time data exist to accurately estimate the r/B value. The value converged upon by AQTESOLV, 1x10^{-5}, can be manually increased to approximately 5x10^{-3} without affecting the early-time shape of the Hantush-Jacob curve for which data exist. For this reason, the latter r/B value was used to calculate the upper limit of the vertical hydraulic conductivity for this system.

Table 11
Summary of Aquifer Test Analysis Results for Well W379 EM

Analysis Results	Aquifer Test Analysis Method Hantush-Jacob (1955)	Hantush (1960)	Neuman-Witherspoon (1969)
Residual Statistics			
Mean	0.005037	0.0004869	0.002433
Variance	0.1087	0.1088	0.126
Standard Error	0.3297	0.3299	0.355
Parameter Solutions[1,2]			
T [gpd/ft]	90,300	90,200	90,200
S [unitless]	1.38×10^{-3}	1.38×10^{-3}	1.38×10^{-3}
r/B [unitless]	*5.00×10^{-3}*	Not Applicable	*3.00×10^{-3}*
β_H [unitless]	Not Applicable	*5.00×10^{-4}*	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	**1.00×10^{-5}**
T^U [gpd/ft]	Not Applicable	Not Applicable	**$6.93 \times 10^{+7}$**
S^U [unitless]	Not Applicable	Not Applicable	**1.00×10^{0}**

[1] Italicized values represent the upper limit of a range of possible values for a given parameter.
[2] Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush (1960) Analysis

Analysis with the Hantush Method was conducted on all of the observation data and produced a solution curve that provides a good visual match with the observation well data. Calculated transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1992). The curve shape is sensitive to aquifer transmissivity and storativity; however, the data collected were not sufficient to identify a unique value for β_H. The value converged upon, $1\text{x}10^{-5}$, can be increased to approximately $5\text{x}10^{-4}$ without affecting the early-time shape of the Hantush curve for which data exist. For this reason, the latter β_H value was used to calculate the upper limit of the confining unit vertical hydraulic conductivity/storativity product for this system.

Neuman-Witherspoon (1969) Analysis

Analysis with the Neuman-Witherspoon Method produced a solution curve provides a good visual match with the available observation data collected at well T627. Again, calculated confined aquifer transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1992). The curve shape is sensitive to confined aquifer transmissivity; however, as with the Hantush-Jacob analysis, not enough late-time data exist to accurately estimate the r/B value. The value converged upon by AQTESOLV, $1\text{x}10^{-5}$, can be manually increased to approximately $3\text{x}10^{-3}$ without affecting the early-time shape of the Neuman-Witherspoon curve for which data exist. For this reason, the latter r/B value was used to calculate the upper limit of the vertical hydraulic conductivity for this system. (Note that the calculated β_{NW}, unconfined aquifer transmissivity, and unconfined aquifer storativity values can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well W379 EM

Calculated upper limits for vertical hydraulic conductivity for the confining unit present at well W379 EM are presented in **Table 12**. From this table, it is observed that the confining unit vertical hydraulic conductivity value calculated from the Hantush-Jacob solution is approximately three times greater than the value calculated from the Neuman-Witherspoon solution. Because both of the solutions present equally good visual matches and generate equally low standard errors, the representative upper limit of the confining unit vertical hydraulic conductivity near well W379 EM is estimated to be an average of the two solutions, or 0.0473 gpd/ft^2.

Table 12
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well W379 EM[1]

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	0.0695	Not Applicable
Hantush (1960)[2]	Not Applicable	0.0000153
Neuman-Witherspoon (1969)	0.0250	Not Applicable
Representative Value	**0.0473**	**Not Applicable**

[1] The values that are presented in this table are upper limit values only. This is because unique solutions could not be obtained for the parameters used to calculate these values.
[2] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

LADWP Well W389 EM (Big Pine Wellfield)

One observation well, well T736, was monitored in addition to the pumping well during the aquifer test conducted at well W389 EM. Observation measurements from well T736 were chosen for analysis, and all of the measurements were analyzed, (except for data collected less than 10 minutes into the test). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well W389 EM was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 13** presents a summary of the aquifer test analysis results for well W389 EM. The final solution curves for each analysis method are presented in **Appendix I**.

It is important to note that the top 30 feet of the screened interval for well W387 EM are located in a potential confining/low permeability unit, (greenish blue silt and clay with medium sand lenses). Because the well was screened in this area, this 30-foot low permeability unit was considered to be part of the confined aquifer. (AQTESOLV expects the screened interval of a pumping well to begin below the confining unit.) However, if analysis was performed assuming the low permeability unit to be part of the confining unit and assuming the screened interval to start immediately below this unit, different results might be obtained.

Table 13
Summary of Aquifer Test Analysis Results for Well W389 EM

Analysis Results	Aquifer Test Analysis Method		
	Hantush-Jacob (1955)	**Hantush (1960)**	**Neuman-Witherspoon (1969)**
Residual Statistics[1]			
Mean	0.0000842	0.00000821	-0.004598
Variance	0.08938	0.0181	0.09644
Standard Error	0.299	0.1345	0.3105
Parameter Solutions[2]			
T [gpd/ft]	90,200	82,900	90,700
S [unitless]	1.61×10^{-3}	1.76×10^{-3}	1.57×10^{-3}
r/B [unitless]	6.05×10^{-3}	Not Applicable	5.10×10^{-3}
β_H [unitless]	Not Applicable	7.17×10^{-3}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	**1.40×10^{-4}**
T^U [gpd/ft]	Not Applicable	Not Applicable	**3.91×10^{-1}**
S^U [unitless]	Not Applicable	Not Applicable	**8.18×10^{-1}**

1 Residual statistics presented for the Hantush Method should not be compared with values from the other two methods as this analysis was performed only on a subset of the data used for analysis with the other two methods.
2 Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush-Jacob (1955) Analysis

Analysis with the Hantush-Jacob Method produced a solution curve that provides a very good visual match with the observation data collected at well T734, including late-time data. Calculated transmissivity and storativity values agree well with earlier estimates by the LADWP (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity.

Hantush (1960) Analysis

Analysis with the Hantush Method was conducted only on the first 210 minutes of data, (excluding the first 10 minutes). This analysis produced a solution curve that provides a very good visual match with the observation data, and calculated transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity/storativity product.

Neuman-Witherspoon (1969) Analysis

Analysis with the Neuman-Witherspoon Method produced a solution curve that provides a very good visual match with the observation data, including late-time data. Calculated confined aquifer transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity. (However, it should be noted that the calculated β_{NW}, unconfined aquifer transmissivity, and unconfined aquifer storativity values can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well W389 EM

Calculated vertical hydraulic conductivity values for the confining unit present at well W389 EM are presented in **Table 14**. From this table, it is observed that the confining unit vertical hydraulic conductivity values calculated from the Hantush-Jacob solution and the Neuman-Witherspoon solution are virtually identical. The representative confining unit vertical hydraulic conductivity near well W389 EM is estimated to be an average of the two, or 0.133 gpd/ft^2.

Table 14
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well W389 EM

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	0.155	Not Applicable
Hantush (1960)[1]	Not Applicable	0.00563
Neuman-Witherspoon (1969)	0.110	Not Applicable
Representative Value	**0.133**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

LADWP Well W383 EM (Independence-Oak Wellfield)

One observation well, well T632, was monitored in addition to the pumping well during the aquifer test conducted at well W383 EM. Observation measurements from well T632 were chosen for analysis, and all of the measurements were analyzed, (except for data collected less than 10 minutes into the test). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well W383 EM was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 15** presents a summary of the aquifer test analysis results for well W383 EM. The final solution curves for each analysis method are presented in **Appendix J**.

Hantush-Jacob (1955) Analysis

Analysis with the Hantush-Jacob Method produced a solution curve that provides a reasonable visual match with the observation data collected at well T632. However, the curve does not match the data measured at time greater than 1000 minutes, nor does it match the data measured at time less than 15 minutes. Calculated transmissivity and storativity values agree well with earlier estimates by the LADWP (LADWP, 1992). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity.

Table 15
Summary of Aquifer Test Analysis Results for Well W383 EM

Analysis Results	Aquifer Test Analysis Method Hantush-Jacob (1955)	Hantush (1960)	Neuman-Witherspoon (1969)
Residual Statistics[1]			
Mean	0.0000617	-0.0003572	-0.0004633
Variance	0.06749	0.03992	0.01913
Standard Error	0.2598	0.1998	0.1383
Parameter Solutions[2]			
T [gpd/ft]	56,400	43,100	50,000
S [unitless]	4.88×10^{-4}	6.05×10^{-4}	5.89×10^{-4}
r/B [unitless]	4.64×10^{-2}	Not Applicable	6.96×10^{-2}
β_H [unitless]	Not Applicable	4.27×10^{-2}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	**4.44×10^{-3}**
T^U [gpd/ft]	Not Applicable	Not Applicable	**1.08×10^{-1}**
S^U [unitless]	Not Applicable	Not Applicable	1.06×10^{-2}

1 Residual statistics presented for the Hantush Method should not be compared with values from the other two methods as this analysis was performed only on a subset of the data used for analysis with the other two methods.
2 Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush (1960) Analysis

Analysis with the Hantush Method was conducted only on the first 100 minutes of data, (excluding the first 10 minutes). This analysis produced a solution curve that provides a relatively good visual match with the observation data, and calculated transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1992). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity/storativity product.

Neuman-Witherspoon (1969) Analysis

Analysis with the Neuman-Witherspoon Method produced a solution curve that provides the best visual match of the three analysis methods with the observation data, matching both early- and late-time data. Calculated confined aquifer transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1992). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity. (However, it should be noted that the calculated β_{NW} and the unconfined aquifer transmissivity values can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well W383 EM

Calculated vertical hydraulic conductivity values for the confining unit present at well W383 EM are presented in **Table 16**. From this table, it is observed that the confining unit vertical hydraulic conductivity value calculated from the Neuman-Witherspoon solution is approximately two times greater than the value calculated from the Hantush-Jacob solution. Because the Neuman-Witherspoon solution presents a higher quality visual match as well as a lower standard error, the representative confining unit vertical hydraulic conductivity near well W383 EM is expected to be closer to the value calculated with the Neuman-Witherspoon solution, and is estimated to be 5.47 gpd/ft^2.

Table 16
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well W383 EM

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	2.74	Not Applicable
Hantush (1960)[1]	Not Applicable	0.0172
Neuman-Witherspoon (1969)	5.47	Not Applicable
Representative Value	**5.47**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

LADWP Well W384 EM (Independence-Oak Wellfield)

One observation well, well T633, was monitored in addition to the pumping well during the aquifer test conducted at well W384 EM. Observation measurements from well T633 were chosen for analysis, and all of the measurements were analyzed, (except for data collected less than 10 minutes into the test). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well W384 EM was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 17** presents a summary of the aquifer test analysis results for well W384 EM. The final solution curves for each analysis method are presented in **Appendix K**.

It is important to note that the top 40 feet of the screened interval for well W387 EM are located in a potential confining/low permeability unit, (sand and gravel, cemented). Because the well was screened in this area, this 40-foot low permeability unit was considered to be part of the confined aquifer. (AQTESOLV expects the screened interval of a pumping well to begin below the confining unit.) However, if analysis was performed assuming the low permeability unit to be part of the confining unit and assuming the screened interval to start immediately below this unit, different results might be obtained.

Hantush-Jacob (1955) Analysis

Analysis with the Hantush-Jacob Method produced a solution curve that provides an acceptable visual match with the observation data collected at well T633. However, the curve does not match the late-time data well, nor does it match data measured at time less than 15 minutes.

Calculated transmissivity and storativity values agree well with earlier estimates by the LADWP (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity.

Table 17
Summary of Aquifer Test Analysis Results for Well W384 EM

Analysis Results	Aquifer Test Analysis Method		
	Hantush-Jacob (1955)	**Hantush (1960)**	**Neuman-Witherspoon (1969)**
Residual Statistics[1]			
Mean	-0.0000309	-0.000170	-0.0004342
Variance	0.04908	0.007146	0.007922
Standard Error	0.2215	0.08453	0.08901
Parameter Solutions[2]			
T [gpd/ft]	36,600	27,200	24,300
S [unitless]	1.97×10^{-4}	2.79×10^{-4}	3.02×10^{-4}
r/B [unitless]	2.77×10^{-2}	Not Applicable	1.17×10^{-1}
β_H [unitless]	Not Applicable	3.58×10^{-2}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	5.68×10^{-2}
T^U [gpd/ft]	Not Applicable	Not Applicable	**1.08×10^{-1}**
S^U [unitless]	Not Applicable	Not Applicable	7.42×10^{-3}

1 Residual statistics presented for the Hantush Method should not be compared with values from the other two methods as this analysis was performed only on a subset of the data used for analysis with the other two methods.
2 Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush (1960) Analysis

Analysis with the Hantush Method was conducted only on the first 200 minutes of data, (excluding the first 10 minutes). This analysis produced a solution curve that provides a good visual match with the observation data, and calculated transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity/storativity product.

Neuman-Witherspoon (1969) Analysis

Analysis with the Neuman-Witherspoon Method produced a solution curve that provides the best visual match of the three analysis methods with the observation data. Calculated confined aquifer transmissivity and storativity values agree well with earlier LADWP estimates (LADWP, 1993). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity. (However, it should be noted that the calculated unconfined aquifer transmissivity can be varied over many orders of magnitude with no visual effect on the curve shape.)

Confining Unit Vertical Hydraulic Conductivity Near Well W384 EM

Calculated vertical hydraulic conductivity values for the confining unit present at well W384 EM are presented in **Table 18**. From this table, it is observed that the confining unit vertical hydraulic conductivity value calculated from the Neuman-Witherspoon solution is approximately one order of magnitude greater than the value calculated from the Hantush-Jacob solution. Because the Neuman-Witherspoon solution presents a higher quality visual match as well as a lower standard error, the representative confining unit vertical hydraulic conductivity near well W384 EM is expected to be closer to the value calculated with the Neuman-Witherspoon solution, and is estimated to be 2.11 gpd/ft^2.

Table 18
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well W384 EM

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	0.180	Not Applicable
Hantush (1960)[1]	Not Applicable	0.000992
Neuman-Witherspoon (1969)	2.11	Not Applicable
Representative Value	**2.11**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

LADWP Well W395 AQ (Symmes-Shepherd Wellfield)

Two observation wells, well T782 and well W394 AQ, were monitored in addition to the pumping well during the aquifer test conducted at well W395 AQ. However, upon looking at the drawdown vs. time plots for both observation wells, it was determined that both of these wells seem to be affected by some outside pumping source and/or external influences, due to significant variation in observed drawdown at late time. For this reason, only the pumping well data from well W395 AQ were chosen for analysis, and all of the measurements were analyzed, (except for data collected less than 10 minutes into the test). A summary of the AQTESOLV inputs used to conduct the aquifer test analysis for well W395 AQ was presented in **Table 2**, and the drawdown vs. time data that was used for this analysis is located in **Appendix C**. **Table 19** presents a summary of the aquifer test analysis results for well W395 AQ. The final solution curves for each analysis method are presented in **Appendix L**.

Hantush-Jacob (1955) Analysis

Analysis with the Hantush-Jacob Method produced a solution curve that provides a very good visual match with all of the pumping well data collected at well W395 AQ. Calculated transmissivity and storativity values agree with earlier estimates by the LADWP (LADWP, 1992).

Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity.

Table 19
Summary of Aquifer Test Analysis Results for Well W395 AQ

Analysis Results	Aquifer Test Analysis Method		
	Hantush-Jacob (1955)	Hantush (1960)	Neuman-Witherspoon (1969)
Residual Statistics[1]			
Mean	0.0000163	-0.0004988	-0.00000601
Variance	0.02339	0.01451	0.02166
Standard Error	0.153	0.1205	0.1472
Parameter Solutions[2]			
T [gpd/ft]	245,800	235,700	225,200
S [unitless]	7.49×10^{-4}	1.23×10^{-3}	1.27×10^{-3}
r/B [unitless]	1.02×10^{-4}	Not Applicable	2.30×10^{-4}
β_H [unitless]	Not Applicable	2.69×10^{-5}	Not Applicable
β_{NW} [unitless]	Not Applicable	Not Applicable	4.24×10^{-5}
T^U [gpd/ft]	Not Applicable	Not Applicable	$1.69 \times 10^{+5}$
S^U [unitless]	Not Applicable	Not Applicable	1.32×10^{-3}

[1] Residual statistics presented for the Hantush Method should not be compared with values from the other two methods as this analysis was performed only on a subset of the data used for analysis with the other two methods.
[2] Bolded parameters can be varied over orders of magnitude without affecting the curve shape.

Hantush (1960) Analysis

Analysis with the Hantush Method was conducted only on the first 1,260 minutes of data, (excluding the first 10 minutes). This analysis produced a solution curve that provides a very good visual match with the pumping well data, and calculated transmissivity and storativity values agree with earlier LADWP estimates (LADWP, 1992). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity/storativity product.

Neuman-Witherspoon (1969) Analysis

Analysis with the Neuman-Witherspoon Method produced a solution curve that provides a very good visual match with all of the pumping well data. Calculated confined aquifer transmissivity and storativity values agree with earlier LADWP estimates (LADWP, 1992). Additionally, the curve shape is sensitive to the parameters needed to calculate the confining unit vertical hydraulic conductivity.

Confining Unit Vertical Hydraulic Conductivity Near Well W395 AQ

Calculated vertical hydraulic conductivity values for the confining unit present at well W395 AQ are presented in **Table 20**. From this table, it is observed that the confining unit vertical hydraulic conductivity value calculated from the Hantush-Jacob solution is approximately five times greater than the value calculated from the Neuman-Witherspoon solution. Because both of the solutions present equally good visual matches and generate equally low standard errors, the representative confining unit vertical hydraulic conductivity near well W395 AQ is estimated to be an average of the two solutions, or 0.158 gpd/ft^2.

Table 20
Estimation of the Confining Unit Vertical Hydraulic Conductivity Near Well W395 AQ

Analysis Method	Confining Unit Vertical Hydraulic Conductivity [gpd/ft^2]	Confining Unit Vertical Hydraulic Conductivity/Storativity Product [gpd/ft^2]
Hantush-Jacob (1955)	0.0560	Not Applicable
Hantush (1960)[1]	Not Applicable	0.0000736
Neuman-Witherspoon (1969)	0.260	Not Applicable
Representative Value	**0.158**	**Not Applicable**

[1] For the Hantush Method (1960), only the product of confining unit vertical hydraulic conductivity and confining unit storativity can be calculated.

SUMMARY OF FINDINGS

Table 21 presents a comparison between the confined aquifer transmissivity and storativity values calculated during this analysis and the existing LADWP estimates. Also included in this table are the estimated representative vertical hydraulic conductivity values of the confining unit based on the analyses presented in this report.

Calculated aquifer transmissivity ranges from 20,000 gpd/ft near well V016GA (Big Pine Wellfield) up to 246,000 gpd/ft at Well W395 (Symmes-Shepherd Wellfield), spanning an order of magnitude. Previous LADWP estimates for transmissivity were presented as either ranges or as a single value. For the six pump test packets where ranges were presented, 16 of the 18 new transmissivity estimates fall within the previously estimated ranges. The two values that lie outside of the previously estimated ranges are both associated with well W384 EM in the Independence-Oak Wellfield. Both estimates are within a factor of two of the range's lower bound. For the three pump test packets that present single transmissivity estimates, all new transmissivity values are within a factor of three of the existing estimates.

Table 21
Summary of Aquifer and Confining Unit Parameters[1]

			Laws		Big Pine				Independence-Oak		Symmes-Shepherd
			W387 EM	**W398 AQ**	**V014GA**	**V016GA**	**W379 EM**	**W389 EM**	**W383 EM**	**W384 EM**	**W395 AQ**
Confined Aquifer Parameters[2]											
T (gpd/ft)	Existing LADWP Estimate		50,000-80,000	120,000	36,000	45,000	80,000-90,000	80,000-100,000	40,000-60,000	35,000-40,000	220,000-300,000
	AQTESOLV Value – Hantush-Jacob (1955)		57,000	**82,000**	41,000	**26,000**	90,000	90,000	56,000	37,000	246,000
	AQTESOLV Value – Hantush (1960)		57,000	**74,000**	36,000	**24,000**	90,000	83,000	43,000	27,000	236,000
	AQTESOLV Value – Neuman-Witherspoon (1969)		54,000	**71,000**	33,000	**20,000**	90,000	91,000	50,000	24,000	225,000
S (unitless)	Existing LADWP Estimate		3×10^{-3}	2×10^{-3}	Not Applicable	Not Applicable	1×10^{-3}	1×10^{-3}	7×10^{-4}	2×10^{-4}	3×10^{-4}
	AQTESOLV Value – Hantush-Jacob (1955)		4×10^{-3}	**6×10^{-4}**	3×10^{-3}	**3×10^{-4}**	1×10^{-3}	2×10^{-3}	5×10^{-4}	2×10^{-4}	7×10^{-4}
	AQTESOLV Value – Hantush (1960)		4×10^{-3}	**1×10^{-3}**	3×10^{-2}	**6×10^{-4}**	1×10^{-3}	2×10^{-3}	6×10^{-4}	3×10^{-4}	1×10^{-3}
	AQTESOLV Value – Neuman-Witherspoon (1969)		3×10^{-3}	**1×10^{-3}**	1×10^{-3}	**2×10^{-3}**	1×10^{-3}	2×10^{-3}	6×10^{-4}	3×10^{-4}	1×10^{-3}
Analysis Method for Existing LADWP Estimates			Modified Theis, Hantush, Modified Hantush	Modified Theis, Hantush	Modified Theis	Modified Theis	Modified Theis, Hantush, Modified Hantush	Modified Theis	Modified Theis, Hantush	Modified Theis	Modified Theis, Hantush, Modified Hantush
Confining Unit Parameters											
Confining Unit Materials Based on Well Log Descriptions			Fine med sand, gravel, and clay	Fine to medium sand with clay and cobbles	Sand, silt, and tight clay	Silty sand, silt, and tight clay	Clay	Silt , clay, and gravel/sand lenses	Sand, clay, gravel	Sand, cemented, black rock	Red sticky clay mixed with fine sand
Representative Aquitard Vertical Hydraulic Conductivity		gpd/ft^2	3.64	**2.41**	3.52	**24.4**	0.0473	0.133	5.47	2.11	0.158
		ft/day	0.486	**0.322**	0.470	**3.26**	0.00632	0.0177	0.731	0.282	0.0211

[1] Bolded numbers represent estimated values to be used with caution because AQTESOLV could not converge on solutions for these data sets.
[2] In this table, transmissivity and storativity values estimated during this analysis have been rounded to the same number of significant figures as the existing LADWP estimates for the purpose of comparison.

The calculated storativity values vary from 3 x 10^{-2} at well V014GA (Big Pine Wellfield) to 2 x 10^{-4} at well W384 EM (Independence-Oak Wellfield), spanning approximately two orders of magnitude. All calculated storativity values demonstrate order of magnitude agreement with previous LADWP estimates. In fact, all storativity values estimated during this analysis are within a factor of four of the existing LADWP estimates.

The calculated confining unit vertical hydraulic conductivity values vary from as low as 0.0473 gpd/ft^2 at well W379 EM (Big Pine Wellfield) to as high as 24.4 gpd/ft^2 at well V016GA (Big Pine Wellfield). An average value was calculated to be approximately 4.65 gpd/ft^2. According to Hollett and others (1991), vertical hydraulic conductivity for the confining unit described as Hydrostratigraphic Unit 2 ranges from 0.006 gpd/ft^2 to 0.015 gpd/ft^2.

The aquifer parameters shown in **Table 21** provide guidance on the typical aquifer parameters found in the Owens Valley, as well as estimated values at specific locations. It is clear from the lithologic data presented in **Appendix B** that the nature of the confining unit is highly variable across the Valley. Only in rare cases (such as the lower portion of the confining unit at V014GA) does the confining unit consist purely of typical low-permeability materials such as “tight clay”. In most cases, the confining unit consists of stratified clays, silts, sands, and even gravels. Because horizontal hydraulic conductivities may exceed vertical hydraulic conductivities by a factor of 100 in highly stratified material (Walton, 1988), “leaky”-type behavior is expected even in the absence of an obvious confining unit.

Comparison of the lithologic description to the calculated vertical hydraulic conductivity of the confining unit does not reveal a consistent, reliable pattern of lithologic description and computed vertical hydraulic conductivity. The absence of a consistent, reliable pattern is believed to be the result of lithologic descriptions (as reported on well construction logs) that are not detailed or consistent enough for valid comparison, thereby highlighting the need for careful and detailed lithologic logging by a qualified geologist during drilling.

It is important to note that because the lithologic logs contain the only information available in order to estimate thicknesses for the confining unit and for the confined aquifer for each location being examined, the level of confidence in the results obtained during this analysis is directly related to the level of confidence placed on the lithologic logs themselves. Confined aquifer thickness and especially confining unit thickness are important parameters needed to ultimately determine the vertical hydraulic conductivity of the confining unit. Re-definition of these parameters based on more accurate lithologic information and additional geophysical information could have a significant effect on the hydraulic conductivity values obtained during this study.

RECOMMENDATIONS FOR FUTURE AQUIFER TESTING

The analysis of previous aquifer tests has resulted not only in improved estimates of the transmissivity and storage coefficient of the confined aquifer, but also what are believed to be reasonable estimates of the vertical hydraulic conductivity of the overlying confining unit. Future aquifer testing in the Owens Valley could be improved by the recommendations presented herein:

- In many cases, the lithologic descriptions of the penetrated materials are generalized, and lack sufficient detail. Lithologic generalizations make it difficult to determine the exact nature of the confining unit and aquifer. During the construction of future wells, careful lithologic logging conducted by a qualified geologist, preferably under the supervision of a Registered Geologist in the State of California, is recommended. In addition, geophysical logging is also recommended.
- During constant-rate aquifer tests, the pumping rate should be kept constant at all times. Evaluation of the nine tests demonstrated that even small changes in pumping rate produce jumps in observed drawdown that are difficult to reconcile during analysis of the results. (See **Appendix H**, which presents the results for well W379 EM for an example.) Control of the pumping rate is facilitated by the use of a flow valve and instantaneous-read flow meter with totalizer.
- Automated dataloggers should be utilized whenever possible (at least in the pumping well) to detect rapidly increasing drawdown during the initial portion of the test. Data loggers are also valuable in detecting variations in pumping rate in the pumped well.
- The length of the constant-rate test must be sufficiently long to observe the late-time effects of leakage if reliable estimates of confining unit properties are to be generated. In general, data obtained after 1,000 minutes (after about 17 hours) was crucial in identifying the leakage factor with both the Hantush-Jacob Method and the Neuman-Witherspoon Method. Late-time data are not needed to create a good match with the Hantush Method; however, this method is significantly less valuable for determining confining layer properties, as this method yields only the product of confining unit vertical hydraulic conductivity and confining unit storativity. For this reason, aquifer test durations of at least 24 hours are recommended, and much longer-term duration tests may be advantageous, depending on the drawdown pattern observed during testing, and the distance to observation wells.
- Because all transient analysis methods used in this report are very sensitive to the radius of observation when the radius is low, and the methods assume a well of infinitesimal diameter, observation wells should be monitored in addition to monitoring drawdown in the pumping well. Ideally, the observation wells should be screened in the same aquifer as the pumping well, and multiple observation wells at various azimuths and distances would be ideal in order to evaluate the horizontal anisotropy and heterogeneity of the aquifer. In general, a more representative and regional evaluation can be made with multiple observation wells at varying distances.
- If feasible and practical, aquifer tests should also include monitoring of the shallow aquifer above the confining unit. All of the methods used in this report assume that there is negligible drawdown in this aquifer, and this appears to have been documented by previous testing (Harrington, 2001). Nevertheless, the shallow aquifer should be monitored during testing to confirm this assumption. In addition, the shallow aquifer is of significant concern from an ecological perspective.

- During aquifer testing, external influences, such as turning off or on of adjacent wells and major changes in surface flow, should be avoided.

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- "Well W383 EM Aquifer Test – Independence-Oak Well Field" (October, 1992)
- "Well W387 EM Test – Laws Field" (May, 1993)
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Appendix A
Glossary of Variables and Terms

Appendix A
Glossary of Variables and Terms

VARIABLES

b'	Confining unit thickness
B	Leakage factor
β_H	Mathematical value calculated by the Hantush Method (This value is used to calculate the confining unit vertical hydraulic conductivity/storativity product with the Hantush Method.)
β_{NW}	Mathematical value calculated by the Neuman-Witherspoon Method (This value is not needed to calculate the confining unit vertical hydraulic conductivity with the Neuman-Witherspoon Method.)
K_r	Aquifer hydraulic conductivity for horizontal flow
K_z	Aquifer hydraulic conductivity for vertical flow
K_z'	Confining unit hydraulic conductivity for vertical flow
r	Distance from the pumped well to the observation well
S	Aquifer storativity
S'	Confined aquifer storativity (In Appendices D – L, however, S' denotes unconfined aquifer storativity for the Neuman-Witherspoon Method)
S^U	Unconfined aquifer storativity (In Appendices D – L, the unconfined aquifer storativity calculated by the Neuman-Witherspoon Method is denoted as S')
T	Aquifer transmissivity
T^U	Unconfined aquifer transmissivity (In Appendices D – L, the unconfined aquifer transmissivity calculated by the Neuman-Witherspoon Method is denoted as T')

DEFINITIONS

Hydraulic Conductivity (K) is the capacity of a porous medium to transmit water. It is measured as the volume of water moving through a unit area of aquifer perpendicular to the direction of flow in unit time under a unit hydraulic gradient.

Leakage Factor (B) is a measure for the spatial distribution of the leakage through a confining unit into a leaky aquifer and vice versa. It is defined by the following equation:

$$B = \sqrt{\frac{Tb'}{K_z'}}$$

Mean as defined as the sum of the differences between each actual y-value and its predicted y-value (from the best-fit line) divided by the total number of measurements.

$$\text{Mean} = \frac{\sum (y_{\text{measured}} - y_{\text{estimated}})}{N}$$

where: y_{measured} = The measured y-value
$y_{\text{estimated}}$ = The predicted y-value (from the regression line)
N = The total number of measurements

Standard Error is defined as the square root of the variance. Standard error is represented by the following equation:

$$\text{Standard Error} = \sqrt{\frac{\sum (y_{\text{measured}} - y_{\text{estimated}})^2}{N}}$$

where: y_{measured} = The measured y-value
$y_{\text{estimated}}$ = The predicted y-value (from the regression line)
N = The total number of measurements

Storativity (S) is the volume of water that a permeable unit releases or takes into storage per unit surface area of the aquifer per unit change in head.

Transmissivity (T) is the capacity of an aquifer to transmit water of the prevailing kinematic viscosity. It is measured as the rate of flow under a unit hydraulic gradient through a cross-section of aquifer having a unit width and full saturated thickness.

Variance is a measure of the dispersion or scatter of a set of values from their predicted values. Variance can be represented by the following equation:

$$\text{Variance} = \frac{\sum (y_{\text{measured}} - y_{\text{estimated}})^2}{N}$$

where: y_{measured} = The measured y-value
$y_{\text{estimated}}$ = The predicted y-value (from the regression line)
N = The total number of measurements

Appendix B
Schematic Representations of the Nine Pumping Tests Selected for Aquifer Test Analysis

Figure B-1
Schematic Representation of Well W387 EM (Laws)

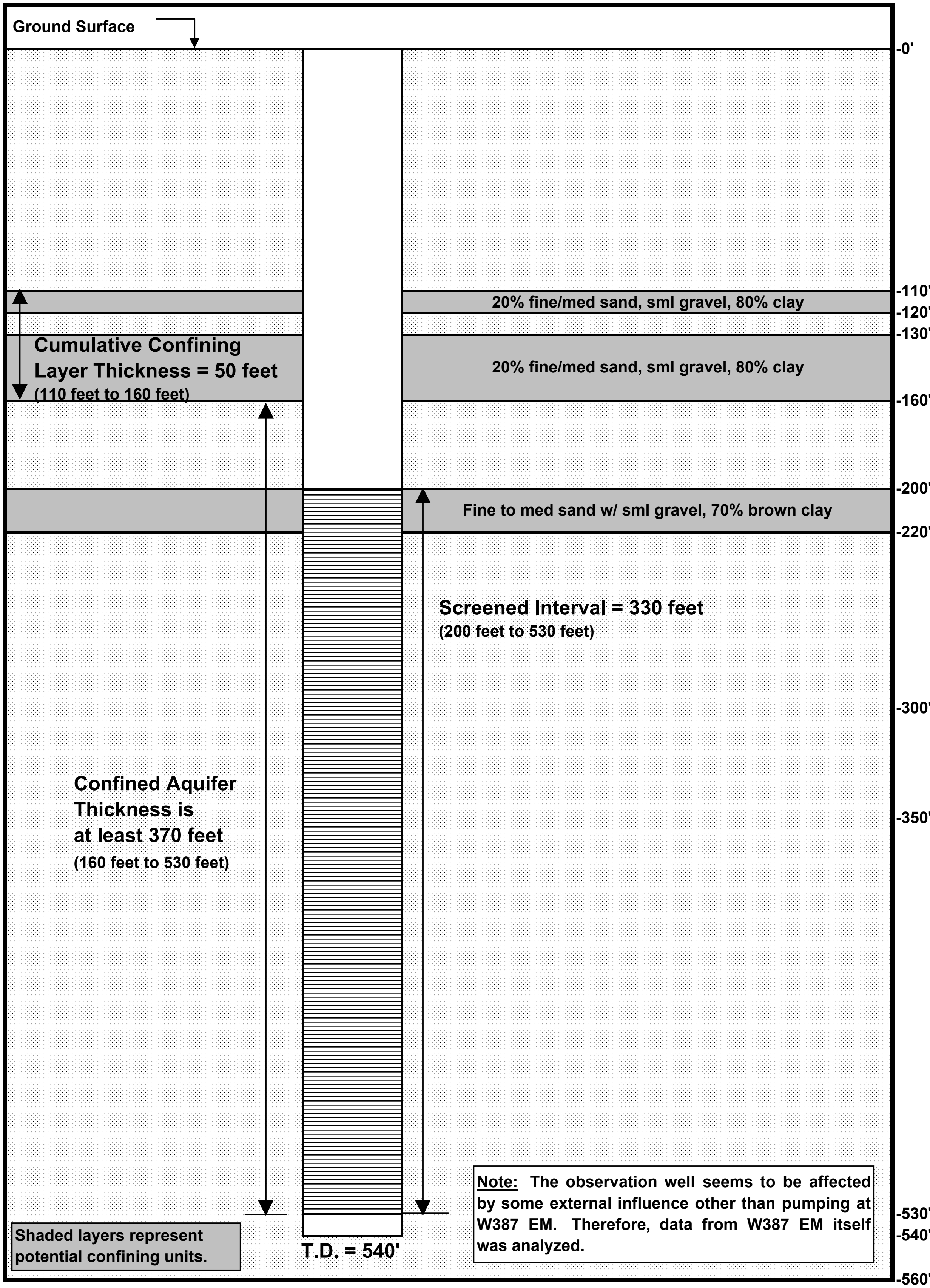


Figure B-2
Schematic Representation of Well W398 AQ (Laws)

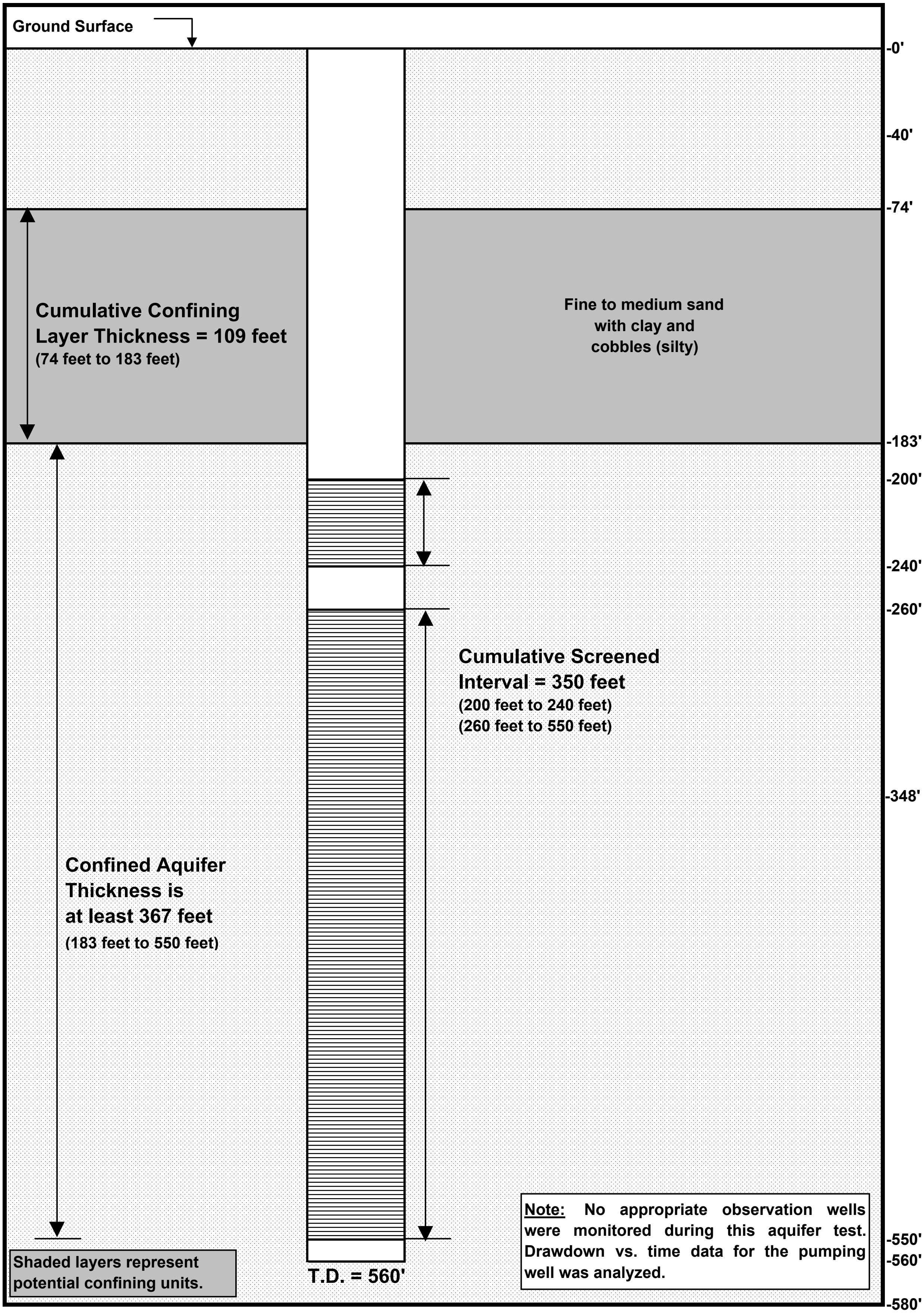


Figure B-3
Schematic Representation of Well V014GA (Big Pine)

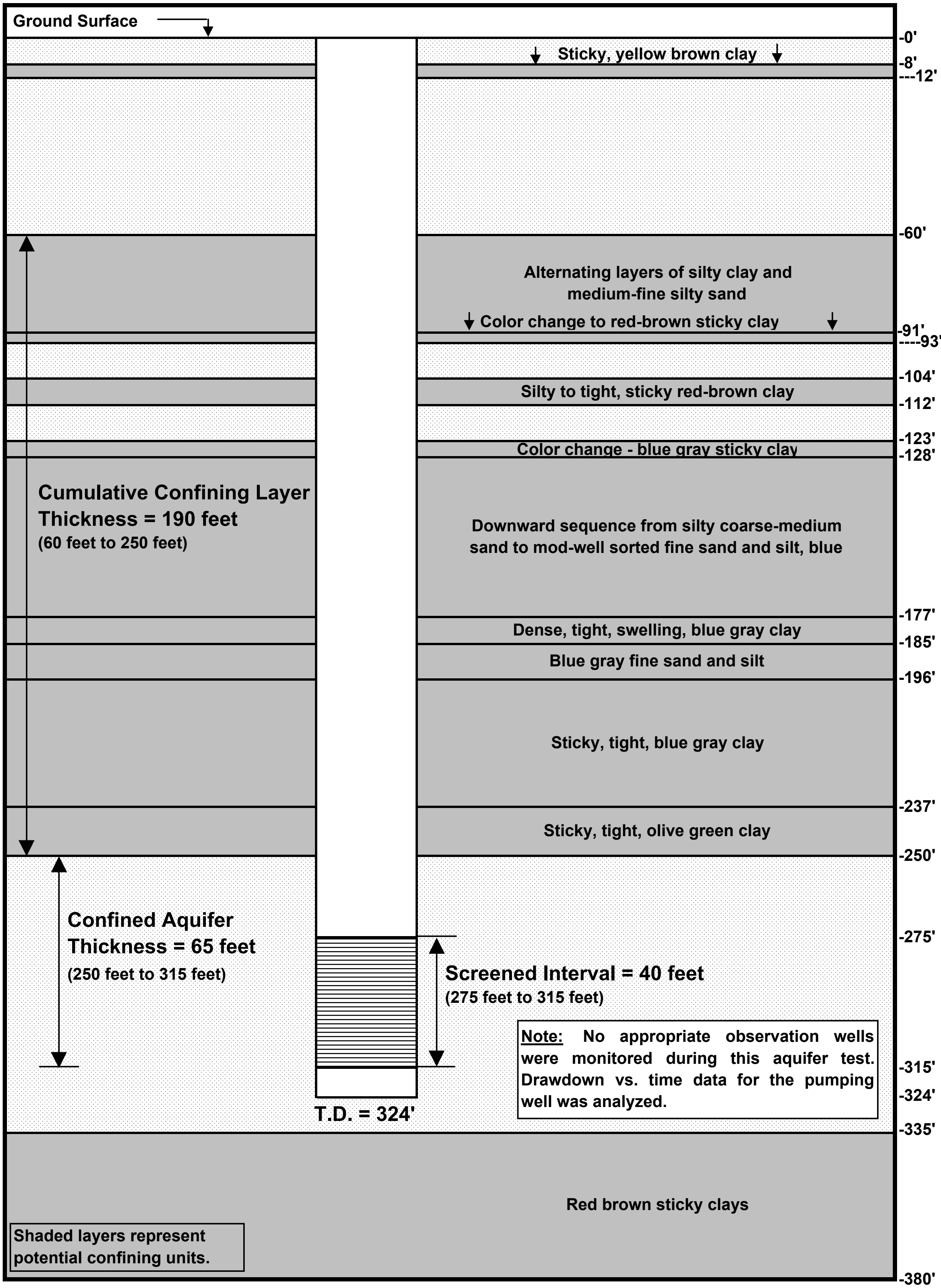


Figure B-4
Schematic Representation of Well V016GA (Big Pine)

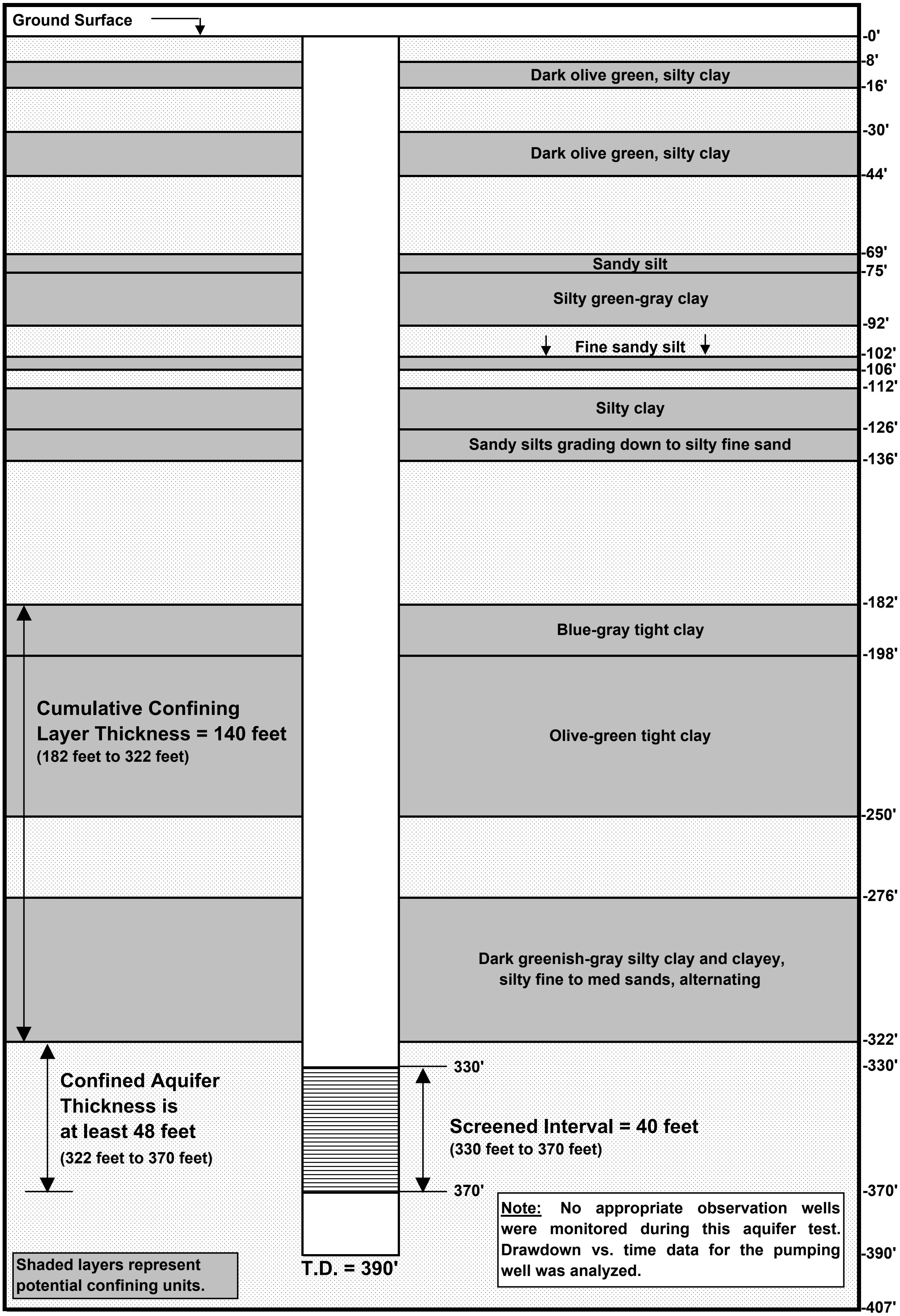


Figure B-5
Schematic Representation of Well W379 EM (Big Pine)

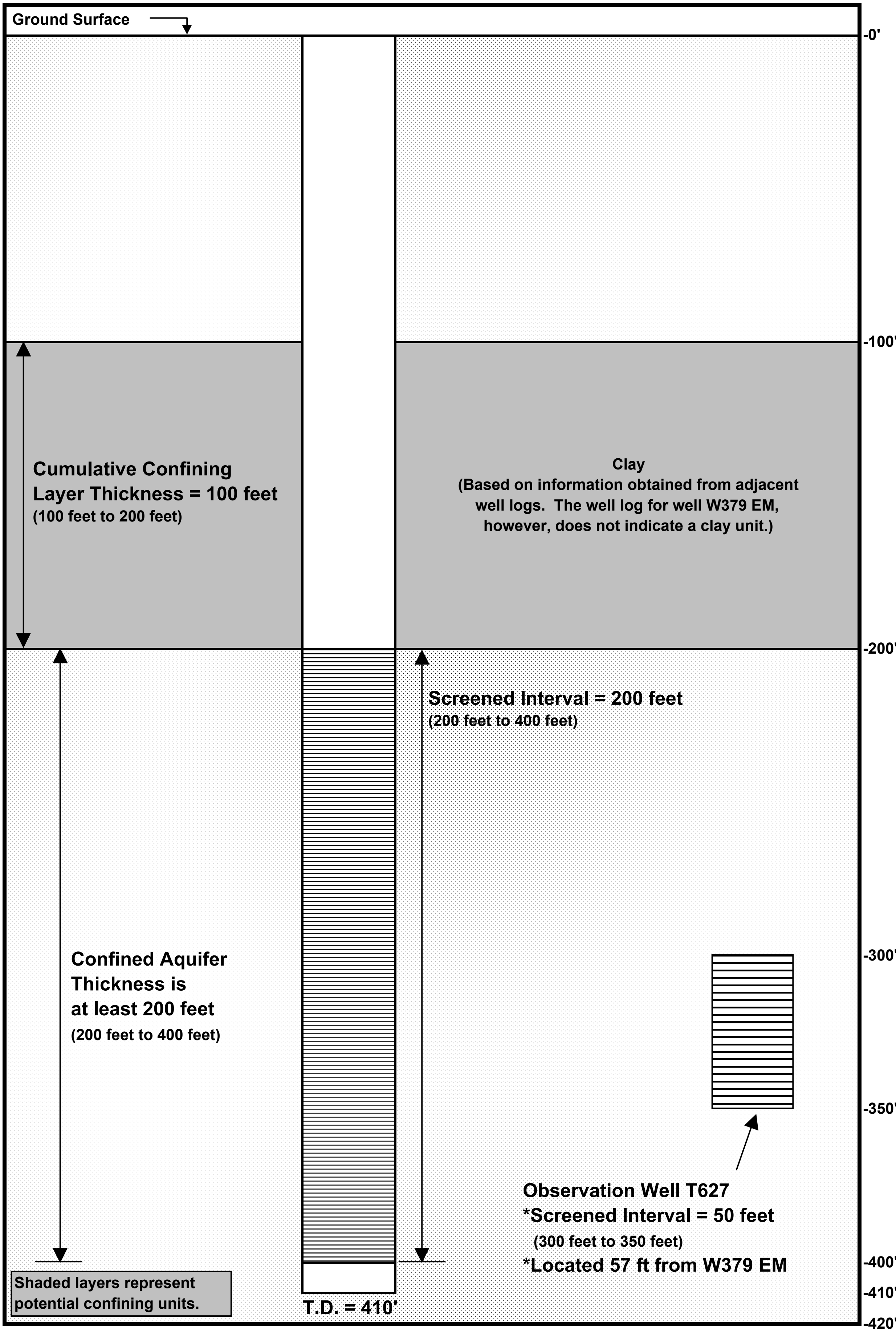


Figure B-6
Schematic Representation of Well W389 EM (Big Pine)

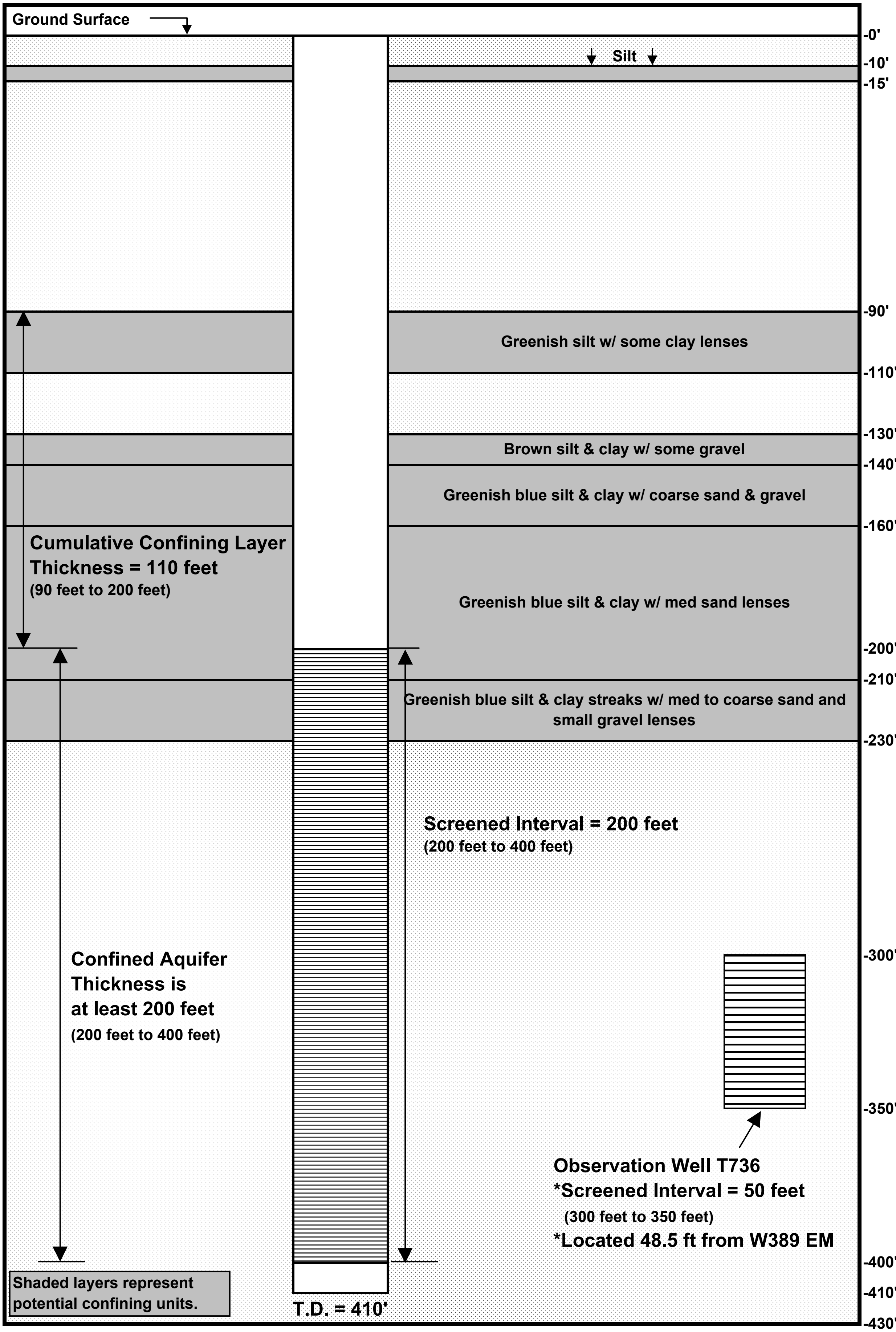


Figure B-7
Schematic Representation of Well W383 EM (Independence-Oak)

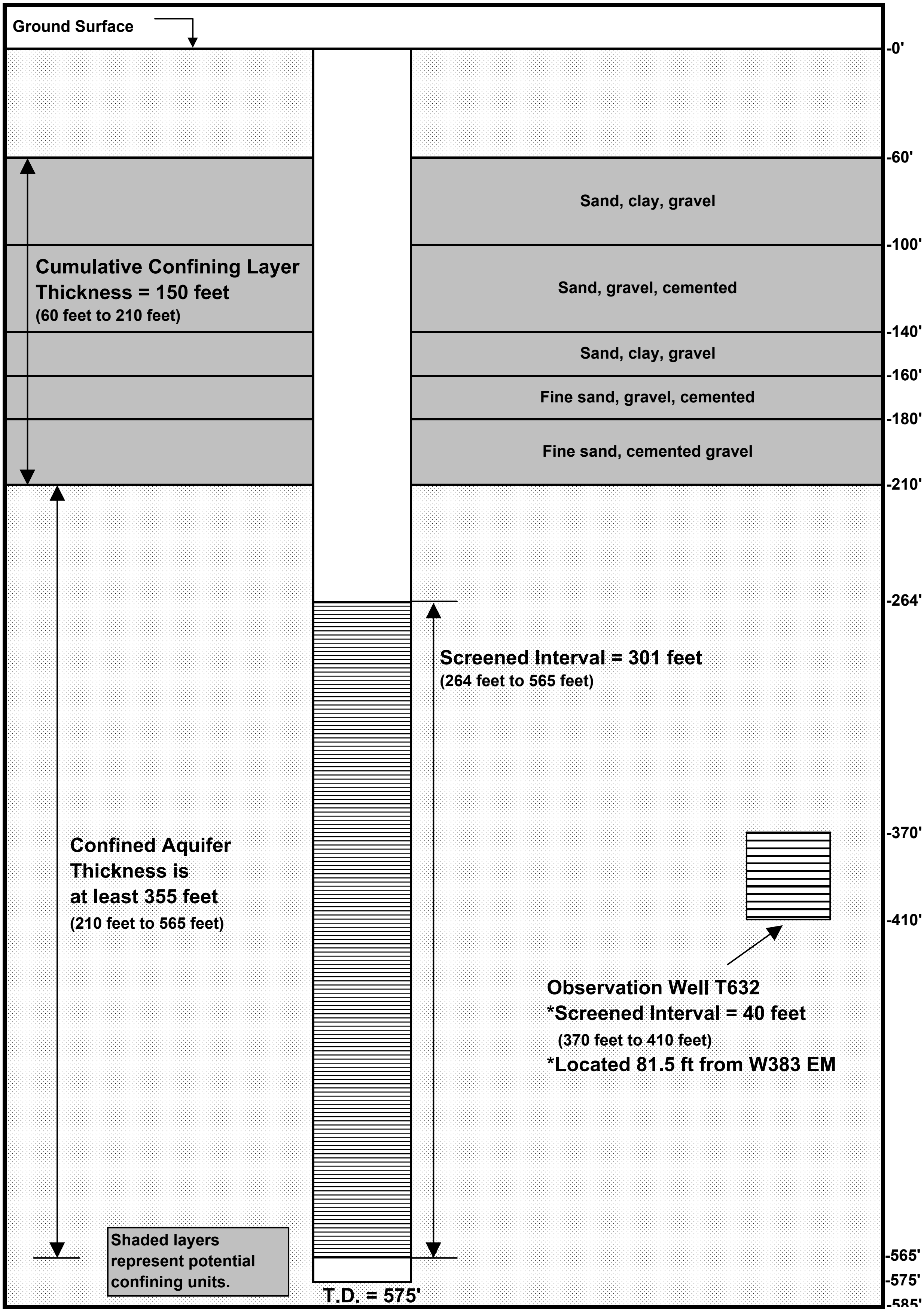


Figure B-8
Schematic Representation of Well W384 EM (Independence-Oak)

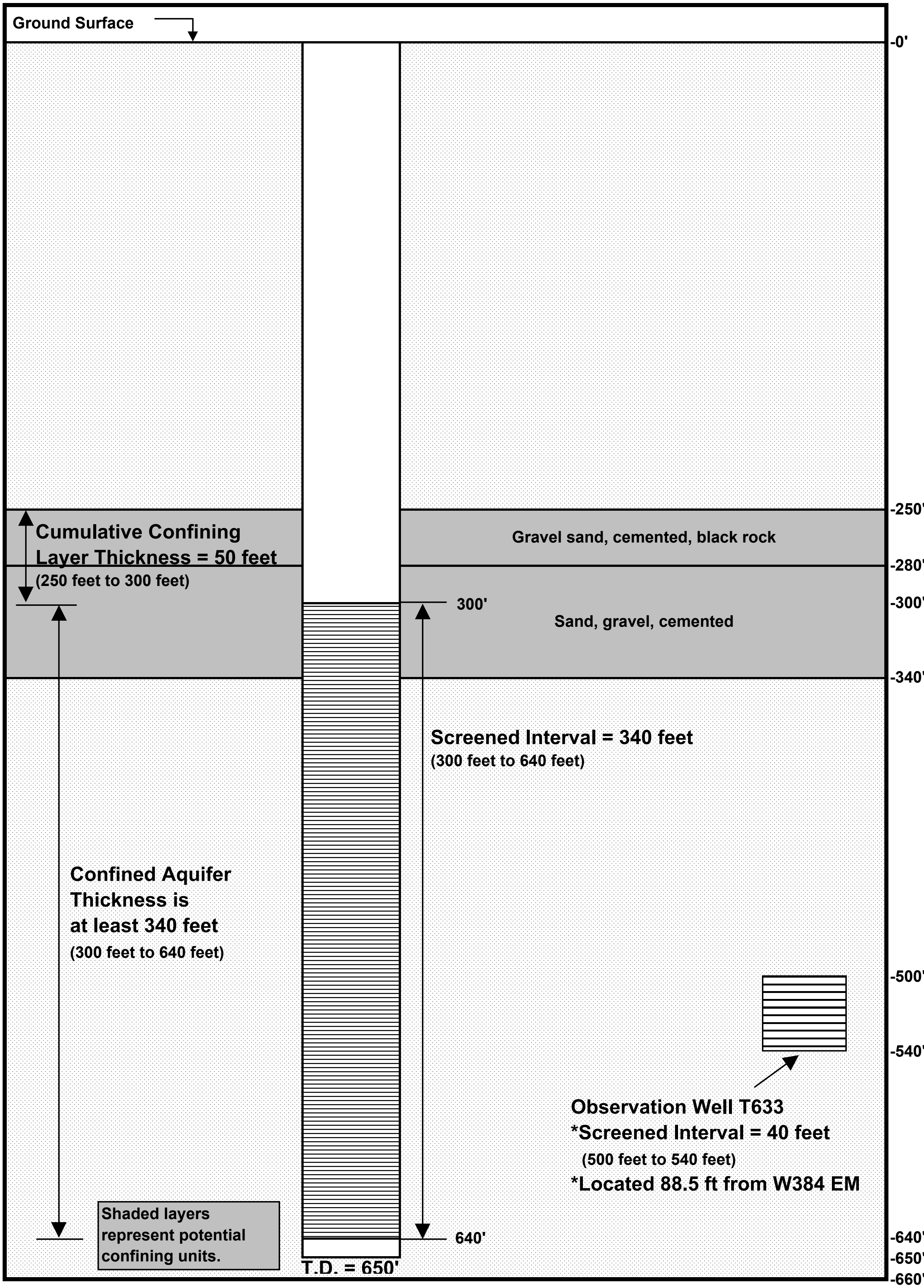
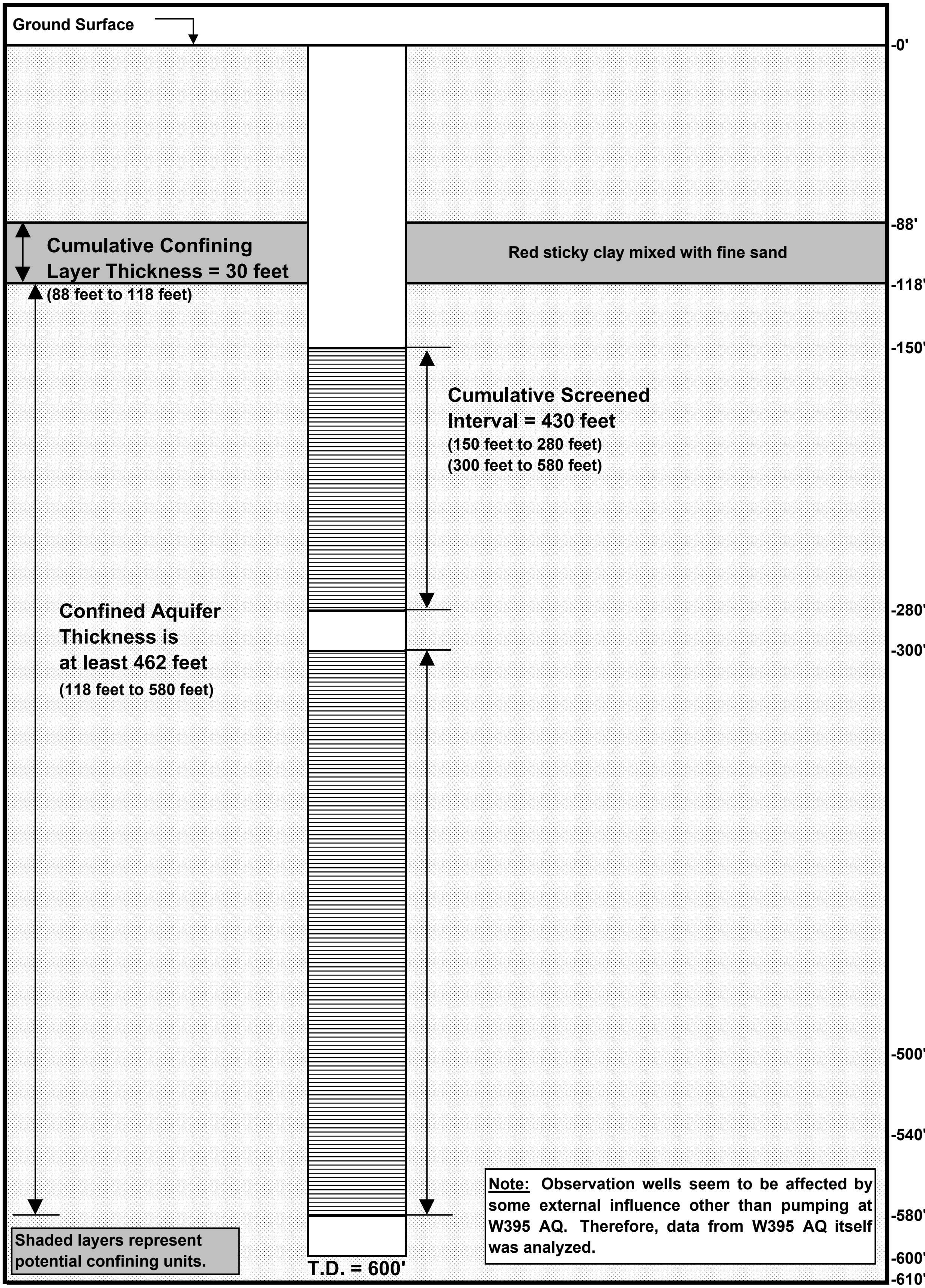


Figure B-9
Schematic Representation of Well W395 AQ (Symmes-Shepherd)



Appendix C
Drawdown vs. Time Data from the Nine Data Sets Selected for Aquifer Test Analysis

Table C-1
Drawdown vs. Time Data for the Aquifer Test Conducted at Well W387 EM (Laws)

Pumping Well Data	
Well W387	
Time (min)	Drawdown (ft)
8	77.83
14	**80.53**
16	**82.36**
31	**86.13**
35	**86.96**
40	**87.74**
45	**88.37**
50	**89.24**
60	**90.04**
70	**91.97**
82	**92.74**
90	**93.04**
100	**93.55**
110	**93.78**
120	**94.22**
140	**95.79**
160	**96.37**
180	**96.73**
200	**98.66**
220	**99.18**
240	**99.44**
290	**100.05**
330	**99.97**
360	**99.88**
390	**102.09**
420	**102.02**
480	**101.92**
540	**101.99**
600	**101.89**
660	**102.79**
720	**102.39**
780	**102.39**
840	**103.39**
900	**103.39**
960	**103.39**
1020	**103.39**
1080	**102.89**
1140	**102.89**
1200	**103.89**
1260	**103.39**
1290	**103.69**
1310	**103.99**
1319	**103.69**

***Only bolded measurements were analyzed**

Table C-2
Drawdown vs. Time Data for the Aquifer Test Conducted at Well W398 AQ (Laws)

Pumping Well Data	
Well W398	
Time (min)	Drawdown (ft)
1	48.36
2	48.36
3	48.93
4	50.09
5	50.67
6	51.24
7	52.40
8	52.40
9	53.55
10	**53.55**
12	**54.13**
14	**54.71**
16	**54.71**
18	**55.86**
20	**56.44**
22	**56.44**
24	**57.02**
26	**57.02**
28	**57.02**
30	**57.02**
35	**58.17**
40	**58.17**
45	**58.17**
50	**58.75**
55	**59.33**
60	**59.33**
70	**60.48**
80	**60.48**
90	**60.48**
100	**60.48**
130	**61.64**
160	**61.64**
220	**62.80**
280	**64.13**
340	**64.70**
400	**65.28**
500	**66.44**
600	**67.59**
800	**68.57**
1000	**68.57**
1140	**68.57**

***Only bolded measurements were analyzed**

Table C-3
Drawdown vs. Time Data for the Aquifer Test Conducted at Well V014GA (Big Pine)

Pumping Well Data			
Well V014GA		Well V014GA (continued)	
Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
1	2.87	**455**	**9.81**
2	3.00	**1430**	**10.25**
3	3.56	**1900**	**10.21**
4	3.44	**2950**	**10.41**
5	3.50	**3330**	**10.35**
6	3.58	**4318**	**10.55**
7	3.62		
8	3.67		
9	3.73		
10	3.76		
12	**3.81**		
14	**3.85**		
16	**3.90**		
18	**3.93**		
20	**3.98**		
25	**4.04**		
30	**4.14**		
35	**4.14**		
40	**4.19**		
45	**4.22**		
50	**4.24**		
55	**4.27**		
60	**4.30**		
70	**4.32**		
80	**4.37**		
90	**4.41**		
100	**4.44**		
110	**4.47**		
120	**4.48**		
135	**4.50**		
150	**4.52**		
165	**4.54**		
180	**4.56**		
195	**4.57**		
210	**4.58**		
225	**4.59**		
240	**4.60**		
241	8.02		
242	8.28		
243	8.39		
244	8.51		
245	8.59		
246	8.66		
247	8.69		
248	8.74		
249	8.79		
250	**8.83**		
255	**8.95**		
260	**9.06**		
265	**9.13**		
270	**9.20**		
275	**9.26**		

***Only bolded measurements were analyzed.**

Table C-4
Drawdown vs. Time Data for the Aquifer Test Conducted at Well V016GA (Big Pine)

Pumping Well Data			
Well V016GA		Well V016GA (cont.)	
Time (min)	Drawdown(ft)	Time (min)	Drawdown(ft)
16	**16.69**	1110	40.31
25	**17.17**	1115	40.53
30	**17.11**	1120	40.80
35	**17.36**	1125	41.00
40	**17.42**	1130	41.07
45	**17.50**	1135	41.20
50	**17.56**	1140	41.32
55	**17.60**	1150	41.07
60	**17.64**	1160	41.22
70	**17.74**	1170	41.38
80	**17.80**	1180	41.54
90	**17.86**	1190	41.75
100	**17.93**	1200	41.82
110	**17.97**	1215	42.11
120	**18.00**	1230	42.24
135	**18.04**	1245	42.43
150	**18.08**	1260	42.55
151	3.21	2637	43.41
152	2.40	5585	45.04
153	2.26	7035	45.16
154	1.78	8425	46.66
155	1.66	9900	45.53
156	1.54	12780	46.32
157	1.42	14220	46.11
158	1.36	15660	46.63
159	1.33		
160	1.27		
165	1.10		
170	0.87		
175	0.82		
180	0.74		
185	0.64		
190	0.58		
195	0.52		
200	0.47		
205	0.43		
210	0.40		
220	0.35		
230	0.27		
240	0.22		
1075	0.02		
1080	0.00		
1087	38.17		
1088	38.37		
1089	38.55		
1090	38.70		
1092	38.98		
1094	39.23		
1096	39.43		
1098	39.59		
1100	39.37		
1105	40.07		

***Only bolded measurements were analyzed.**

Table C-5
Drawdown vs. Time Data for the Aquifer Test Conducted at Well W379 EM (Big Pine)

Observation Well Data		Pumping Well Data (not analyzed)	
Well T627		Well W379	
Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
1	7.40	1	24.90
2	8.62	2	27.30
3	10.68	3	29.60
4	11.83	4.3	31.70
5	12.65	5	32.50
6	13.32	6.5	32.90
7	13.64	7	33.20
8	14.17	8	33.95
9	14.59	9.5	34.18
10	**15.02**	10.5	35.00
15	**16.51**	12	35.60
20	**17.41**	14	36.16
25	**18.10**	16	36.71
30	**18.69**	18	37.15
40	**19.82**	20.5	36.90
50	**20.89**	22	37.12
60	**21.33**	24	37.49
70	**21.94**	26	37.78
80	**22.39**	28	38.10
90	**22.78**	30	38.20
105	**23.41**	35	38.90
120	**23.77**	40	39.40
135	**24.18**	45	39.95
150	**24.61**	50	40.24
165	**24.90**	56	40.70
180	**25.31**	60	40.60
210	**26.67**	70	41.45
240	**27.26**	84	42.05
270	**27.69**	90	42.20
300	**28.05**	92	42.37
330	**28.37**	100	42.60
360	**28.66**	110	42.87
390	**29.04**	120	42.95
420	**29.24**	130	43.28
		142	43.53
		150	43.74
		160	44.02
		170	44.27
		181	44.33
		193	46.42
		200	46.46
		211	46.95
		220	47.05
		240	47.38
		250	47.60
		260	47.60
		271	47.85
		285	48.00
		300	48.14
		315	48.18
		330	48.27
		360	48.62
		380	48.86
		420	49.00

***Only bolded measurements were analyzed.**

Table C-6
Drawdown vs. Time Data for the Aquifer Test Conducted at Well W389 EM (Big Pine)

Observation Well Data		Pumping Well Data (not analyzed)			
Well T736		Well W389		Well W389 (cont.)	
Time (min)	Drawdown (ft)	Time (min)	Drawdown(ft)	Time (min)	Drawdown(ft)
1	6.07	1	29.60	720	59.70
2	9.23	2	36.30	780	60.10
3	11.04	3	38.80	840	60.50
4	12.37	4	40.30	900	60.50
5	13.42	5	41.50	960	60.70
6	14.22	6	42.20	1020	60.70
7	14.62	7	42.10	1080	60.80
8	15.09	8	42.70	1140	61.50
9	15.50	9	43.10	1200	61.70
10	**15.75**	10	43.30	1260	61.90
12	**16.37**	12	43.90		
14	**16.97**	14	44.40		
16	**17.48**	16	44.90		
18	**17.94**	18	45.40		
20	**18.37**	20	45.80		
25	**19.25**	25	46.60		
30	**19.97**	30	47.40		
43	**21.40**	35	48.00		
45	**21.56**	40.5	48.50		
50	**21.93**	45	48.80		
55	**22.31**	50	49.10		
60	**22.63**	55	49.50		
66	**22.97**	60	49.70		
70	**23.23**	65	50.00		
75	**22.80**	70	50.30		
80	**23.76**	75	50.70		
85	**24.04**	80	51.00		
90	**24.20**	85	51.30		
97	**24.45**	90	51.30		
100	**24.54**	95	51.40		
105	**24.72**	100	51.50		
110	**24.86**	110	51.70		
115	**25.04**	120	52.10		
120	**25.20**	135	52.60		
135	**25.66**	150	52.70		
150	**25.97**	165	52.80		
165	**26.24**	180	53.00		
180	**26.47**	195	53.30		
195	**26.79**	210	53.60		
210	**27.07**	240	56.20		
225	**28.01**	255	56.30		
240	**28.40**	270	56.60		
255	**28.62**	289	56.60		
270	**28.85**	300	56.80		
285	**29.99**	315	56.90		
300	**29.18**	330	57.10		
330	**29.52**	345	57.40		
360	**29.85**	360	57.30		
390	**30.13**	390	57.60		
420	**30.42**	420	57.90		
1203	**34.09**	480	58.40		
1215	**34.10**	540	58.70		
1230	**34.16**	600	58.80		
1245	**34.26**	660	59.30		

***Only bolded measurements were analyzed**

Table C-7
Drawdown vs. Time Data for the Aquifer Test Conducted at Well W383 EM (Independence-Oak)

Observation Well Data		Pumping Well Data (not analyzed)			
Well T632		Well W383		Well W383 (continued)	
Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
1	3.69	3	96.41	690	143.26
2	7.21	4	97.61	720	143.91
3	9.44	6	125.16	750	144.21
4	11.04	7	126.66	780	144.48
5	12.28	8	127.51	810	144.54
6	13.29	9	128.41	840	144.18
7	14.19	10	129.31	870	144.76
8	14.91	12	130.96	900	144.41
9	15.58	14	132.46	930	143.75
10	**16.17**	16	132.71	960	143.84
12	**17.15**	18	133.11	990	144.19
14	**17.95**	20	133.71	1020	144.34
16	**18.66**	22	134.11	1050	144.48
18	**19.24**	24	134.61	1080	144.56
20	**19.73**	26	134.96	1110	144.43
22	**20.16**	28	135.09	1140	145.26
24	**20.53**	30	135.46	1170	145.43
26	**20.94**	35	135.56	1200	145.54
28	**21.29**	40	136.21	1230	145.43
30	**21.59**	45	136.51	1260	146.09
35	**22.24**	50	136.76	1290	145.13
40	**22.78**	55	136.66		
45	**23.26**	60	136.71		
50	**23.63**	65	136.85		
55	**23.94**	70	137.31		
60	**24.21**	75	137.26		
65	**24.50**	80	137.42		
70	**24.75**	85	137.39		
75	**25.00**	90	137.55		
80	**25.18**	100	138.31		
85	**25.36**	110	138.88		
90	**25.53**	120	138.84		
100	**25.78**	130	139.46		
110	**26.13**	140	139.39		
120	**26.31**	150	139.66		
130	**26.54**	160	139.94		
140	**26.71**	170	139.71		
150	**26.92**	180	139.66		
161	**27.06**	200	139.56		
170	**27.18**	220	138.91		
180	**27.28**	240	138.62		
200	**27.42**	260	142.62		
220	**27.50**	280	142.51		
240	**27.57**	300	142.35		
260	**28.15**	330	141.97		
280	**28.29**	360	141.89		
300	**28.41**	390	141.66		
330	**28.50**	420	141.59		
360	**28.58**	450	140.99		
390	**28.61**	480	143.53		
420	**28.63**	510	143.01		
450	**28.65**	540	142.60		
480	**29.07**	570	142.83		
1275	**29.99**	600	143.32		
1290	**29.94**	630	143.47		
1320	**29.89**	660	142.56		

***Only bolded measurements were analyzed.**

Table C-8
Drawdown vs. Time Data for the Aquifer Test Conducted at Well W384 EM (Independence-Oak)

Observation Well Data				Pumping Well Data (not analyzed)			
Well T633		Well T633 (continued)		Well W384		Well W384 (continued)	
Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
1	1.92	**450**	**20.55**	5	68.33	630	78.30
2	4.49	**465**	**20.54**	6	69.88	660	78.22
3	6.24	**480**	**20.56**	7	71.13	690	78.07
4	7.48	**1290**	**22.33**	8	71.33	720	78.20
5	8.43	**1305**	**22.30**	9	72.03	750	84.40
6	9.18	**1320**	**22.31**	10	72.63	780	84.64
7	9.80			12	73.53	810	81.68
8	10.34			14	74.18	840	81.31
9	10.79			16	74.73	870	81.24
10	**11.16**			18	75.23	900	81.21
12	**11.82**			20	75.53	930	81.32
14	**12.37**			25	75.98	960	83.95
16	**12.84**			30	76.53	990	85.14
18	**13.23**			35	76.63	1020	85.60
20	**13.56**			40	77.03	1050	85.12
22	**13.87**			45	77.18	1080	83.13
24	**14.14**			50	77.34	1110	83.32
26	**14.41**			55	77.58	1140	83.40
28	**14.63**			60	77.83	1170	83.34
30	**14.82**			65	77.83	1200	83.27
35	**15.24**			70	78.10	1230	83.15
40	**15.63**			75	78.08	1260	83.10
45	**15.94**			85	78.13	1290	83.30
50	**16.23**			90	78.18	1320	83.36
55	**16.53**			100	78.33		
60	**16.73**			110	78.38		
65	**16.92**			120	78.53		
70	**17.15**			130	78.66		
75	**17.33**			140	79.48		
80	**17.46**			150	79.33		
85	**17.62**			160	79.83		
90	**17.73**			170	80.10		
100	**17.97**			180	79.58		
110	**18.21**			190	79.78		
120	**18.43**			200	79.75		
130	**18.63**			210	79.40		
140	**18.85**			225	79.53		
150	**19.03**			240	79.13		
160	**19.21**			260	79.58		
170	**19.39**			280	80.13		
180	**19.47**			300	79.73		
190	**19.59**			330	79.63		
200	**19.67**			360	79.08		
210	**19.70**			390	74.88		
225	**19.82**			405	74.18		
240	**19.89**			420	80.13		
260	**20.06**			435	79.47		
280	**20.21**			450	79.02		
300	**20.28**			465	78.88		
320	**20.32**			480	78.73		
340	**20.35**			510	78.68		
360	**20.31**			540	78.48		
420	**20.54**			570	78.63		
435	**20.57**			600	78.53		

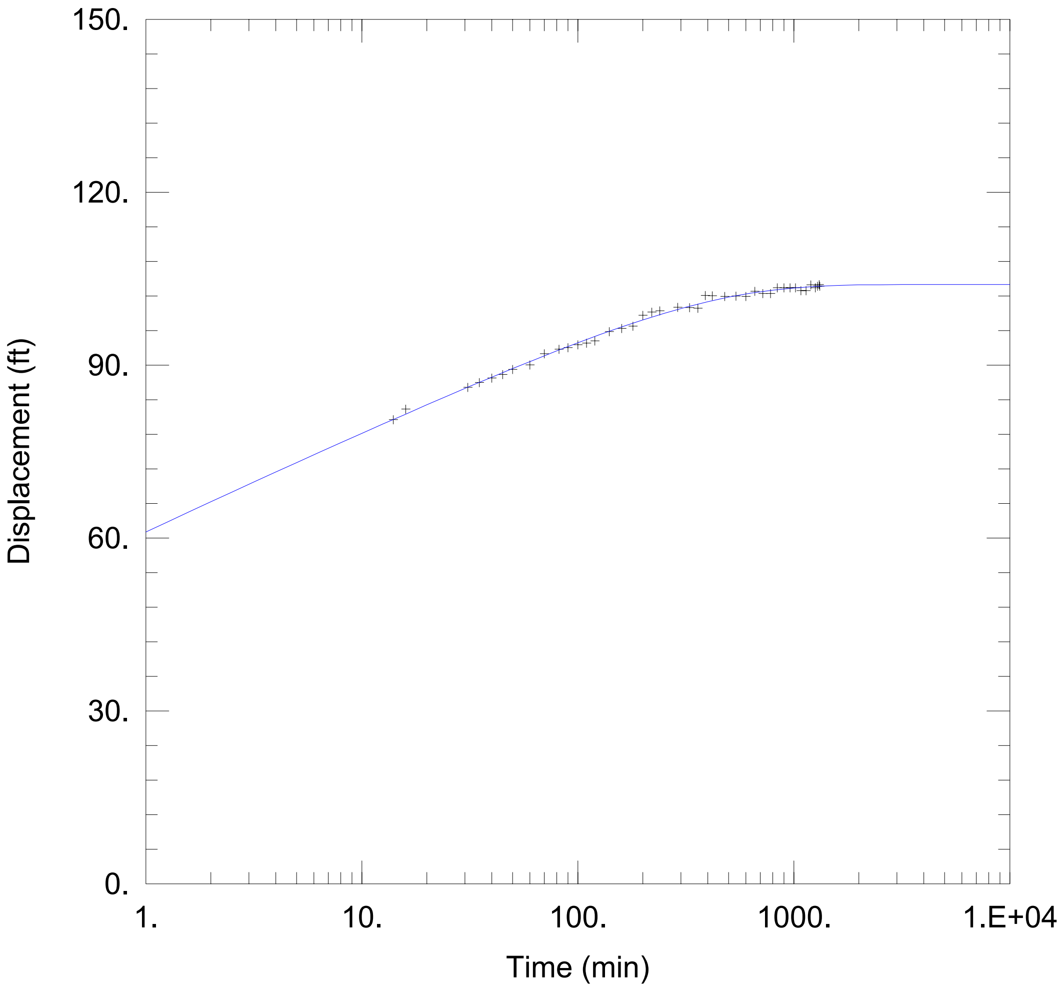
***Only bolded measurements were analyzed.**

Table C-9
Drawdown vs. Time Data for the Aquifer Test Conducted at Well W395 AQ (Symmes-Shepherd)

Pumping Well Data			
Well W395		Well W395 (cont.)	
Time (min)	Drawdown (ft)	Time (min)	Drawdown (ft)
2	16.64	**1200**	**25.85**
3	17.05	**1260**	**25.77**
4	17.55	**1380**	**25.75**
5	17.97	**1560**	**25.75**
6	18.35	**1740**	**25.65**
7	18.59	**1800**	**25.91**
8	18.75	**1980**	**26.01**
9	18.98	**2160**	**26.38**
10	**19.29**	**2400**	**26.46**
12	**19.53**	**2640**	**26.59**
14	**19.78**	**2880**	**26.75**
16	**19.98**	**3000**	**26.67**
18	**20.22**	**3360**	**26.85**
20	**20.46**	**3720**	**26.94**
25	**20.78**	**4080**	**27.07**
30	**20.81**	**4320**	**26.95**
40	**21.43**	**4440**	**26.95**
45	**21.50**	**4800**	**26.97**
50	**21.80**	**5160**	**27.02**
55	**21.94**	**5520**	**27.00**
60	**22.06**	**5755**	**27.04**
70	**22.07**		
80	**22.36**		
90	**22.64**		
100	**22.76**		
110	**22.75**		
120	**22.87**		
130	**22.90**		
140	**22.99**		
150	**23.12**		
160	**23.27**		
170	**23.26**		
180	**23.40**		
195	**23.45**		
210	**23.48**		
240	**23.64**		
270	**24.15**		
300	**24.25**		
360	**24.50**		
420	**24.73**		
480	**25.06**		
540	**25.06**		
600	**25.15**		
660	**25.27**		
720	**25.35**		
780	**25.46**		
840	**25.50**		
900	**25.54**		
960	**25.76**		
1020	**25.78**		
1080	**25.58**		
1140	**25.75**		

***Only bolded measurements were analyzed**

Appendix D
AQTESOLV Output for
Well W387 EM (Laws)



WELL TEST ANALYSIS

Data Set: \...\387 EM_HJ.aqt
Date: 12/04/02 Time: 14:58:37

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W387 EM
Test Date: April 1987

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W387 EM	0	0

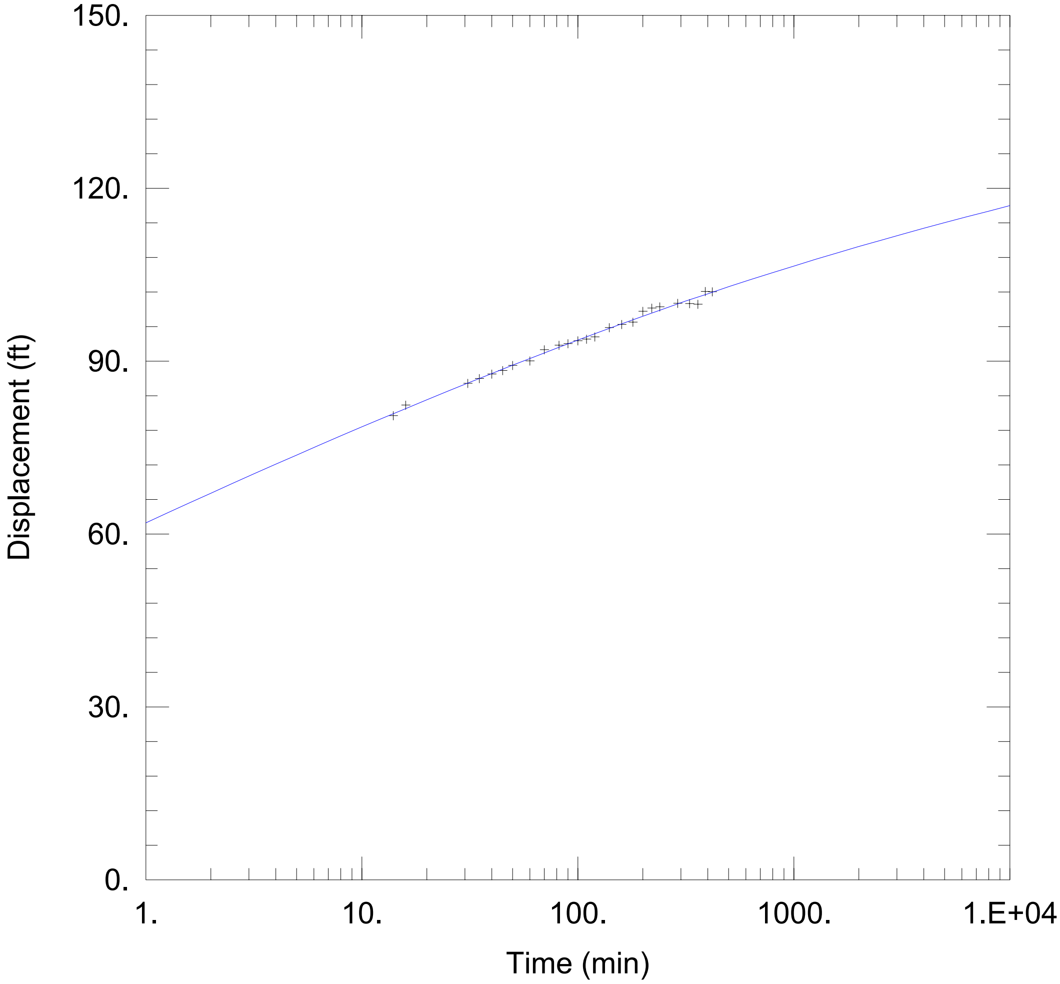
Observation Wells

Well Name	X (ft)	Y (ft)
+ W387 EM	1.17	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 5.298 ft^2/min
S = 0.004245
r/B = 0.001337
Kz/Kr = 1.
b = 370. ft



WELL TEST ANALYSIS

Data Set: \...\387 EM_H.aqt
Date: 12/04/02 Time: 14:58:50

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W387 EM
Test Date: April 1987

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W387 EM	0	0

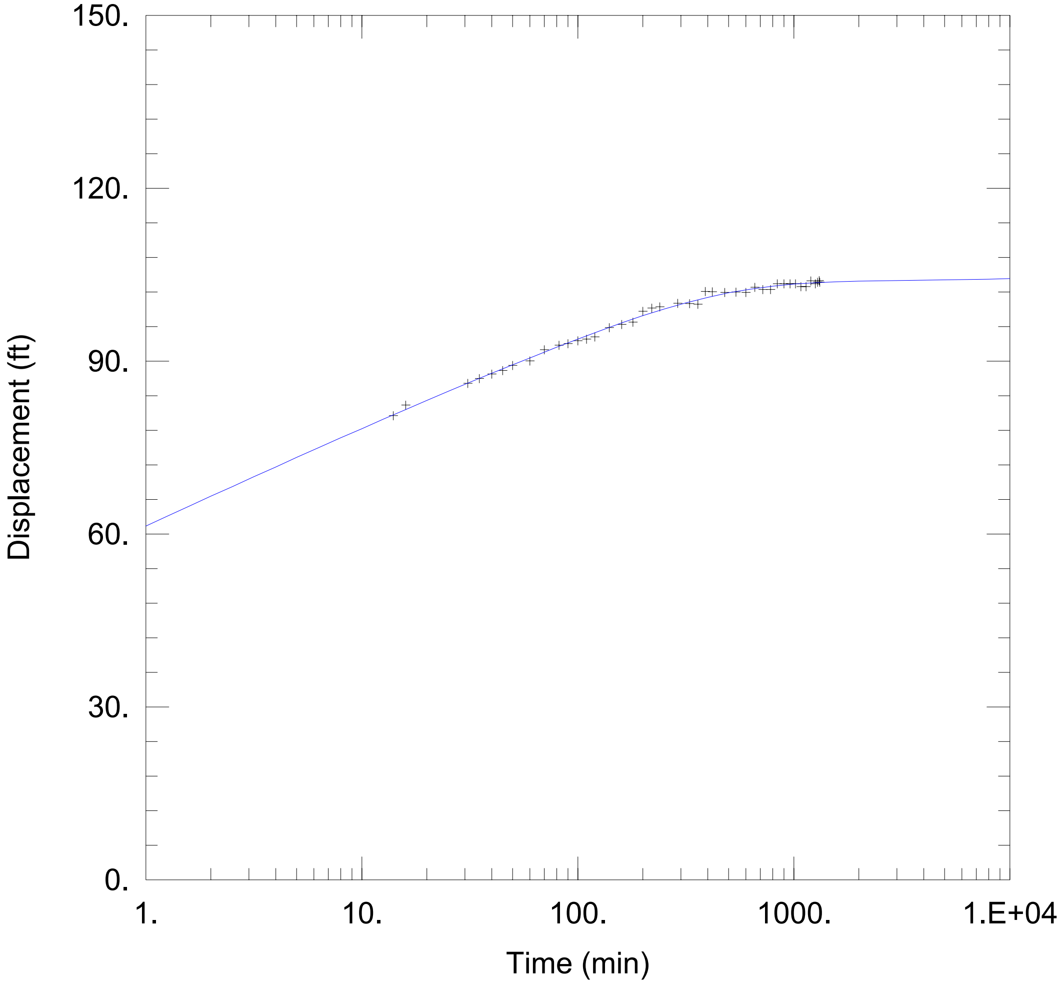
Observation Wells

Well Name	X (ft)	Y (ft)
+ W387 EM	1.17	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 5.273 ft^2/min
S = 0.003745
ß = 0.0002972
Kz/Kr = 1.
b = 370. ft



WELL TEST ANALYSIS

Data Set: \...\387 EM_NW.aqt
Date: 12/04/02 Time: 14:58:58

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W387 EM
Test Date: April 1987

AQUIFER DATA

Saturated Thickness: 370. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W387 EM	0	0

Observation Wells

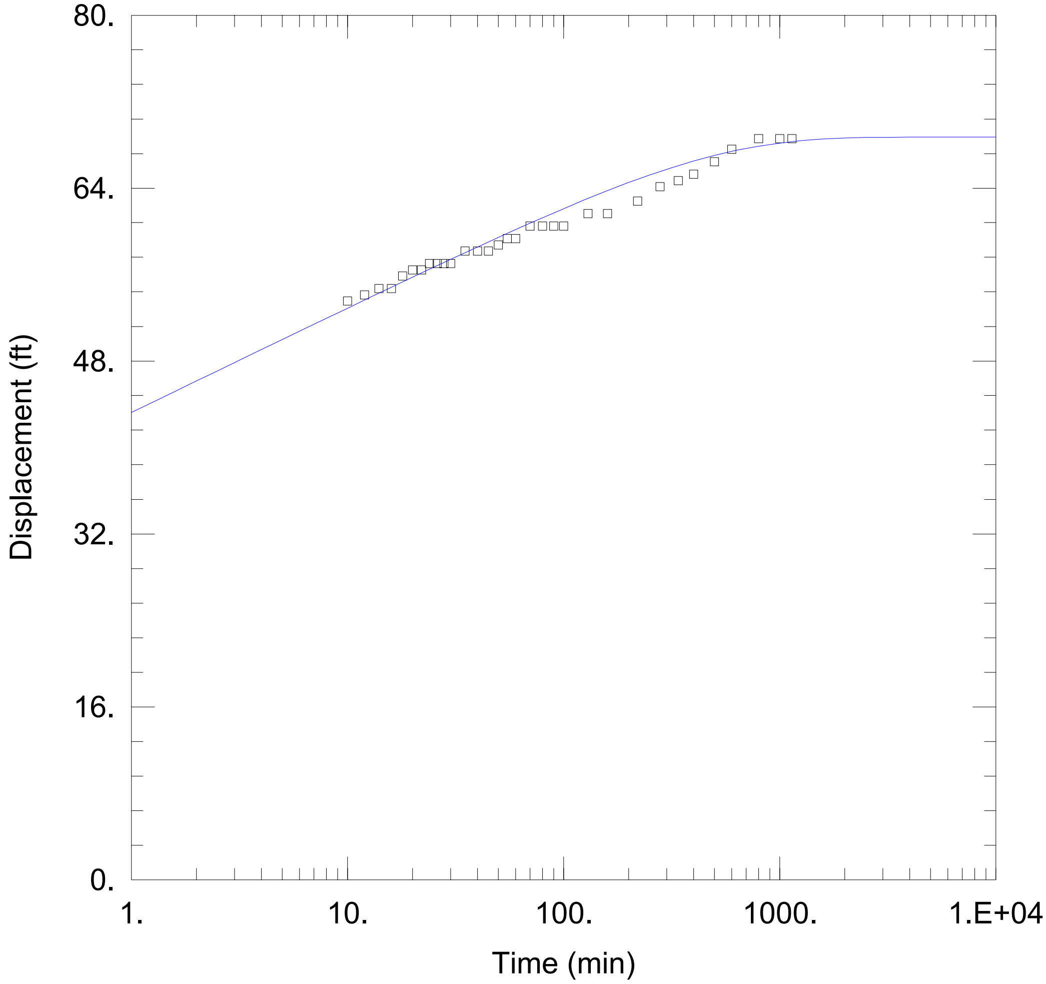
Well Name	X (ft)	Y (ft)
+ W387 EM	1.17	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Neuman-Witherspoon

T = 4.976 ft^2/min
r/B = 0.001344
T' = 1.243E-05 ft^2/min
S = 0.002734
ß = 0.0003301
S' = 1.

Appendix E
AQTESOLV Output for
Well W398 AQ (Laws)



WELL TEST ANALYSIS

Data Set: \...\398 AQ_HJ.aqt
Date: 11/14/02 Time: 18:06:59

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W398 AQ
Test Date: April 1991

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W398 AQ	0	0

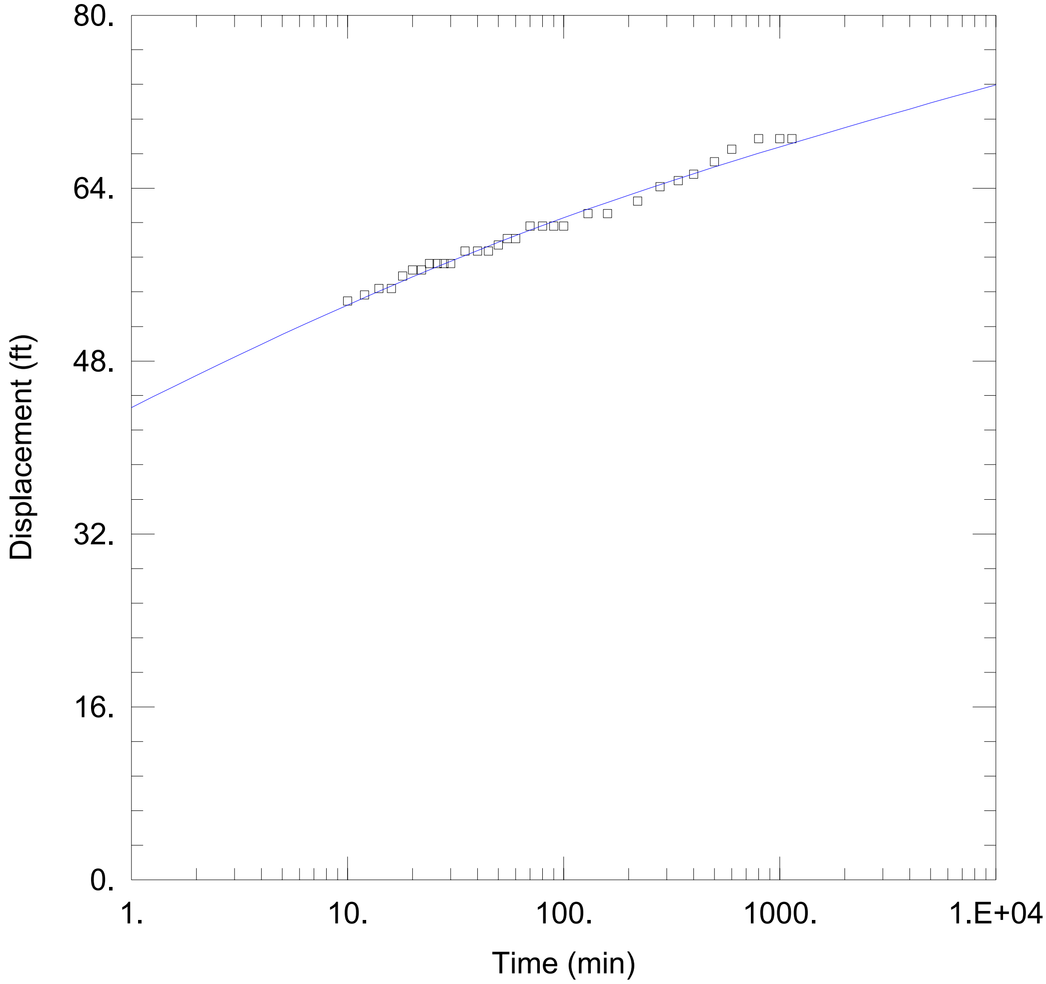
Observation Wells

Well Name	X (ft)	Y (ft)
□ W398 AQ	1.17	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 7.575 ft^2/min
r/B = 0.0003715
b = 367. ft
S = 0.0005757
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\398 AQ_H.aqt
Date: 11/14/02 Time: 18:09:05

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W398 AQ
Test Date: April 1991

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W398 AQ	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ W398 AQ	1.17	0

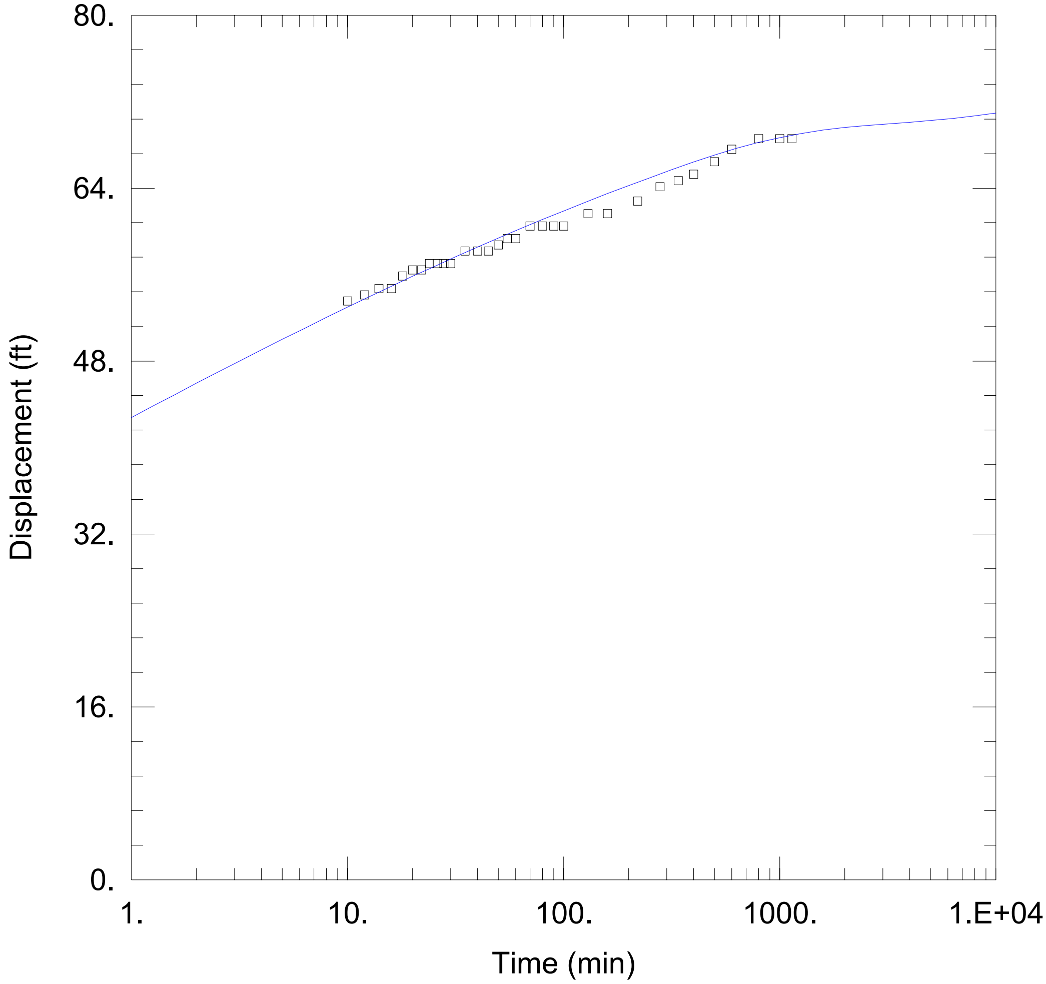
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

T = 6.908 ft^2/min
ß = 0.0004571
b = 367. ft

S = 0.001019
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\398 AQ_NW.aqt
Date: 11/14/02 Time: 18:14:56

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W398 AQ
Test Date: April 1991

AQUIFER DATA

Saturated Thickness: 367. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W398 AQ	0	0

Observation Wells

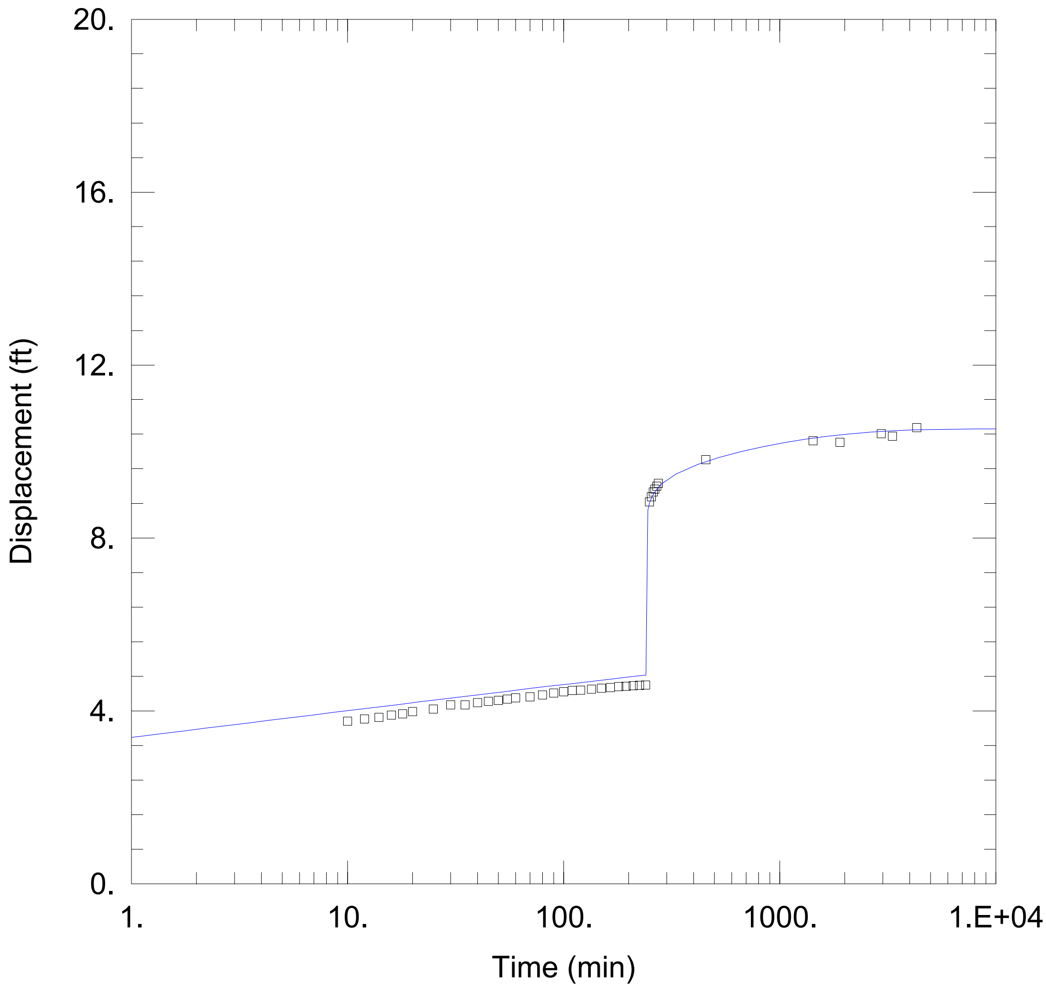
Well Name	X (ft)	Y (ft)
□ W398 AQ	1.17	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Neuman-Witherspoon

T = 6.597 ft^2/min
S = 0.001411
r/B = 0.0008318
ß = 0.0003981
T' = 0.1 ft^2/min
S' = 0.1

Appendix F
AQTESOLV Output for
Well V014GA (Big Pine)



WELL TEST ANALYSIS

Data Set: \...\V014GA_HJ.aqt
Date: 11/14/02 Time: 11:01:13

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: V014GA
Test Date: September 1984

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
V014GA	0	0

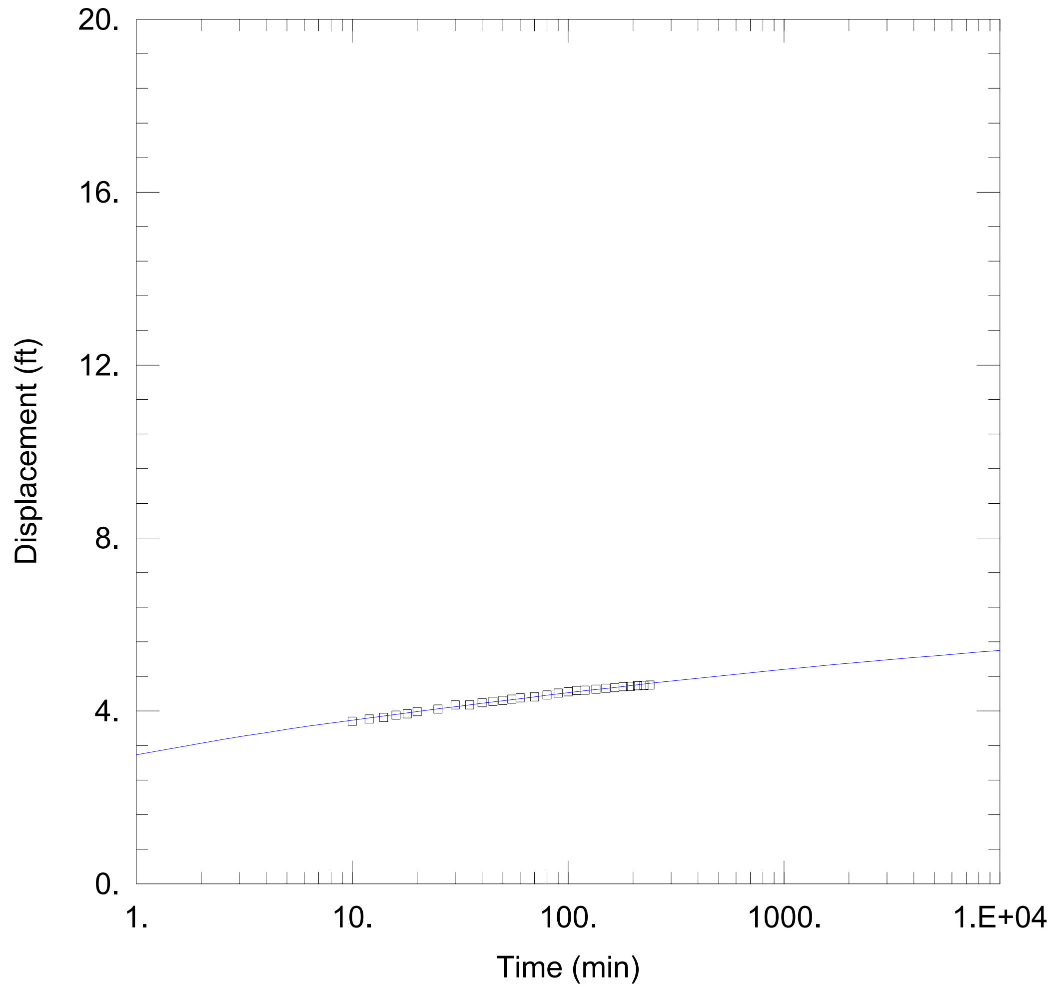
Observation Wells

Well Name	X (ft)	Y (ft)
□ V014GA	0.667	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 3.767 ft^2/min
S = 0.003406
r/B = 0.0004555
Kz/Kr = 1.
b = 65. ft



WELL TEST ANALYSIS

Data Set: \...\V014GA_H.aqt
Date: 11/14/02 Time: 15:11:01

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: V014GA
Test Date: September 1984

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
V014GA	0	0

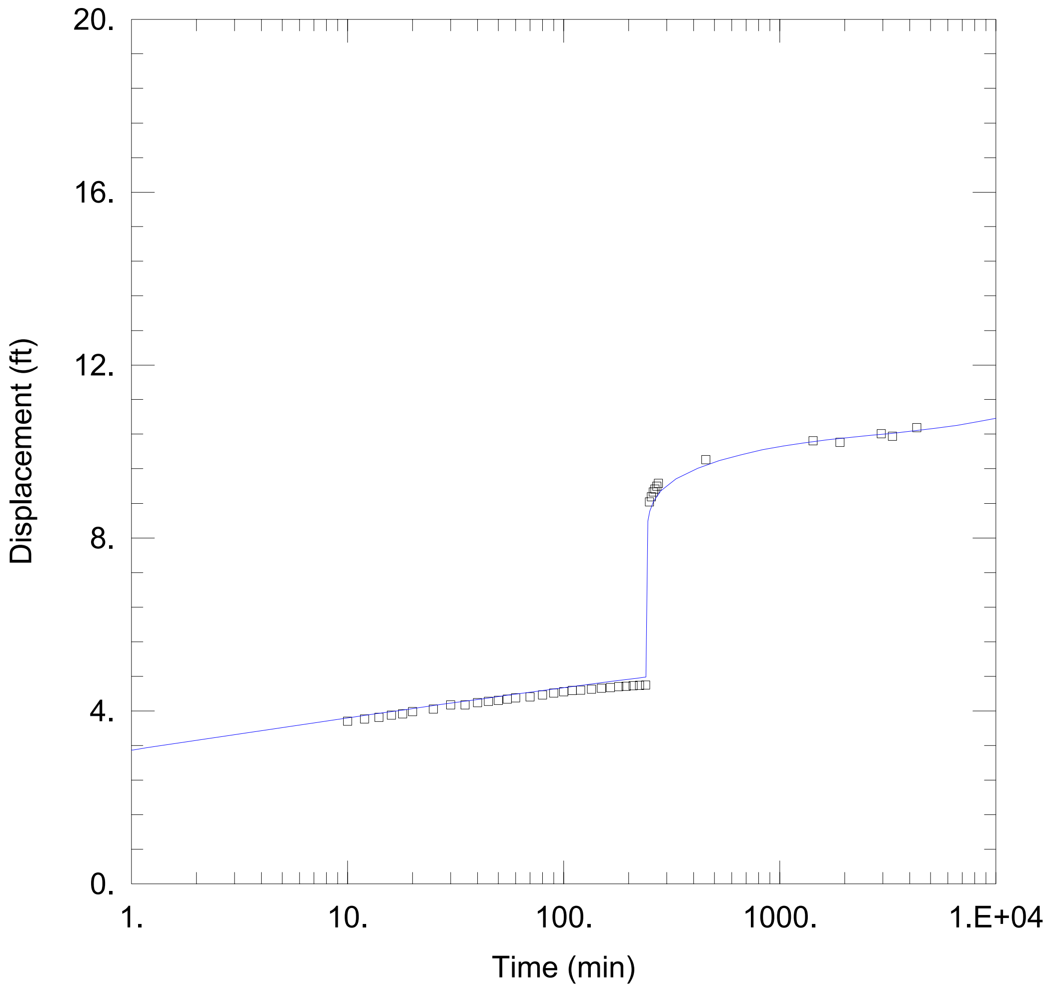
Observation Wells

Well Name	X (ft)	Y (ft)
□ V014GA	0.667	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 3.36 ft^2/min
S = 0.02747
ß = 0.0005159
Kz/Kr = 1.
b = 65. ft



WELL TEST ANALYSIS

Data Set: \...\V014GA_NW.aqt
Date: 11/14/02 Time: 13:16:50

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: V014GA
Test Date: September 1984

AQUIFER DATA

Saturated Thickness: 65. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
V014GA	0	0

Observation Wells

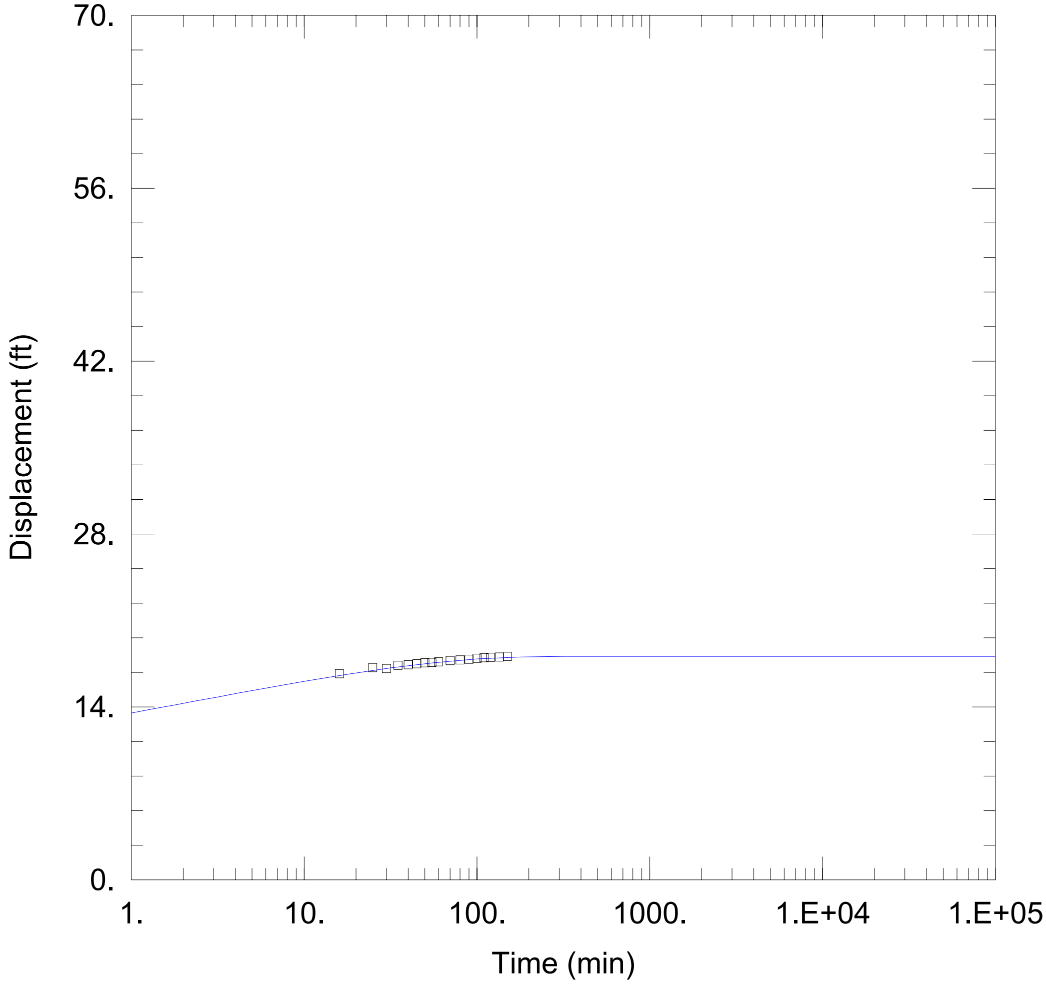
Well Name	X (ft)	Y (ft)
□ V014GA	0.667	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Neuman-Witherspoon

T = 3.03 ft^2/min
S = 0.001406
r/B = 0.0004962
ß = 0.0001114
T' = 0.0001049 ft^2/min
S' = 0.01583

Appendix G
AQTESOLV Output for
Well V016GA (Big Pine)



WELL TEST ANALYSIS

Data Set: \...\V016GA_HJ.aqt
Date: 11/14/02 Time: 18:25:27

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: V016GA
Test Date: June 1985

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
V016GA	0	0

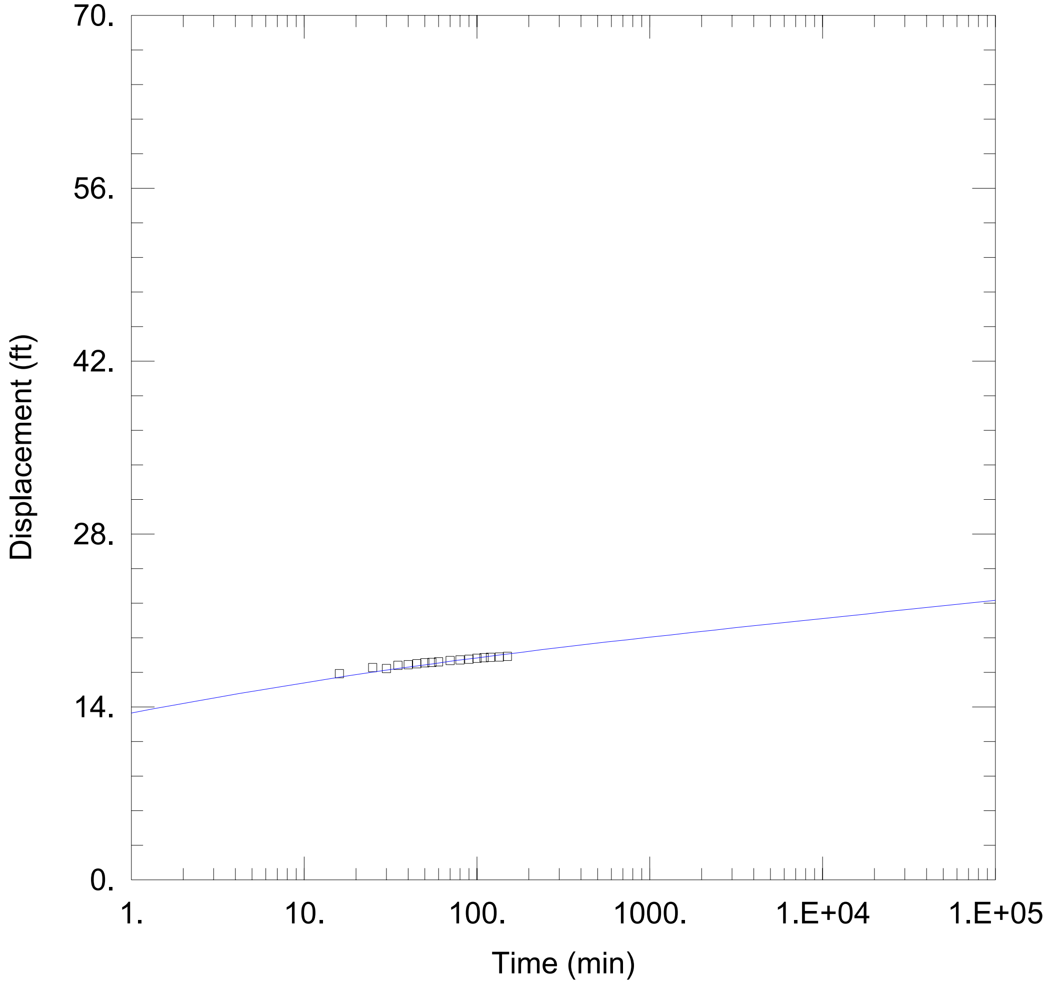
Observation Wells

Well Name	X (ft)	Y (ft)
□ V016GA	0.625	0

SOLUTION

Aquifer Model: Leaky Solution Method: Hantush-Jacob

T = 2.383 ft^2/min
r/B = 0.0007413
b = 48. ft
S = 0.0003162
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\V016GA_H.aqt
Date: 11/14/02 Time: 18:42:15

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: V016GA
Test Date: June 1985

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
V016GA	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ V016GA	0.625	0

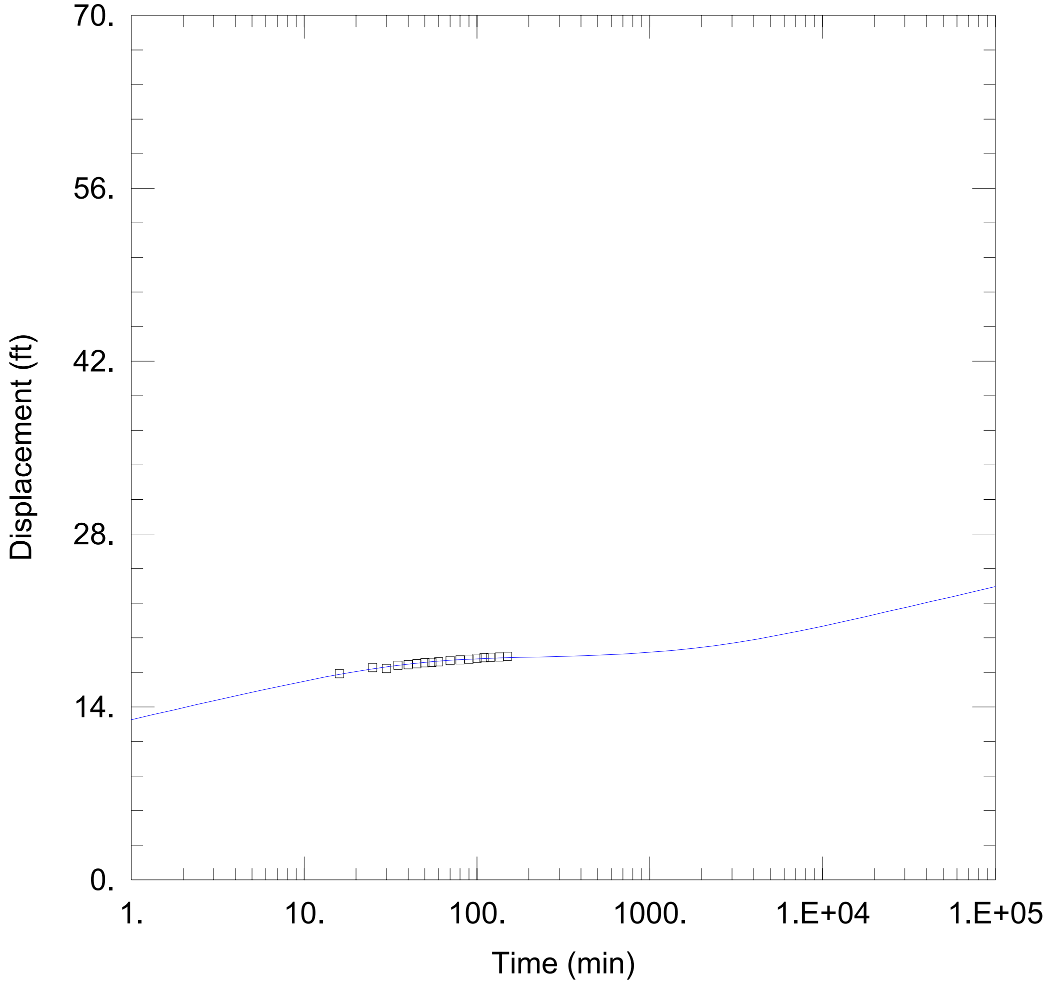
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

T = 2.21 ft^2/min
ß = 0.0004798
b = 48. ft

S = 0.0005653
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\V016GA_NW.aqt
Date: 11/14/02 Time: 18:46:39

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: V016GA
Test Date: June 1985

AQUIFER DATA

Saturated Thickness: 48. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
V016GA	0	0

Observation Wells

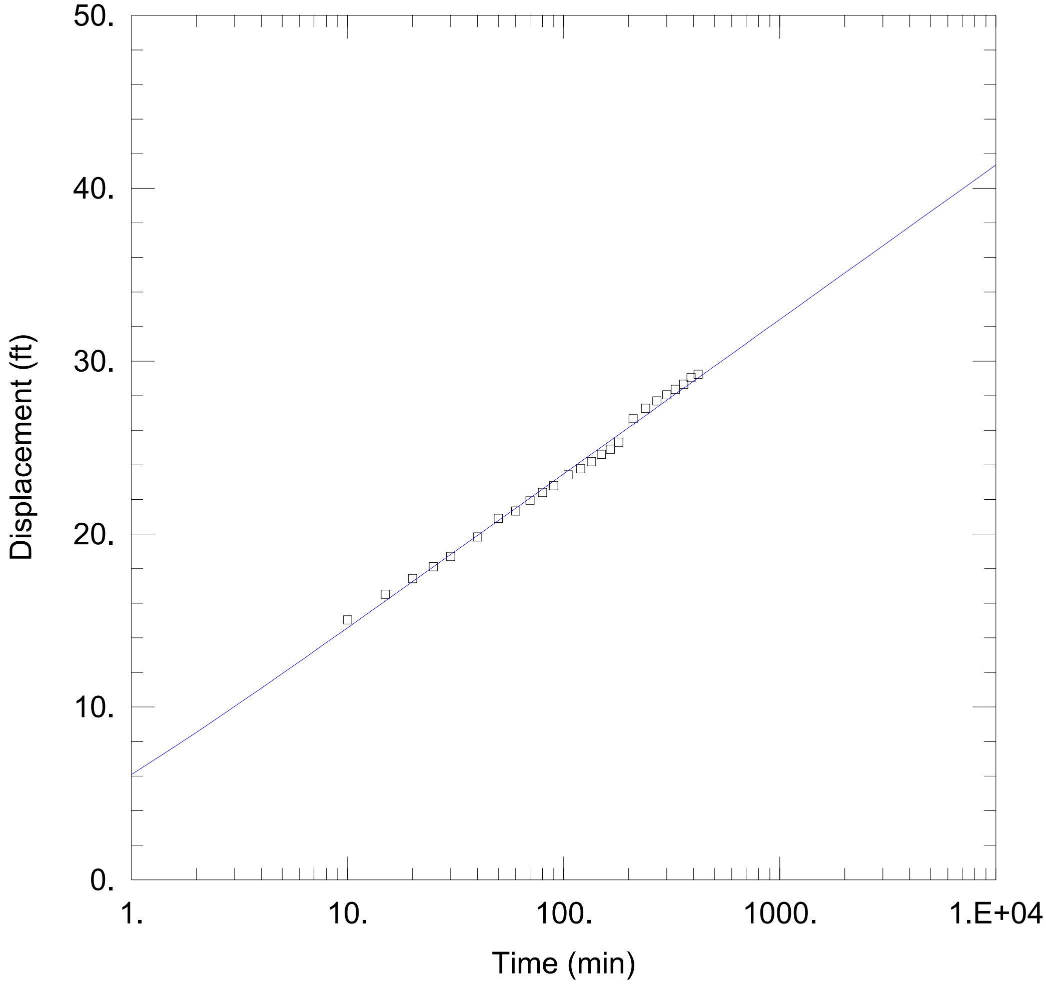
Well Name	X (ft)	Y (ft)
□ V016GA	0.625	0

SOLUTION

Aquifer Model: Leaky Solution Method: Neuman-Witherspoon

T = 1.852 ft^2/min
r/B = 0.002692
T' = 0.1 ft^2/min
S = 0.001585
ß = 0.0004184
S' = 0.08913

Appendix H
AQTESOLV Output for
Well W379 EM (Big Pine)



WELL TEST ANALYSIS

Data Set: \...\379 EM_HJ.aqt
Date: 11/14/02 Time: 15:37:56

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W379 EM
Test Date: August 1986

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W379 EM	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ T627	57	0

SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush-Jacob

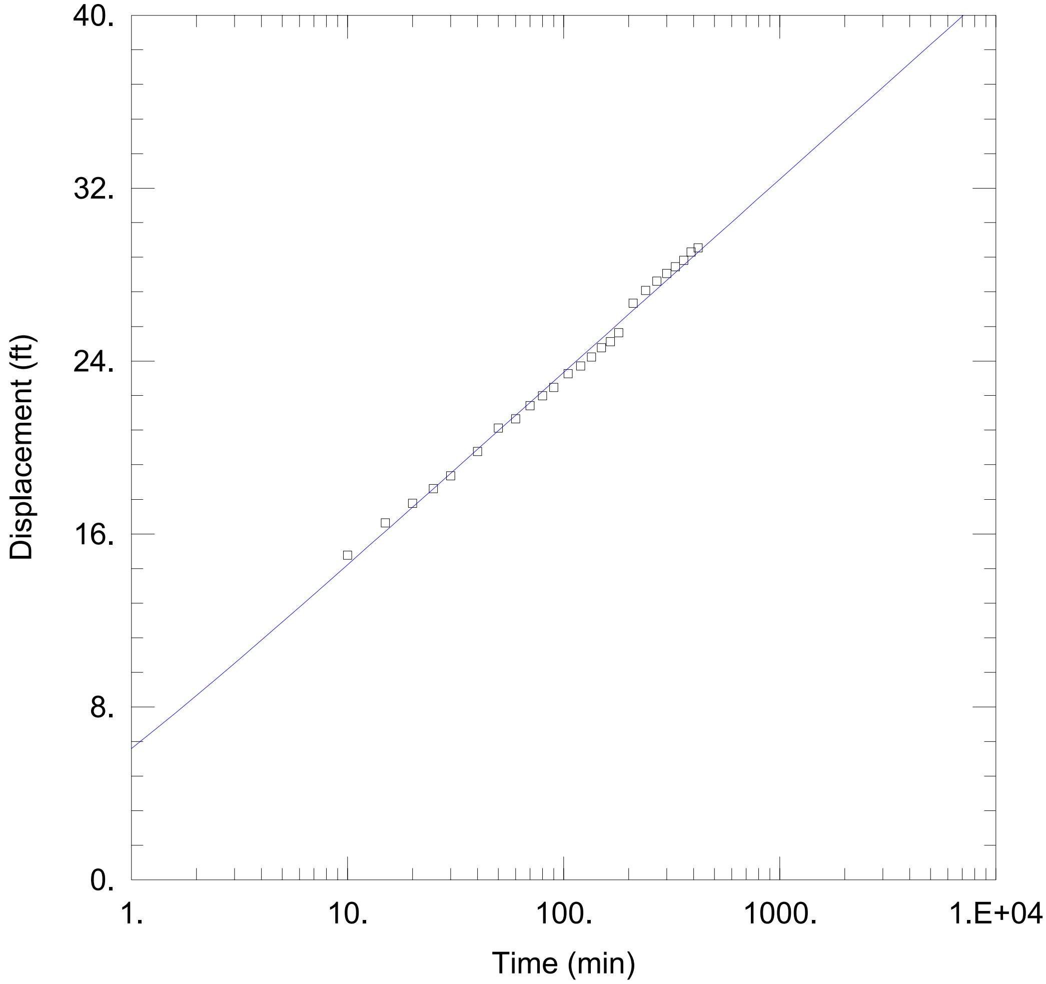
T = 8.385 ft^2/min

S = 0.001378

r/B = 1.E-05

Kz/Kr = 1.

b = 200. ft



WELL TEST ANALYSIS

Data Set: \...\379 EM_H.aqt
Date: 11/14/02 Time: 15:44:57

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W379 EM
Test Date: August 1986

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W379 EM	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ T627	57	0

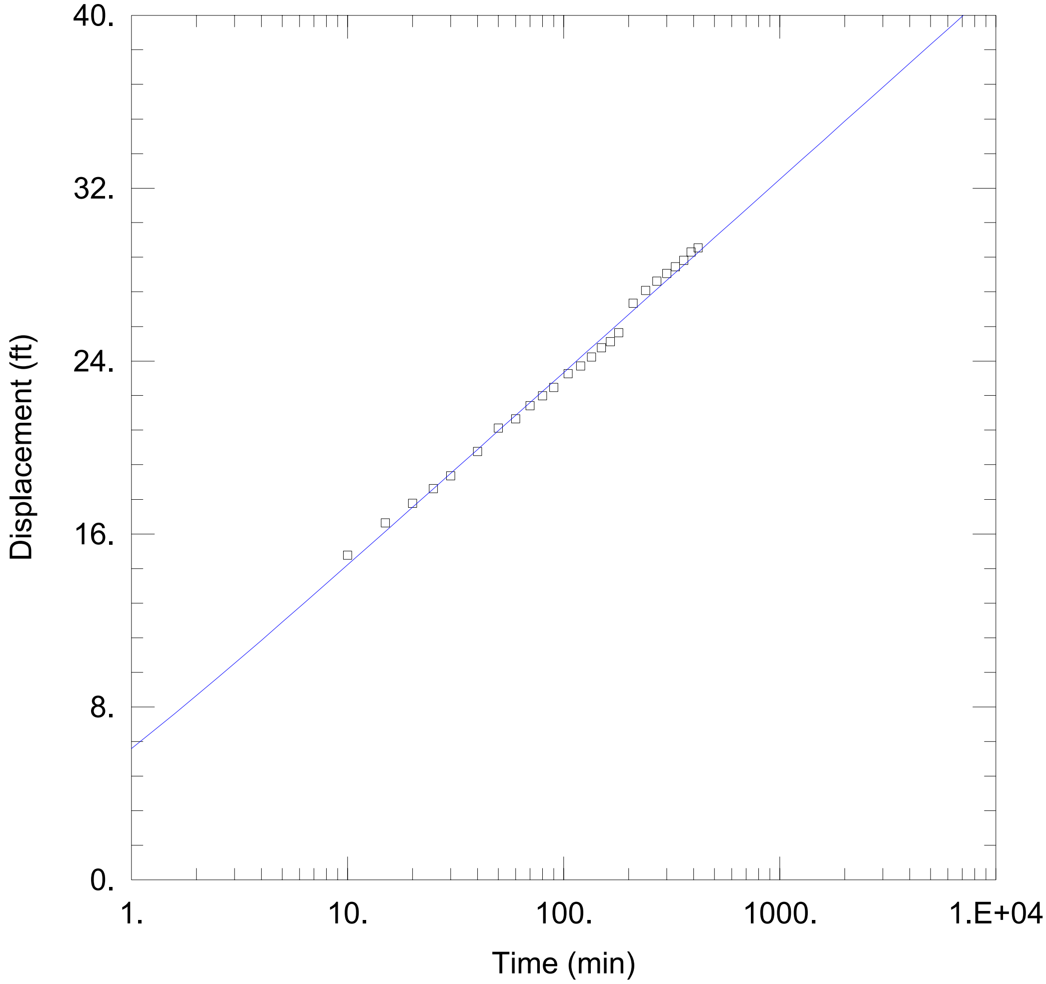
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

T = 8.378 ft^2/min
ß = 1.E-05
b = 200. ft

S = 0.001381
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\379 EM_NW.aqt
Date: 11/14/02 Time: 15:55:56

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W379 EM
Test Date: August 1986

AQUIFER DATA

Saturated Thickness: 200. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W379 EM	0	0

Observation Wells

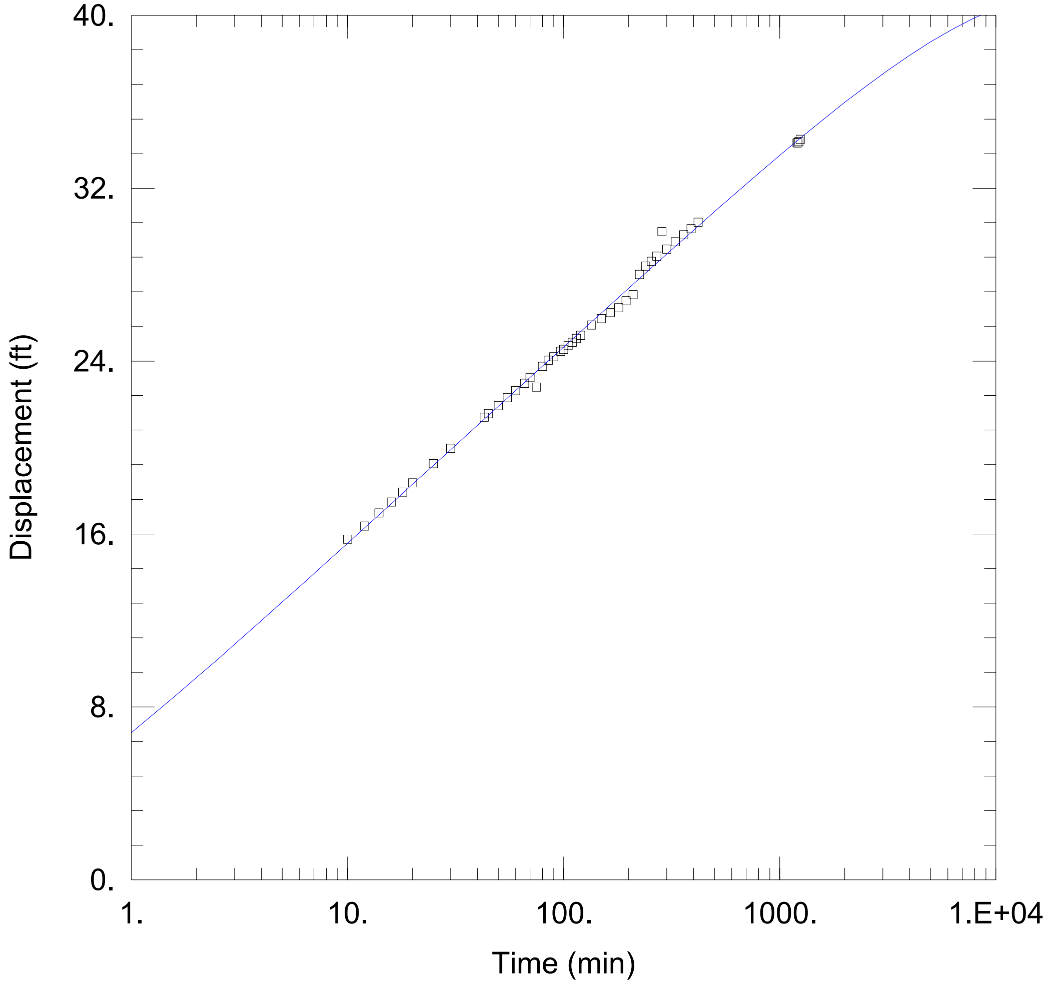
Well Name	X (ft)	Y (ft)
□ T627	57	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Neuman-Witherspoon

T = 8.377 ft^2/min
S = 0.001382
r/B = 1.E-05
ß = 1.E-05
T' = 6430.2 ft^2/min
S' = 1.

Appendix I
AQTESOLV Output for
Well W389 EM (Big Pine)



WELL TEST ANALYSIS

Data Set: \...\389 EM_HJ.aqt
Date: 11/13/02 Time: 19:17:36

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W389 EM
Test Date: April 1987

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W389 EM	0	0

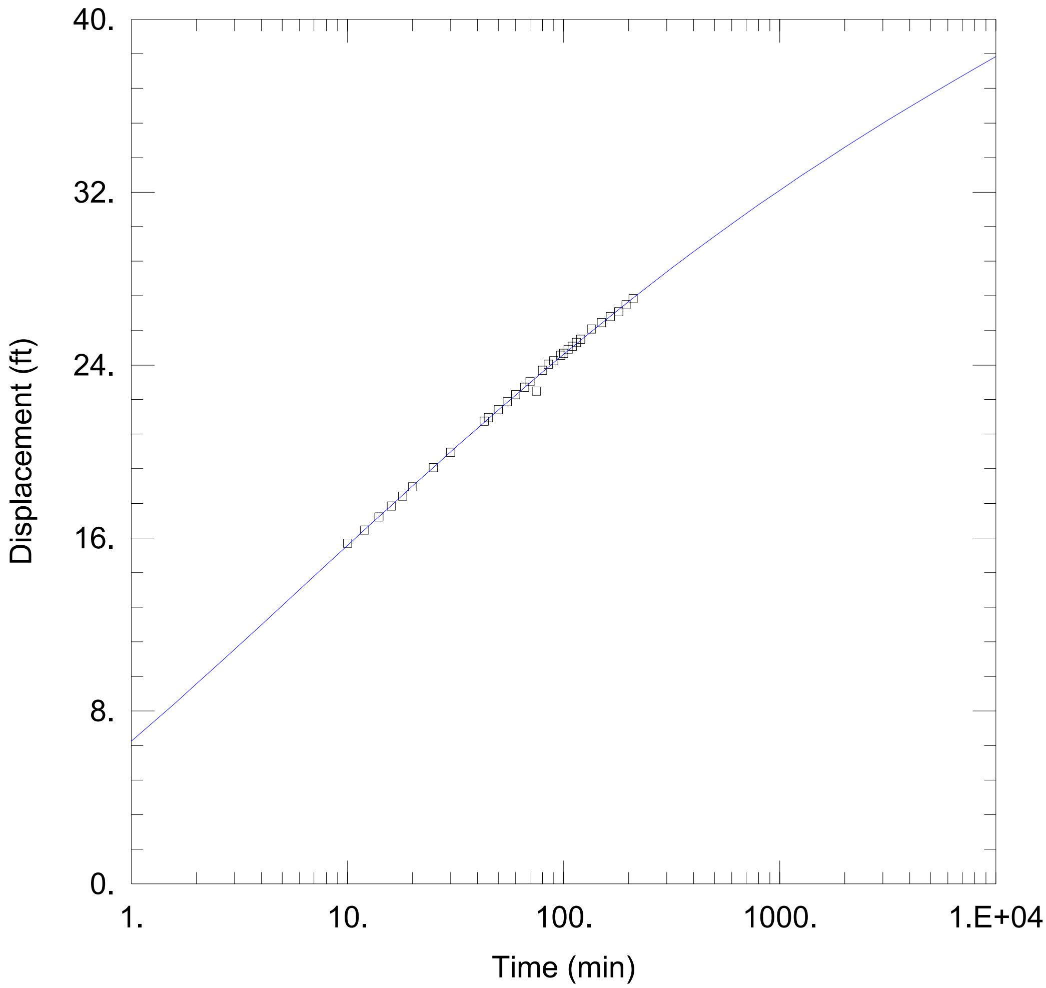
Observation Wells

Well Name	X (ft)	Y (ft)
□ T736	48.5	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 8.376 ft^2/min
S = 0.001611
r/B = 0.006052
Kz/Kr = 1.
b = 200. ft



WELL TEST ANALYSIS

Data Set: \...\389 EM_H.aqt
Date: 11/14/02 Time: 10:22:12

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W389 EM
Test Date: April 1987

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W389 EM	0	0

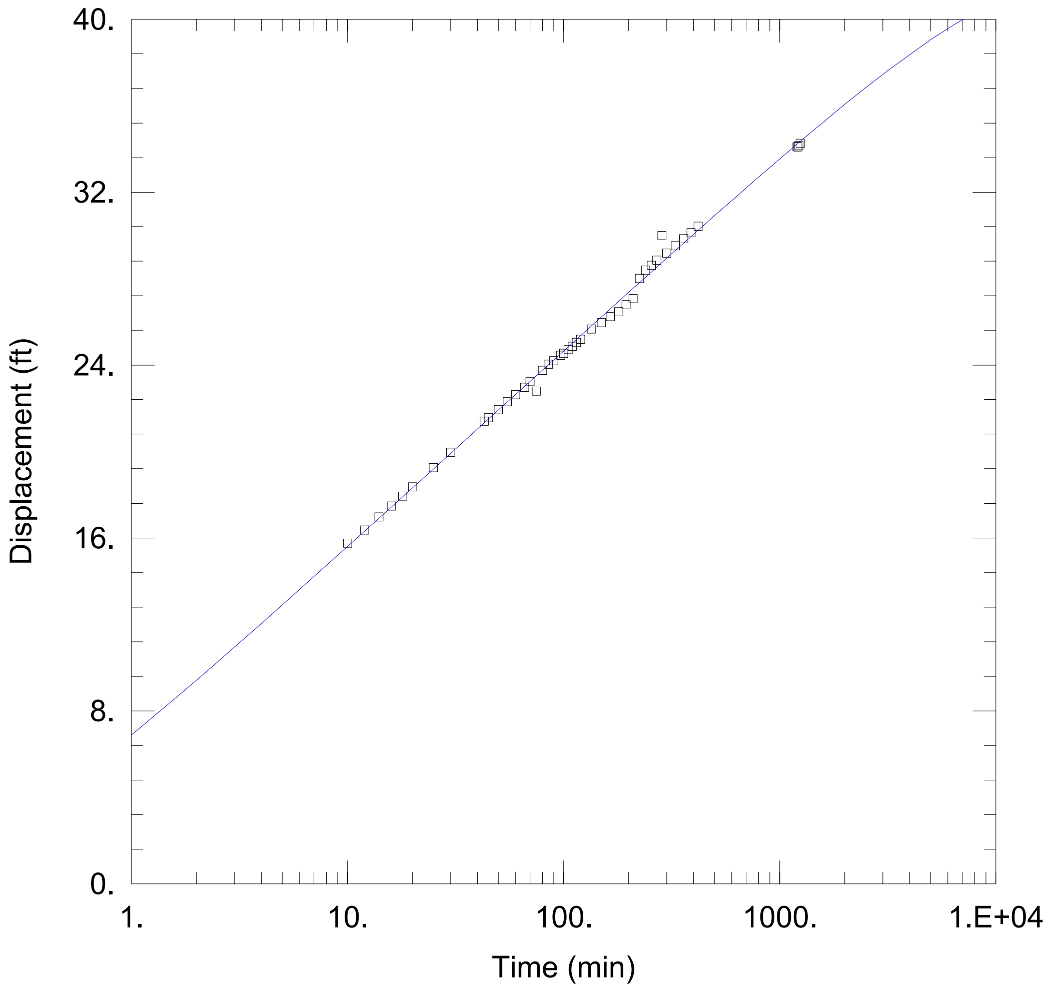
Observation Wells

Well Name	X (ft)	Y (ft)
□ T736	48.5	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 7.694 ft^2/min
S = 0.001763
ß = 0.007174
Kz/Kr = 1.
b = 200. ft



WELL TEST ANALYSIS

Data Set: \...\389 EM_NW.aqt
Date: 11/14/02 Time: 10:45:30

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W389 EM
Test Date: April 1987

AQUIFER DATA

Saturated Thickness: 200. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W389 EM	0	0

Observation Wells

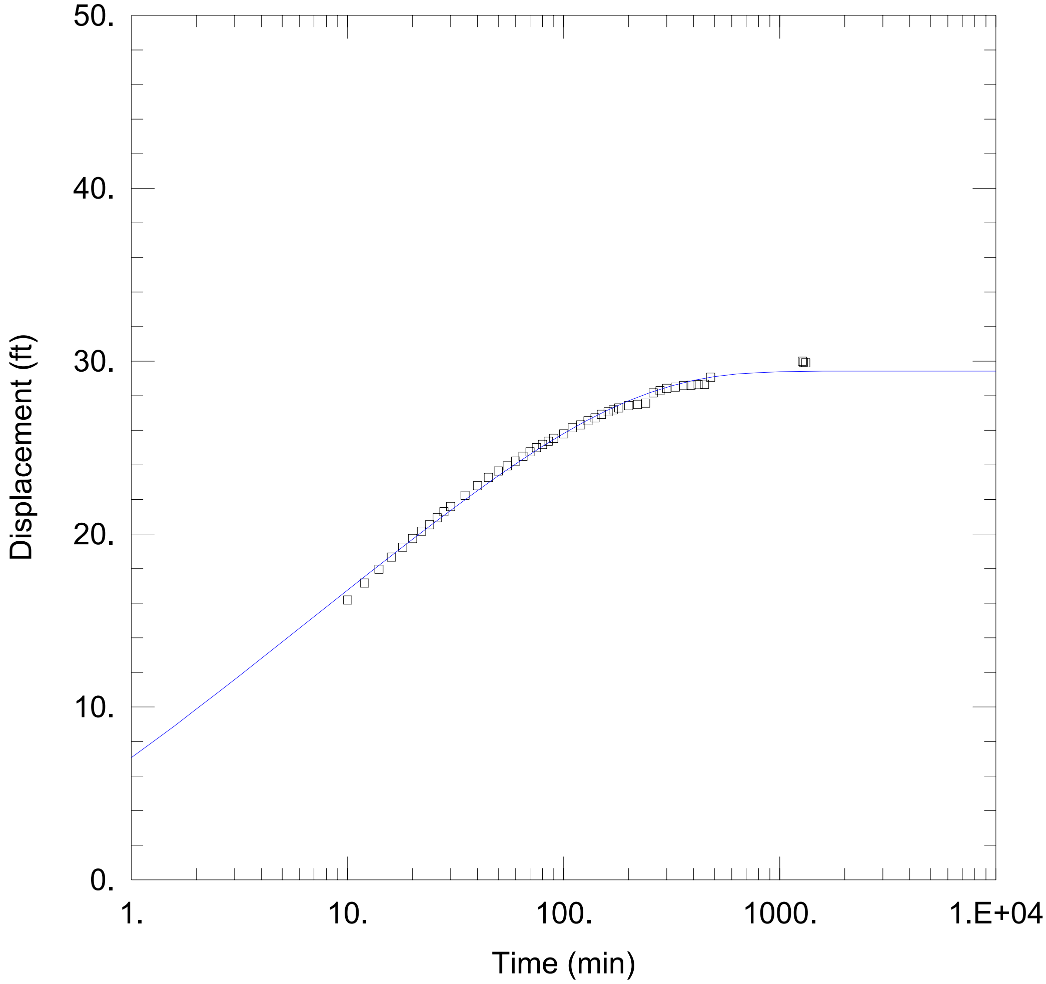
Well Name	X (ft)	Y (ft)
□ T736	48.5	0

SOLUTION

Aquifer Model: Leaky Solution Method: Neuman-Witherspoon

T = 8.418 ft^2/min
r/B = 0.005099
T' = 3.626E-05 ft^2/min
S = 0.001568
ß = 0.0001397
S' = 0.818

Appendix J
AQTESOLV Output for
Well W383 EM (Independence-Oak)



WELL TEST ANALYSIS

Data Set: \...\383 EM_HJ.aqt
Date: 11/13/02 Time: 19:03:05

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W383 EM
Test Date: October 1986

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W383 EM	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ T632	81.5	0

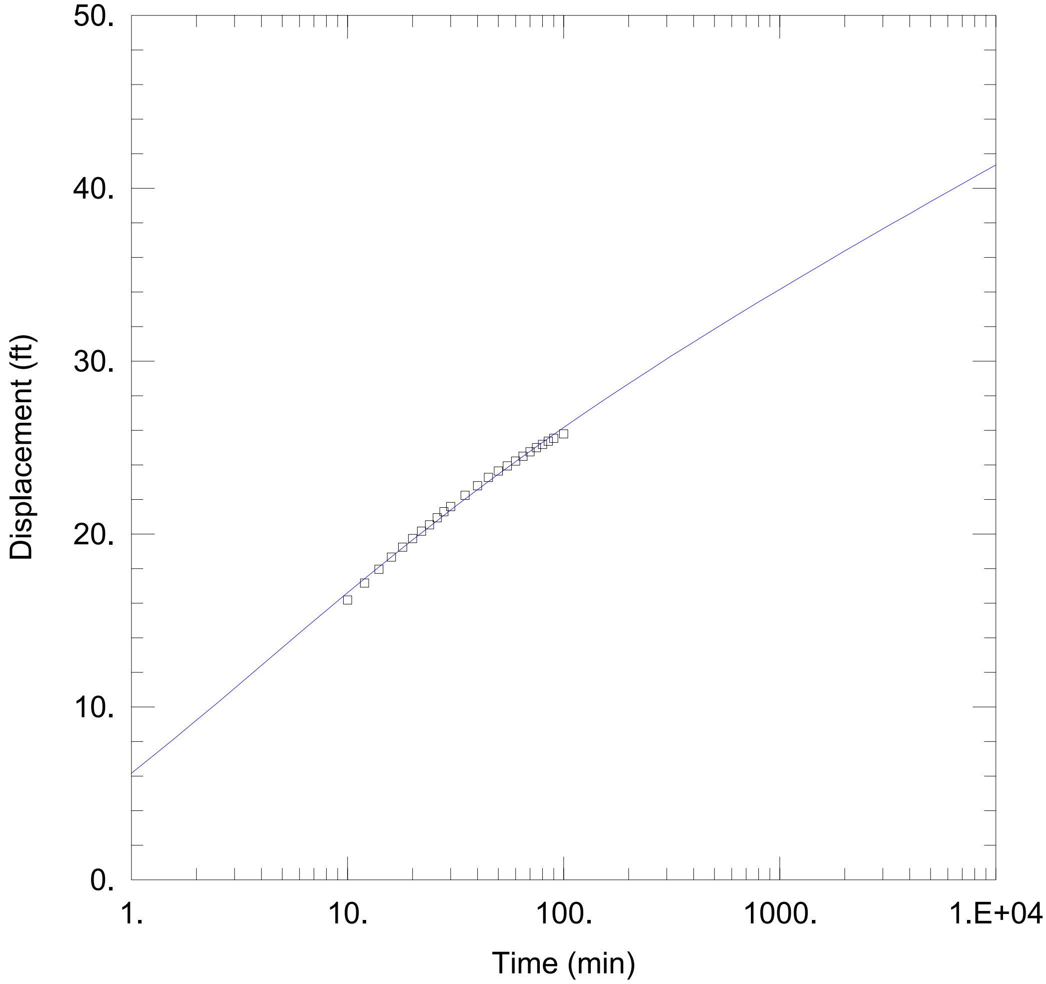
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush-Jacob

T = 5.232 ft^2/min
r/B = 0.04637
b = 355. ft

S = 0.000488
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\383 EM_H.aqt
Date: 11/13/02 Time: 19:05:39

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W383 EM
Test Date: October 1986

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W383 EM	0	0

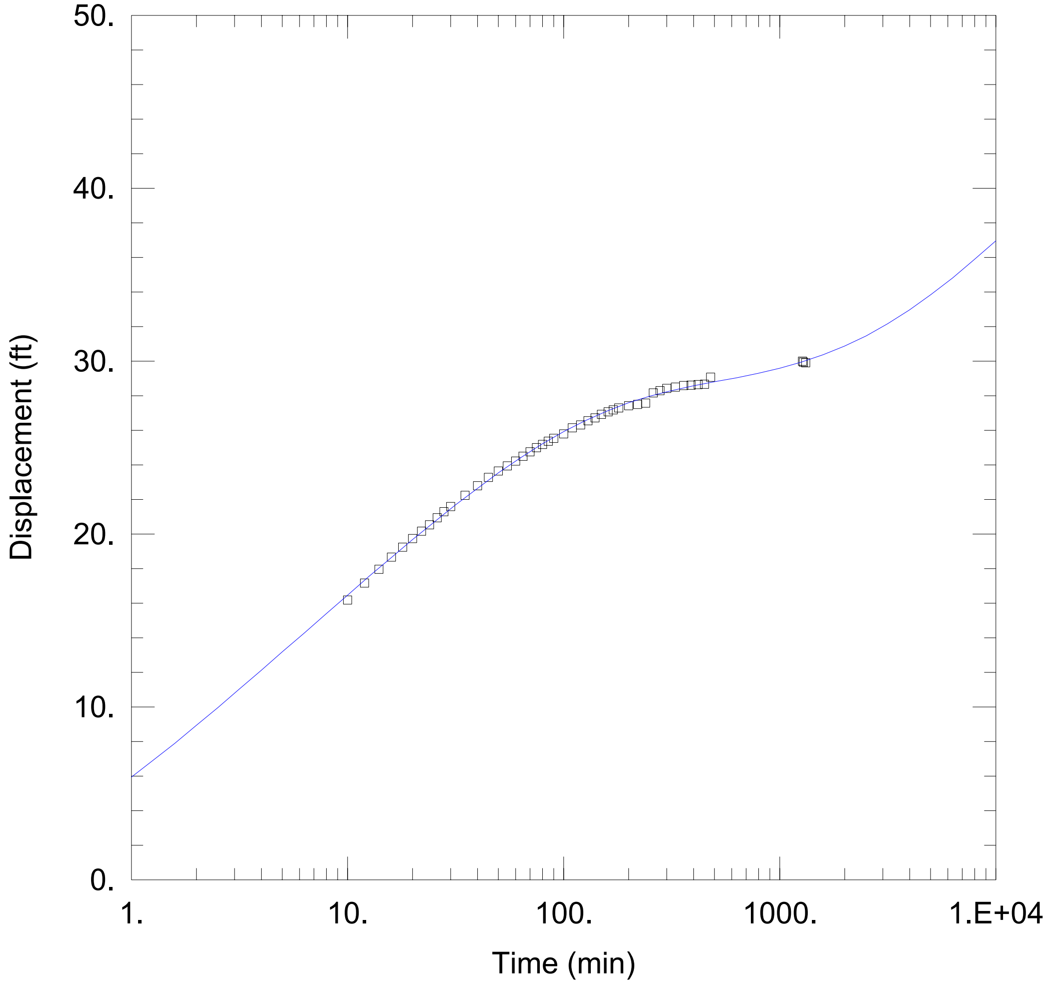
Observation Wells

Well Name	X (ft)	Y (ft)
□ T632	81.5	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 3.997 ft^2/min
ß = 0.0427
b = 355. ft
S = 0.0006054
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\383 EM_NW.aqt
Date: 11/13/02 Time: 19:08:44

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W383 EM
Test Date: October 1986

AQUIFER DATA

Saturated Thickness: 355. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W383 EM	0	0

Observation Wells

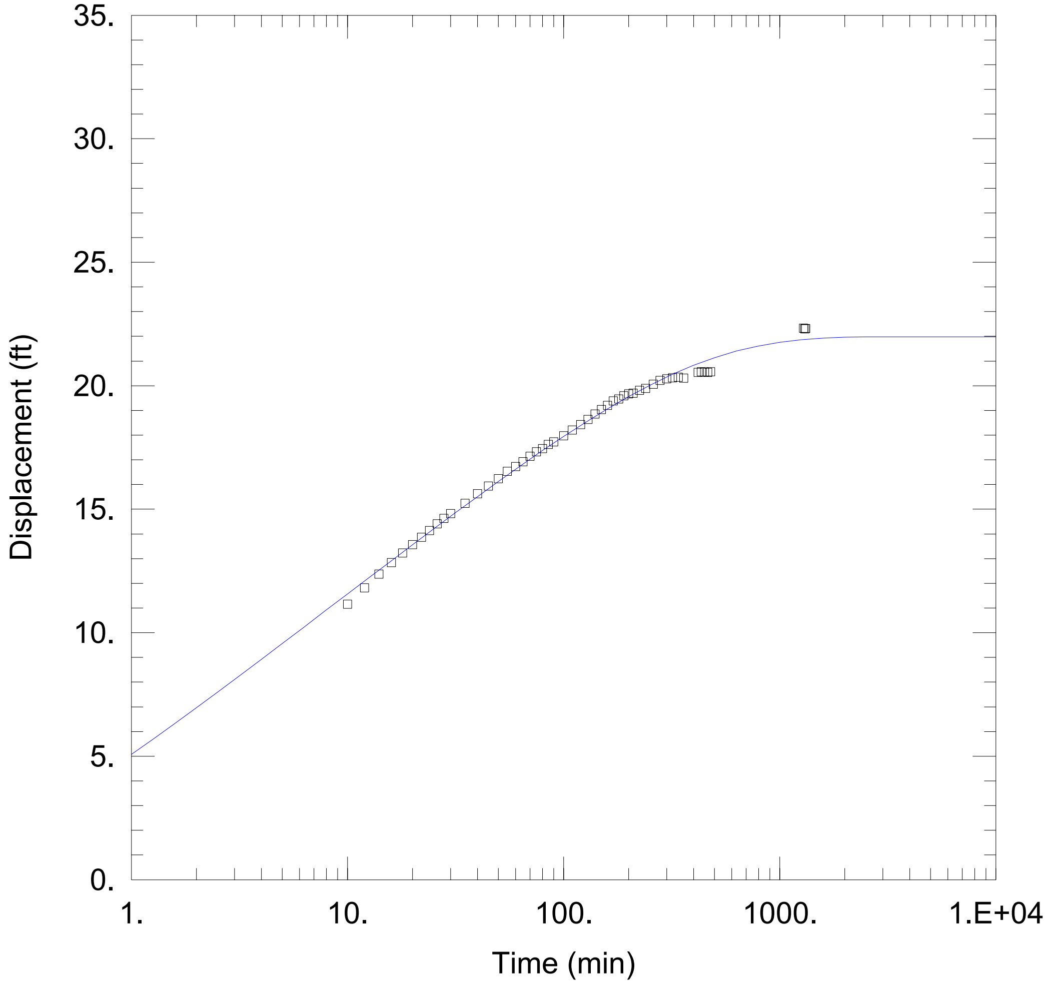
Well Name	X (ft)	Y (ft)
□ T632	81.5	0

SOLUTION

Aquifer Model: Leaky Solution Method: Neuman-Witherspoon

$T = 4.641$ ft^2/min
$r/B = 0.06958$
$T' = 1.E-05$ ft^2/min
$S = 0.0005891$
ß = 0.004444
$S' = 0.01057$

Appendix K
AQTESOLV Output for
Well W384 EM (Independence-Oak)



WELL TEST ANALYSIS

Data Set: \...\384 EM_HJ.aqt
Date: 11/13/02 Time: 18:46:44

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W384 EM
Test Date: September 1986

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W384 EM	0	0

Observation Wells

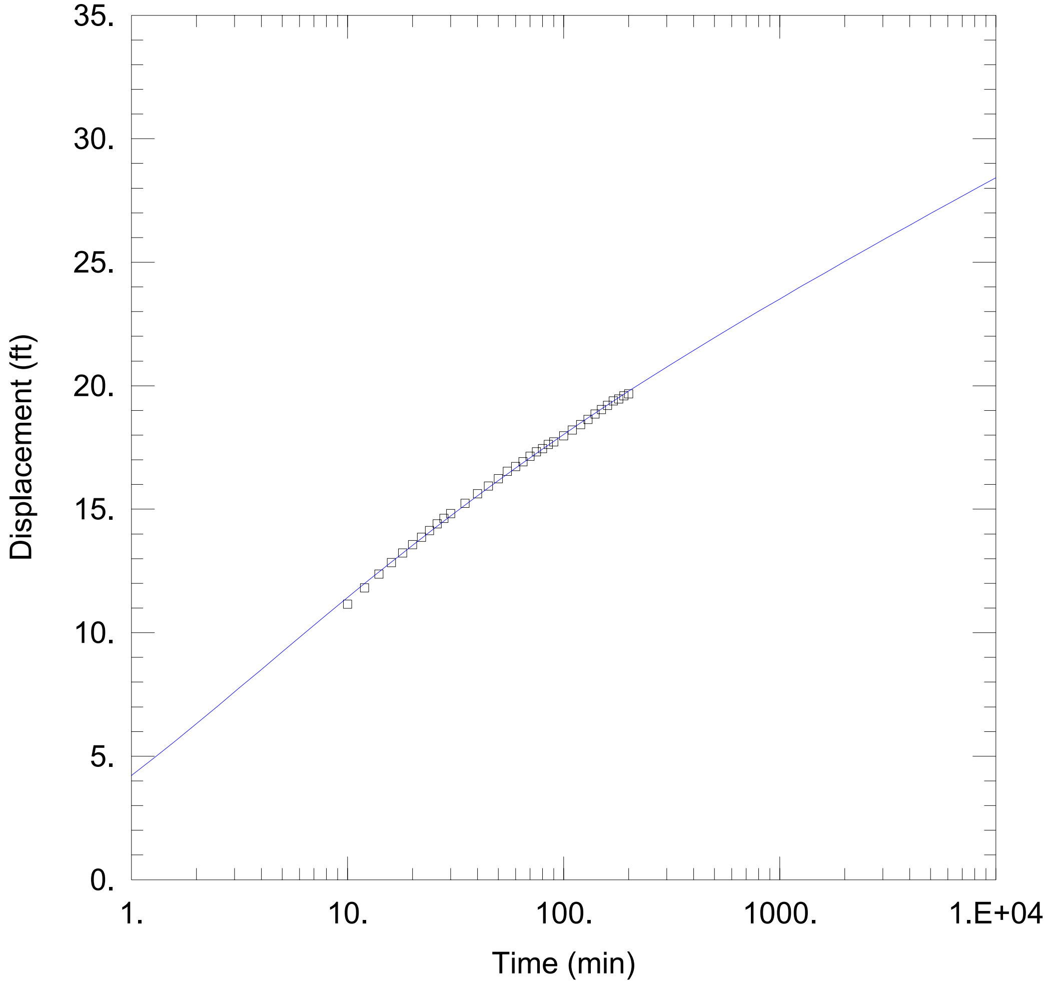
Well Name	X (ft)	Y (ft)
□ T633	88.5	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 3.401 ft^2/min
r/B = 0.02774
b = 340. ft

S = 0.0001972
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\384 EM_H.aqt
Date: 11/13/02 Time: 18:50:23

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W384 EM
Test Date: September 1986

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W384 EM	0	0

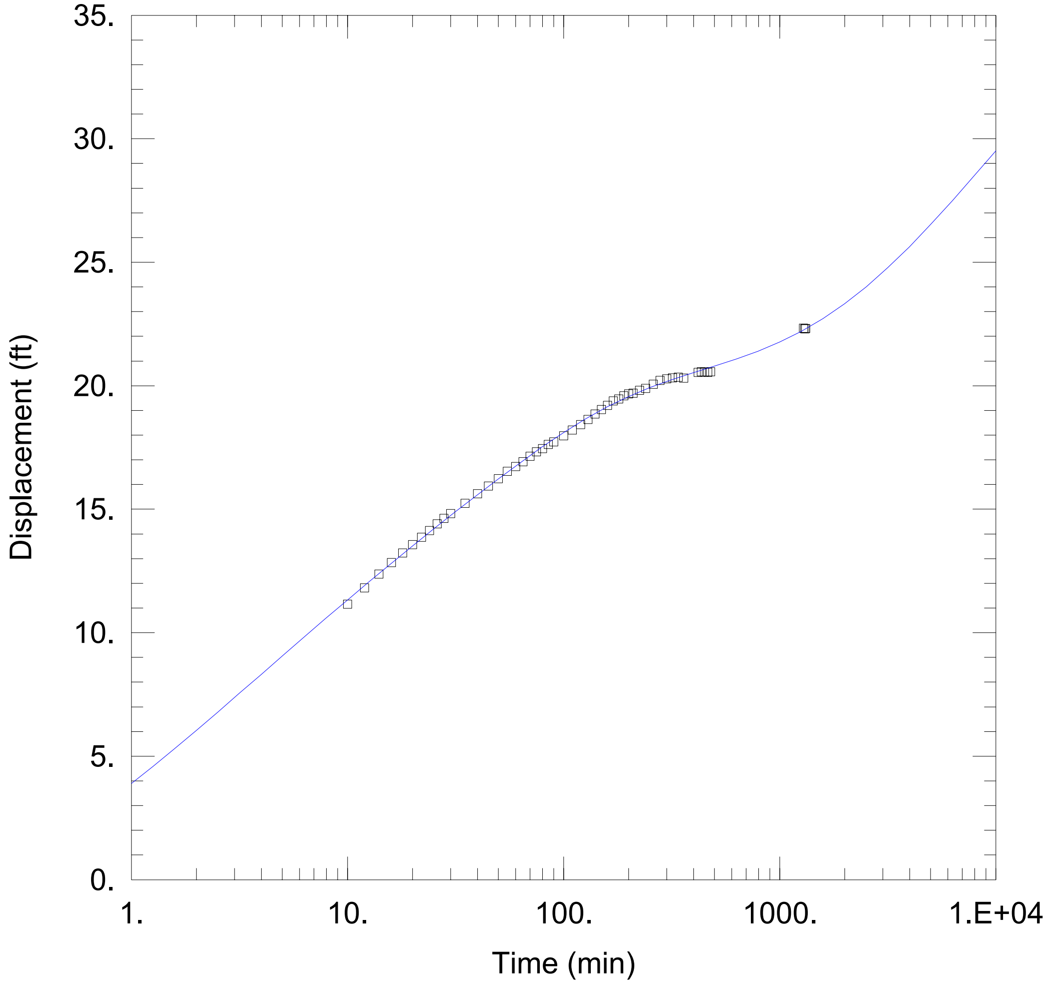
Observation Wells

Well Name	X (ft)	Y (ft)
□ T633	88.5	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 2.526 ft^2/min
ß = 0.0358
b = 340. ft
S = 0.0002785
Kz/Kr = 1.



WELL TEST ANALYSIS

Data Set: \...\384 EM_NW.aqt
Date: 11/13/02 Time: 18:56:38

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W384 EM
Test Date: September 1986

AQUIFER DATA

Saturated Thickness: 340. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W384 EM	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ T633	88.5	0

SOLUTION

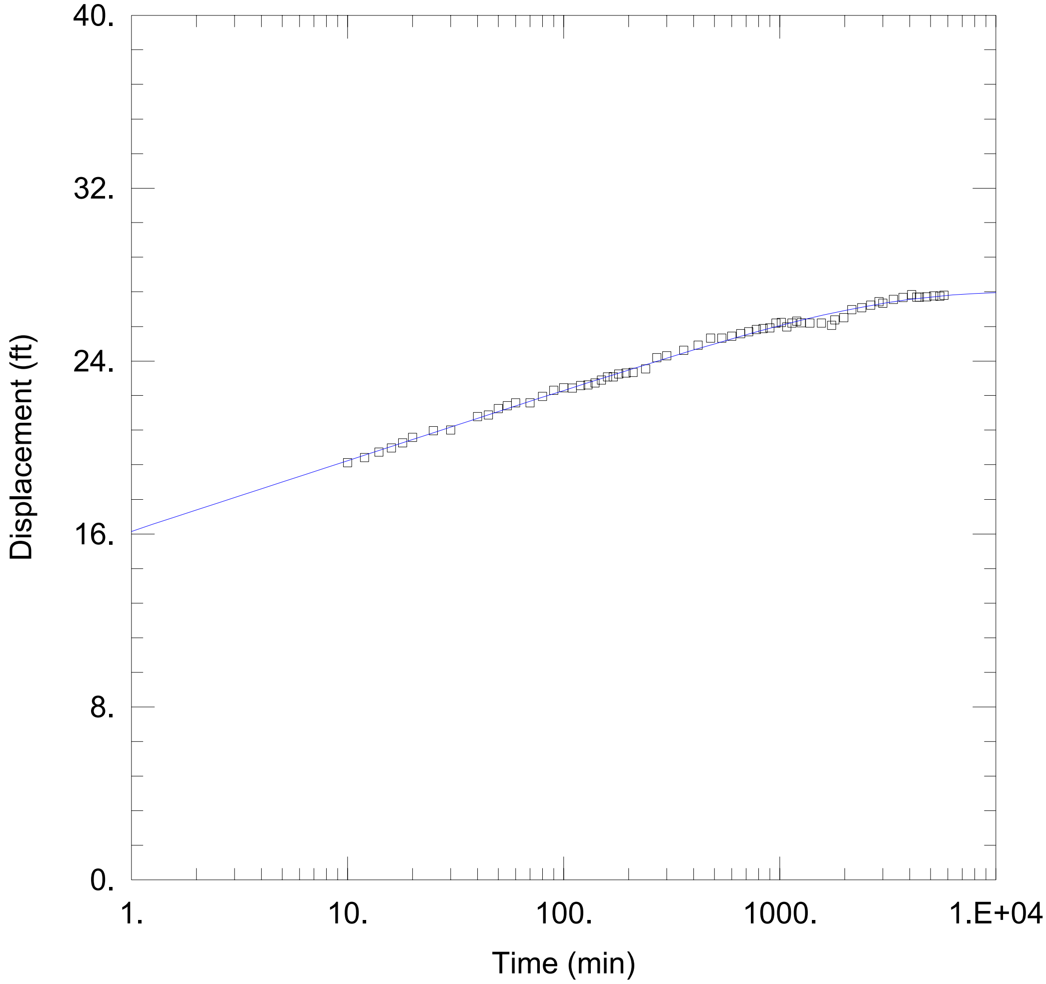
Aquifer Model: Leaky

Solution Method: Neuman-Witherspoon

T = 2.256 ft^2/min
r/B = 0.1166
T' = 1.E-05 ft^2/min

S = 0.0003022
ß = 0.05682
S' = 0.007418

Appendix L
AQTESOLV Output for
Well W395 AQ (Symmes-Shepherd)



WELL TEST ANALYSIS

Data Set: \...\395 AQ_HJ.aqt
Date: 11/14/02 Time: 16:22:39

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W395 AQ
Test Date: January 1989

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W395 AQ	0	0

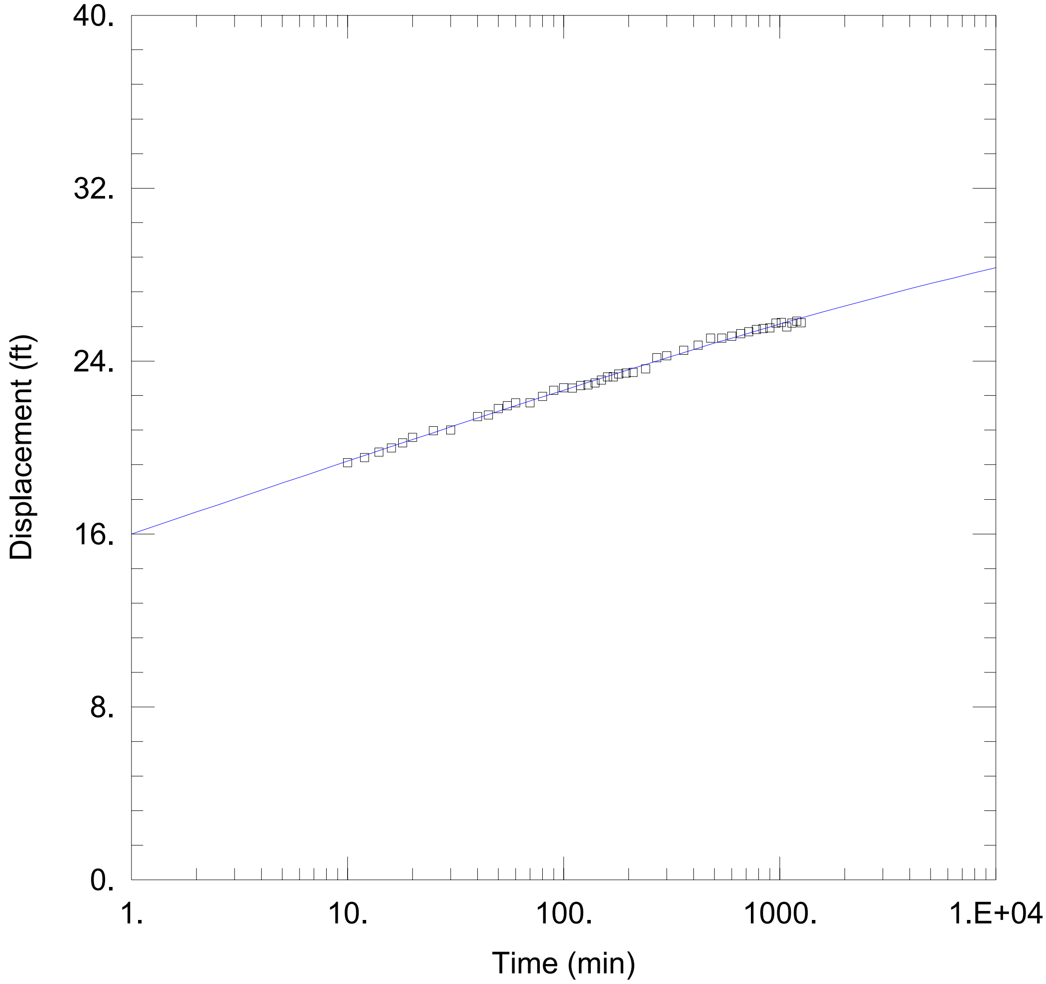
Observation Wells

Well Name	X (ft)	Y (ft)
□ W395 AQ	1.17	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 22.82 ft^2/min
S = 0.0007491
r/B = 0.0001019
Kz/Kr = 1.
b = 462. ft



WELL TEST ANALYSIS

Data Set: \...\395 AQ_H.aqt
Date: 11/14/02 Time: 17:15:06

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W395 AQ
Test Date: January 1989

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W395 AQ	0	0

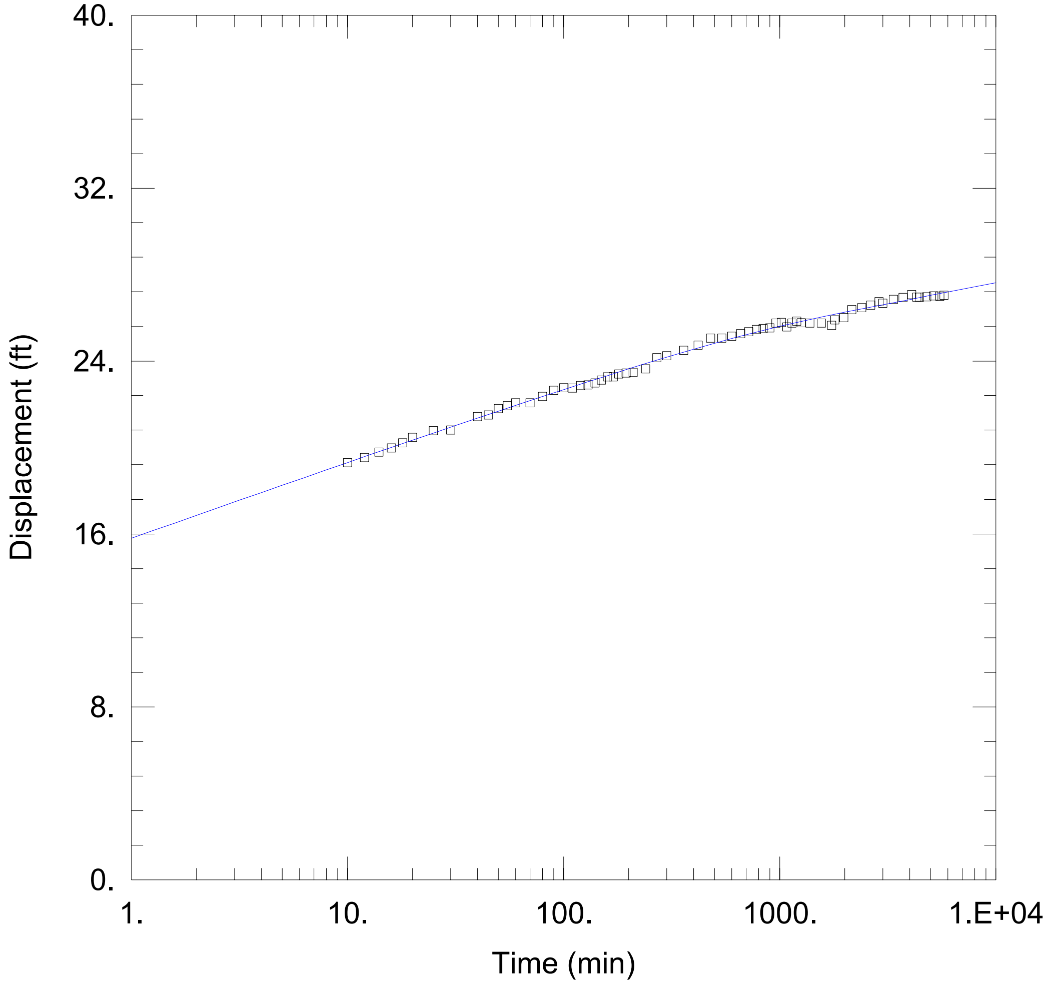
Observation Wells

Well Name	X (ft)	Y (ft)
□ W395 AQ	1.17	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 21.88 ft^2/min
S = 0.001233
ß = 2.687E-05
Kz/Kr = 1.
b = 462. ft



WELL TEST ANALYSIS

Data Set: \...\395 AQ_NW.aqt
Date: 11/14/02 Time: 17:09:25

PROJECT INFORMATION

Company: MWH
Client: LADWP
Test Well: W395 AQ
Test Date: January 1989

AQUIFER DATA

Saturated Thickness: 462. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
W395 AQ	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ W395 AQ	1.17	0

SOLUTION

Aquifer Model: Leaky Solution Method: Neuman-Witherspoon

T = 20.91 ft^2/min
r/B = 0.0002295
T' = 15.7 ft^2/min

S = 0.001273
ß = 4.235E-05
S' = 0.001318

Appendix M
Sample Calculations

Appendix M
Sample Calculations

Sample Calculation #1:

Calculation of the Confining Unit Vertical Hydraulic Conductivity (K_z') using the Hantush-Jacob Method (1955) for Well W387 EM

Known Parameters	**Parameter Value for Well W387 EM Analysis**
Thickness of Confining Unit (b')	50 feet
Radial Distance from the Center of Pumping (r)	1.17 feet
Parameters Yielded by the Hantush-Jacob Method (1955)	**Parameter Value for Well W387 EM Analysis**
Aquifer Transmissivity (T)	5.298 ft^2/min
Aquifer Storativity (S)	0.004245
Radial distance divided by the leakage factor (r/B)	0.001337

By definition, $\left(\frac{r}{B}\right) = \frac{r}{\sqrt{\frac{T \cdot b'}{K_z'}}}$

So, $K_z' = \frac{T \cdot b'}{r^2} \cdot \left(\frac{r}{B}\right)^2 = \frac{(5.298\ \text{ft}^2/\text{min}) \cdot (50\ \text{feet})}{(1.17\ \text{feet})^2} \cdot (0.001337)^2 = 0.000346\ \text{ft/min} = 3.73\ \text{gpd/ft}^2$

Sample Calculation #2:

Calculation of the Confining Unit Vertical Hydraulic Conductivity/ Storativity Product $(K_z' \cdot S')$ using the Hantush Method (1960) for Well W387 EM

Known Parameters	**Parameter Value for Well W387 EM Analysis**
Thickness of Confining Unit (b')	50 feet
Radial Distance from the Center of Pumping (r)	1.17 feet
Parameters Yielded by the Hantush-Jacob Method (1955)	**Parameter Value for Well W387 EM Analysis**
Aquifer Transmissivity (T)	5.273 ft^2/min
Aquifer Storativity (S)	0.003745
Hantush β	0.0002972

$$\text{By definition, } \beta = \frac{r}{4} \cdot \sqrt{\frac{K_z' \cdot S'}{b' \cdot T \cdot S}}$$

$$\text{So, } K_z' \cdot S' = \frac{16 \cdot \beta^2 \cdot b' \cdot T \cdot S}{r^2} = \frac{16 \cdot (0.0002972)^2 \cdot (50\text{ feet}) \cdot (5.273\text{ ft}^2/\text{min}) \cdot (0.003745)}{(1.17\text{ feet})^2}$$

$$= 0.00000102\text{ ft/min} = 0.0110\text{ gpd/ft}^2$$

Note: The storativity of the confining unit may be estimated by dividing the confining unit vertical hydraulic conductivity/storativity product calculated with the Hantush Method by one of the confining unit vertical hydraulic conductivity estimates generated with either the Hantush-Jacob Method or the Neuman-Witherspoon Method. However, because the resultant storativity value would be highly uncertain due to the combination of two separate analysis methods, and because obtaining the confining unit storativity was not the ultimate objective of this analysis, this calculation was not performed.

Sample Calculation #3:

Calculation of the Confining Unit Vertical Hydraulic Conductivity (K_z') using the Neuman-Witherspoon Method (1969) for Well W387 EM

Known Parameters	**Parameter Value for Well W387 EM Analysis**
Thickness of Confining Unit (b')	50 feet
Radial Distance from the Center of Pumping (r)	1.17 feet
Parameters Yielded by the Hantush-Jacob Method (1955)	**Parameter Value for Well W387 EM Analysis**
Confined Aquifer Transmissivity (T)	4.976 ft^2/min
Confined Aquifer Storativity (S)	0.002734
Radial distance divided by the leakage factor (r/B)	0.001344
Neuman-Witherspoon β	0.0003301
Unconfined Aquifer Transmissivity (T^U)	0.00001243
Unconfined Aquifer Storativity (S^U)	1.0

$$\text{By definition, } \left(\frac{r}{B}\right) = \frac{r}{\sqrt{\dfrac{T \cdot b'}{K_z'}}}$$

$$\text{So, } K_z' = \frac{T \cdot b'}{r^2} \cdot \left(\frac{r}{B}\right)^2 = \frac{(4.976\ \text{ft}^2/\text{min}) \cdot (50\ \text{feet})}{(1.17\ \text{feet})^2} \cdot (0.001344)^2 = 0.000328\ \text{ft/min} = 3.54\ \text{gpd/ft}^2$$

Note, confining unit vertical hydraulic conductivity can also be obtained from the Neuman-Witherspoon β value. However, in order to perform this calculation, both the confined aquifer vertical hydraulic conductivity and the confining unit storativity must be known. See below:

$$\text{By definition, } \beta = \frac{r}{4b}\sqrt{\frac{K_z' \cdot S'}{K_z \cdot S}} \;\Rightarrow\; K_z' = \frac{16b^2 \cdot \beta^2}{r^2} \cdot \frac{K_z \cdot S}{S'}$$

Where: b = Confined Aquifer Thickness
K_z = Confined Aquifer Vertical Hydraulic Conductivity
S' = Confining Unit Storativity

Due to these limitations, calculation of the confining unit vertical hydraulic conductivity was performed only using the calculated r/B value for the purposes of this technical memorandum.